8[TH] INTERNATIONAL CONFERENCE ON TRACERS AND TRACING METHODS

TRACER 8
TRACERS AND TRACING METHODS

CONFERENCE GUIDE & ABSTRACTS BOOK

FROM TUESDAY 26[TH] FEBRUARY, 2019 TO THURSDAY 28[TH] FEBRUARY, 2019, IN DÀ NANG, VIETNAM.

SUMMARY

INTRODUCTION

Welcome in Da Nang!

Dear participants,

it is our great pleasure to welcome you in Da Nang, Vietnam, for the eighth TRACER Conference. Following seven conferences that have been held over the last twenty years on three continents, TRACER 8 will now set up in Asia. It is a unique opportunity to exchange and learn breakthrough novelties about tracing.

Tracing is a proven and very useful method allowing hydrodynamic investigations for a lot of situations in industry, subsoil investigations, environment, etc. It is used by many scientists and engineers in many areas. It is also a necessary tool to validate models and simulations, especially for new approaches of Computational Fluid Dynamics with reactions or Compartmental Modeling. During the conference, all aspects of tracing will be exposed, from methods and technics, applications in several domains to simulation including virtual tracing with CFD. Other related topics will also be discussed such as radioactive particles tracking or tomography.

Tracer 8 is a unique opportunity to meet the best tracing specialists and the best tracer teams.

The conference is structured around five themes:

- Theme 1: Environment, Environmental engineering, Hydrology, Sediment, Safety
- Theme 2: Radioactive particles tracking, Tomography, Gamma Scanning, Neutron backscattering
- Theme 3: Reservoir, Well, Interwell, Geothermal energy, Dam, Nuclear waste storage
- Theme 4: Methodology, Theory, Modeling, and Simulation
- Theme 5: Tracing for industry

We hope to see you in Da Nang for TRACER 8 conference!

Julien Laurent and Olivier Potier

Chairs of the conference

CHAIRS OF THE CONFERENCE

Olivier Potier

LRGP, CNRS, ENSGSI, Université de Lorraine

Nancy, France

Julien Laurent

Icube, ENGEES, CNRS Université de Strasbourg

Strasbourg, France

HISTORY

1998	The first conference on "Tracers and tracing methods" has been organized in Nancy, France, in November 1998 as a national French event. The main organiser was the former ‘Laboratoire des Sciences du Genie Chimique’, (LSGC, UPR CNRS 6811) that became ‘Laboratoire Réaction et Génie des Procédés’ (LRGP, UPR 3349) in 2010.
2001	The second conference on the same subject has been conceived as an international event, and was conducted again in Nancy, France by the same organizer of the first conference. It took place in May 2001.
2004	The third conference, briefly called "Tracer 3", was held in Ciechocinek, Poland in June 2004. The host institution was Warsaw University of Technology.
2006	The fourth conference, "Tracer 4" has been organized in Autrans, France in October 2006 by the Commissariat à l'Energie Atomique, CEA, Grenoble.
2008	The fifth conference, "Tracer 5" was held in Tiradentes in the state of Minas Gerais in Brazil, in October 2008. The organizer was Centro de Desenvolvimento da Technologia Nuclear, CDTN, in Belo Horizonte, Brazil.
2011	The sixth conference, "Tracer 6" was conducted in Oslo, Norway at the Institute for Energy Technology (IFE) in June 2011.
2014	The "Tracer 7" International Conference was held in Marrakech, Morocco in October 2014 organized by the “Centre National des Sciences et des Techniques Nucléaires (CNESTEN)” and Morocco Radio-Isotopes Association (MORIA).

The International Society for Tracer and Radiation Applications (ISTRA) was founded during the Tracer 7 conference in Marrakesh in October 2014, as a non-profit organization with the aim of promoting international cooperation in this field.

The primary objective of the “Tracer” conferences remains to present the current status and trends on tracing methods and their applications. It is opportunity for attendees from different fields to exchange scientific information and knowledge about tracer methodology and applications in one field that may also be applied, with modifications, in another field.

The TRACER 8 conference is co-organized between three entities namely:

- ISTRA (International Society of Radiation and Tracers Application), Vienna, Austria
- PROGEPI (Center for the promotion of process engineering in industry) Nancy, France
- CANTI (Centre for Applications of Nucleaar Technique in Industry), Vietnam

DISCOVER Đà Nẵng

Da Nang is one of the cultural and educational centres of Vietnam, and it is also one of the biggest cities in Vietnam. The city is located along Han River so that the French often called Da Nang as “Tourane”. Da Nang has an area of 1.200 km^2 and its total population is about 800.000 people.

It is not only convenient location but also easily accessible port. Situated on the path of national route 1A and the North-South railway, it is known as a hub for transportation.

Da Nang city shares the border with Thua Thien Hue in the North, Quang Nam province in the South and The Eastern Sea. It is far 764 kilometers from Hanoi to the North, 964 kilometers from Ho Chi Minh City to the South and 108 kilometers from Hue ancient capital to the North-South.

The nature blesses Da Nang to be located near three world culture heritage sites: Hue ancient capital, Hoi An old quarter and My Son Holy Land. It is not only the center of three world heritages but also has many famous destinations that tourists cannot forget when visiting the city. Da Nang has a long coast with many beautiful beaches such as Non Nuoc, My Khe, Thanh Kh, Nam O with unforgettable nature.

The Han River and the bridge over the Han River-the first bridge in Vietnam-the pride of Vietnamese, are two symbols of Da Nang. The bridge over the Han River represents the new life, aspiration of the people of Da Nang. This bridge does not only enhance transportation but promotes the potential economy and is a cultural mark of the Da Nang.

Beaches are the source of inspiration that Da Nang has. They are not only clean but also the most attractive beaches in Vietnam. The city along the Han River- this beautiful city is an ideal destination for tourists coming to Da Nang.

COMMITTEES

CONFERENCE CHAIRS

Julien LAURENT, Strasbourg, France

Olivier POTIER, Nancy, France

LOCAL ORGANIZING COMMITTEE

Quang NGUYEN HUU, Lâm Đong, Vietnam

Dang NGUYEN THE DUY, Lâm Đong, Vietnam

SCIENTIFIC COMMITTEE

Rachad ALAMI, Morocco

Tor BJØRNSTAD, Kjeller, Norway

Patrick BRISSET, Vienna, Austria

Sergio CHIVA VINCENT, Castellón de la Plana, Spain

Dionysios DIONYSIOU, Cincinnati, United States

Dominique DUMAS, Vandoeuvre-les-Nancy, France

Catherine HUGHES, Sydney, Australia

Iqbal Hussain KHAN, Islamabad, Pakistan

Harish Jagat PANT, Mumbai, India

Thorsten JENTSCH, Dresden, Germany

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Rubens MARTINS MOREIRA, Minas Gerais, Brazil

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Olivier POTIER, Nancy, France

Zdzislaw STEGOWSKI, Krakow, Poland

Jovan THERESKA, Vienna, Austria

Jim WICKS, Oxford, United Kingdom

CONFERENCE CO-ORGANIZED BY

ISTRA

International Society of Radiation and Tracers Application

PROGEPI

Center for the promotion of process engineering in industry

CANTI

Centre for Applications of Nuclear Technique in Industry

CONFERENCE VENUE

LOCATION

GRAND TOURANE HOTEL

Address:

252 Vo Nguyen Giap Street, Son Tra District,

Da Nang City, Viet Nam

Phone number:

+84 236 3778 888

The congress will take place at the Grand Tourane Hotel – Da Nang-Vietnam

Grand Tourane Hotel Da Nang is conveniently located just 5 km from Da Nang International Airport and a short walk from the beautiful My Khe Beach. This Hotel is a 1-minute walk from the beach. It offers an outdoor pool and free Wi-Fi.

The hotel has a 24-hour front desk and a charming garden where guests can relax with a coffee.

An airport shuttle service is available (extra charge). The on-site restaurant serves authentic Vietnamese cuisine.

WELCOME DESK

A permanence will be ensured at the reception desk for the duration of the conference. Do not hesitate to come to us if you want information about administrative, technical, organizational social or scientific aspects.

Opening time:

- Tuesday 26: 07:30 AM to 10:00 AM
- Wednesday 27: 08:00 AM to 9:30 AM
- Thursday 28: 08:00 AM to 9:00 AM

CONFERENCE LOCATION

Conference	Ballroom 2nd floor
Poster exhibition	Foyer - Outside the Ballroom 2nd floor
Conference lunch	Buffet lunch – Bella Vista Restaurant – 3rd floor
Coffee breaks	Foyer - Outside the Ballroom 2nd floor
Gala dinner	Bella Vista Restaurant

INSTRUCTIONS
FOR DELEGATES AND PRESENTERS

NAME BADGES

When you register at the office, a name badge will be provided. All delegates, staff and presenters must wear their name badges at all times throughout the conference and social events.

SAFETY

For safety reasons, we recommend that delegates do not leave their personal computer or personal belongings in the conference room.

INFORMATION FOR PRESENTERS

The conference room will be set up with a laptop connected to a projector and presentation screen, a remote control with laser pointer will be at your disposal. To avoid any technical bug and too long installation delay, it is preferable that you do not use your personal computer (unless otherwise noted). If you want to use particular formats such as video, sending your presentation in advance is highly recommended. Using a local file is preferred rather than reading an online file.

To ensure better chaining presentations, we invite you to anticipate the loading of your presentations. Please contact your moderator to load your presentation on the computer present in the conference room, ideally half a day before you session.

ORAL COMMUNICATIONS

The time granted for oral presentation will be of 15 minutes: setting up + 10 minutes of presentation + 5 minutes of exchanges. Please check your speaking times and respect the schedule, in order to guarantee a fluent program flow.

FLASH ORAL COMMUNICATIONS

Flash oral presentations are intended for authors of papers accepted as a poster. You will have in addition to a dedicated exhibition space to display your poster, a real oral presentation time of 4 minutes to present your communication.

The time granted for flash oral presentation will be of 4 minutes, including the time of presentation and setting up. Please check your speaking times and respect the schedule, in order to guarantee a fluent program flow.

POSTERS SESSION

The posters will have to be brought and hung Tuesday 26/02 in the morning, they will remain posted throughout the symposium in the Foyer (2nd floor).

Each author is responsible for the display and the removal of his post. Please make sure your poster is posted the day of your corresponding session, ideally at the beginning of the day. Do not forget to collect them at the end of the day. Otherwise they will be destroyed.

PRACTICAL INFORMATION

CALL

If you want to receive calls in Vietnam the nation prefix for Vietnam is: 84. Examples:

from Europe dial: 00 + 84 + the city code + the number.
from USA or Canada: 011 + 84 + the city code + the number

EMERGENCY NUMBERS:

113 Police
114 Fire
115 Ambulance / First aid

CURRENCY

The currency of Viet Nam is the Vietnamese Dong. The currency code for Dong is VND, and the symbol is ₫.

Conversion rate (January 2019):

Europe	Unites states	Canada	Australia	China
1€ = 26388 ₫	1 US$ = 23155 ₫	1 CAN$ = 17436 ₫	1 AU$ = 16590 ₫	1 ¥ = 212 ₫
10000₫ = 0,38 €	10000 ₫ = 0,43 US$	10000 ₫ = 0,57 CAN$	10000 ₫ = 0,60 AU$	10000 ₫ = 4,70 ¥

TAXI

MaiLinh CORPORATION	**Mai Linh** +84 511 356 5656 https://mailinh.vn/
VINASUN TAXI	**Vinasun** +84 511 368 6868 http://www.vinasuntaxi.com
You can also order a taxi directly from the reception of your hotel	

TOURIST OFFICE

Da Nang Visitor Center

108 Bạch Đằng, Hải Châu 1, Hải Châu, Đà Nẵng 550000

+84 236 3550 111

https://danangfantasticity.com

SOCIAL PROGRAM

WELCOME COCKTAIL

FEBRUARY 25TH AT 8:00 PM

To welcome you and start well the 8th International Conference on Tracers and Tracing Methods, a "Icebreaker" buffet will be proposed at the "Bella Vista Restaurant".
It will be a great opportunity to meet the participants of the congress in a friendly atmosphere, to discuss and discover the place before the beginning of the scientific presentations the next day, Monday 25th February.

Included in the registration fee

GALA DINNER

FEBRUARY 27TH AT 8:00 PM

After your two days conference, we will be happy to propose you the Gala Dinner.
It will be served at the "Bella Vista Restaurant", where the « chef » will make you discover culinary delights, in a sumptuous buffet of specialties.
During this dinner, you will be accompanied by a local musical group, a folk show, and other animations. Combined with the mesmerizing view on Da Nang City and its seashore, this dinner which will offer you an unforgettable evening out of time.

Not included in the registration fee

GALA EVENING ANIMATION

Traditional dancing performance of local ethnic group

Cham people are an ethnic group of Austronesian origin in Southeast Asia. Their contemporary population, a diaspora, is concentrated between the Kampong Cham Province in Cambodia and Phan Rang–Tháp Chàm, Phan Thiết, Ho Chi Minh City and An Giang Province in Southern Vietnam.
The Cham culture is diverse and rich because of the combination of indigenous cultural elements (plains culture, maritime culture, and mountain culture) and foreign cultural features (Indian cultures and religions such as Buddhism; early Han Chinese influences; Islam)

DETAILED SCIENTIFIC PROGRAM

DETAILED PROGRAM

Session 1:
Environment, Environmental engineering, Hydrology, Sediment, Safety

Session 2:
Radioactive particles tracking, Tomography, Gamma Scanning, Neutron backscattering

Session 3:
Reservoir, Well, Interwell, Geothermal energy, Dam, Nuclear waste storage

Session 4:
Methodology, Theory, Modeling, Simulation

Session 5:
Tracing for industry

REMINDER OF INSTRUCTIONS

Oral communication
The time granted will be of 15 minutes
(including setting up, your presentation and a short period of questions)

Flash oral communication
The time granted will be of 4 minutes
(including setting up and your presentation)
Also possible to display the poster at the exhibition poster

Poster exhibition
Display of your poster on the panels provided for this purpose

Tuesday 26th

Time	Session
	Welcome 8:00AM-9:00AM
	Opening talks (20') 9:00AM-9:20AM
	Keynote lecture Samstag Randal 9:20AM-10:00AM
	Oral Session 1 -part 1 10:00AM-10:45AM
10:00 AM	220742
10:15 AM	230598
10:30 AM	231698
	Coffee break (30') 10:45AM-11:15AM
	Oral Session 1 - part 2 11:15AM-12:45t a
11:15 AM	232525
11:30 AM	232573
11:45 AM	233265
12:00 AM	234767
12:15 AM	234771
12:30 tM	235011
	Lunch (1:30) 12:45t a -2:15PM
	Oral Session 2 - Part 1 2:15PM-3:30PM
2:15 PM	225052
2:30 PM	225053
2:45 PM	232221
3:00 PM	232495
3:15 PM	233098
	Coffee break (30') 3:30PM - 4:00PM
	Flash oral communication Session 1 (1:15) 4:00PM-5:15PM
	Oral Session 2 - Part 2 5:15PM-6:15PM
5:15 PM	233202
5:30 PM	233274
5:45 PM	233374
6:00 PM	234673

Wednesday 27th

Time	Session
	Welcome 8:30AM-9:00AM
	Keynote lecture Bjørnstad Tor 9:00AM-09:40AM
	Oral Session 3 - Part 1 09:40AM-10:40AM
09:40 AM	232562
09:55 AM	233122
10:10 AM	220199
10:25 AM	233427
	Coffee break (30') 10:40AM-11:10AM
	Oral Session 3 - Part 2 11:10AM-12:25t a
11:10 AM	233116
11:25 AM	233379
11:40 AM	224600
11:55 AM	233132
12:10 tM	233398
	Lunch (1:35) 12:25t a -2:00PM
	Oral Session 4 - Part 1 2:00PM-3:00PM
2:00 PM	233254
2:15 PM	233321
2:30 PM	234145
2:45 PM	234691
	Coffee break (30') 3:00PM-3:30PM
	Oral Session 4 - Part 2 3:30PM-4:15PM
3:30 PM	234073
3:45 PM	233225
4:00 PM	234794
	Flash oral communication Session 2 (1:15) 4:15PM-5:30PM
	Gala dinner *Start at 8:00PM*

Thursday 28 th

Time	Session
	Welcome 8:30AM-8:45AM
	Keynote lecture Jean-Pierre Leclerc 8:45AM-09:25AM
	Oral Session 5 - Part 1 9:25AM-10:10AM
09:25 AM	230174
09:40 AM	232420
09:55 AM	232656
	Coffee break (30') 10:10AM-10:40AM
	Flash oral communication Session 3 (1:00) 10:40AM-11:40AM
	Oral Session 5 - Part 2 11:40AM-12:25t a
11:40 AM	232702
11:55 AM	233394
12:10 tM	234768
12:25 tM	234783
	Closing session 12:40t a -13:00PM
	Lunch (1:30) 13:00PM-2:30PM

SCIENTIFIC PROGRAM - KEYNOTES LECTURES

KN KEYNOTES LECTURES
SPECIAL SESSION

KEYNOTES LECTURES

Reference	Start time	Duration	Oral communication
K1	*Day 1 9:20 AM*	*40'*	***Tracer Test and Modelling of Wastewater Treatment Aeration Tanks*** *Samstag Randal* *Civil and Sanitary Engineer (United States)*
K2	*Day 2 9:00 AM*	*40'*	***Tracer-Based Well Inflow Monitoring*** *Bjørnstad Tor, Sira Terje* *Institute for Energy Technology, IFE (Norway)*
K3	*Day 3 8:45 AM*	*40'*	***Tracer experiments and CFD modeling for a better occupational risk prevention*** *Jean-Pierre Leclerc* *Head of Process Engineering department, INRS, France*

SCIENTIFIC PROGRAM - ORAL COMMUNICATION

DAY 1: Tuesday 26th

S1 ORAL SESSION 1:
DAY 1: Tuesday 26th

Environment, Environmental engineering, Hydrology, Sediment, Safety

ORAL SESSION 1

Reference	Start time	Duration	Oral communication
220742	10:00 AM	15'	***Radiotracer Study to Ascertain the Efficacy of Fly Ash Disposal*** *Yelgaonkar Vivek,* *Board Of Radiation and Isotope Technology (India)*
230598	10:15 AM	15'	***Calibration of a nucleonic gauge for Pacific and Atlantic Oceans: Panama case*** *Pinzon Reinhardt (1), Aguilar (2) (3), Rivera Felipe (1), Hoo Henry (4), Sánchez Xavier (4)* *1 - Centro de Investigaciones Hidráulicas e Hidrotécnicas (CIHH). Universidad Tecnológica de Panamá (UTP) (Panama), 2 - Facultad de Ciencia y Tecnologia de la Universidad Tecnlógica de Panamá (Panama), 3 - Universidad Tecnologica de Panama (Panama), 4 - Facultad de Ingeniería Civil. Universidad Tecnológica de Panama (UTP) (Panama)*

ORAL SESSION 1				
	231698	10:30 AM	15’	***Investigation of Hydrodynamics of an Electrocoagulation Reactor for Water Defluoration using Radiotracer Technique*** *Ben Abdelouahed Haifa* *Centre National des Sciences et Technologies Nucléaires (Tunisia)*
	232525	11:15 AM	15’	***Evaluation of Hydraulic Performance of an Anaerobic Pond using Radiotracer Technique*** *Wendy Adwet* *Institute of Nuclear Science and Technology, University of Nairobi (Kenya)*
	232573	11:30 AM	15’	***Optimization of the Accuracy Measurement with Nuclear Gamma Gauge for high suspended Cohesive Sediments Concentration*** *Ouardi Afaf* *CNESTEN (Morocco)*
	233265	11:45 AM	15’	***Calibration of the Gauge of Density XDP30*** *Saadaoui Abdelaziz, Jainija Alaa, Abdelghafour Ezzahri, Outayad Rabie* *CNESTEN (Morocco)*
	234767	12:00 PM	15’	***Anaerobic Digesters Mixing Optimization through Tracer Test and CFD Modeling*** *Arnau Rosario (1), Climent Javier (2), Martínez-Cuenca Raúl (1), Chiva Sergio (1)* *1 - Universitat Jaume I (Spain), 2 - Grupo Gimeno (Spain)*
	234771	12:15 PM	15’	***Monte Carlo Modeling of the Potential Distribution of Internal Dose based on Random Active Particle Location to Organisms in the Sediment Bed*** *Ouardi Afaf (1), Chughes Cath (2)* *1 - Centre National de l'Energie des Sciences et des techniques Nucléaires (Morocco), 2 - Australian Nuclear Science and Technology Organisation (ANSTO) (Australia)*
	235011	12:30 PM	15’	***Transfer of Micropollutants by Urban Run-off with Different Hydrological Scenarios*** *Motelica Mikael (1), Al Juhaishi Mohammed (2), Muller Fabrice (2)* *1 - Institut des Sciences de la Terre d'Orléans (France), 2 - ISTO (France)*

S2 **ORAL SESSION 2:**
DAY 1: Tuesday 26th

Radioactive particles tracking, Tomography, Gamma Scanning, Neutron backscattering

ORAL SESSION 2	Reference	Start time	Duration	Oral communication
	225052	2:15 PM	15’	***Microalgae Cell Trajectories via Radioactive Particle Tracking (RPT)*** *Sabri Laith (1), Sultan Abba (2), Aldahhan Muthanna (3) (4)* *1 - Multiphase Flow and Reactors Engineering Applications Laboratory (mFReal) (United States), 2 - Chemical Engineering Department in University of Technology (Iraq), 3 - Multiphase Flow and Reactors Engineering Applications Laboratory (mFReal) (United States),* *4 - Cihan University-Erbil, Iraq (United States)*

ORAL SESSION 2	**225053**	2:30 PM	15’	***Local Gas Holdup in Fluidized Bed Reactor using Gamma-ray Computed Tomography Technique (CT)*** *Efhaima Abdelsalam (1), Sabri Laith (2), Aldahhan Muthanna (3) (4)* *1 - Higher Colleges Of Technology, Abu Dhabi (United Arab Emirates),* *2 - Multiphase Flow and Reactors Engineering Applications Laboratory (mFReal) Department of Chemical and Biochemical Engineering, Missouri University of Science and Technology (United States), 3 - Multiphase Flow and Reactors Engineering Applications Laboratory (mFReal) (United States), 4 - Cihan University-Erbil, Iraq (United States)*
	232221	2:45 PM	15’	***Development of Gamma Column Scanning by CT Scanning Technique for Lab-Scale Column*** *Myaing Khaing Nyunt (1), Oo Zin Bo (2), Htut Myo Zaw (2)* *1 - Atomic Energy Division (Myanmar, Burma),* *2 - Nuclear Physics Department (Myanmar, Burma)*
	232495	3:00 PM	15’	***Fluka Monte Carlo Simulation of Gamma Photon Transport through a Distillation Column, Designed using ChemSep Software*** *Baricholo Peter, Chirume Witness, Mudono Stanford* *National University of Science and Technology (Bulawayo) (Zimbabwe)*
	233098	3:15 PM	15’	***Experimental Research on Dynamic Paraffin Visualization Using Gamma-Ray Tomography Technique*** *Wibisono Wibisono* *Center for Isotope and Radiation Application, Batan (Indonesia)*
	233202	5:15 PM	15’	***Gamma Scanning Technique for Investigating De-Ethanizer Column: On Field Experimental at NGL Plant*** *Azmi Bayu* *Center for Isotopes and Radiation Application- Batan (Indonesia)*
	233274	5:30 PM	15’	***Liquid Level Measurement in Distillation Column Simulator by Neutron Backscattering Technique*** *Lwin Khin Ye (1), Hlaing Moe Phyu* *Division of Atomic Energy (Myanmar, Burma)*
	233374	5:45 PM	15’	***Using the Gamma Scan Technique for Diagnostic and Troubleshooting in Industrial Plants*** *Duy Dang, Minh Tran* *Centre for Applications of Nuclear Technique in Industry (Vietnam)*
	234673	6:00 PM	15’	***Hydrodynamics of Binary Fluidized Bed Employing Radioactive Particle Tracking*** *Roy Shantanu (1), Pant Harish J. (2), Roy Sangram (1)* *1 – indian Institute of technology (India), 2 - Isotope Production and Applications Division, Bhabha Atomic Research Centre (India)*

DAY 2: Wednesday 27th

S3 ORAL SESSION 3: DAY 2: Wednesday 27th

Reservoir, Well, Interwell, Geothermal energy, Dam, Nuclear waste storage

ORAL SESSION 3	Reference	Start time	Duration	Oral communication
	232562	9:40 AM	15’	***Natural Stable Isotopes To Detect Leakage In Mining Tailings Dams*** *Moreira Rubens* *Nuclear Technology Development Center (Brazil)*
	233122	9:55 AM	15’	***Application of Tracer Techniques in Investigation of Leakage in Earthen Dam*** *Nguyen Huu Quang* *Huong Huynh Thi Thu (Vietnam)*
	220199	10:10 AM	15’	***Application of Radiotracer Techniques for Geothermal Reservoir Management in Kenya*** *Omondi Collins (1), Mangala Micheal (2)* *1 - Kenya Bureau of Standards (KEBS) (Kenya),* *2 – University of Nairobi (Kenya)*
	233427	10:25 AM	15’	***Using Tracer Tests in the Management of Reinjection into Geothermal Systems*** *Axelsson Gudni* *Iceland GeoSurvey (Iceland)*
	233116	11:10 AM	15’	***Tracer Class Combination for Interwell Tracer Tests ? Joining Cost-effective Robustness to State-of-the-Art Selectivity*** *Puls Christoph, Schnöller Johannes, Davidescu Bogdan-George, Kadnar Rainer* *OMV Exploration & Production GmbH (Austria)*
	233379	11:25 AM	15’	***Investigation of Structural Properties of Barrier Materials for Nuclear Waste Storage using Non-radioactive Tracers*** *Erenturk Sema, Haciyakupoglu Sevilay, Senkal Filiz* *Istanbul Technical University (Turkey)*
	224600	11:40 AM	15’	***Investigation of Radiotracer's Capability in Water Flooding System using Laboratory Sand Pack Column: A Preliminary Study*** *Othman Noraishah* *Plant Assessment Technology, Malaysian Nuclear Agency (Malaysia)*
	233132	11:55 AM	15’	***Tracer for Determination of Dispersion Coefficient of Water in Core Sample*** *Nguyen Huu Quang (1) (2) (3)* *1 - Huong Huynh Thi Thu (Vietnam), 2 - Noha Najem (Kuwait),* *3 - Waleed Al-Bazzar (Kuwait)*
	233398	12:10 PM	15’	***Non Target Monitoring Tracers and Emerging Tracers for Enhanced Reservoir, Well Integrity and Risk Management*** *Preud'homme Hugues (1), Mahmoud Khaled (2), Shomar Basem (2), Reynaud Stéphanie (1), Grassl Bruno (1)* *1 - IPREM-UMR5254, E2S (France), 2 - QEERI - HBKU (Qatar),*

S4 **ORAL SESSION 4:**
DAY 2: Wednesday 27th

Methodology, Theory, Modeling, Simulation

ORAL SESSION 4	Reference	Start time	Duration	Oral communication
	233254	2:00 PM	15’	***Review of the International Standard ISO 2975 on Tracer Methods for the Measurement of Single-phase Flows in Closed Conduits*** *Jentsch Thorsten B. O. (1), Thereska Jovan (2), Brisset Patrick (3)* *1 - Helmholtz-Zentrum Dresden-Rossendorf (Germany),* *2 - IAEA expert and consultant (Austria), 3 - IAEA (Austria)*
	233321	2:15 PM	15’	***Recent Status of Industrial Application using Radioisotope in Korea*** *Moon Jinho, Sung-Hee Jung, Jang-Guen Park* *Korea Atomic Energy Research Institute (South Korea)*
	234145	2:30 PM	15’	***Numerical RTD as a Tool for Compartmental Modeling of Water Basin*** *Jourdan N.(1) (2) , Kanniche M. (2), Neveux T. (2), Potier O. (1)* *1 - Laboratoire Réactions et Génie des Procédés (France),* *2 - EDF R&D (France)*
	234691	2:45 PM	15’	***Comparison between Potassium Bromide and Lithium Chloride as Feasible Tracer for Assessing Hydraulic Performance in Anaerobic Digesters*** *Climent Javier (1), Corominas Lluis (2), Kyser Ayla (2), Arnau Rosario (1), Chiva Sergio (1), Pita Cristina (3), Bonmatí August (4)* *1 - Universitat Jaume I (Spain), 2 - Instituto Catalán de Investigación del Agua - ICRA (Spain), 3 - Universitat de Girona (Spain), 4 - IRTA (Spain)*
	234073	3:30 PM	15’	***Significance of Quality Management Systems in Tracer Services to Industry*** *Masinza Stanslaus Alwyn* *Technical Services (Kenya)*
	233225	3:45 PM	15’	***Utilization of Efficient Signal Processing Techniques for Sealed Sources Radioisotopes Identification*** *Kasban Hani* *Engineering Department, Nuclear Research Center (Egypt)*
	234794	4:00 PM	15’	***Numerical Tracer Simulation in Algal Raceway Pond using Momentum Source and Dynamic Mesh Methods*** *Teshome Tewodros, Pham Le Anh, Laurent Julien* *ICUBE Laboratoire des sciences de l'ingénieur, de l'informatique et de l'imagerie (France)*

DAY 3: Thursday 28th

S5 ORAL SESSION 5:
DAY 0: Thursday 28th

Tracing for industry

ORAL SESSION 5	Reference	Start time	Duration	Oral communication
	230174	9:25 AM	15’	***Identification of Flow Abnormalities in Pulp Digesters using Radiotracers*** *Sheoran Meenakshi (1), Chandra Avinash (1), Goswami Sunil (2), Sharma Vijay K. (2), Pant Harish J. (2), Bhunia Haripada (1), Gautam Arvind K. (3) 1 - Department of Chemical Engineering, Thapar Institute of Engineering & Technology, Patiala (India), 2 - Isotope Production and Applications Division, Bhabha Atomic Research Centre (India), 3 - Chemical Engineering Department, R.B.S. Engineering Technical Campus, (India)*
	232420	9:40 AM	15’	***Use of Radioactive Tracers for Measurement of Flowrate Distribution in Industrial Flotation Circuits*** *Diaz Francisco (1), Bustos Pablo (2), Vinnett Luis (3), Vallejos Paulina (3), Yianatos Juan (3)* *1 - Trazado Nuclear (Chile), 2 - Minera Los Pelambres (Chile), 3 - Universidad Santa Maria (Chile)*
	232656	9:55 AM	15’	***Determination of Leaks and Passes in Vapour Generators by the uUse of Proper Radiotracer for Aqueous and Organic Phases*** *Sebastian Carlos* *Universidad Ricardo Palma-Centro de Investigacion (Peru)*
	232702	11:40 AM	15’	***Residence Time Distribution Measurements in a Pilot-Scale Cross Flow Trickle Bed Reactor using Radiotracer Technique*** *Pant H.j.* *Bhabha Atomic Research Center (India)*
	233394	11:55 AM	15’	***Determination of Residence Time and Performance of a Heat Exchanger in a Natural Gas Fractionation Plant of Liquids*** *Maghella Gerardo, Maguiña Jose* *Instituto Peruano de Energia Nuclear (Peru)*
	234768	12:10 PM	15’	***The Torus Photobioreactor : A Tool for Metabolic Flux Analysis*** *Legrand Jack* *University of Nantes (France)*
	234783	12:25 PM	15’	***Radiometric Methods for Optimization of Phosphate Transport Process by « Slurry Pipe »*** *Mimount Samira (1), Alami Rachad (2), Saadaoui Abdelaziz (1)* *1 - Centre National de l'Energie des Sciences et Techniques Nucléaires (Morocco), 2 - Rachad (Morocco)*

SCIENTIFIC PROGRAM – FLASH ORAL COMMUNICATION

DAY 1: Tuesday 26th

P1 FLASH ORAL COMMUNICATION
DAY 1: Tuesday 26th

4:00PM-5:15PM
4 min per presentation

FLASH ORAL COMMUNICATION – SESSION 1

Reference	Duration	Presentation of the communication
235362	4’	***Modelization of the Aeraulic in a Wood-burning Appliance*** *Roda Bounaceur (1), Olivier Herbinet (1), Frédérique Battin Leclerc (1), Jean-Pierre Leclerc (1*), Céline Le Dreff (2), Sylvain Aguinaga (2), Frédéric Robic (3)* *1- Laboratoire Réaction et Génie des Procédés, LRGP UMR 7274 - CNRS, France, 2 - CSTB, France, 3 - LORFLAM, France, *Jean-Pierre leclerc is now working at INRS, Institut National de Recherche et de Sécurité pour la prévention des accidents du travail et des maladies professionnelles*
229374	4’	***Soil Radioactivity and Erosion around Ugii lake of Arkhangai province in Mongolia*** *Tseveen Erkhembayar* *Erkhembayar Tseveen (Mongolia)*
230822	4’	***Hybrid Clay Composites based on Nonionic Surfactants as potential Solutions in Water Remediation*** *Guégan Régis (1) (2)* *1 - Institut des Sciences de la Terre d'Orléans (France),* *2 - Faculty of Science and Engineering (Japan)*
231832	4’	***A study to investigate the Use of Natural Radionuclides as Radiotracers in Sedimentation Processes*** *Bezuidenhout Jacques* *Stellenbosch University (South Africa)*
232760	4’	***Use of the Radiotracer Technique for the Evaluation of Sanitary Networks*** *Derivet Milagros, Fernández Gómez Isis, Carrazana González Jorge, Capote Ferreira Eduardo, Cuesta Borges Jaime, Flores Juan Pedro* *Centro de Protección e Higiene de las Radiaciones (CPHR) (Cuba)*
233085	4’	***Development and Qualification of Underwater Radiation Monitoring System*** *Park Jang-Guen (1), Jung Sung-Hee (1), Jinho Moon (1), Daemin Oh (2), Sungwon Kang (2), Kim Youngsug (2)* *1 - Korea Atomic Energy Research Institute (South Korea),* *2 - Korea Institute of Civil Engineering and Building Technology (South Korea)*
233434	4’	***Historical Review of the Studies performed by CDTN in Latin America, using Tracers in the Fields of Sediment Transport and Dispersion of Effluents in Water Environment*** *Bandeira Jefferson (1), Salim Lécio (1), Aun Pedro (1), Bomtempo Virgílio (1), Moreira Rubens (1), Pinto Amenônia (1), Minardi Paulo (1), Castro José (1), Wilson Jr Geraldo (2)* *1 - Nuclear Technology Development Center, CDTN (Brazil),* *2 - Federal University of Rio de Janeiro, UFRJ-COPPE (Brazil)*
234233	4’	***Determination of trace Elements in Surface Water at Xuan Huong Lake – Dalat City using Total ? Reflection X-Ray Fluorescense (TXRF)*** Nguyen An Son, Thi Ngoc Ha Pham, Dong Suk Soo, Thi Nguyet Ha Nguyen, Dinh Trung Nguyen, Ngoc Dieu Quynh Tran, Viet Huy Le, Sang Thi Minh Nguyen, Lan Thi Ha Le, Tuoi Thi Bui *Dalat University (Vietnam)*

FLASH ORAL COMMUNICATION – SESSION 1	**234641**	4'	***Characterizing Sediments for Black Sands as Possible Radiotracer for Sediment Transport Studies*** *Kilel Kennedy (1) (2), Mangala Michael (1), Gatari Michael (1), Mathu Eliud (3), Koech Nehemiah (1)* *1 - Institute of Nuclear Science and Technology, University of Nairobi (Kenya), 2 - School of Science and Technology, Faculty of Military Science, Stellenbosch University (South Africa), 3 - Institute of Mineral Processing and Mining, South Eastern Kenya University (Kenya)*
	234759	4'	***Analysis of Residence Time Distribution using Radioactive tracer Technique for a Waste Water Treatment Unit at Tema Oil Refinery*** *Appiah Godfred Kofi (1), Danso Kwaku (2), Akaho Edward (2)* *1 - Ghana Atomic Energy Commission (Ghana), 2 - University of Ghana (Ghana)*
	236021	4'	***Evolution of Residence Time Distribution for an s-MBR over an Acclimation Period operating at infinite Sludge Retention Time : an Experimental Approach*** *Arce Velasquez Juan David, Laurent Julien* *ICUBE Laboratoire des sciences de l'ingénieur, de l'informatique et de l'imagerie (France)*
	220745	4'	***Investigation of Cause of Temperature Variation Across a Packed Bed*** *Yelgaonkar Vivek* *Board of Radiation and Isotope Technology (India)*
	223754	4'	***Investigation of Distillation Column Malfunctions in the Zimbabwean Chemical Industry using Gamma Ray Scanning Technique*** *Chirume Witness (1), Baricholo Peter (1), Mudono Stanford (1), Alami Rachad (2)* *1 - National University of Science and Technology (Bulawayo) (Zimbabwe), 2 - Centre National de L'Energie Des Sciences et Des Techniques Nucleaires (Morocco)*
	225056	4'	***Hydrodynamics in Internal-loop Airlift Reactor via non-invasive Gamma Ray Techniques*** *Sabri Laith (1), Sultan Abbas (2), Aldahhan Muthanna (3) (4)* *1 - Multiphase Flow and Reactors Engineering Applications Laboratory (mFReal) Department of Chemical and Biochemical Engineering, Missouri University of Science and Technology (United States), 2 - Chemical Engineering Department in University of Technology (Iraq), 3 - Multiphase Flow and Reactors Engineering Applications Laboratory (mFReal) (United States), 4 - Cihan University-Erbil, Iraq (Iraq)*
	225059	4'	***Characterize the non-similarity scale-up methodology based on Dimensionless Groups of Gas-solid Spouted Beds via (RPT) and (CT)*** *Ali Neven (1), Al-Juwaya Thaar (2), Sabri Laith (3), Aldahhan Muthanna (2) (4)* *1 - Nuclear Engineering, University of New Mexico (United States), 2 - Multiphase Flow and Reactors Engineering Applications Laboratory (mFReal) (United States), 3 - Multiphase Flow and Reactors Engineering Applications Laboratory (mFReal) Department of Chemical and Biochemical Engineering, Missouri University of Science and Technology (United States), 4 - Cihan University-Erbil, Iraq (Iraq)*
	227493	4'	***Design and Development of Distillation Column Model*** *Hlaing Mp* *Division of Atomic Energy, Department of Research and Innovation, Ministry of Education, Myanmar (Myanmar, Burma)*

	230449	4’	***Ring Scan Gamma CT system and Image Reconstruction with Sparse Views*** *Jung Sung-Hee (1), Moon Jinho (1), Park Jang-Geun (1), Park Miran (2), Cho Seungryong (2)* *1 - Korea Atomic Energy Research Institute (South Korea),* *2 - Korea Advanced Institute of Science and Technology (South Korea)*
	232511	4’	***A Calibration Facility for In-Situ Gamma-Ray Detector*** *Sehone Alfred (1), Newman Richard (2), Maleka Peane (3)* *1 - South African Military Academy (South Africa),* *2 - Stellenbosch University (South Africa), 3 - iThemba LABS (South Africa)*

DAY 2: Wednesday 27th

P2 FLASH ORAL COMMUNICATION
DAY 2: Wednesday 27th
4:15PM-5:30PM
4 min per presentation

	Reference	Duration	Presentation of the communication
FLASH ORAL COMMUNICATION – SESSION 2	**232514**	4’	***Design and Application of Gamma Densitometer on pipes by using Cs-137 (0.662 MeV) Gamma Photon*** *Shein Hnitthit* *Ministry of Education (Myanmar, Burma)*
	232700	4’	***Effect of Additives on Anti-Wear Properties of Lubricant Studied by Thin Layer Activation Technique*** *Biswal Jayashree* *Bhabha Atomic Research Centre (India)*
	232963	4’	***Investigation of Wear Properties of Different Materials by using Thin Layer Activation (TLA) with Activities under the Free Handling Limit (FHL)*** *Ditroi Ferenc (1), Takacs Sandor (1), Wopelka Thomas (2), Jech Martin (2)* *1 - Institute for Nuclear Research (Hungary),* *2 - Austrian Compatence Center for Tribology (Austria)*
	232987	4’	***Application Of Gamma Computed Tomography (CT) In The Determination Of Agarwood Formation And Pipeline Scaling*** *Affum Hannah (1), Abdelwahed Haifa (2), Abdulla Jaafar (3)* *1 - Ghana Atomic Energy Commission, National Nuclear Research Institute (Ghana), 2 - Centre National des Sciences et Technologies Nucléaires (Tunisia), 3 - Malaysia Nuclear Agency (Malaysia)*
	233302	4’	***Gamma Scanning Application in Column Scanning*** *Kairu Wilson* *Institute of Nuclear Science & Technology, University of Nairobi (Kenya)*
	234643	4’	***Radio graphic Examination of Fabricated Products (« Jua Kali ») in Kenya*** *Mangala Michael* *Institute of Nuclear Science and Technology, University of Nairobi (Kenya)*
FLASH ORAL	**234689**	4’	***Neutron Backscatter Gauge for the Measurement of Different Phases : Scans and Modelisation*** *Outayad Rabie* *Centre National de L'Energie Des Sciences et Des Techniques Nucleaires (CNESTEN) (Morocco)*

	234738	4’	***Imaging Deposits and Corrosion of Pipes by Tomography*** *Saadaoui Abdelaziz, Abdelghafour Ezzahri, Jainija Alaa , Outayad Rabie* *Centre National de L'Energie Des Sciences et Des Techniques Nucleaires (CNESTEN) (Morocco)*
	234748	4’	***Malfunction Investigation in Catalyst Column Using Industrial Gamma Scanning*** *Wibisono Wibisono, Rahmatia Firliyani, Azmi Bayu, Stefanus Megy* *Center for Isotopes and Radiation Application- BATAN (Indonesia)*
	233387	4’	***Thermodynamic Behaviors of Selenium Ions onto Barrier Material using Radiotracer Technique*** *Haciyakupoglu Sevilay, Erenturk Sema* *Istanbul Technical University (Turkey)*
	233124	4’	***Leaching of Oil/Water Partitioning Compounds from Immobile and Bypassed Oil in Porous Media*** *Nguyen Huu Quang* *Huong Huynh Thi Thu (Vietnam)*
	234745	4’	***Challenges in the Applications of Radioisotopes in Nigerian Industries*** *Okoh Sunday (1), Arabi Suleiman (2)* *1 - Centre for Energy Research and Training (Nigeria),* *2 - Department of Geology (Nigeria)*
	230820	4’	***Performance Assessment of Dynamic Systems using Analytic Solution*** *Ali Elsayed (1), Kasban Hani (2)* *1 - Engineering Department, Nuclear Research Center, Atomic Energy Authority (Egypt), 2 - Engineering Department, Nuclear Research Center (Egypt)*
	234787	4’	***Data Fusion Approach for Improving the Reliability of Radiographic Testing and other Complementary NDT Techniques*** *Oujebbour Fatima Zahra* *Division of Industrial Applications, National Center of Energy Science and Nuclear Techniques (CNESTEN) (Morocco)*
	233335	4’	***Simulations for Industrial Radiotracers Experiments*** *Elmoujarkach Ezzat , Siddig Mohammed Mohammed, Banoqitah Essam, Mousa Tariq* *King Abdulaziz University (Saudi Arabia)*
	240000	4’	***Problem of the Sensitivity of Schmidt Number in Simulation of Tracing with CFD*** *Olivier Potier, Rainier Hreiz (1), Julien Laurent (2)* *1 - LRGP (Nancy, France), 2 - ICUBE Laboratoire des sciences de l'ingénieur, de l'informatique et de l'imagerie (Strasbourg, France)*
	232822	4’	***Some Thermodynamic Aspects of Tracer Plumes evolving in Natural Streams at « Dynamic Equilibrium »*** *Constaín Alfredo* *Hydrocloro Technologies S.A.S (Colombia)*
	235765	4’	***Development of "Compartmental Modelling" Methodology of Flowing Systems with or without Chemical Reaction Using Tracing Experiments and Computational Fluids Dynamics Simulations*** *Jean-Pierre Leclerc, Jérémie Haag* *Institut National de Recherche et de Sécurité, INRS (France)*

DAY 3: Thursday 28th

P3 FLASH ORAL COMMUNICATION
DAY 3: Thursday 28th

10:40AM-11:40AM
4 min per presentation

	Reference	Duration	Presentation of the communication
FLASH ORAL COMMUNICATION – SESSION 3	**230497**	4'	***Monitoring of Copper Recovery from Flotation Tailings by Leaching Process Using Radiotracer*** *Rogowski Marcin (1), Smolinski Tomasz (1), Pyszynska Marta (1), Owczarek Dominik (2), Chmielewski Andrzej (1)* *1 - Institute of Nuclear Chemistry and Technology (Poland), 2 - Faculty of Chemical and Process Engineering Warsaw University of Technology (Poland)*
	230819	4'	***Flow rate Measurement in Water Pipelines using Radiotracer Technique*** *Ali Elsayed (1) (2)* *1 - Engineering Department, Nuclear Research Center, Atomic Energy Authority (Egypt), 2 - Engineering Department, Nuclear Research Center (Egypt)*
	232231	4'	***Experimental RTD Modeling in a Liquid Flow System using Deconvolved Radiotracer Response Signals*** *Abdelbari Amar* *Department of NDT, Sudan Atomic Energy Commission (Sudan)*
	233183	4'	***Radiotracer Investigation of Clinker Milling at East African Portland Cement*** *Gitau Jimmy (1) (2), Gatari Michael (2)* *1 - Kenya Bureau of Standards (Kenya),* *2 - Institute of Nuclear Science and Technology, University of Nairobi (Kenya)*
	233283	4'	***Application of Radiotracer Technology: Laboratory Experiments and Modelling using Flow Rig*** *Kairu Wilson* *Institute of Nuclear Science & Technology, University of Nairobi (Kenya)*
	233478	4'	***Leak Test in Underground Hydrocarbon Pipeline using Pig-radiotracer Method*** *Sugiharto Sugiharto* *Sugiharto Sugiharto (Indonesia)*
	234788	4'	***Stability Study of Gold -198 Nanoradiotracer in Petroleum Derivatives*** *Kenup-Hernandes Hericka (1), Barreira Brandão Luís Eduardo (1), Ambrósio Roque Evelin (1), Ramos Gonçalves Eduardo (2), Xavier Da Silva Ademir (3)* *1 - Instituto de Engenharia Nuclear (Brazil), 2 - Instituto Federal Fluminense (Brazil), 3 - Programa de Engenharia Nuclear (Brazil)*
	235760	4'	***Investigations of Sparger Design Effect on Residence Time Distribution in Bubble Column Reactor Using Industrial Radiotracer Au-198 and Tc-99m*** *Mohd Yunos Mohd Amirul Syafiq (1), Hussain Siti Aslina (2), Yusoff Hamdan Mohamed (2)* *1 - Plant Assessment Technology Group, Industrial Technology Division, Malaysia Nuclear Agency, Malaysia (Malaysia), 2 - Department of Chemical and Environmental Engineering, Universiti Putra Malaysia, Malaysia (Malaysia)*
	236253	4'	***Use of I123 Radiotracer to Model the Oil Non-Ideal Laminar Flows in Pipelines*** *GonÇalves Eduardo (1), Brandão Luis Eduardo (2), Hernandes Hericka (2), Dualibi Filho Julio Cesar (3), Braz Delson (4)* *1 - Eduardo Ramos Gonçalves (Brazil), 2 - Luis Brandão (Brazil), 3 - Hericka Hernandes (Brazil), 4 - Julio Cesar Dualibi (Brazil), 5 - Delson Braz (Brazil)*

FLASH ORAL COMMUNICATION – SESSION 3	**220743**	4’	***Investigation of the Cause of Decrease in PTA Production*** *Yelgaonkar Vivek* *Board of Radiation and Isotope Technology (India)*
	220744	4’	***Identification of leaky heat Exchanger in a Series using Mo-99 as Radiotracer*** *Yelgaonkar Vivek* *Board of Radiation and Isotope Technology (India)*
	225055	4’	***Liquid Mixing Behavior in Upflow Moving Bed Hydrotreater Reactor (MBR) Reactor Using Advanced Liquid Tracer Technique*** *Alexander Vineet (1), Al-Bazzaz Hamza (2), Aldahhan Muthanna (1)* *1 - Multiphase Flow and Reactors Engineering Applications Laboratory (mFReal) (United States), 2 - Kuwait Institute of Scientific Research (Kuwait)*
	225058	4’	***Gas Phase Mixing Behavior in Upflow Moving Bed Hydrotreater Reactor (MBR) Using Advanced Gas Tracer Technique*** *Alexander Vineet (1), Al-Bazzaz Hamza (2), Aldahhan Muthanna (1) (3)* *1 - Multiphase Flow and Reactors Engineering Applications Laboratory (mFReal) (United States), 2 - Kuwait Institute of Scientific Research (Kuwait),* *3 - Cihan University-Erbil, Iraq (Iraq)*
	225060	4’	***Axial Dispersion and Mixing of Coolant Gas within a Separate-effect Prismatic Modular Reactor*** *Said Ibrahim (1), Taha Mahmoud (1), Alexander Vineet (2),* *Aldahhan Muthanna (2) (3)* *1 - Chemical Engineering Department, Faculty of Engineering, Alexandria University, Egypt (Egypt), 2 - Multiphase Flow and Reactors Engineering Applications Laboratory (mFReal) (United States),* *3 - Cihan University-Erbil, Iraq (Iraq)*
	230325	4’	***Solvent Extraction Process for the Recovery of Copper from Flotation Tailings Investigated Using Radiotracer*** *Smolinski Tomasz (1), Herdzik-Koniecko Irena (1), Rogowski Marcin (1), Pyszynska Marta (1), Owczarek Dominik (2), Chmielewski Andrzej (1)* *1 - Institute of Nuclear Chemistry and Technology (Poland),* *2 - Faculty of Chemical and Process Engineering Warsaw University of Technology (Poland)*

P4 POSTER EXHIBITION

POSTER EXHIBITION	Reference	Presentation of the communication
	234692	***Hydraulic Study of a real Scale Subsuperficial Flow constructed Wetland using CFD Simulation and Tracer Experiments*** *Climent Javier (1), Miguel David (1), Garcia-Tirado Ruben (2), Chiva Sergio (2), Arnau Rosario (2), Martinez-Cuenca Raul (2)* *1 - FACSA (Spain), 2 - Universitat Jaume I (Spain)*
	233309	***Isotope Tracing Application in Source Apportionment of Tropospheric Black Carbon in Nairobi, Kenya*** *Kirago Leonard (1) (2), Kiriinya Lindah (2), Ng'ang'a David (2), Gatari Michael (2), Andersson August (1)* *1 - Stockholm University (Sweden),* *2 - Institute of Nuclear Science and Technology, University of Nairobi (Kenya)*
	234094	***Use of Radioactive Tracers and Nucleonic Gauges to solve Problems related to Sediment Transport in Dam's Channels and the Origin of Stagnant Water in some Dam's Plots faced by the INGA Site*** *Kabeya Ngalamulume Dieudonné (1), Kawende Omer (2)* *1 - C.G.E.A/C.R.E.N-K (Congo, Kinshasa), 2 - SNEL (Congo, Kinshasa)*
	234693	***Tracer Techniques for Validating CFD Modelling of Open Channel UV Disinfection Systems*** *Climent Javier (1), Gargallo Sara (1), Chiva Sergio (2), Martinez-Cuenca Raul (2), Carratala Pablo (3), Garcia Mairena (1)* *1 - FACSA (Spain), 2 - Universitat Jaume I (Spain), 3 - Universtat Jaume I (Spain)*

PLENARY SPEAKERS

GUEST SPEAKER PRESENTATION

Randal W. Samstag

Position held: Owner and Engineer
Research group: Randal W. Samstag Civil and Sanitary Engineer

CONTACT:
Email address: rsamstag@rsamstag.com
Phone: +1 (206) 851-0094

PRESENTATION:
Randal W. Samstag is a wastewater treatment process engineer with forty years of experience in consulting and municipal engineering. He has degrees from Stanford University and the University of California in Berkeley in the United States. He is a licensed civil engineer in California and Washington States and a licensed sanitary engineer in Washington. In the 1980s he first started managing projects for laboratory, field and computational fluid dynamic (CFD) testing of sedimentation tanks. Over the years since he has completed over twenty similar projects for wastewater treatment sedimentation and aeration tanks. He was introduced to tracer testing by Robert M. Crosby, the developer of a series of innovative techniques for dye and solids profile testing of sedimentation tanks.

Mr. Samstag was an early adopter of CFD for application to waste water processes. He is the author of the FORTRAN program TANKXZ, which solves for solids settling and dye and solids transport. TANKXZ incorporates a k-epsilon turbulence model and uses the SIMPLE method of Patankar. For the past fifteen years he has been a user of the commercial CFD software Fluent and open source software, OpenFOAM. He is an active member of the management team for the IWA working group for CFD and the manager of the LinkedIn Group “CFD for Wastewater.”

KEYNOTES LECTURES

Day 1, start time 9:20 AM
Duration: 40’
Title: Tracer Test and Modelling of Wastewater Treatment Aeration Tanks

GUEST SPEAKER PRESENTATION

Tor Bjørnstad, Dr. Philos.

Previous:
Chief Scientist and Head of Department for Reservoir and Exploration Technology at Institute for Energy Technology (IFE) in Norway,
Professor in Nuclear Chemistry/Radiochemistry at University of Oslo.

At present:
Special Adviser, Department for Tracer Technology, Institute for Energy Technology (IFE), Norway
Professor Emeritus, Nuclear Chemistry/Nuclear Physics, University of Oslo, Norway

CONTACT:
Address: Instituttveien 18, P.O.Box 40, NO 2027 Kjeller, Norway
Phone: +47 908 38 408
E-mail: tor.bjornstad@ife.no

PRESENTATION:
40 years experiences in nuclear chemistry and radiochemistry at different universities and research institutions. More than 30 years experiences in activities related to geospheric tracing of mass flow mainly in the petroleum production and geothermal energy industries but also in various other industrial, environmental and civil society processes.

Various technical keywords are:

A. Development of tracer methods for reservoir evaluation, process studies (heat exchangers, separators, scrubbers, reaction barrels), multiphase transport in pipelines, leak detection.
B. Application of gamma and neutron transmission techniques for process studies
C. Radioanalytical chemistry including neutron and charged particle activation analysis
D. Physical and radiochemical separation methods for radionuclides and radiolabelled compounds.
E. Basic nuclear studies on production and characterization of short-lived nuclei far from stability

KEYNOTES LECTURES

Day 2, start time 9:00 AM
Duration: 40'
Title: Tracer-Based Well Inflow Monitoring

GUEST SPEAKER PRESENTATION

Jean-Pierre LECLERC

Position held: Head of Department
Research group: Process engineering department at French National Research and Safety Institute for Prevention of Occupational Accidents and Diseases (INRS)

CONTACT:
Email address: jean-pierre.leclerc@inrs.fr
Phone: +33383502100

PRESENTATION:

- Ph.D. and Habilitation in process engineering
- Head of PROGEPI 1997-2002, Deputy-Director of the Laboratory of Chemical Engineering Sciences 2003-2009 and Deputy-Director of the Laboratory Reactions and Chemical Engineering 2010-2014.
- Several years abroad as an expert on water supply and sanitation systems for humanitarian Non-Governmental Organizations (Afghanistan, Rwanda…)
- 30 years of research activities on tracing, modeling and development of industrial processes for the treatment of wastewater and industrial wastes
- Co-authors of around 80 publications, 100 conference presentations and 90 industrial reports
- Since 2015 head of Process engineering department at French National Research and Safety Institute for Prevention of Occupational Accidents and Diseases (INRS)

KEYNOTES LECTURES

Day 3, start time 8:45 AM
Duration: 40’
Title: Tracer experiments and CFD modeling for a better occupational risk prevention

KEYNOTES LECTURES

3 ABSTRACTS

Tracer Test and Modelling of Wastewater Treatment Aeration Tanks

R. W. Samstag[1]

[1]*Engineer and Owner, Randal W. Samstag Civil and Sanitary Engineer, US*
rsamstag@rsamstag.com

ABSTRACT

Hydraulic characteristics of activated sludge aeration tanks with different geometry and aeration systems were measured using slug dye tracer tests. The results suggest that multiple pass fine bubble aeration systems have a much greater plug flow characteristic than would have been predicted by previous research, based on tank geometry alone. Test results from single pass aeration tanks showed less plug flow character than did tanks with more folding. Dye tests in a mechanically aerated oxidation ditch displayed a nearly ideally completely mixed characteristic. If nitrification is taken as an example process and the equivalent tanks-in-series model is taken as the measure of tank hydraulic characteristics, the effect of hydraulic characteristics on treatment efficiency can be estimated. Reactor theory predicts that this influence will be moderated by diminishing returns. The significance of this research is to recommend in favor of fine bubble aeration tanks or mechanically aerated tanks with at least three tanks in series for any system intended to achieve efficient ammonia removal. Reactor theory suggests that increases in the degree of tank partitioning beyond this, however, cannot be justified by improvements in
treatment efficiency alone.

In this research the tanks-in-series model was used to characterize the hydraulic characteristics of activated sludge aeration tanks. The tanks-in-series model is fully described in Levenspiel (1972). In this single-parameter model the fluid flow through a reactor is taken as analogous to flow through a series of uniformly mixed, equal-volume tanks. This model was "widely used" at the time of Levenspiel's book in 1972 and is the basis for most current models for biological treatment. See, for example, Henze et al. (2000).

RESULTS AND DISCUSSION

Results of the tracer tests are presented in Figure 1. The three different aeration tanks were each modeled as a whole and for a partial volume of the tank. The figure shows that the four-pass fine bubble tank had a typically plug flow hydraulic characteristic, compared to the single pass tank, which had a characteristic closer to completely mixed, even without recirculation. The single oxidation ditch exhibited an almost fully completely mixed characteristic. Figure 2 presents results from biokinetic modelling of ammonia removal using a custom Michaelis Menton model of a series of cases with increasing numbers of equivalent tanks in series. The modelling demonstrates that after about three tanks in series, increasing the number of tanks in series has little impact on effluent ammonia concentration. While the tracer tests for the oxidation ditch tank indicated complete mixing, recent work by Rehman (Rehman 2016) has shown that in similar tanks a wide variation in dissolved oxygen and reactant concentration can occur. The paper will try to explain this apparent discrepancy. The presentation will also discuss tracer experiments in activated sludge clarifiers.

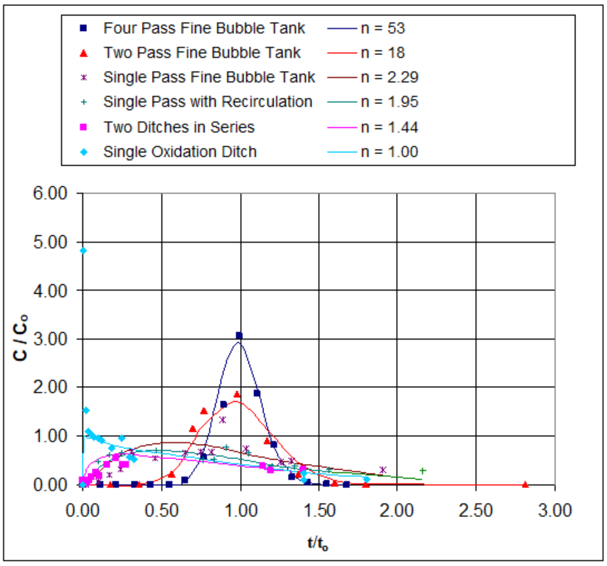

Figure 1 Tracer test results

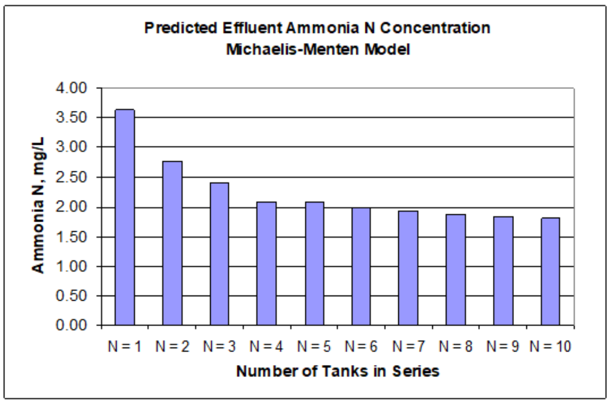

Figure 2 Biokinetic model results

KEYWORDS:

Activated sludge, aeration, residence time distribution, plug flow, completely mixed, nitrification, hydraulic characteristics

REFERENCES

- Levenspiel, Octave (1972) *Chemical Reaction Engineering*, Second Edition, Wiley and Sons, New York.
- Henze, Mogens; Gujer, Willi; Mino, Takashi; and van Loosdrecht, Mark; eds., IWA Task force on Mathematical Modeling for Design and Operation of Biological Wastewater Treatment Plants (2000) "Activated Sludge Models ASM1, ASM2, ASM2d, and ASM3", *Scientific and Technical Report No 9*, IWA Publishing.
- Rehman, Usman (2016) *Next generation bioreactor models for wastewater treatment systems by means of detailed combined modelling of mixing and biokinetics*, PhD thesis, Ghent University.

Tracer-Based Well Inflow Monitoring

Tor BJØRNSTAD[1] and Terje SIRA[1]

[1]*Flow Technology and Environmental Analysis,*
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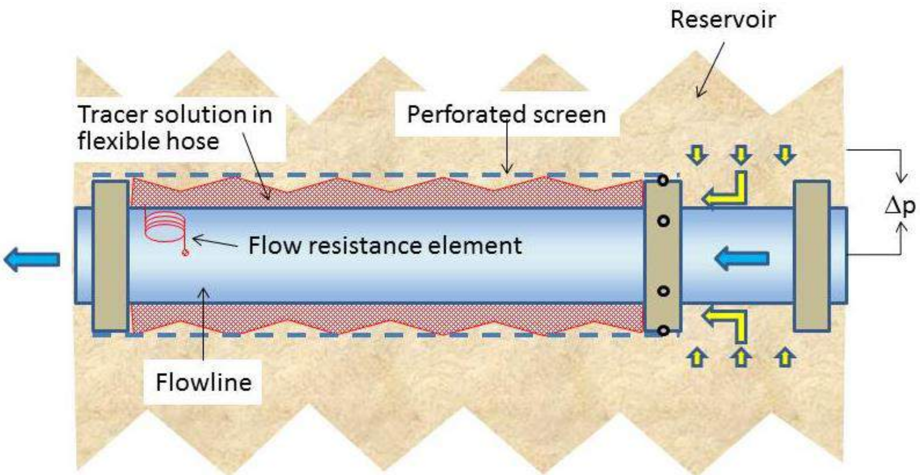
ABSTRACT

Measurement of depth-differential mass fluid (oil, water, gas) inflow in production wells has been a challenge for a long time: Where in the well are the effective production zones? Various approaches have been proposed including the DTS technology which is based on the use of optical fibers in the well responsive to the specific heat capacity of the various fluids [1], the "painting" of a slowly solvable tracer compound on the inner wall of the production pipeline [2] and the imbedding of a solvable tracer compound in a polymer matrix placed at defined positions in the sand screen [3]. None of these methods are sufficiently quantitative and/or ruggedized to be reliably operated over extended times (years).

The present paper reports on a new method which requires that the well completion includes so-called ICD technology (ICD = Inflow Control Device). This is an oil and/or water inflow devise with an adjustable inflow restriction. The flow characteristics of the ICD are known, i.e. the relation between the differential pressure over the ICD and the mass flow through the ICD is calibrated and known. Then, by measuring the real (true) differential pressure **Δp** over the ICD, mass flow over the device can be calculated. The main task is then to establish a method to measure **Δp**.

The method comprises a flexible tracer chamber containing a fluid tracer (or tracer solution). The flexible part of the chamber stays in contact with the annulus (reservoir) pressure (higher pressure), and there is a connection to the production well internals through a flow resistance element (lower pressure). A sketch of the principle is given in the Fig. below:



The flow characteristics of this flow resistance (**k**) are measured in the lab. The differential pressure over the tracer chamber is identical to that over the ICD. A common differential pressure is around 5 bars. Tracer will be released at a very low flow rate $\mathbf{c_{trac}}$, typically of 1-5 mL/d depending of the actual flow rate through the ICD which create an actual differential pressure **Δp**. By measuring the viscosity **μ** of the tracer fluid, the following relation is valid for the flow rate $\mathbf{F_{trac}}$ of the tracer out of the chamber:

$$F_{trac} = \frac{k \cdot c_{trac}}{\mu} \cdot \Delta p$$

The same amount of tracer which enters the production tubing from the tracer reservoir will exit the production tubing topside (at the production platform). By measuring the tracer concentration at the exit ($\mathbf{c_{top}}$ diluted in a volume $\mathbf{V_{top}}$), we can determine the $\mathbf{\Delta p}$ from the following relation:

$$\boldsymbol{V_{top} \cdot c_{top} = F_{trac} = \frac{k \cdot c_{trac}}{\mu} \cdot \Delta p}$$

Solving for $\mathbf{\Delta p}$ gives:

$$\boldsymbol{\Delta p = \frac{V_{top} \cdot c_{top} \cdot \mu}{k \cdot c_{trac}}}$$

Knowing $\mathbf{\Delta p}$ and the flow resistance characteristics of the ICD, the production flow entering the tube at the production zone where the tracer release device is installed can be calculated.

Tracer chambers with different tracers may be installed at different positions (depths) in the well. With realistic tracer chamber dimensions, this inflow monitoring devise will be operational for 5-30 years depending on the tracer applied and, of course, on the total mass inflow across the ICD. The method has been patented [4].

For the moment, the method cannot clearly and quantitatively distinguish between aqueous and organic phase, but an approach to solve this issue is underway.

KEYWORDS:

Oil production, tracer monitoring, production wells, depth differential mass inflow, ICD

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Tracer experiments and CFD modeling for a better occupational risk prevention

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ABSTRACT

This conference presents an overview of the use of tracer experiments and CFD modeling for better occupational risk prevention. These results were obtained at Industrial airflow laboratory from process engineering department by Emmanuel Belut, Francis Bonthoux, Romain Guichard, François-Xavier Keller, Jennifer Klingler, Sullivan Lechêne, Laurence Robert.

When it is not possible to reduce sufficiently the emission of pollutants in workplaces, in order to protect health of the workers, it is particularly important to identify the source of emission and to capture emissions of pollutants by an efficient local exhaust system. Several examples of source emission characterizations using tracer experiment and CFD simulation are presented (wood dust from hand-held power tools, nanoparticles in industries or laboratories, dust from asphalt planer …). Tracer experiments are used to characterize the efficiency of fume hoods and local exhaust systems. Moreover the exhaust systems are never working under steady state conditions. Fume hoods are subjected to airflow disturbances induced by local perturbations (doors opening/closing, workers in motion, interaction with others fume hoods and general ventilation unsteadiness). CFD modeling is used to estimate the impact of these fluctuations. The general ventilation of the building is also affected by perturbations. High wind may affect the containment of asbestos in removal worksites. Large Eddy Simulations of the wind flow around a building allow predicting the pressure fluctuations. These fluctuations are used as an input signal of an internal unsteady network compartments model of the ventilation system to predict the containment of asbestos. Finally, workers are sometime exposed to VOC's from storages. Simulation of the transfer of pollutant from material to the work place depends both on source and ventilation. Modeling and tracer experiments allow to predict the behavior of the VOC and to prevent risk for the workers.

KEYWORDS:

Occupational risk prevention, pollutant source, ventilation, tracers, CFD

SESSION 1

ENVIRONMENT, ENVIRONMENTAL ENGINEERING, HYDROLOGY, SEDIMENT, SAFETY

22 ABSTRACTS

Radiotracer Study to Ascertain the Efficacy of Fly Ash Disposal

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ABSTRACT

Thermal power plants generate several tons of fly ash every day. Safe disposal of fly ash is a major issue as it contains many toxic chemical constituents which may pollute the environment. One of the modern methods of fly ash disposal is to judiciously dump its slurry in a nearby abandoned open cast mine void.

Fly ash generated from one of the captive power plants in Eastern India, was being disposed off by making its homogenized slurry in the proportion of 70%water + 30% fly ash, at a constant outflow rate in to a mine void of an opencast mine filled with rain water.

Since the fly ash is disposed off in to the void water, the fly ash may leach in to the void water. It was opined that heavy metals present in the fly ash may also leach out in to the surface water. Subsequently the leachates could get percolated in to the ground water contaminating the ground water in the surrounding bore wells which could have harmful environmental impact.

A Toxicity characteristic leaching procedure (TCLP) and water extraction test was used to study the leaching of heavy metals from the fly ash. The findings of TCLP and water extraction test showed that the leaching was well within the acceptable international limits. They also concluded that the plume movement is at a pace of maximum 700m in 30 years starting from March 2014 using a groundwater mass transport model MT3D.

However, to comply with the conditions for environmental clearance i.e. to investigate the transport of the heavy metals leached out from the fly ash, a radiotracer study for heavy metals transport was recommended by Ministry of Environment and Forest (MoEF).

Radiotracer techniques are effective means to measure and establish the flow pattern in various systems and used for various applications like studies of residence time distribution, sediment transport, effluent dispersion, flow rate measurements, etc.

It was proposed to label the fly ash with a suitable radiotracer while disposing it in to the mine void and to study its spatial and temporal distribution in the water of mine void and its subsequent progress in to the surrounding bore wells.

For this study, fly ash was labelled with Sc-46 (half-life- 84 days and gamma energy-0.88 & 1.11 MeV) and dumped in to the mine void in the similar method of bulk fly ash disposal. Spatial and temporal distribution of the radiotracer was monitored using underwater radiation detector and plume movement was monitored at certain time intervals. In order to assess the leaching of trace elements into the groundwater, eight bore wells were dug at strategic locations in the vicinity and surrounding the mine void. Water samples from these bore wells were analysed using a gamma ray spectrometer for the presence of Sc-46. It was observed that the radiotracer was spread over the limited portion in the surface water of the mine void and Sc-46 was not present in the water samples sampled drawn from bore-wells.

KEYWORDS

fly ash, mine void, heavy metals, radiotracer, half-life, gamma ray spectrometer

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Soil Radioactivity and Erosion around Ugii lake of Arkhangai province in Mongolia

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ABSTRACT

The specific radioactivity concentrations of uranium, thorium, potassium were measured in soil samples, which was collected around Ugii lake of Arkhangai province in Mongolia, using gamma-spectrometer. Results of measurements of natural and man-made radioactive nuclides in soil samples were presented. There was determined soil erosion in these areas.

INTRODUCTION

The Arkhangai Aimag was established in 1725, entitled to Sain Noyon Khan Aimag. After the victory of the People's revolution, it was renamed to Tsetserleg Mandal Uuliin Aimag in 1923, followed by Arkhangai Aimag in 1931. The area of Aimag is divided into three regions: high mountain, forest steppe, steppe. It borders the Khobsgol to the north; Uvurkhangai Aimag to the northeast and east; Bayankhongor Aimag to the southwest; and Zabkhan Aimag to the northwest. The average height is 2,414m above sea level. The highest place is Kharlagtain Saridag of 3,539m, and the lowest place is Okhon Tamiriin Belchir of 1,290m. The beautiful northern Khangai Region is full of high mountains, wide canyons, clean lakes, long rivers, colorful flowers, delicious fruits, birds, and wild animals. Area: 55,300 km^2 holding 28.2% of the Mongolia. It has a continental climate, and the average temperature of each month ranges from 15 degrees below zero to 15 degrees. The temperature reaches up and down even to 47 degrees and 40.6 degrees below zero. The average annual rainfall is 350-450mm, and most of them are concentrated from April to July [1].

Ugii lake is located in the centre of Mongolia,and in the territory of Arkhangai province is one of the biggest lakes of Mongolia and has 27 km square area. Average depth is 6.64m, in some sections 15.3m, coastal length is 23.5m. Ugii lake abounds in various types of fish and birds, which creates a incredible natural beauty. Ugii Lake also provides a favorable condition for research work and traveling. One of favourite destination for fishing in central Mongolia. Ugii Lake attracts travelers, tourists and nature researchers from Mongolia as well as from foreign countries. More than 150 types rare species of birds dwelling in Ugii lake.

We have collected soil samples around Ugii lake of Arkhangai province in Mongolia and measured specific activity of isotopes in these samples and determined soil erosion.

KEYWORDS:

radiation, dose, level, soil, erosion

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Calibration of a nucleonic gauge for Pacific and Atlantic Oceans: Panama case

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ABSTRACT

Waste waters contribute to serious pollution problems not just in Panama Canal basin but also at the Panama Bay influencing marine and coastal environment [1]. Panama country is surrender by two oceans: Pacific and Atlantic. The main goal of this study is establish a density calibration curves that will relate the counting rate measured by the detector of the gauge to a given concentration value i.e. density of sediments deposited in navigation channels in both oceans. A second objective will be to contribute in reducing contamination level to international water quality standards, through an efficient sediment transport monitoring program in a Panama Canal basin.

STUDY SITES

Alhajuela Lake: The Alhajuela reservoir, was created by means of the construction of the dam Madden in 1935. It has an area of contribution of sediments of 976 km². Its current water storage capacity is 657.5 Mm³ (Fig.1). At present, it is losing storage capacity due to the great amount of sediments that enter it. [2]
Dredging Pacific and Atlantic sites: Dredging activities to enable safe navigation by Post-Panamax vessels upon completion of the Panama Canal expansion are vital. A total of 8.7 million cubic meters of underwater material were dredged.

Fig. 1. A view of Alhajuela Lake and a possible sites to study the sediment transport (By Thomas Römer/OpenStreetMap data, CC BY-SA 2.0, https://commons.wikimedia.org/w/index.php?)curid=19678675

Methodology: Nucleonic Gauge calibration.

A XDP30 gauge, data acquisition system, 6 Plexiglas containers and a balance of high precision were used (Fig. 2). **Taking examples**: The sediment or mud were taken from the same waterway (Pacific and Atlantic sites) focus to the revision. **Preparation of the containers**: The accuracy of the calibration may be definitely reduced by the existence of dirt in the vessels; therefore, they were washed by clear water and cleaned from any remains. To get the counting rate ***No*** corresponding to 0g/L concentration i.e. density 1, the first container is filled by clear sea water. A good stirring of the mixture (mud + water) was necessary. After the preheating time of the X-ray tube (around 5 minutes), the first sample was placed between the tube and the detector, record the counting rate ***No*** related to clear sea water and measure its weight ***Mo***. The second specimen containing the mixture was placed in the same spot, recorded the counting rate ***NI*** and measured its weight ***M1***. This operation was repeated for all the remaining containers. Finally, the calibration curves are obtained by relating the counting rate ***N*** measured to the varying suspended sediment concentration values [3].

		
X Ray profiler and winch system/Altaix System	A Plexiglas recipient	Adqusicition system

Fig. 2. Equipment, and supplies used for the calibration

KEYWORDS:

Nucleonic gauge, sediment, calibration, navigation

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Hybrid Clay composites based on nonionic surfactants as potential solutions in water remediation

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ABSTRACT

Clay minerals with their large specific surface area, ion exchange capacities and outstanding hydration properties with an exfoliation of the nanosheets that can self-assembled in liquid crystalline phases [1] display particular interests as adsorbent materials, reinforcers in polymer nanocomposites as well as host matrix for the preservation of biomolecules or to confine and orientate guest molecules in hybrid materials.

Surfactants used as chemical modifier to develop hybrid organoclay materials and/or in association with clay mineral in solution generate a hydrophobic environment improving and enlarging the possible applications of raw clay minerals [2-3].

In this present contribution, we focus on the preparation of novel organoclays based on nonionic surfactants [4-5] and discuss and compare their properties and possible uses to conventional cationic organoclay systems (i.e. prepared with alkylammonium cationic surfactants) and raw clay minerals. Non-ionic organoclays with their dual hydrophilic/hydrophobic behaviors, unlike cationic ones showing a hydrophobic surface, and untreated clay minerals displaying a hydrophilic behavior, represent the most polyvalent material for the adsorption of a wide range of micropollutants showing different chemical nature but also a hydrophilic behavior intermediate between the two other adsorbents [6].

KEYWORDS [HEADING 1 STYLE]:

Adsorption, water, organic contaminants, organoclays, hybrid materials

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Investigation of hydrodynamics of an electrocoagulation reactor for water defluoration using radiotracer technique

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ABSTRACT

Radiotracer technique is used to investigate a lab scale electrocoagulation reactor for natural water defluoration. The aim objective of the study is to determine the hydrodynamic behavior of the reactor to validate its flow dynamics models.

The water defuoration process using electrocoagulation method consolidates three fundamental associated processes, operating synergistically to remove fluoride: electrochemistry, coagulation and hydrodynamics. Hence three corresponding zones are identified in the studied reactor.

The reactor is configured with an electrochemical chamber of 2 liters volume followed with a solid/liquid separation chamber of 11 liters volume. The separation chamber is inclined at a designated 5 degree angle to the recovery of the settled flakes at the bottom and the top of the reactor. The reactor has one inlet and two outlets, one outlet to continuously recover the floating flakes and a second upstream outlet to recover the treated water. [1]

Residence time distribution (RTD) of the process is measured at different specific positions of the reactor using Technicium-99m. The radiotracer is injected instantaneously into the reactor and monitored at four specific locations of the reactor using four collimated scintillation detectors (NaI) connected to a data acquisition system. The experiment is performed at different operating conditions of current and flow rate parameters. The measured RTDs are treated and analyzed to obtain flow parameters such as the Peclet number, number of mixing-cell, and proportion of flow rate exchanging.

The treated RTD curves are then modeled using suitable mathematical models [2], and the values of the parameters are obtained. The results of the investigation are used to evaluate and compare the flow performance, quantify the degree of mixing, and visualize the prevailing flow patterns of the reactor at each zone of the process.

Results of the investigation reveal that the whole defluoration process using electrocoagulation method behaves as a complex combination of four different flow models at all tested operating conditions.

The radiotracer investigations enabled to attribute to each zone of the reactor its specific mixing model. To the first zone corresponds a semi-open piston model. To the second zone (electrochemical chamber) corresponds a perfectly agitated mixer with recycle model. And to the third zone (separation chamber) corresponds two outlets: one to recover floating flakes and one to recover the treated water, to both of them corresponds a perfectly agitated mixer. However the parameters of these identified models (Peclet number, number of mixing-cell, proportion of flow rate exchanging) vary with applied operating conditions (current and flow rate).

KEYWORDS:

Water defluoration, electrocoagulation technique, Radiotracer, Technicium-99m, Residence time distribution, flow models, degree of mixing and RTD modeling.

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A study to investigate the use of natural radionuclides as radiotracers in sedimentation processes

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ABSTRACT

Radiotracers is an important indicator when studying bedload transport and sedimentation. The use of these artificial radiotracers however raises various environmental concerns. This article will explore the use of natural black sand with high concentration of uranium and thorium as a possible alternative to artificially activated radiotracers. Natural occurring radionuclides concentrations in various natural areas with alluvial deposits will be explored. A pilot study of radionuclide distributions on a beach due to alluvial deposited black sand will also be discussed. Conclusions on the viability of black sand as radiotracer will finally be summarised.

NATURAL OCCURRING RADIONUCLIDES

The natural occurring radionuclides of thorium, uranium and potassium is present in varying concentrations in all rocks and sand. The uranium nuclide usually has the lowest activity concentrations, and potassium by far the highest concentrations. Natural radionuclides is consequently a powerful tool when studying sediment characteristics. Natural radionuclide concentrations were therefore acquired and mapped by means of *in situ* measurements at various locations. These locations included beaches, pans and rivers in South Africa, Mozambique, Botswana and Namibia. The distribution of the naturally radionuclides demonstrated good agreement with the geophysical characteristics of the areas which includes underlying sedimentation processes. These studies also showed that radionuclide mapping provides valuable information on beach formation and erosion.

BLACK SAND

Black sand that contains high levels of heavy minerals with accompanying natural radionuclides was also gathered from some of the sites and analysed. Uranium and thorium concentrations in excess of 550 Bq/kg and 950 Bq/kg, respectively, were measured in the black sand. Very low concentrations of potassium were however detected. These exceptionally high levels of radionuclides gave rise to the idea that black sand can be used as a natural radiotracer when studying sediment transport. This article will explore the possible utilization of natural thorium and uranium in black sand as radiotracers, means of a pilot study that was done on the beach at Richards Bay, South Africa.

CONCLUSIONS

The variation of concentrations of natural nuclides can provide information on sedimentation processes in different terrestrial environments. Potassium seems to be a good indicator of deposition, but only over short periods. Uranium and thorium provides short and long period deposition indications. Thorium provide some indication in certain environments over long periods of deposition. Uranium and thorium in black sand can be utilized as a possible natural for radiotracer for sediment studies but more short term dynamic deposition studies is required.

KEYWORDS:
Uranium, thorium, black sand, natural radiotracers.

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Evaluation of hydraulic performance of an anaerobic pond using radiotracer technique

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ABSTRACT

Radiotracer experiment was carried out in anaerobic pond to assess its hydraulic performance. Iodine-131 was injected 40m upstream from the inlet of the pond and its passage through the channel and the entire pond was monitored by 7 detectors. Volumetric flow rate of the inlet channel at the time of injection was estimated to be $0.059 m^3 s^{-1}$ which provided the theoretical mean residence time (MRT) to be 3.5 days. The measured residence time distribution (RTD) at the outlet was treated and experimental MRT was determined to be 5.8 hours. It was found that about 93% of the geometric volume within the pond was dead. The measured RTD was modeled to describe and visualize the flow pattern of wastewater within the pond. Based on the measured MRT, percentage of dead volume and identified flow patterns, it was concluded that the hydraulic performance of the pond was catastrophically poor and no longer fit for the purpose it was meant for.

INTRODUCTION

Wastewater Stabilization Ponds (WSPs) are large, shallow basins used for treatment of municipal and industrial wastewater by involving natural processes both algae and bacteria [1]. They are most efficient and commonly used method for treatment of wastewater in tropical and subtropical regions of the world.

The efficiency of a WSP system mainly depends upon hydrodynamic characteristics of different ponds. Most of the ponds are designed to have a specific retention time, percentage of tolerance of deposition and a plug flow pattern within the ponds for efficient treatment. In practice, the flow deviates from the desired flow pattern due to several flow abnormalities. Radiotracers are often used to identify flow abnormalities in industrial process systems [2]. Present paper describes a radiotracer study carried out to measure hydraulic parameters and flow investigation in WSP (anaerobic pond) of Dandora WSP system in Nairobi, Kenya.

RADIOTRACER EXPERIMENT

About 135 mCi of I-131 was instantaneously injected into the channel 40 meters upstream from the inlet of the pond. The radiotracer was monitored per second at two locations in the channel and five different locations in the pond using a 12-channel data acquisition system (DAS). The detector D0 and D1 mounted in the inlet channel and separated by a distance of 20 m were used to measure the flow rate. The first monitoring location was 20 m downstream of the injection point to allow mixing of radiotracer within the cross-section of the channel. In addition to the flow rate measurement, the detector D1 also provide the time of entry of the radiotracer into the pond. The detectors D2, D3, D4 and D5 mounted at different locations within the pond were used to investigate distribution of the radiotracer into different sections of the pond, whereas the detector D6 was used to monitor RTD of the wastewater within the pond.

RESULTS AND DATA ANALYSIS

Pulse velocity method was used for the measurement of the flow rate. The radiotracer concentration data measured at two locations in the channel was treated and MRT was determined. The difference of the first moments of the two curves provided MRT of radiotracer between D0 and D1 to be 21seconds. The volume between the two locations was determined to be $1.24 m^3$. Thus, the flow rate was determined to be 5101 m^3/d.

The radiotracer concentration data measured at the outlet of the pond was treated for background correction, zero-shift, dwell time and tail correction before estimating the MRT, dead volume and modeling the data. Exponential regression method was used to extrapolate and complete the tail. The THYNRTD software was used for data treatment [3]. From the treated curve, the MRT of the wastewater was determined to be 5.8 hours. Since the geometrical volume of the pond was 17860.5 m^3 and the flow rate measured was 5101 m^3/d, the theoretical MRT was estimated to be 3.5 days. The comparison of experimentally measured and theoretically estimated MRTs provides estimates of dead (V_d) and active (V_a) volumes within the reactor as 93% and 7% respectively.

Modelling

DTSPro software was used for modeling the RTD data. The tank-in-series model with two parallel streams, bypass and recirculation was found to be appropriate fit to the measured RTD.
The comparison of the experimental and model simulated RTD curves and the values of the model parameters (Table 1) corresponding to best fit curve are as shown in Fig.1.

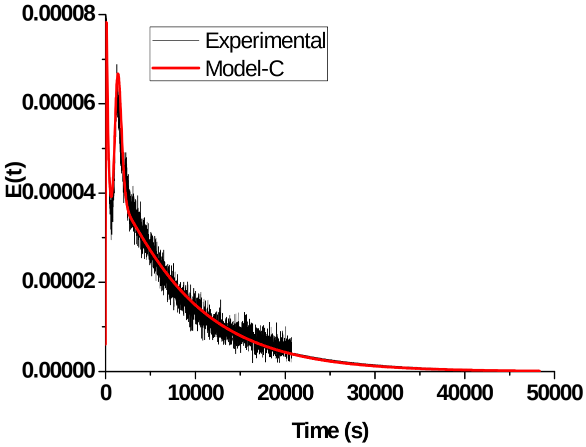

Table 1: Results of RTD Modeling

Flow Streams	Main Flow stream			Bypass Flow stream
Flow Fraction	0.962 (96.2%)			0.038 (3.8%)
Sub Streams	Parallel flow Stream-1	Parallel flow Stream-2	Recirculation Stream	--
Flow Fraction	0.08 (8%)	1.002 (100.2%)	0.12 (12%)	--
τ_m(S)	3450	16000	300	470
N	18	1	3	2
τ_{ex}(S)	--	7000	--	500
K	--	0.11	--	0.2

τ_m: Model predicted MRT, τ_{ex}: Time of exchange between active and dead volume, N: Tank number, K: exchange ratio

Fig.1. Experimental and Model-C simulated RTD curves and Parameters

CONCLUSIONS

A radiotracer investigation was successfully carried out to measure RTD of wastewater stabilization pond in Kenya. It was found that most of the volume of the pond was dead due to deposition of sediments within the pond and chocking of one of the inlet feed pipes leading the wastewater to flow through one of the feed system. Various models were tried to simulate the measured curve but tanks-in-series model with two parallel streams, bypassing and recirculation was found to be fitting well to the measured RTD curve. Based on the results, the pond was not found to be functioning as expected and needs to be cleaned and redesigned to avoid the settling of the solids within the pond. This investigation was first of its kind to be conducted in Kenya and will go a long way to promote the use of radiotracer technology in Kenya.

KEYWORDS

wastewater stabilization pond, residence time distribution, radiotracer, iodine-131, mean residence time, dead volume

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Optimization of the accuracy measurement with nuclear gamma gauge for high suspended cohesive sediments concentration

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ABSTRACT

The Monte Carlo simulations of radiation transport that are commonly applied to design and optimization both; instrumentation as well as experimental set up used to evaluating sediment transport. This numerical kit tool has been used for this purpose but also can contribute to enhance the accuracy of the measurement interpretation. The heterogeneities in the sediments media was deeply examined by adopting a geometrical model. It consist on a cube (12cmx12cmx12cm) filled with water and spheres. In the first time, the granulometry of sediment was chosen homogenate and the distances between the spheres were keepted fixe and the relative sediments sizes are considered varying from 100µm to 0.2mm. For the sediment diameter larger than 300µm, the heterogeneity of the water sediment can be quantified. However, for lower sizes (less than 300µm) the mixture can be assumed as homogenate. This results, shows good agreement with the predicted influence on the interaction process particle-sediment (> 300µm) reported by Nathan & al 2011.
Also simulation results shows a kind of correlation between the sediment size and the spectra in the detector for energies less than 30keV and this is more seen when we use more efficient detector as BGO.
The effect of heterogeneity size of sediment mixture on the detector response was also investigated. It was deduced that the response is depending on the predomination sediment size in the sediment mixture. Other aspects related to cohesive sediments structure, such as Electro-kinetic properties of the particles, are under investigation.

KEYWORDS:

Suspended *cohesive sediment*, Geant4, nuclear gauge, Flocs.

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Use of the Radiotracer technique for the evaluation of sanitary networks

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ABSTRACT

Using the radiotracer technique to establish the connections among different reference points, this work presents the results from the studies carried out for the determination of the tracing of the sanitary network in a hospital located in Havana, Cuba. The radiotracer used in this investigation was In-113m, and the detection system was based on NaI(Tl) scintillation detectors (2"x 2") coupled to a Data Logger through 50 m coaxial cables. The acquisition software PM4 permitted the visualization of the temporal variation of the count rate. All the detection system is from FORCE TECHNOLOGY, Denmark. The result showed the internal connections and discharges of the sanitary registers in different buildings (A, B, C, D and M) form the hospital. In some specific points from the studied buildings, possible obstructions or leakages were identified. Based on the provided information about the characterization of the sanitary networks, and the identified destinies of the sanitary discharges, the authorities from the hospital could define a policy for the management of the growing sanitary discharges, taking into consideration the incorporation of new buildings, aimed to avoid or reduce the impact of the sanitary discharges in the environment.

Development and Qualification of Underwater Radiation Monitoring System

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ABSTRACT

Water is one of the most important natural resources and has to be prevented from any contaminations. In particular, small amounts of artificial radioactive materials with long half-life such as ^{137}Cs which can be generated by an accident of nuclear facilities could cause radioactive contamination in water, extensively. The interest in the radioactive contamination issues have been increasing all over the world since the Fukushima nuclear facility disaster in Japan, and various radiation monitoring system has been developed to monitor radioactive concentration in air. However, it is still a challenge to monitor radiation in water due to its detection distance, supply of electric power, water-proof design, and so on [1-4]. Recently, researchers at the Korea Atomic Energy Research Institute (KAERI) have developed an underwater radiation monitoring system to detect ^{137}Cs (662 keV) and ^{131}I (364 keV), which are produced by nuclear fission. The monitoring system is designed to float on the water by buoy and use solar panel for self-powered operation. In this study, various experiments and simulations were carried out to determine a detector sensor taking the cost to benefit ration into account and evaluate the minimum detectable activity and the activity conversion factor to operate the system.

There are many types of detector sensor and they have their own properties. Among them, BGO, CsI(Tl), $LaBr_3$(Ce) and NaI(Tl) cylindrical radiation detectors (2 inch in diameter and 2 inch in length) were considered for the system [5]. Their performances were estimated by a Monte Carlo simulation in terms of the energy resolution and detection efficiency and compared each other [6, 7]. The BGO detector provided the best performance, the NaI(Tl) detector, however, was chosen taking the cost to benefit ratio into consideration. Based on the results of this, an NaI(Tl) detector was associated with multi-channel analyser (MCA) in a waterproof device.

To measure the activity conversion factor, a tank (1.9 m in diameter and height) was filled with water and ^{68}Ga radioactive source was mixed in water instead ^{137}Cs and ^{131}I due to its long half-life which could cause radioactive contamination after experiments. The detection signals along with the source activity were measured and compared to the simulation data under the same conditions. Based on the comparison, the activity conversion factors for ^{137}Cs and ^{131}I were estimated to be 1.86×10^{-2} (Bq/L)/count and 1.38×10^{-2} (Bq/L)/count, respectively [8-10]. The minimum detectable activity was calculated from the background detection data in water and the activity conversion factor to 0.83 Bq/L for ^{137}Cs and 0.95 Bq/L for ^{131}I.

KEYWORDS:

Underwater Radiation, Radiation monitoring, Radioactive Contamination, Performance evaluation.

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Calibration of the Gauge of density XDP30

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ABSTRACT

Calibration of the new XDP30 X-ray Gauge is a mandatory step before using it for real-time measurements of sediment density or concentration. There are several parameters to consider in order to succeed and to arrive at a logical and representative calibration curve. According to the direction of the gauge, the movement of the sediments during the calibration and the approach used, the results are very different. Taking these factors into account and choosing the right method will lead to better results that will certainly benefit the users of this gauge.

KEYWORDS:

Calibration, concentration, density, X rays

Isotope Tracing Application in Source Apportionment of Tropospheric Black Carbon in Nairobi, Kenya

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ABSTRACT

Witnessed increased economic activities in Kenya and indeed Sub-Saharan Africa (SSA) have led to increased air pollution events. Industry, traffic, domestic, and agricultural sectors all contribute to the pollution levels, with severe consequences on both local and regional climate and human respiratory health. Black Carbon (BC) formed from incomplete combustion of biomass and fossil fuels is one of the health- detrimental components of the airborne particulate matter, with sub-Saharan Africa as one of the global hotspots for BC. However, due to the currently low number of ground-based observations in Kenya and the region, the uncertainties in impact of BC on climate and health are particularly large. This study applies dual-carbon isotope approach (radiocarbon $^{14}C/^{12}C$ and stable carbon $^{13}C/^{12}C$ isotope ratio); to quantitatively quantify the relative contribution from different combustion sources mainly fossil fuels and biomass burning. The ^{14}C in fossil sources are completely depleted while the biomass sources have a distinct $\Delta^{14}C$ signature, allowing calculation of the fossil versus biomass fraction with high precision. On the other hand, $\delta^{13}C$ reflects a specific combination from different sources [1]. Ambient $PM_{2.5}$ samples were collected at an urban background site in Nairobi, Kenya, using a high-volume sampler. Samples were collected once a week over a 24 hour period on pre-combusted quartz filters (140 mm diameter), from April 2014 to April 2016. The collected filter samples were packaged and shipped to Stockholm university for chemical and isotopic analyses. A few samples were analyzed for BC concentrations with a thermal-optical transmission analyzer using NIOSH 5040 protocol [2]. The BC fraction assigned for isotopic analysis was isolated and cryogenically trapped after conversion to CO_2 using a modified Sunset Laboratory instrument [2]. The carbon isotopic compositions $\Delta^{14}C$ and δ13C were analyzed at the U.S.-NSF National Ocean Science Accelerator Mass Spectrometry (NOSAMS) facility, and fractional contributions of radiocarbon- extinct fossil fuel combustion sources versus contemporary biomass burning sources determined. Partial results of this study will be presented during the conference.

We appreciate training support on tracers by International Atomic Energy Agency and research capacity support at University of Nairobi by International Science Programme, Uppsala University, Sweden.

KEYWORDS:

radiocarbon isotope ratio, SSA, Air Pollution, human respiratory, climate

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Historical review of the studies performed by CDTN in Latin America, using tracers in the fields of sediment transport and dispersion of effluents in water environment

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ABSTRACT

This paper tries to summarize the set of works carried out with the participation of CDTN (Nuclear Technology Development Center) in Latin America, from the 1970s to the present days, with the use of tracers and nuclear gauges in sedimentological studies, and also using tracers in studies of dispersion of effluents in water environment.

We will give a statistical view considering the several objectives sought with each of the applications (siltation and dredging in navigation channels and harbors; behavior, in rivers, of fine sediment dredged in reservoirs and dumped downstream; studies of dispersion of industrial and thermal effluents).

We will try to highlight more relevant studies, and we will conclude on the potential of the use of activable tracers for the determination of the long term behavior of fine sediments dredged and dumped in water environment, not yet used in practice.

In conclusion, this paper highlights the importance, already demonstrated in Latin America that has the use of tracers in the determination of sediment transport and the dispersion of effluents.

BACKGROUND

The CDTN, an autarchy of the Brazilian Nuclear Energy Commission (CNEN) began its activities with the application of nuclear techniques in 1962, through its Radioisotope Laboratory, with constant support from the IAEA, from the beginning of its activities. Initially, industrial tracer applications were carried out and, from 1968 on, studies of sediment transport and effluent dispersion were also carried out (Aun and Bandeira, 1995).

The 1970s and 1980s in Brazil were marked by the vigorous improvement of its port facilities, implying dredging to deepen access channels, turning basins and mooring berths, as well as the construction of new harbors, such as: 1) Madeira Island, in Sepetiba Bay, Rio de Janeiro State; 2) Suape, Pernambuco State and 3) Alumar, in São Luis City, Maranhão State. In addition, several industries have required studies on effluent disposal in the coastal or estuarine region. The CDTN worked intensively in collaboration with the National Institute of Waterways Research (INPH) and with several industries, such as Brazilian Oil Company (PETROBRAS) and its subsidiaries, and also with private companies.

The tracer used for the study of sandy bottom sediment transport is the ground glass labelled with ^{198}Au or ^{192}Ir. In order to study the behavior of fine sediment dredged and dumped from Hopper dredgers or barges, and also to study the behavior of naturally occurring fine sediment in suspension, from subsurface injections, mud labelled with ^{198}Au was always used. Since 2000, with the development of the technology for labelling fine sediment with ^{99m}Tc, radioactive tracer widely used in Nuclear Medicine, which was carried out in the laboratories of the CDTN through chemical reduction of ^{99m}Tc eluted in the form of TcO_4^-, the study of the natural behavior of fine sediment in suspension was performed only with this tracer, which presents many advantages over the use of ^{198}Au (Bandeira and Salim, 2017).

For the effluents dispersion studies ^{82}Br, ^{198}Au and ^{99m}Tc (in the form of TcO_4^-) as well as fluorescent tracers (Rhodamine WT and Fluorescein) are used. Currently, fluorescent tracers are most commonly used for this type of study. Table 1 shows a summary of the sites and types of experiments performed with radioactive and fluorescent tracers and nuclear gauges.

Table 1 - Sites and types of experiments performed with tracer techniques by CDTN in Latin America

	STUDIES USING RADIOACTIVE AND/OR FLUORESCENT TRACERS				NUCLEAR GAUGES
	Effluent dispersion	Bottom sediment transport	Suspended sediment transport		Sedimentation (3)
			Dredging dumping (1)	Subsuperficial injection (2)	
BRAZIL					
Rio Grande, RS	X	X	X		
Imbituba, SC	X	X			
Paraná River basin, PR		X			
Iguape, SP	X	X			
Santos, SP		X	X		
São Sebastião, SP	X				
Ilha Grande bay, RJ	X				
Sepetiba bay, RJ			X		
Rio de Janeiro, RJ			X		
Macaé and Barra do Furado, RJ	X				
São Francisco River basin, MG				X	
Paraiba do Sul river basin, MG				X	
Vitória, ES			X		
Salvador, BA	X				
Aracajú and Sergipe State coast, SE	X	X			
Maceió, AL	X				
Suape, PE		X			
Recife, PE			X		
Natal and Rio Grande do Norte State coast, RN	X	X			
Luiz Correia, PI				X	
São Luis, MA		X	X	X	X
Belém, PA		X	X		
Manaus, AM	X				
OTHER COUNTRIES					
Colombia		X			X
Uruguai		X	X	X	X
Chile		X			
Venezuela		X		X	
Notes					
(1) Labelling the fine sediment with ^{198}Au, in the well of dredger or barge					
(2) Labelling the fine sediment with ^{198}Au or ^{99m}Tc, for studying its natural behavior in suspension					
(3) Measurement of density profiles of fine sediment deposited in harbours and reservoirs					

KEYWORDS: water environment, sediment transport, effluent dispersion, tracers, dredging

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Determination of trace elements in surface water at Xuan Huong Lake – Delat city using total-reflexion X-ray fluorescence (TXRF)

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ABSTRACT

The regular assessment of a water source is important for safety. Specifically, the concentration of trace elements in water reflects the pollution level. Urbanization, industrialization, fertilizer and other plant protection products have all had an effect on the environment, especially water and air quality. The main objective of this study was to evaluate the trace elements contained in surface water from Xuan Huong Lake – Dalat city. Trace elements analysis was performed by using Total Reflection X-ray Fluorescence (TXRF). In general, the concentrations of some metal elements exceeded acceptable limits, according to standards set in Vietnam as well as in many other countries.

KEYWORDS:

TXRF, trace elements, surface water

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Characterizing Sediments for black sands as Possible Radiotracer for Sediment Transport studies

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ABSTRACT

The aim of the study was to characterize sediments from river Tiva to determine presence of black sands. Nuclear analytical techniques were applied to determine the elemental composition and activity concentration of radionuclides in the sand samples. Energy Dispersive X-ray Fluorescence (EDXRF) was used to determine the concentration of Ti, Fe and Zr which are associated with black sands. While gamma spectrometer was used to determine activity concentration for radionuclides in the sands samples (^{238}U, ^{232}Th, and ^{40}K). The mean values for Iron (Fe) was 73135±6027µg/g, titanium (Ti) was 22976±1971 µg/g, and zirconium (Zr) 1115±136 µg/g.). The activity concentration of ^{238}U was 8.45±0.58 Bq/Kg, ^{232}Th was 205±31 Bq/Kg and ^{40}K was 365±232 Bq/Kg. The findings of the research was that there is presence of black sands in river Tiva sediments as confirmed by XRD analyses indicating the presence of mineral ilmenite. The subsequent studies will involve the application of the radioactivity to study sediment transport studies.

INTRODUCTION

Black sands contains mineral monazite which have high levels of radionuclides. Presence of radionuclides makes it a natural radiotracer for application in sediment transport studies to solve problems in coastal engineering systems. Most of the radiotracers established for sediment transport are artificial radiotracers such as ^{198}Au, ^{46}Sc, and ^{192}Ir (IAEA, 2014). When using artificial radiotracers, there is the challenge of getting government approval due to the radiation safety and radioactive waste concerns. Therefore, there is need to look for an alternative radiotracers that can be used for the studies and give the same results. The presence of ^{232}Th and ^{238}U in the blacks motivate us to apply natural radioactivity due to presence of ^{232}Th radionuclide to study the sediment transport studies.

STUDY AREA AND METHODS

Study Area

Kitui is about 145 km East of Nairobi, bound by latitude 1^0 00' and 1^0 30' S and longitudes 38^0 00' E. Specifically the area under study is geographically found at the west of Kitui where much reduced remnants of an older erosion cycle stand deeply above the deeply dissected sub-Miocene peneplain..

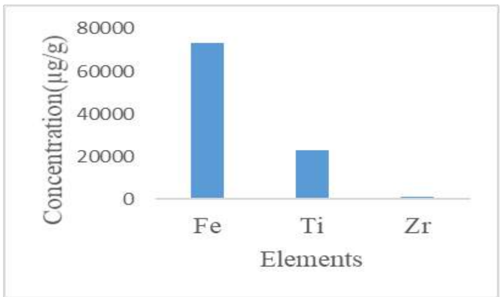
Materials and Methods

Sediment samples were collected directly using the auger at depth ranging from 0-50cm below the river bed and at interval of 100 m along the river channel. For EDXRF analysis thin pellets of 2.5 cm in diameter of weights between 0.1-0.3 grams was prepared. EDXRF analyses were conducted to determine the elements such as Ti, Zr, and Fe which are associated with black sands.

The activity concentration of radionuclides was determined by placing the sand samples on the HPGe detector and counted for at least 10 hours. The activities of the ^{238}U and ^{232}Th were determined indirectly using gamma lines of the known members found in their respective series.

RESULTS

The heavy elements associated with black sands such as Ti, Fe and Zr were determined. The mean values for Iron (Fe) was 73135±6027µg/g, titanium (Ti) was 22976±1971 µg/g, and zirconium (Zr) 1115±136 µg/g (figure 1). The activity concentration of ^{238}U was 8.45±0.58 Bq/Kg, ^{232}Th was 205±31 Bq/Kg and ^{40}K was 365±232 Bq/Kg (figure 2).



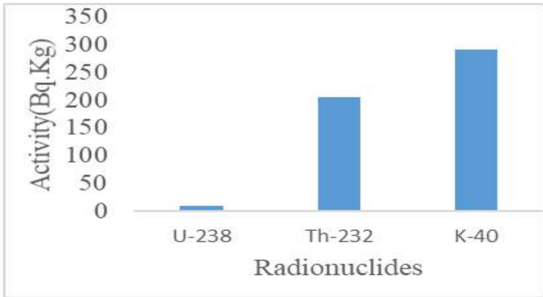


Figure 1: Mea*n concentration values of* elements in Sands *Figure 2: Activity concentrations of radionuclides*

CONCLUSION AND RECOMMENDATION

The results shows that, there is high concentration of Titanium in the sands indicating the presence of black sands in the sediments of river Tiva. There is also presence of Zr (1115±136 µg/g) in the river sediments which characterizes the presence of mineral monazite associated with black sands. The radioactivity measurements were high hence indicating presence of monazite minerals associated with high level of ^{232}Th (205±31 Bq/Kg).

If black sands from the area of high deposition like coastal area where the river terminates is concentrated, there might be high concentration of thorium radionuclide. ^{232}Th can be used as tracer for sediment transport studies since black sands have same physical properties as sediments in the sea.

KEY WORDS

black sands, radionuclide, radiotracer, radioactivity, thorium

ACKNOWLEGMENT

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Hydraulic study of a real scale subsuperficial flow constructed wetland using CFD simulation and tracer experiments

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ABSTRACT

Constructed wetlands are a sustainable and efficient technology for wastewater treatment which finds its better application in rural areas. This work presents a numerical model for a real scale vertical subsurface flow constructed wetland that has been experimentally validated with tracer experiments. The transient simulation shows a good but limited agreement with experimental data and evidences the main contribution of top fine media strata to the system hydraulic retention time. Finally, some suggestions have been made in order to improve the CFD simulation tool so that it can be properly used for the system optimization.

INTRODUCTION

Constructed wetlands (CW) are extensively used in the wastewater treatment of rural areas because of the low energy consumption and high pollutant removal efficiency. Their performance relies on the physical, chemical and biological processes driven by the media-microorganism-vegetable to achieve particulate contaminants retention and soluble organic molecules degradation [1]. Furthermore, if aerobic and anoxic conditions are combined, as it is common in hybrid systems with vertical and horizontal Subsurface Flow CW (SSFCW), nitrogen removal is also possible.

As it has been extensively reported, pollutants removal efficiency ultimately depend on the hydraulic performance of the system. For this reason, computational fluid dynamics (CFD) simulations techniques are a useful tool to study, characterize and predict the flow behaviour through the wetland under different design constrains and operational conditions and consequently optimize the whole system [1].

In the last years, several CFD approaches for SSFCW and other porous media systems have been developed but few of them have been experimentally validated by tracer experiments [1, 2]. Moreover, most of those studies are focused on continuous systems which operate in a stationary regime so they haven't faced the conceptual and operational problems in Residence Time Distribution (RTD) analysis that arise when unsteady and unsaturated conditions occur [3]. Also, there is a lack of information on the effect of medium size on the spread of tracer response [4]. In this work a SSFCW CFD model has been developed and validated contributing to these lines of research.

MATERIALS AND METHODS

A hydraulic study of a real 75 m2 SSFCW with vertical flow in Castillo de Villamalefa (Spain) has been conducted using simulation and experimental techniques. The wetland operates in discontinuous loads, easing the oxygenation of the influent as it advances through the media, which is composed of 3 differenced strata of different gravel and sand sizes. The influent is distributed using an equidistantly perforated hose and, at the bottom, the effluent is collected using a slotted pipe network which is connected to several aeration vertical chimneys to ease medium aeration between each influent load.

A two-phase 3D CFD model of this configuration has been developed through the use of ANSYS-FLUENT® Academic Research Release 18.2 software. The model domain has been reduced taking advantage of the wetland geometric periodicity and left-right symmetry. Wastewater discharge has been modelled as uniformly distributed rectangular sections along the top surface imitating puddle formation due to the water entry inhomogeneities. In order to ensure an exclusively gravity-induced flow, atmospheric pressure conditions have been fixed in both inlet and outlet in the system. The model includes two continuous phases (water and air) by using the volume of fluid (VOF) method and a porous media submodel which considers viscous and inertial effects over both phases. The flow has been determined as transitory, and laminar flow assumption has been made.

Different media particles have been characterized in the laboratory using granulometry measurements and permeability tests in order to calibrate the solid-liquid interaction. Some model parameters reported in Table 1 have been acquired from bibliography [2]. Furthermore, tracer experiments have been carried out at full scale in order to detect defects of the fluid behavior and calculate the mean residence time through the Concentration vs Time tracer response curves which has been used to validate the original SSWF configuration in the CFD model.

RESULTS AND CONCLUSIONS

Simulation results show a relatively good but limited agreement with experimental tracer data. The position and magnitude of the peak is reasonably well reproduced, but the long tail from the experimental data is clearly not reproduced. This may be caused both by the assumptions in the geometry simplification and the simplicity of the porous media model used, which does not take into account effects as gravel mixing or the gravel wetting, that tends to accumulate water inside the wetland. This indicates that a full geometrical model is desirable, leading to huge computation times, and the need of more complex models for the gravel distribution and its interaction with the liquid.

Flow simulation results analysis demonstrates the determinant influence of the top strata which makes main contribution to the hydraulic retention time due to its higher flow resistance. Medium and coarse strata have little effects over retention time but are expected to have a strong effect on water mixing and aeration since flow acceleration through the unsaturated media promotes phases mixing.

To conclude, CFD simulations by using standard models provide some interesting results about the SSFCW hydraulic performance and predict the magnitude and position in the initial moments of the flow. However, the validation against experimental data demonstrates the need for more complex hydraulic models and an accurate geometry description in order to provide an accurate description of their performance and serve as design and optimization tools. The main points of interest for further research are the effect of medium size over the tracer recovery and the effect of the media on the fluid mixing.

KEYWORDS:

Wetlands; CFD; Tracers; Hydrodynamics

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Analysis of residence time distribution using radioactive tracer technique for a waste water treatment unit at Tema oil refinery

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ABSTRACT

The waste water discharged from the operational activities of the Tema Oil Refinery (TOR) contained very high crude oil content of about 100 ppm, in excess of the Environmental Protection Agency (EPA) approved standard of 10ppm in the discharged water.

To meet the effluent quality demands of the EPA, the research was undertaken to use radiotracer technique to diagnose the operational problems of the Dissolved Air Floatation (DAF) unit used for oil/water separation at the treatment plant of TOR. The physical separation tank having three subsections connected in series, namely pH adjuster, coagulation and flocculation sections was used. Gallium-68 (Ga-68) radiotracer with activity of 12 mCi was introduced at the inlet of the tank and the movement of the water through the sections followed by monitoring the radiotracer. Waste water first enters the pH adjuster before moving to the coagulation and flocculation sections respectively. Detectors placed at the outlet of each of the sections recorded the Residence Time Distribution (RTD) respectively.

The results indicated that the sections had dead volumes of 4.12%, 11.1% and 13.5% respectively for the pH adjuster, coagulation and flocculation sections respectively. Based on the results the power of the agitators for the sections should be increased from 200 rpm to 250 rpm for pH adjuster and coagulations sections and from the operational range of 22-68 rpm to 100 rpm for the flocculation section to improve mixing efficiency and reduce dead volume. The flow rate of water through the tank should be reduced from $20m^3$/hr to $15m^3$ /hr to increase the contact time between the water and acid/basic solution , coagulant and flocculants in the three sections for higher process efficiency and better effluent quality which will lead to an increase in discharged water quality.

DISCUSSION OF RESULTS

For the section 1 which is the pH adjuster, a concentration time curve of the data was obtained from detector 1 before any corrections were made. The RTD curve was done with tracer count rate plotted against time in minutes. Tanksfit software developed by the South African radiotracer group, was available for data analysis and only takes count rate input against time but not the normalized data. From the result table and RTD curve for section 1, the PH adjuster is in good working condition. This is because the system response is approximately the same as that predicted by the model. Theoretical (model) and experimental (moment) mean residence time (MRT) are 27.22 and 26. 10 respectively hence effective volume is approximately 95.88% which indicates good mixing.

Sections (1+2) describe the progressive flow of the water through the first two sections of tank the pH adjust and the coagulation sections. The measured response curve for the section (1+2+3) which is representative of the whole tank, is very similar to that of the section (1+2)
The ideal curves and measured data in the graph provide evidence of deviation from ideal mixing behavior. The measured response curves display longer tails than the models as compared to the tank in series model.

This is usually attributed to tracer being retained in poorly mixed zones. The tracer is then released at a slower rate than the bulk of the tracer, thus producing the long tail in the response curves. This is further confirmed by the presence of 11.1% stagnant zone in section (1+2) and 13.5% for the whole tank, with these stagnant zones present at the corners. From the Tankfit simulation of the data from the detector three which is representative of the whole tank, the tank behaves like 2.1 well mixed tanks connected in series

From the graph obtained, the MRT is 70.56 minutes and that of model is 81.65 minute. The appearance of the response curves earlier than mode predication could have any of the following physical interpretations;

i. Contact time is not sufficient to ensure maximum mixing
ii. Design volume is too small or the effective volume is too small
iii. The flow rate is too high
iv. Short circuiting or bypassing is possible in the tank

The design flow rate may be too high leading to a reduction in the contact time between the water and the coagulation and flocculation agents respectively

KEYWORDS:

Waste water treatment plant, Gallium-68, radiotracers.

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Anaerobic Digesters Mixing Optimization through tracer test and CFD modeling

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ABSTRACT

Anaerobic digestion is one of the recommended processes for the sludge stabilization. According to this, the optimization of Anaerobic digestion process is concerning Waste Water Treatment Plants. In this study, two full-scale Anaerobic Digesters (AD) with DYNOMIX as external recirculation mixing system were studied by means of tracer test and Computational Fluid Dynamic simulations. The validation of the simulations were carried out through inert tracer test. Single phase Non-Newtonian 3D CFD simulations were perform to assess different operational parameters like recirculation flow and a 3-blade propeller. Tracer test showed that an internal propeller in the core of the AD could avoid dead volumes and produce an ideal CSTR. Typical design and mixing parameters, such as Turnover rate or Uniformity index(UI), were studied to characterize the degree of mixing in each operational scenario. Turnover rate and dilution factor showed the hydrodynamic effect offered by both mixing methods: while the recirculation of the sludge by means of an external pump leads to a sludge's rotational movement, propeller upgrades raw sludge mixing with the old one. The temporal evolution of the UI during tracer test showed that the higher recirculation flow, the faster the digester is homogenized. 200% of the maximum recirculation flow and active propeller showed similar results but the installation of a propeller would be more cost-effective.

INTRODUCTION

Anaerobic digestion has become one of the most profitable treatments for the stabilization of the sludge in the past years in wastewater treatment plants (WWTPs). One of the major concerns regarding anaerobic digestion is the assessment of the hydraulic behavior of the municipal anaerobic digesters. Mostly, the hydraulic retention time (HRT) and the state of the mixture inside the tank are relatively poorly understood in the daily operation, being complicated to propose improvements in the design as well as in the operation. In wastewater treatment plants, the major concern regarding to this process unit is to quantify active volumes and HRT of the tank. Taking experimental data from tracer tests allows obtaining the global fluid behaviour in real-scale but sometimes, it might be not cost-effective due to it is still a tedious and expensive work when it is applied independently. It is needed a deeply evaluation of the flow pattern and turbulence parameters (kinetic energy, stresses, etc.) to assess the hydrodynamics phenomena inside a full-scale digester. CFD can provide this through numerical simulation of non-Newtonian fluid motion. Nevertheless, it will need verification through experimental data such as tracer experiments.

The major aims of this study are focused on: (1) developing a real full-scale CFD model to reproduce hydraulics in detail; (2) verifying the CFD model using tracer tests and comparing the performance of two tracers; (3) Evaluation and optimization of mixing degree.

MATERIALS AND METHODS

Two real anaerobic digester tank of 3400 m^3 of a municipal WWTP were analyzed (Figure 1). Mixing was provided by an external recirculation pump system (DYNOMIX) and an extra propeller, which work continuously and discontinuously respectively. Tracer tests were conducted using different tracers: fluorescent tracer, Lithium Chloride (LiCl) and Potassium Bromide (KBr). An exhaustive sampling campaign was carried out during 40 days (fluorescent tracer) and 70 days to obtain thoroughly the RTD at the outlet (Figure 3). Fluorescent tracer test showed a dead volume at the rated power but LiCl and KBr tests stated an ideal continuously stirred tank reactor (CSTR) at the AD with rated power and intermittent 3-blade propeller. On the other hand, viscosity was measured at 38ºC to calibrate the shear thinning rheological behavior of the fluid.

Numerical simulations were accomplished through the use of the commercial CFD code *ANSYS® Academic Research Release 17.2* [1]. Three-dimensional Eulerian non-Newtonian single-phase simulations were performed to reproduce accurately hydrodynamics. Liquid phase was defined as a non-Newtoninan fluid using Ostwald-de-Waele submodel [2]. Two different scenarios (with and without propeller) and different recirculation flows, ranging from 50 to 200% of maximum recirculation flow rate, were studied to evaluate dead volume according to different criteria in literature (Figure 2). The steady-state simulation was applied to accurately obtain the hydrodynamics of the studied anaerobic After that, the calculation of hydrodynamics was blocked and a transient simulation was run to reproduced the tracer test with a variable increasing time step. Transient results were used to study the mixing performance of the different simulated scenarios. Recommended design parameters of mixing systems such as Unit Power (UP), HRT or Digester Volume Turnover Time (DVTT) in anaerobic digestion were evaluated [3], [4]. Turnover rate, Dilution factor and Uniformity index were calculated by means of transient results.

RESULTS AND DISCUSSION

The global hydrodynamic behavior was correctly validated by means of RTD during 70 days (Figure 3). RTD was calculated by CFD and compared to LiCl and KBr tracers at the outlet which presented similar results. The concentration of tracer reached was equalized in less than 1 day at different measuring points within the digester showing a CSTR hydraulic performance. One tracer test was run for each operational condition and it was stated that RTD-CFD simulations would be more cost effective than experimental tracer test. Low velocities inside the tank and sticky effect of viscosity induced stagnant zones. Dead volume percentage was calculated comparing different bibliography criteria; it can be directly related not only with the recirculation flow rate but also with the mixing system features. Mixing was evaluated through DVTT, HRT, UP and in terms of power. The recommended values of agitation design contrast with those obtained in the CFD simulations and tracer tests: Recommended parameters would increase the power needed to mixing the sludge whereas tracer test showed an ideal CSTR.

Turnover rate and Dilution factor were calculated by means of the numerical simulations (Table 1). They could explain mixing efficiency on different CFD simulations: while the turnover rate exposes the number of turns by time, the dilution factor states how effective is the recirculation flow on the global circulation of the anaerobic digester. The more recirculation flow entails more turnover rate and dilution factor. Nevertheless, B0 (with propeller) was the scenario with higher dilution factor but its turnover rate was lower than A1. Another parameter analyzed was the Uniformity Index (UI) as proposed by [5]. It stated that a 0.02 UI value states a complete mixing inside the digester and this value was reached at 0.9 h in A0. Thus, the homogenization time can be stablished at 6.1 h, 1.5 h, 0.91 h, 0.45 h and 0.35h for the scenarios A3, A2, A0, A1 and B0. The reduction of the homogenization time from A3 (without recirculation flow) to A2 (with 50% of the maximum recirculation flow) emphasize the significance of the recirculation flow on the global hydrodynamics of the system. Propeller’s momentum source allowed decreasing the homogenization time from 0.91 h to 0.35 h. All mixing parameters agree that propeller’s activation is more efficient than an increase of the recirculation flow: in terms of power installed.

KEYWORDS:

Anaerobic digestion; CFD; Tracer test; Mixing optimization.

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Monte Carlo modeling of the potential distribution of internal dose based on random active particle location to organisms in the sediment bed

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ABSTRACT

This paper is dedicated to evaluate the average dose and dose distribution for aquatic organisms for two radio-nuclides ^{192}Ir and ^{46}Sc using Monte Carlo calculation. The internal dose was calculated by the uniform isotropic model for aquatic animals, and by GEANT4, which can simulate a photon transport in environmental media with different densities, for aquatics animals. In the modelling all the target animals are defined as a simple 3D elliptical shape. To specify the internal radiation source it is assumed that aquatic animals are fully immersed in infinite and uniformly water, and the on-bed animals are living on the surface of a horizontally infinite randomly contaminated sediment bed, and the in-sediment organisms are living at the centre of a horizontally infinite and randomly contaminated sediment bed to a depth of 50cm.

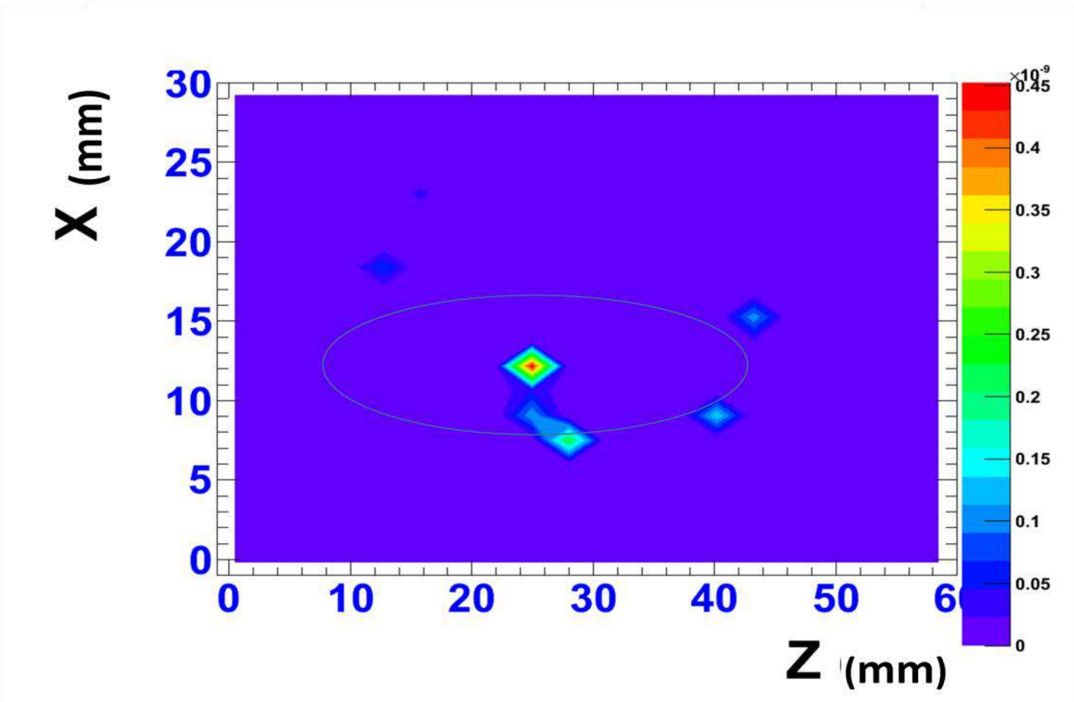

Figure1: Simulated Dose Distribution generated by ^{192}Ir source point (1Bq) located inside flatfish

KEYWORDS: Dose, non-human species, uniform isotropic model, Monte Carlo simulation.

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Transfer of Micropollutants by Urban Run-off with Different Hydrological Scenarios

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ABSTRACT

The rapid urbanization growth associated with a great increase in the percentage of the total global population living in urban areas are responsible for a large portion of environmental risk to the aquatic environment and degradation of the surface water quality (COD, BOD, metals, PAHs) (Gromaire-Mertz et al., 1999). The impact of this rapid growth has received much attention on natural resources and environmental quality (Roche et al., 2014). This growth has directly impacted land use and land cover and also changed the biogeochemical cycles of stormwater, wastewater and drinking water systems (Chambers et al., 2016). When rain falls on impervious surfaces in developed or developing urban areas, storm) water drains collect rainwater and particulate and dissolved contaminants that accumulate on surface during dry days and that run off roads, roofs and gutters in wet days.

As a result (storm) water run-off from urban environments is considered to be a significant source of pollutants such as TSS which impacts the quality of receiving waters (Leutnant et al., 2016).

The objective of this study was to assess, quantify and determine the environmental impact of trace metals on natural hydrosystems contributed by urban run-off of a medium-size city. Three urban active catchments areas of the Orleans agglomeration with the most significant input in terms of run-off on the Loire River were investigated with two hydrologic scenarios (dry and wet weather). Water samples were collected in rain water drainage systems during different campaigns over ten months (2015-2016) at the catchment outlet on the river Loire for the above mentioned urban catchments. For each sample physical-chemical parameters important for water quality were measured such as total suspended solids (TSS), turbidity, pH, conductivity dissolved organic carbon (DOC) were determined. Additionally trace metals solid concentrations in suspended matter and total dissolved concentrations for Cd, Cu, Pb and Zn were determined (Al-Juhaishi et al., 2015).

The flows at the outlets of the different water quality parameters were evaluated and compared with those from the four main wastewater treatment plants (WWTP) and those from the Loire. The estimated loads of the three sub-urban basins accounts for approximately 166.61% of the load of the four WWTP. The three sub-basins have a small impact on the Loire in terms of annual flows (about 1.62% for wet weather case).

Two versions of a conceptual model of accumulation / washoff were evaluated to estimate pollutant runoff; the classical version and a modified version in which the pollutant accumulation parameter has a logarithmic form. The performances of the models were found acceptable for the TSS and the COD. The Nash-Sutcliffe (NS) coefficients were found as 0.84 and 0.85 for the two versions at the Egouttier sub-basin. For trace elements in particulate phase, the correlation with the experimental measured value was found good as well. In general, when a measured flow was less than 1 $kg.ha^{-1}$, the modified model was no longer applicable.

The first simulation tests of the quality and quantity of urban runoff were carried out with MIKE URBAN, which equips both MOUSE and SWMM modeling software. For water quantity, the hydrographs indicated that the maximum flow obtained with SWMM was always lower than that obtained with MOUSE. For water quality, TSS mass was still more strongly impacted by the leaching of TSS in the MOUSE model than in the SWMM model.

This work can be considered as the first step of the evaluation work of urban run-off for the Orléans agglomeration. It provides a solid foundation for a future monitoring programs.

KEYWORDS:

Trace metals, urban run-off, conceptual model, MIKEURBAN, SWMM, MOUSE.

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Modelization of the aeraulic in a wood-burning appliance

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ABSTRACT

The objective of the project research project is to take into account the impact of aeraulics in a wood burning appliance, in order to better manage the distribution of gas flows, in view of optimizing combustion and thus reducing pollutant emissions at the source. To this end, this whole project proposes two complementary modeling approaches, which will be coupled with experimental measurements of Residence Time Distribution (RTD) and pollutant emissions.

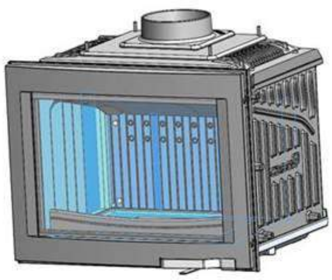
The work presented here deals with the modeling of the flow by Computational Fluid Dynamics, the experimental measurements of RTD and their analysis, as well as the modeling of the aeraulic within the heating appliance using the DTS-Pro software [1].

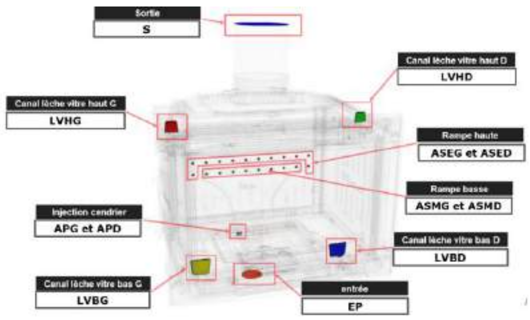
These early CFD modeling works, as well as the overall flow model proposed using the DTS Pro software based on experimentally measured Residence Time Distributions (RTD), are promising. They made it possible to set up a methodology adapted to the study of the aeraulic in a wood-burning appliance according to two distinct approaches and they provide results that prove to be coherent and complementary.

In this paper, we do not present results coming from CFD modelling.

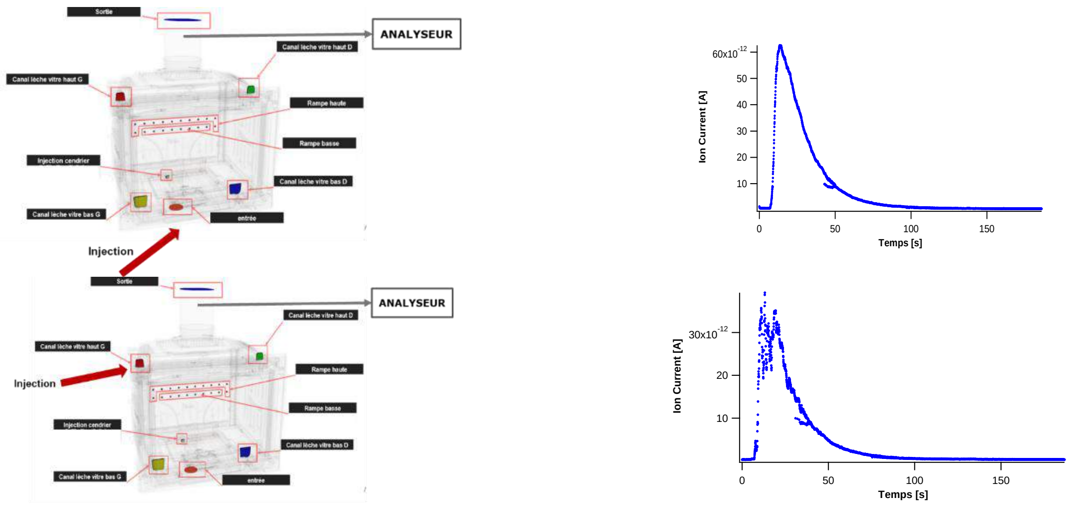
DESCRIPTION OF THE WOOD-BURNING APPLIANCE 1

Experimental Resident Time distribution have been studied by introducing tracer in different position of a wood-burning appliance. We have choose Krypton (m/z 84) as a tracer and the analytical system OmniStar with a mass range of 1–200 amu from PFEIFFER to analyze the gas flow in continue.

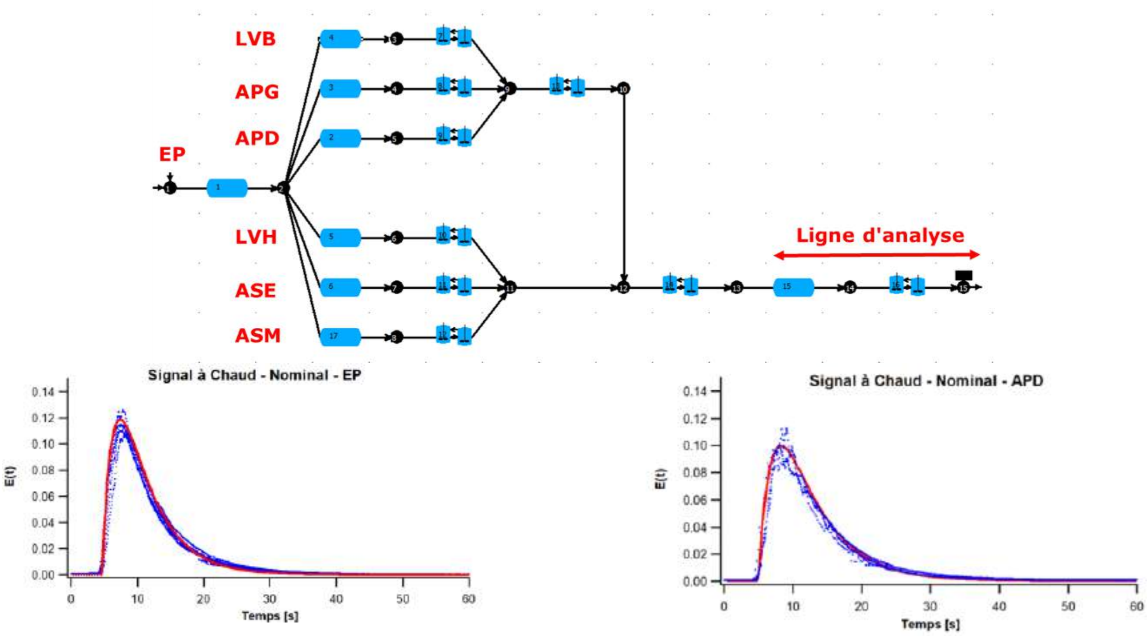




Depends on the position of the injection we obtained different kind of signal.



Using the software DTS-Pro we propose an aeraulic model for the wood-burning appliance. Whatever the position on the injection of tracer, the experimental and simulated result are in good agreement. This model allow us to determine the resident time distribution inside the oven, roughly it take 11 s from the entrance to the outlet.



ACKNOWLEDGMENT:

The authors gratefully acknowledges the Agence De l'Environnement et de la Maitrise de l'Energie (ADEME) for the financial support of this work.

KEYWORDS:

aeraulic, wood-burning appliance, combustion

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Evolution of residence time distribution for an s-MBR over an acclimation period operating at infinite sludge retention time: an experimental approach.

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ABSTRACT

The objective of this work is to analyses the real evolution of residence time distribution (RTD) inside a submerged membrane bioreactor (s-MBR) that will acclimate biomass to high ammonium content influents and working at infinite sludge retention time (SRT). For this purpose, the influence of certain parameters as; inlet gas pressure, the real work volume and the suggested hydraulic residence time (HRT) – 30h as a specific parameter for the specific decentralized treatment application- will be analyzed over the MBR mixing hydraulics in both clear water and acclimated sludge over the time. Two months of acclimation will be analyzed and careful measurement of the RTD profile over the time will reveal information on the degree of mixing in the reactor and any effects that the parameters named above may have on the hydraulic conditions at different times of the acclimation period. RTD profiles were generated using salt solutions in clean water and a conservative tracer for sludge acclimation period. The preliminary results over clear water show and influence from the gas flow over the real working volume (identifying stripping phenomena), but most important an influence of the applied HRT over the RTD was identify in a qualitative analyze.

INTRODUCTION

This project aims to the development of a decentralized and autonomous yellow wastewater treatment unit, as a technical and ecological solution been cost-effective and economical, green and sustainable, and finally safe in protecting the environment, public health, and water quality. Optimization of this s-MBR, however, requires detailed understanding of the kinetics of biological nutrient removal (BNR), the performance of membrane separation over the time and evolution of the hydraulic conditions in the bioreactor.

MBRs are usually assumed as completely mixed flow reactors (CSTR) and designed based mainly on the biokinetics and fouling potential of the treatment system. In practice hydrodynamics and the hydraulic profile plays an important role since it determines the reactor's residence time and liquid distribution in the entire reactor. Mixing characteristics are very important for the MBR systems because they can affect both the efficiency of organic removal and the settling and rheological characteristics of the sludge (Neuman,2002. Dunn 2003). Achieving a good mixing encourages the transfer of substrates and oxygen to the microorganisms and ensures the effective use of the entire reactor volume avoiding dead zones areas. That is why evaluating the evolution of RTD - as a tool to determine the impact of the several operating parameters on mixing efficiency - over a period of mass accumulation inside the reactor will be important to better understand MBR performance.

Experimental protocol

To acclimate biomass in wastewater treatment unit, a compact treatment system composed by a 34L submerged membrane bioreactor (MBR) was carried out in laboratory conditions. The required MBR hydraulic residence time is 30 hours for the application. Aeration by an internal diffuser is ensured permanently. This diffuser provides only one membrane pore size. Variation for the inlet pressure gas will be the only variable controlling the bubbles size and in this way the oxygen transfer. Variations on pumping rate of feed and permeate will variate HRT. The representative scheme is shown in Figure 1.

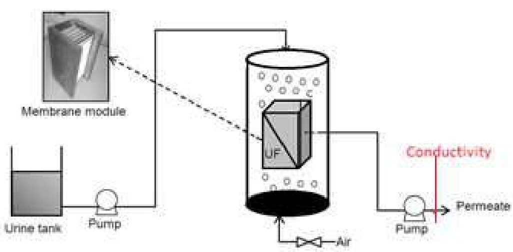

Figure 1. Schematic diagram of a lab-scale submerged membrane bioreactor.

Results

In order to evaluate the effects of aeration rate on the hydraulic performance of MBR, tracer studies were carried out on the s-MBR with three various inlet air pressures. There is no significant difference of RTDs obtained from those variations indicating that aeration was enough to create mixed conditions. Then, variation of HRT was done in first instance in order to analyses the behavior of the MBR. Dramatically different RTDs were observed from the MBR with and without aeration. The RTD profile of the MBR pilot is non-symmetrical with a long-extended tail which indicated an intermediate behavior between plug flow and completely mixed regimes.

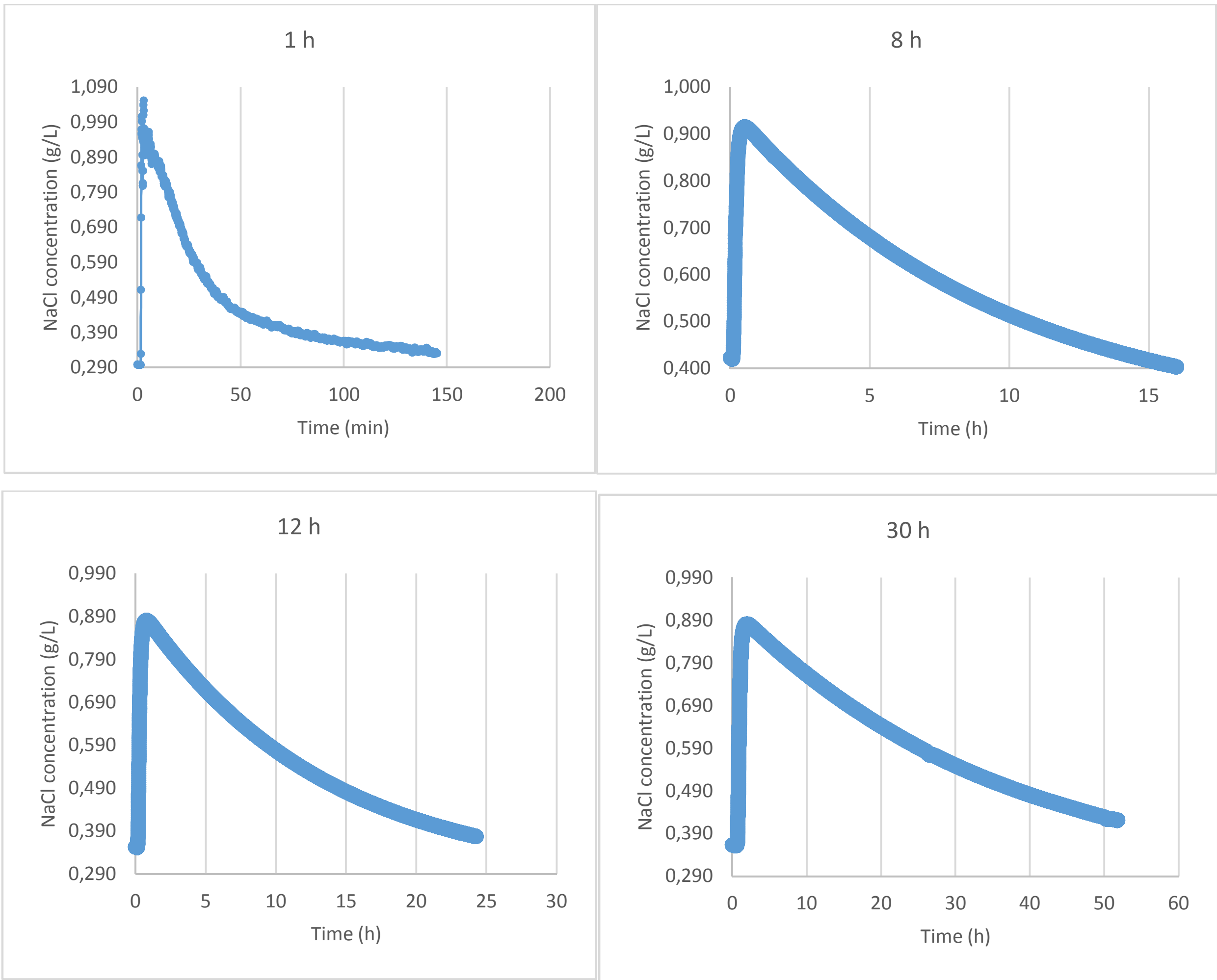

Figure 2. C(t) curves of s-MBR with variation in HRT.

After a very fast pic, the RTD profile resembles the completely mixed flow or the decrease in the tracer concentration follows an exponential decay function. To better understand those results they can be quantitatively assessed using various relationships between the hydraulic residence time (τ), peak time (τp), and the mean residence time (τm), and then evaluate the presence of dead zones/short circuiting within the reactor. The aeration rate variation experiments confirmed that aeration does not have significant effects on the flow behavior of small systems. Tracer studies have been carried out s- MBR and it is evident that mixing has significant effect on the hydrodynamics of MBR.

KEYWORDS

Hydraulic residence time, Real distribution time, Infinite sludge retention time.

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SESSION 2

RADIOACTIVE PARTICLES TRACKING, TOMOGRAPHY, GAMMA SCANNING, NEUTRON BACKSCATTERING

25

ABSTRACTS

Investigation of Cause of Temperature Variation Across a Packed Bed

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ABSTRACT

In petroleum refineries and chemical process industries, vessels, equipment and pipelines are not transparent. Generally, process parameters are monitored using instrumentation installed in the plant. But with the prolonged usage and hostile industrial conditions, instruments deviate from their properties. In such cases assertive and efficient planning of the shutdown becomes difficult.

To monitor the health of the mechanical internals and to understand process anomalies there is no equivalent techniques to radioisotope applications. To diagnose and identify the operational problems, mechanical integrity of the internals and reduce the downtime, radioisotope technology is well established throughout the world.

In one of the leading refineries of India, temperature difference was observed over one of the packed beds in a vacuum distillation unit (VDU) column, which was affecting the product quality. VDU is one of the important columns of this petroleum refinery which mainly consists of five packed bed and products are withdrawn from side streams. The products are Vacuum diesel, LLVGO, LVGO, HVGO and Slop cut from top to bottom bed respectively. The problem of uneven temperature distribution was found in the HVGO bed.

To identify the actual cause of the temperature difference, gamma scanning of the bed was carried out. A section of the VDU column consisting packed bed, liquid distributor above the bed and chimney tray below the bed were investigated. The data was collected along the four chords and two diagonal lines over the bed and stored in the Data Acquisition System.

Interpretation of the data showed that in the upper half of the bed liquid distribution was not uniform. In the south east direction of the bed, less liquid was seen from the distributor, which was the main reason for the temperature difference, however the liquid distribution in the lower portion of bed was uniform. The liquid distributor was positioned horizontally. No significant coking and channeling was observed, also the nozzles for the side streams in the chimney tray below the bed were not chocked.

KEYWORDS

radioisotope technology, packed bed, liquid distributor, channeling

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Investigation of distillation column malfunctions in Zimbabwean chemical industry using gamma ray scanning techniques

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ABSTRACT

A 60Co sealed gamma source and NaI scintillation detector were used to scan a prototype laboratory scale and local industrial scale distillation columns. The prototype distillation column was fabricated and used to simulate malfunctions and scanned; the resulting density profile was interpreted. A laboratory prototype winch to lower down the source and detector along a prototype distillation column, together with a tilting stand to empty the radiation source from the transportation package into a source holder for gamma scanning were fabricated. A collimated source and detector was mounted on opposite sides of the column and synchronously lowered down along the length of the column while height versus intensity profiles were measured and recorded. A relative density profile of the column contents was obtained and analyzed for the detection of malfunctions. ChemSep was used to model and simulate a distillation column prototype for separating a binary mixture of water and methanol with 0.5 mole fraction of each component. The behavior of the distillation column was modeled using MESH equations, which in this work have been solved through ChemSep in order to study the effect of different parameters. The desired methanol recovery was 97%, and in the simulation this was achieved using a total of 9 trays at feed plate 7. An investigation of number of trays' effect on methanol recovery was performed and results show that as the number of trays increases, the separation improved. As the number of trays is kept constant and the feed tray position is moved down the column, the top composition becomes richer in the more volatile component. The interaction and transport of ^{60}Co gamma photons with the distillation column and its contents, methanol-water solution as well as energy spectrum from ^{60}Co were simulated using Fluka. The results of the interaction and transport of gamma photons are presented on a color map denoting energy deposition on the column and its contents. More energy is deposited on the column walls and plates as compared to the energy deposited in the region between the trays.

KEYWORDS:

prototype distillation column, gamma ray scanning, relative density profile, simulation, modeling, Monte Carlo simulation.

Microalgae Cell Trajectories via Radioactive Particle Tracking (RPT)

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ABSTRACT

Radioactive particle technique (RPT) is an advanced non-invasive technique used isotope particle to track the desired phase. 2 mm Cobalt-60 particle has been used in this work to track the liquid phase in microalgae culturing to provide the cell location (cell trajectory) inside the photobioreactors.

In the present contribution, a green microalgae Scenedesmus which useful for energy production, these species showed an excellent candidate for biofuel and wastewater treatments. This microorganism was cultured in an internal-loop split photobioreactor, this kind of reactor has excellent heat and mass transfer and also has great gas-liquid mixing due to their significant circulation inside the column. 5.5 inches of a cylindrical Plexiglas column has been used in this study including a Plexiglas plate which installed inside the column in 5 cm above the base of the column. This plate provides two section inside the reactor column, riser and downcomer zones.

The cells movements inside the photobioreactors are the key to increase the reactor productivity [1]. And this is the major problem in autotrophic cells culturing, due to their movements between the light and dark zone inside the photobioreactors practically at dense culturing, this information, unfortunately, is unclear yet. Thus, in this work, RPT technique [2], [3] was employed to investigate for the first time the cells locations, while the microalgae are running. Also, this technique provides in-depth the details in hydrodynamics in split photobioreactors, such as liquid velocity filed, shear stresses, and turbulence kinetic energy for the air-water-microalgae system. The results demonstrated the feasibility and the potential of RPT technique in the analysis of the hydrodynamics in photobioreactors and of the cells tracking for culturing microalgae. Moreover, the present work provides, for the first time, benchmarking data to validate the photobioreactor models and computational fluid dynamics (CFD) simulations and consequently will essential to improve the performance of the reactor. The results and discussion will provide for the conference.

KEYWORDS

microalgae culturing, photobioreactors, RPT, cell trajectory.

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Local Gas Holdup in Fluidized Bed Reactor using Gamma-ray Computed Tomography Technique (CT)

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ABSTRACT

Fluidized bed reactor is a gas-solid system and it's considered an important process in chemical, petrochemical industries. This kind of reactors provides a good mixing, height mass and heat transfer between the phases.

In this study, an advanced non-invasive gamma ray computed tomography (CT) technique [1], [2] was used to study the local gas and solid holdup visually and their radial profiles for gas– solid fluidized beds reactor at different axial levels. The experiments consist of a 14 cm and 44 cm in diameter and 168 cm height of cylindrical Plexiglas column [3], and a sheet of porous polyethylene material [4], [5]with pore size 40 μm was used as gas distributor. The effect of various superficial gas velocity 25, 30 and 35 cm/sec, and effect of different kind of bed materials glass beads 210 μm and copper 210 μm, have been investigated.

The results show that gas holdup increases by increasing the superficial gas velocity, and decreasing the particle density increases the gas holdup in the bed. And also, the present work provides, for the first time, benchmarking data to validate the gas–solid fluidized beds models and computational fluid dynamics (CFD) simulations and consequently will essential to improve the performance of the reactor. More results and discussion will obtained in the conference.

KEYWORDS

fluidized beds hydrodynamics Gamma ray computed tomography gas holdup solid holdup.

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Hydrodynamics in Internal-loop airlift reactor via non-invasive gamma-ray techniques

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ABSTRACT

In present contribution, an advanced non-invasive gamma ray computed tomography (CT) and radioactive particle tracking (RPT) techniques were used to study the hydrodynamics parameters liquid velocity field, shear stresses, turbulence kinetics energy, and local gas hold up for air-water system in internal-loop cylindrical airlift reactor. This kind of reactors has wide range of application such as, chemical and biochemical process, due to their simple construction and work. The experiments consist of a 5.5 inches in diameter and 59 inches height of cylindrical Plexiglas column [1].

Also, a sheet of Plexiglas was inserted inside the column which divided it in to two equal area, riser and downcomer sections and installed above the column base in 2 inches. A stainless steel sparger was used to introduce the aeration system to the column in the riser section. Therefore, in this work, an advanced radioactive particle tracking (RPT) technique [2], [3], have been used to find out the details of the multiphase flow dynamics in a cylindrical split airlift reactor. The cylindrical reactor is a Plexiglas column in 5.5-inch (0.14m) inner diameter and 59 inches (1.5m) high, with a thin Plexiglas split plate (3mm) which divided the column into two equivalent section, riser, and downcomer, which supported above the column base in 5 cm. Air is bubbled through a 5 cm diameter ring sparger installed it in the riser section. This sparger had 5mm diameter and made from a stainless steel tube with 15 holes each one has 1mm diameter drilled facing upward.

The measurements covered the entire reactor, as well as in the individual structure regions, the top (above the split plate), the bottom (below the split plate), the riser, and the downcomer sections; all are also characterized. An advanced four-point optical fiber probe has been used for this measurements. The culturing medium was monitored by using optical density device and the viscosity and surface tension properties were monitored as well.

The present work provides, for the first time, benchmarking data to validate the gas–solid fluidized beds models and computational fluid dynamics (CFD) simulations and consequently will essential to improve the performance of the reactor.

KEYWORDS

photobioreactor, gamma-ray techniques, hydrodynamics

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Characterize the non-similarity scale-up methodology based on dimensionless groups of gas-solid spouted beds via (RPT) and (CT)

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ABSTRACT

Spouted beds are gas-solid granular contactors suitable to handle heavy, coarse, sticky, and/or irregularly shaped solids through cyclic flow patterns. Gas-solid spouted beds have various industrial applications, particularly physical transformation processes such as coating, drying, and granulation and chemical transformations such as gasification and other reaction processes [1-3]. In this work, we implemented the radioactive particle tracking (RPT) and gamma ray computed tomography (CT) techniques to further evaluate and validate in details our newly developed mechanistic scale up methodology based on matching radial profile of gas-holdup. The non-invasive techniques CT and RPT as shown in Figure 2 and 3, have been equiped with two different spouted bed diameters of 0.076 m and 0.152 m were used. Three sets of conditions were implemented which consist of the conditions of the reference case, conditions that provided similar gas holdup radial profile to that of the reference case and conditions that provided non-similar gas holdup radial. The DSCT platform is made up of three main plates one above the other consecutively; a base plate, a view or circular plate, and a projection plate. The base plate can move vertically up and down to capture the vertical view of an object. The view plate is a circular plate on the top of the base plate and can rotate 360 degree /197 times or views around an object during one scan. The projection plate is on the top of the view plate and can move in increments of 0.13 degree for 21 positions to simulate a fan beam with 315 projections. The radioactive isotopes used in the DSCT are Cesium (Cs-137) with initial activity of about 300 mCi and Cobalt (CO-60) with initial activity of about 50 mCi where each source is shielded and has a window in a way to represent a point source with a fan beam of 40 degree. The detectors are of 2 in size and collimated with a lead collimator of a slit of area =1/16th x 2/16th in^2 effectively reducing the size of each detector to 1/16th x 2/16th in^2. The platform can scan columns up to 24 in diameter. The DSCT has been implemented in our laboratory to measure the solids holdup cross-sectional distributions of TRISO nuclear fuel particles spouted beds coaters (6 in diameter) for the development of the Very High-Temperature Nuclear Reactor (VHTR) fuel. The results confirm the validation of the scale up methodology in terms of obtaining closers dimensionless values and radial profiles of the components of the particles velocities, normal stresses, shear stresses and turbulent kinetic energy. The results further advance the knowledge and understanding of the gas-solids spouted beds provide deeper insight on their solids dynamics and presenting important benchmarking data for validating computational fluid dynamics codes and models. More results and discussion will provide in the conference.

KEYWORDS

Scale-up methodology, CT, RPT, Spouted beds reactor.

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Design and Development of Distillation Column Model

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ABSTRACT

A qualified workforce is an important competitive factor for the economy of a country. Division of Atomic Energy tries to equip students with the knowledge, skills and competencies that will enable them to find employment and achieve their career aspirations in radioisotope techniques for the industrial application.

A real distillation process is complicated by many factors and many components. A model is a small system which is operated to find out about the behavior of a process before using it on a large industrial scale. So model distillation column was designed and constructed for a real scale practicing. It was designed for various conditions by flow velocity changing inside the column. It was constructed with rounded acrylic pipe with a dimension of 300 mm diameter and 2000 mm in height.

Gamma ray scanning is based on the gamma ray transmission technique. It is applicable for inspection of many types of industrial process columns with different diameters including tray column, packed-bed column and other process vessels. Scanning profile provided a clear picture of the column inside, giving the internal structure, defects and column process state without interrupting the process.

Gamma scanning technique was simulated for on-line investigating of the process performance and trays situation with constructed distillation column, by using 4 mCi ^{60}Co gamma source, NaI (Tl) scintillation detector, manipulation system (winchers) and ColScanCK1 Data Acquisition (DAQ) system with NibraS software.

Scanning results could determine possible malfunctions such as destroyed, collapsed, flooding, forming, entrainment, weeping of inside the column.

This simulation distillation column is to assist individuals in learning more effectively with the goal of improving performance in petrochemical and chemical process industries.

DESIGN AND CONSTRUCTION OF SIMULATION COLUMN

Simulation column was constructed with rounded acrylic pipe with a dimension of 300 mm diameter and 2000 mm in height. It was designed with 12 trays; distance between each other is 12 cm. It is trayed type column, trays # 1 to # 7 are single pass trays and remaining are double pass trays. There is one packed bed in the column. The packing was randomly filled with pieces of plastic pipe as a Raschig rings.

PVC pipe is used as an inlet pipe. Water reservoir is made of Steel and water is cycling by using water proof pump. Distributor was placed at the top of the column.

Gamma Scanning

On line scan measurement to figure out the condition in model distillation column. The scanning work performed using a ^{60}Co gamma source with 4 mCi activity, a NaI(Tl) scintillation detector, two manipulation systems (winchers) and ColScanCK1 DAQ system with NibraS software to investigate condition of all trays by manual traversing mechanism.

Refer to the mechanical drawing of the column, the point at elevation of 500 mm was assigned as starting point of the scan and it was notified as 0 mm. Two scan lines were conducted; one for single pass trays and one for double pass trays within the left and right down comer areas of distillation column. To keep a systematic and complete record of column operating conditions, off-line investigation (Blank Scan) also conducted.

After installation of radioactive source with container and required equipments, the scanning work was performed to investigate condition of all trays starting from the bottom of the column at elevation of 500 mm to distributor at elevation of 2200 mm above ground level. All winchers have ruler. The wincher cables are 80 m long made of steel wire to drive source and detector holders moving up. Scan step and sampling time of the scanning are 10 mm and 2 second respectively.

Gamma scanning technique has been demonstrated for on-line investigating of the process performance and trays situation of model distillation column.

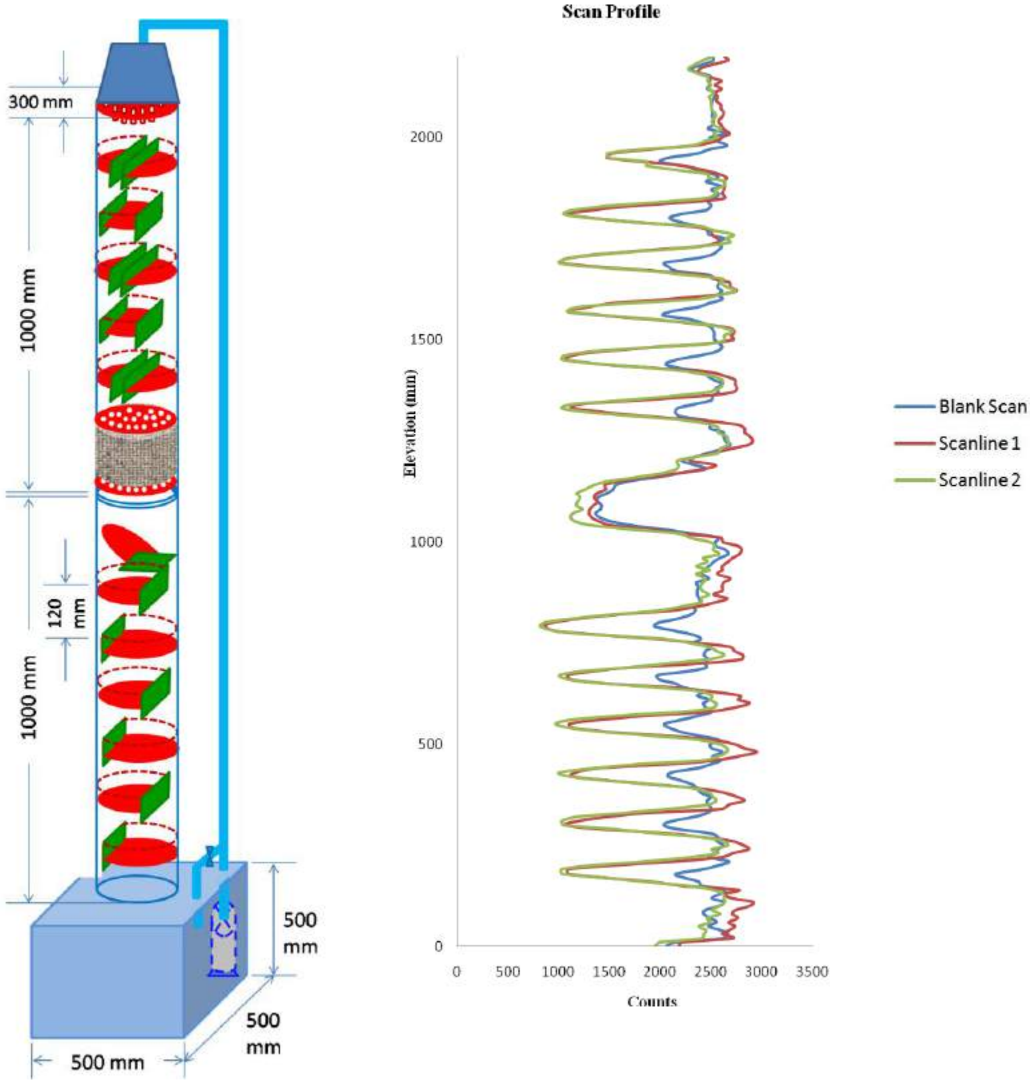

Fig. Gamma column scanning results for constructed distillation column are compared with drawing of column

KEYWORDS:

distillation column model, gamma column scanning, trayed column, packed bed

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Ring Scan Gamma CT system and Image Reconstruction with Sparse Views

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ABSTRACT

While the conventional non-destructive testing relying on 2-D film radiography is mostly targeted for welded parts, process diagnosis needs to address what is happening inside the vessels and pipelines by sensing the spatial distribution of the process media. Industrial process investigation using gamma computed tomography (CT) helps understand the patterns of cross-sectional distribution of non-radioactive materials at each phase as presented in 1990s, and it is also considered an indispensable tool for the development of new processes including nuclear fuel coating for the Very-High-Temperature Nuclear Reactors. Compared to the medical tomography, objects to be investigated are much different in terms of size, material density, location, internal elements, physical properties (temperature, pressure) and etc. Due to these specific circumstances, radioisotopes emitting gamma radiation with a high penetrating capability have been considered as the best option so far.

However, translating the theoretical principles of CT imaging into practice is not a trivial thing but rather a challenge in industrial process diagnosis. Continuing efforts have been made to develop a simple, low-cost, and accessible method for gamma-ray imaging. The imaging system takes up a substantially large space around the processing system to be investigated in a fan-beam geometry. In addition to this installation challenge, image reconstruction is subject to various limiting factors that include the penetration depth of gamma-ray, energy resolution of the detecting system, pixel size of the detector, limited number of projection views, and so on. Monte Carlo studies have also been actively investigated to test the feasibility of gamma-CT imaging in various applications. Gamma CT imaging can now address huge imaging target such as distillation columns that have been previously investigated by gamma radiation density profiling only. The researchers have assessed the reconstructed image quality and showed potential possibilities of the gamma CT imaging in the field. Since the detectors are fixed around a vessel in the prototype imaging system, they may be placed in the blind zone when a radioisotope is rotating. However, this study showed a feasibility of reducing the overall size of an imaging system. Nonetheless, multiple detectors surrounding the outer circumference of a vessel still pose challenges; the CT imaging system is complicated and quite heavy. The problem of CT imaging system complexity and its associated weight issue become more serious when using multiple radioisotopes for multi-phase flow system. Despite of the significantly large and complicated system, the quality of the reconstructed image was rather poor mostly due to the limited amount of projection data at a given phase in a fast-flow process investigation.

A single radiation source with a single radiation detector can be a better option to lowering the weight of imaging system in this regard. In this work, we have developed a circular scanning system that combines a single source and single detector. In contrast to a parallel scanning geometry, a circular scanning system was shown to use relatively a smaller space as will be described in the following section. Although the proposed system may take less number of projections per given scanning time compared to a multiple detector system, it may find applications where the weight issue is critical with the investigated processes being reasonably stable for the period of scanning time. Additionally, the image reconstruction algorithm has been accordingly developed to address sparse-view gamma CT imaging in this work.

On top of the sparse-view imaging challenge, there exists a low photon-flux issue in the gamma CT imaging. Unlike an x-ray tube-based CT imaging, the photon flux out of a gamma source is quite low. For instance, a typical CT scanner operating at 120kVp produces an output exposure in the air of about 25mR in 1s with the tube current of 1 mA at 50 cm away from the x-ray focal point. This exposure is equivalent to an x-ray flux of 6.7×10^6 x-ray photons/mm^2. A radioactive point source at a distance of 50 cm with an activity of 3.7×10^{10} Bq can produce a flux of ~1.2×10^4 gamma-photons/mm^2 over the same time interval. Therefore, at 50 cm from the source, a typical tube current of 200 mA in an x-ray CT system would produce an equivalent activity reaching 4.14×10^{15} Bq (112,000 Ci), revealing unrealistic counterpart of a radioactive source.

In an attempt to cope with sparsely sampled highly noisy data, total-variation minimization (TVM) method was used for the image reconstruction and its performance was compared with an expectation maximization

(EM) algorithm in this study. Compressive sensing (CS) theory enables us to obtain acceptable image quality from the incomplete data. The TV algorithm is based on the CS theory and its excellent performance in sparse-view CT applications has been reported. We have adopted the TVM algorithm to deal with the insufficient data acquired by the proposed circular single-source single-detector gamma-CT imaging system.

KEYWORDS:

Ring scan gamma CT, total-variation minimization, compressive sensing theory.

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Development of Gamma Column Scanning by CT Scanning Technique for Lab-Scale Column

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ABSTRACT

Radioisotope techniques mainly used of the gamma radioactive sealed source supply the information on a system by observing and evaluating density changes in the measured media. The main aim of the research work is development of the column scanning with the used of computed tomography scanning for the visualization of the column internals to assist in interpretation and diagnosis of gamma-ray transmission densitometry scanning of column. Gamma Scanning is an online diagnostic tool which allows inspection of process column internals without interrupting operation. The technique uses a collimated beam of gamma rays which passes through the column wall. By measuring the intensity of the radiation transmitted through the column, the density of the material inside the column was able to determine. A scan profile gave the information about the density of material inside the vessel which needed to compare the structure of column's design for trouble shoot the column performance. In the present work, gamma scanning of lab scaled column by computed tomography CT scanning was carried out to improve the visualization of column internals giving cross sectional image rather than scan profiles. The design and model of lab-scaled gamma-ray scan column was constructed at Nuclear Physics Laboratory. This system consist of four levels of tray structure pipe vessel column and ^{137}Cs gamma source strength of 2.67 MBq and NaI(Tl) scintillation detector with lead collimator was used for gamma CT scanning measurement. The design of the lab scaled column consisted with four levels of tray structure levels and tested with different density absorber materials inside the column. Gamma transmission CT measurements were carried out for the six scanning position of scan column. From the measured gamma transmitted data cross sectional images of each layer for the column were reconstructed by image reconstruction program created in MATLAB by 2D image reconstruction and 3D visualization of image reconstructions program which was implemented in MATLAB graphical user interface GUI. The cross sectional images of each scan layer are added together for the whole scan column to create 3D volume image. The experimental gamma-ray scanning images showed sufficient resolution to reveal the density distribution inside the pipe vessel which assists the inspection of column internals. The results of reconstructed images indicated the clear graphical interpretation of internal structure of lab-scaled gamma scan column and developed to 3D visualization of the whole column vessel by MATLAB. The newly developed column scanning systems and created image reconstruction program are suitable for troubleshooting analysis of column in field applications.

KEYWORDS: *gamma CT scanning, gamma transmission, image reconstructions, lab scaled column, 3D visualization*

1. INTRODUCTION

Radioisotope techniques mainly used of the gamma radioactive sealed source supply the information on a system by observing and evaluating density changes in the measured media.[1] The main aim of the research work is development of the column scanning with the used of computed tomography CT scanning measurement for the visualization of the column internals to assist in interpretation and diagnosis of gamma-ray transmission densitometry scanning of column.[2] The transmission of gamma rays through a heterogeneous medium is accompanied by attenuation of the incident radiation, and the measurement of this attenuation quantifies the line integral of the local mass density distribution along the path traversed by the beam [3].

2. MATERIAL AND MEHTODS

For the visualization of lab-scale column internals transmission of gamma CT scanning measurements were performed with the used of an encapsulated gamma ray source ^{137}Cs positioned on one side of the object to be scanned, and a collimated detector 1x1 inch scintillation detector NaI(Tl) arranged on the other side. For the visualization of the column, the gamma transmission measurements have been carried out for the six scanning positions of the lab-scaled column. From the set of measured gamma transmitted data of require projections are used to reconstruct the cross sectional images by implemented program in graphical user interface GUI in

MATLAB for the easily assessment for image reconstructions and data processing for measurement. In order to improve the image reconstruction, back projection BP and filter back-projection FBP with filters as Ram-Lak, Shepp-Logan, Cosine, Hamming and Hann and interpolation methods like nearest neighbor , linear, spline, pchip (shape-preserving piecewise cubic) and cubic were tested in the implemented image reconstruction in MATLAB.[4]

2.1 Experimental Set Up for Lab –scale Gamma Scan Column

In lab-scaled column scanning measurement system, the electronic system of gamma-ray spectroscopy system and detection system for gamma transmission measurements are set up with CASSY sensor with MCA. In this system, the scanning column material was set up to be able to scan rotational and translational movements on sample rotator between the fixed source and detector mounting system. Radiation source and detector were fixed in opposite alignment with source to detector distance 63 cm to measure the transmitted gamma-ray through the scanning object. Scanning column was moved 0.75 cm in each step of translational movement for 24 cm effective length and rotated 5.625degree of rotational motion for 32 views per 32 projections.

The scanning position of the whole column vessel for the gamma transmission measurement is performed for different tested material for determination of internal structure of lab-scale column vessel. The scanning was performed for six layers of the lab-scale column design with scan-1four absorber layer, scan-2 sand with air hole layer, scan -3 two absorber layer, scan - 4 water layer, scan- 5 tray structure layer and scan- 6 air layer inside the PVC pipe column vessel. The source and detector are linearly fixed on opposite and the object was moved translational to acquire individual projection of the whole measurements. After the completion of the linear measurements, the object is rotated to the next angular position to acquire the next set of measurements at each position of the scanning layer. The measured scanned intensity profile data were saved into default output file with (*.mat) extension for image reconstructions.

2.2 Implementation of Image Reconstruction Program by MATLAB

The images of column vessel were obtained from the measured intensity profile data by using 2D image reconstruction and 3D visualization program in MATLAB. In this program the gamma transmitted data are used to generate cross sectional images by using back projection BP algorithm and filter back projection FBP algorithms with different filter functions. 2D image data are used to produce 3D voxel image of the column vessel by multi load script program created and developed in MATLAB. In the 2D image reconstruction program includes three axis area of the intensity profile, image sinogram and reconstructed images. In the development of the image reconstruction from 2D to 3D image visualization which was performed by using with image processing and visualization tools in MATLAB package. In the creation of 3D image visualization program, the 3D volume data was created from multi-slices 2D reconstructed image data and profiles from measurement of six scan position of lab-scaled column with the use of smooth 3 and squeeze functions.

3. CONCLUSION

For the improvement in gamma column scanning, gamma imaging technique of computed tomography CT measurements were made for the lab-scaled scan column. Gamma imaging techniques improved the gamma ray absorption scan column by giving cross sectional images of at each scan layers. In the current research work focus on developing a new approach on the gamma scan test using image reconstruction techniques that would result on a clear graphical cross sectional image rather than scan profiles. Two dimensional density distribution 2D images would ease the visualization and identification of problems, process and phenomena on a column vessel. Furthermore, features hidden on a conventional (gamma scan) technology, due to the mean density values, would be revealed on an image technology. Gamma CT techniques developed for the column scanning in the visualization of column more easily determining internal structure.

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Fluka Monte Carlo simulation of gamma photon transport through a distillation column, designed using ChemSep software

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ABSTRACT

ChemSep software was used to simulate and design a distillation column prototype for separating a binary mixture of water and methanol. The behaviour of the distillation column was modelled using MESH equations, which in this work have been solved through ChemSep in order to study the effect of different parameters. The desired methanol recovery was 97%, and in the simulation this was achieved using a total of 9 stages and the feed supplied at tray number 7. As the number of trays is kept constant and the feed tray position is moved down the column, the top composition becomes richer in the more volatile component. The interaction and transport of ^{60}Co gamma photons with the distillation column and its contents, methanol-water solution as well as energy spectrum from ^{60}Co were simulated using Fluka Monte Carlo software package. The results of the interaction and transport of gamma photons are presented as energy deposition on the column and its contents. More energy is deposited on the column walls and plates as compared to the energy deposited in the region between the trays, where there is mostly vapour space.

INTRODUCTION

Monte Carlo simulation of radiation transport and interaction with matter is the most reliable way of predicting the effects of gamma rays [1]. The interaction of gamma photons with matter follows well established laws. Gamma photons can either be absorbed due to the photoelectric effect, scattered by an atom, or converted into an electron–positron during pair production in the field of an atom. The effects of a beam of gamma photon passing through a medium are as a result of many individual interactions because a photon can interact many times before it is absorbed or escapes from the medium [2]. The above processes release kinetic energy to electrons, which escape the atom and also interact with the medium as the secondary particles [3].

The approach to this project was to design a laboratory scale prototype distillation column which will be used to simulate all possible malfunctions that arises in industries during distillation processes. The diameter, height of the distillation column, number of trays and tray separation needed to achieve the degree of separation were determined using ChemSep software, a program which performs multi-component separation process calculations [4]. The prototype distillation column with seven trays was designed using ChemSep, and was modelled in Fluka geometry. A beam of ^{60}Co gamma photons was simulated and incident on the model distillation column. Fluka is a particle physics Monte Carlo software package for simulation of radiation transport [5]. These photons were tracked right from birth and during interaction with the distillation column until their energy falls below minimum threshold or when they escape the region of interest.

Fluka Simulation results

The result is represented as energy deposition on the column in the form of a color map. The figure below shows that attenuation of gamma photon energy is more pronounced at tray position while there is less attenuation in regions between the trays.

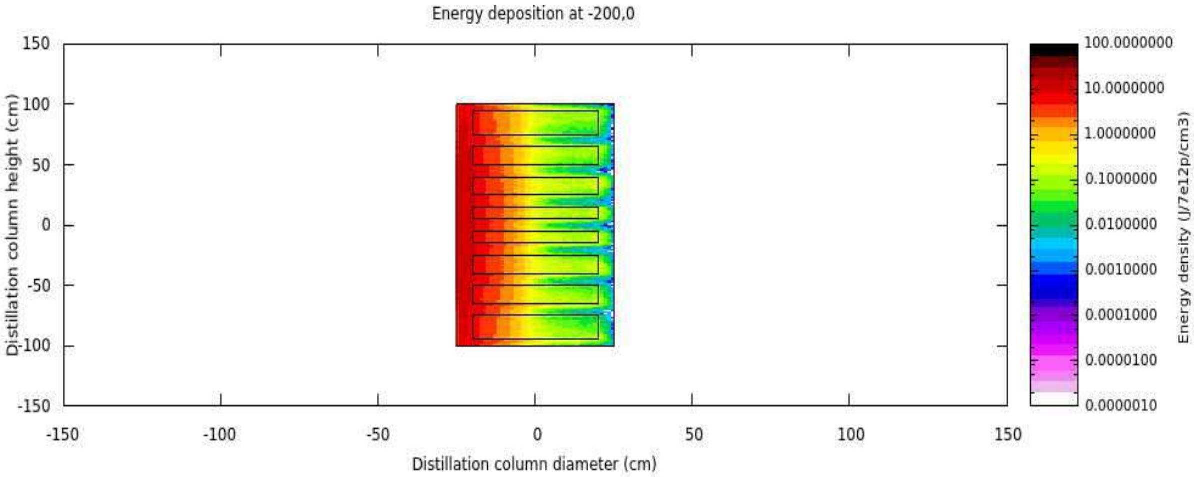

Figure 1. Simulated energy deposition on a prototype distillation column using Fluka

Conclusions and recommendations

The result of the Monte Carlo simulation of gamma photon transport through the distillation column, agrees well with literature. The color map result suggest that if a radiation detector was to be moved along the length of the distillation column, at tray positions it will record less intensity and more intensity at region between trays. Thus energy deposition on the distillation column can be easily converted and represented in the form of a density profile which is distillation column elevation against transmitted intensity. Simulation of all possible malfunctions will be done on the distillation column while running the process and scanned and corresponding interpretations of the density profile will be made.

KEYWORDS

gamma photons, distillation column, simulation, prototype, density profile

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A Calibration Facility for *In-Situ* Gamma-Ray Detector

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ABSTRACT

In-situ measurements are affected by changes in the geometry of the landscape. To calibrate *in-situ* detectors, one make use of test pads (airborne and water bottom applications) and/or test pits or drums (borehole applications). These calibration techniques have limitations in resembling the actual *in-situ* conditions that needs to be measured. Due to these challenges, a dedicated calibration facility, made of building bricks, is required. The calibration facility do not necessary contain only one radionuclide and determining calibration parameters requires unfolding all the contributions from radionuclide present in the in the facility. This limits the accuracy of the activity concentration from *in-situ* gamma-ray spectra. These limitations can be removed by using combinations of Monte-Carlo simulations and a calibration facility. Monte Carlo simulations are used in instances, where measurements would require too much time, expensive or are even impractical to consider and moreover to account for the differences between the calibration and other geometries.

The calibration facility or brick castle is constructed at iThemba LABS, Cape Town, Western Cape, South Africa. Initially the brick castle is designed to house and calibrate an 8 cm diameter detector (MEDUSA). The MEDUSA (Multi-Element Detector for Underwater Sediment Activity) is used in tracing the dynamic transport of sediments along the industrial harbor of Saldanha Bay, West Coast of South Africa.

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Design and Application of Gamma Densitometer on pipes by using Cs-137 (0.662 MeV) Gamma Photon

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ABSTRACT

In this study gamma-ray transmission methods are used to measure the density inside a medium with fixed dimensions by using NaI(Tl) scintillation detector. The radioactive source used in the experiment was Cs-137 of activity 2.6 MBq and the NaI(Tl) $(2''\times 2'')\,detector$ scintillation spectroscopy. Measurement have been made to determine density of the material very accurately by using a narrow collimated beam method which effectively excluded corrections due to small angle and multiple scattering of photons with the created program GDGS (Gamma Density Gauge System) by MATLAB working with GUI (Graphical User Interface). The values of the density (ρ) of inside the medium are found to be good agreement for the quality control for the product material in industrial field. Typical applications of this meter are mining and metallurgical industries, pulp and paper, food and animal feed processing, chemical and petrochemical industrial and off share drilling fluid/mud applications.

KEYWORDS: *gamma densitometer, gamma-ray transmission methods, matlab (matrix laboratory) gui (graphical user interface)*

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Effect of Additives on Anti-Wear Properties of Lubricant Studied by Thin Layer Activation Technique

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ABSTRACT

In the present investigation, thin layer activation analysis technique (TLA) has been used to evaluate the anti-wear properties of various automobile lubricant formulations. The material used in the wear experiments are disc gears made of EN31 steel, which is a representative of automobile gears. The discs were irradiated with high energy proton beam from an accelerator and the activity loss as a consequence of wear was monitored using a gamma spectrometer. A calibration curve was obtained by stacked foil irradiation method under similar beam condition as that of the discs. The calibration curve was used to convert the activity loss in the sample to thickness loss, thereby to quantify the wear. Four different types of additives were mixed with the base lubricant and the wear rate of the disc was measured in presence of individual lubricant formulation.

KEYWORDS:

Thin layer activation, Lubricant, Anti-wear

INTRODUCTION

Engine oils or lubricants are used in different equipments to reduce friction and wear, thus provide long life and low maintenance to the engine. Incorporation of suitable additive to a lubricant enhances the property of the base lubricant. The aim of the current study was to examine the effect of different additives on anti-wear behavior of a synthetic heavy duty gear lubricant. The anti-wear property has been studied on a disc-on disc tribometer using thin layer activation (TLA) technique. For this study disc gear made of EN 31 steel was labeled with small amount of radioactivity by irradiating with proton beam from an accelerator. The activity loss was monitored by using a NaI(Tl) scintillation detector assembled with multichannel analyzer. The activity loss was directly correlated to material loss or wear rate.

EXPERIMENTAL

Disc gears made up of EN 31 steel (1.5 Wt% C, 0.52 wt% Mn, 0.22 wt% Si, 1.3 wt% Cr, 0.05 wt% S and 0.05 wt% P and 96.36 wt% Fe) were irradiated with 13 MeV proton beam using BARC-TIFR Pelletron accelerator facility, Mumbai. The nuclear reaction involved in this study is $^{56}Fe(p,n)^{56}Co$. The product ^{56}Co has a half life of 77.3 days and gamma energies 846.77 KeV (100%) and 1238.28 KeV (67 %). The wear experiments were conducted on a disc-on-disc tribometer. Four different additives, such as, h-BN, MoS_2, graphite and Cu nanoparticles were mixed with the base lubricant and tested for anti-wear property.

RESULTS AND DISCUSSION

The wear behavior of the disc gear was studied in presence of five lubricant formulations named as, L1-L5, having different additives as shown in Table-1. When the wear rate becomes lower, that will show best anti-wear behavior of the lubricant formulation. Here the activity loss as a course of wear was measured. To obtain actual material loss or thickness loss of the disc gear a calibration curve was generated by stacked foil method as shown in figure 1. The experimental data were treated and analyzed. A typical curve of relative remnant activity with time of a disc gear in a particular experimental condition is shown in figure 2. It was observed that, for 200 rpm speed and 30 KgF load, lubricant containing h-boron nitride as additive has better anti wear property as compared to the virgin lubricant. The wear rate was measured to be 39 nm/minute in L2.

TABLE.1 Properties of lubricants

Lubricant formulation	Additive (0.2 wt%)	Wear rate (nm min^{-1})	Properties of base lubricant used in L1-L5
L1 L2 L3 L4 L5	No additive h-BN MoS_2 Graphite Cu nanoparticles	1008 39 159 158 255	Density: 0.89 g/cm^3 Kinematic viscosity at 100 0C: 13.9 $mm^2\ s^{-1}$ at 40 0C: 142 $mm^2\ s^{-1}$ Pour point: -30 ^0C Flash point: 234 ^0C

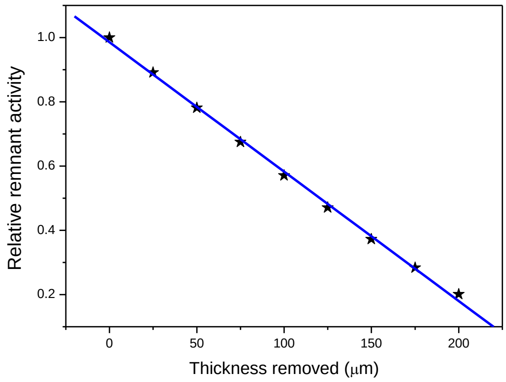

Fig 1: Calibration curve

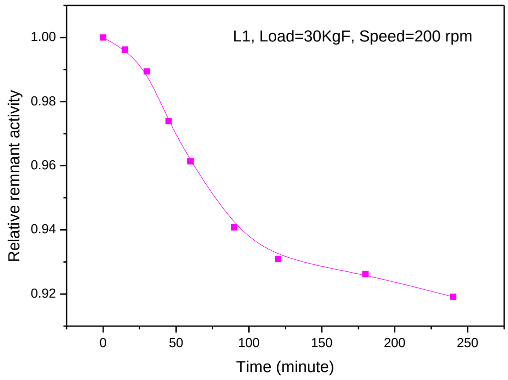

Fig 2: Relative activity loss with time for L1

CONCLUSION

Addition of h-boron nitride to the lubricant significantly enhances the anti-wear property of the lubricant compared to other additives. The wear rate in this case was measured to be 39 nm/minute.

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Investigation of Wear Properties of Different Materials by using Thin Layer Activation (TLA) with Activities under the Free Handling Limit (FHL)

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ABSTRACT

Measuring wear, corrosion and erosion in industry is a very important task. The wear measurement by using radioactive tracer have been introduced first in the second half of the 20th century and used nowadays extensively, especially in the automotive industry [1-3]. There is a list of materials (elements) in connection with the producible radioisotopes to be used as radioactive tracers in wear measurements [4]. The tracer radioisotope is produced in the surface or body of the part to be investigated by using nuclear reactions produced by neutron or charged particle irradiation. If one uses neutrons, the whole body will contain the radioactive tracer, if one uses charged particles, only a thin layer of the surface a geometrically well determined spot will be activated. This method is called Thin Layer Activation (TLA). In the beginning both the production of radioactive tracers and the tracer application (wear measurement) have been performed in licensed radiochemical laboratories, because of the relatively high level of activities. The production and application sites could be several hundred (or thousand) km apart from each other (both are licensed sites). In this case also a licensed transportation company was necessary. Recently, a method was developed to use radioisotope tracers with activities below the so-called Free Handling Limit (FHL). In such a way only the production site must own a radioactivity license, the application site is allowed to use one batch of tracers under the Free Handling Limit.

CHARGED PARTICLE ACTIVATION

If one intends to produce racer radioisotopes the straightforward way is the charged particle activation. The small and medium-size particle accelerators are available worldwide and used mainly for research and medical radioisotope production. All of them can accelerate protons but there are same with the availability for deuteron, alpha-particle and even ^{3}He-particle acceleration. The most technical materials in industry contain the elements iron, copper, tin, etc., from which proper radioisotopes can be produced with the available beams and energies. Out of proton beam the deuteron option is very important, referring e.g. to one of the most frequently used industrial tracer radio-isotope ^{57}Co, which can be produced via deuteron induced nuclear reaction on iron. In special cases the availability of ^{3}He beam can be important if the sample to be activated contains only carbon (e.g. the commonly used hard coating DLC (diamond-like-carbon)), where ^{7}Be can be produced by ^{3}He activation.
When selecting the proper isotope for internal tracing the following conditions must be fulfilled:

- The cross section of the producing reaction should be large enough to produce the required activity economically and its maximum should be within the energy range of the available accelerator
- The radioisotope to be produced should have proper half-life for the planned experiment and should have intense gamma-lines with proper energy for the detection
- The calculated activation profile should correspond to the expected wear (corrosion, erosion) rate

Free Handling Limit (FHL)

According to the European and country regulations there is an extended list of radioisotopes with different safety related data, among others the so called Free Handling Limit (FHL). If a radioisotope or a mixture of different radioisotopes have activity under the corresponding FHL, the package is not subject to the corresponding radioactivity law and can be freely transported. In the case of mixture this condition is calculated by taking into account the ratios of individual radioisotopes to the individual FHL value.

Wear measurement

If the activity of the surface layer to be investigated is under the Free Handling Limit the sample is allowed to be used in any laboratories or industrial sites without license for radioactive material handling. In this case only one batch of such samples can be used in the same time and after performing the experiment all radioactive remains and waste must be delivered to dedicated radioactive disposal or licensed laboratory storage.

Because of the relatively low activity the wear measurement can be performed by using sensitive detectors in relatively small volumes. The wear can be followed by measuring the change of the activity (corrected by half-life) in the sample itself or by measuring the activity removed from the friction surface by the cooling/lubricating liquid.

KEYWORDS:

Charged particle activation; Free Handling Limit (FHL); Thin Layer Activation (TLA)

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Application Of Gamma Computed Tomography (CT) In The Determination Of Agarwood Formation And Pipeline Scaling

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ABSTRACT

The progress of resin (agarwood) formation in an Aquilaria was investigated using gamma computed tomography. The 5-yr old tree of equivalent diameter 13 cm which had been innoculated 14 months earlier was scanned for 6 hours using the GammaSpider, a portable industrial gamma tomographic system equipped with low-energy gamma ray source of Am-241 of strength 199 mCi and a collimated 1-inch NaI detector for data collection. In-situ experimental reconstructed images revealed that the formation of the resin was inadequate and therefore another scan was recommended in 6 months. In a related research, a raw water pipeline serving a refinery was scanned using the GammaSpider. The objective of the scan was to identify or detect the presence of scales in a 20-yr old 8-inch raw water pipe. A collimated Caesium-137 source of activity of 48 mCi was used and a collimated 1-inch NaI detector in conjunction with a single-channel analyser was used for data collection. The scan lasted 6 hrs. The image obtained after reconstruction using an algorithm showed that there was no indication of scaling in the pipeline.

INTRODUCTION

Computed tomography (CT) using ionizing radiation such as gamma-ray or X-ray, is a powerful imaging technique that can provide a cross-sectional view or a volumetric view of the interior of an object. Data is collected by radiation detectors at many different angles and are then transformed into meaningful 2D or 3D images, using mathematical algorithms and computed codes [1]. A wide variety of applications of CT has arisen in recent years for non-destructive evaluation (NDE) and testing of industrial components, geological objects, bioscience samples, automotive parts and archaeological artifacts [2,5].

Agarwood, also known as oud, oodh, agar or aloeswood, is a dark resinous heartwood that forms in Aquilaria and Gyrinpos trees (large evergreens native to southeast Asia) when they become infected with a type of mould. Prior to infection, the heartwood is odourless, relatively light and pale coloured. However, as the infection progresses, the tree produces a dark aromatic resin in response to the attack, which results in a very dense, dark, resin embedded heartwood. The resin embedded wood, commonly called agarwood, is valued in many cultures for its distinctive fragrance, and thus is used for incense and perfumes [4]. One of the main reasons for the relative rarity and high cost of agarwood is the depletion of the wild resource. For the same reasons, efforts are being made to cultivate the species domestically. The tree is inoculated with a chemical that induces or initiates the decomposition of the tree and produces the resin in the process. In this paper, the progress of resin formation in Aquilaria tree after the inoculation was investigated using GammaSpider, a portable clamp-on computer tomographic scanner developed for in-situ applications by the Malaysia Nuclear Agency. A pipeline section was also scanned for scaling or fouling using Gamma Spider. GammaSpider is a portable CT system consisting of two major parts - the mechanical hardware and the system software. The hardware section comprises five main components: a radioactive source with holder and collimator, a radiation detector with holder and collimator, a pair of linear translation arms each 80 cm in length, a circular motion frame (C-frame) 80 cm of inner diameter and an electronic and power supply box. All these are mounted on a hexagonal shape of clamp-on jig. The system software consists of three main programmes: system control and data acquisition, pre-processing and analysis, and image reconstruction [3].

RESULTS AND DISCUSSION

The scan revealed that the formation of the resin in the tree was low. The location and size of the agarwood in the tree trunk cross-section was also detected by CT technique. Another scan was therefore recommended in six (6) months. The pipeline scan did not reveal any scaling in the pipeline. This means that the water treatment plant was efficient as all hardness causing elements have been removed.

KEYWORDS:

Computed tomography, industrial, scaling, agarwood, image reconstruction, gamma source, detector

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Experimental Research on Dynamic Paraffin Visualization Using Gamma-Ray Tomography Technique

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ABSTRACT

The application of gamma-ray tomography in industry is growing and challenging as time goes by. For several years gamma-ray tomography technique has been designed and evaluated for monitoring and investigating industrial two-phase flow, especially for process inside the pipe [1]. The gamma-ray tomography for investigating either process unit or distribution unit has been extensively studied. The mechanical structure geometry to be suitable in any case, has been developed recently by some researchers [2]. However, transmission gamma tomography experiments were often carried out in statical object, meanwhile in reality the materials object in unit process were dynamic. Material level or mechanic process system was one of examples dynamic material in industrial process. This research is important enough as a preliminary study to simulate complexity of circumstances industry. In petroleum, chemical, oil and gas industry exist two-phase flows unit process [3]. In this experiment, paraffin was choosen because major concern in the production and transportation of hydrocarbon fluids, especially in refinery unit process that carried losses caused by paraffin. Paraffin deposition and crystallization in two-phase flow is one of the problems usually occurred in the field. Paraffin wax has been defined as the organic compounds found in crude oil with relatively high molecular weight and mainly contains carbon and hydrogen atoms. Wax precipitation can occur from gas condensate, light oil and heavy oil fluids at temperatures as high as 338.7 K [4] . The problems caused by wax precipitation such as decreasing production rates, increasing power requirements, and failure of facilities.

In a previous study about the motion of an object within a 2-D bed was analysed. The object was found to describe cycles, moving from the surface of the bed to a certain depth and back to the surface [5]. In the field of computer science, to visualize moving objects in industrial inspection used video sequence which is based on representing moving objects by a binary mask in each frame [6]. In monitoring industrial process such as coating process, transverse motion was affecting optical computed tomography system properties (beam displacement, transverse resolution) and emphasized the importance of investigation dynamic material [7]. The objective of this experiment was to study the use of gamma-ray tomography technique to visualize the dynamic paraffin. The configuration system consisted of a collimated gamma radiation source Cs-137 (80 mCi) and a scintillation detector NaI(Tl) which moved parallelly called first generation tomography method. The reconstructed images successfully distinguish the density profile of static and dynamic paraffin through its pixel value. Gamma-ray tomography is a suitable technique to visualize the dynamic process in process industry.

DESIGN AND EXPERIMENTAL METHODS

The experiments were carried out using tomography system which has been developed by Center of Isotope and Radiation Application BATAN laboratory. The paraffin was set in the middle of measurement system, with configuration seen in figure 1.

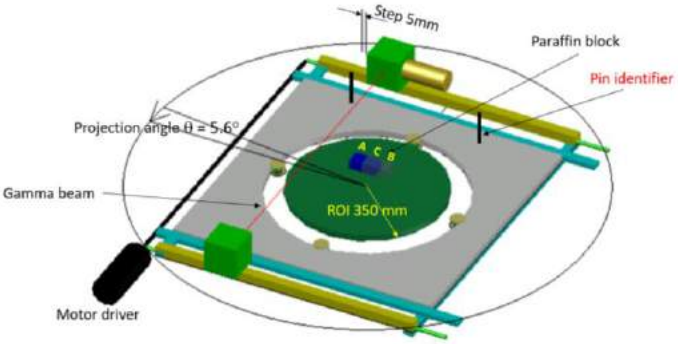

Figure 1. Tomography system

The experiment was designed to give reconstruction description of gamma tomography transmission results on paraffin object with a width and thickness is 95 mm x 55 mm x 60 mm. Paraffin object was beeing dynamic in position when scanned in two areas A and B. Measurement area was divided into three sections, section A 60 mm, B 60 mm, and C 35 mm. Section A plus C refers to A position, and section B plus C refers to B position. Section C was area that continuesly occupied by paraffin block, while positions A and B were areas that alternately filled with paraffin or in empty space.

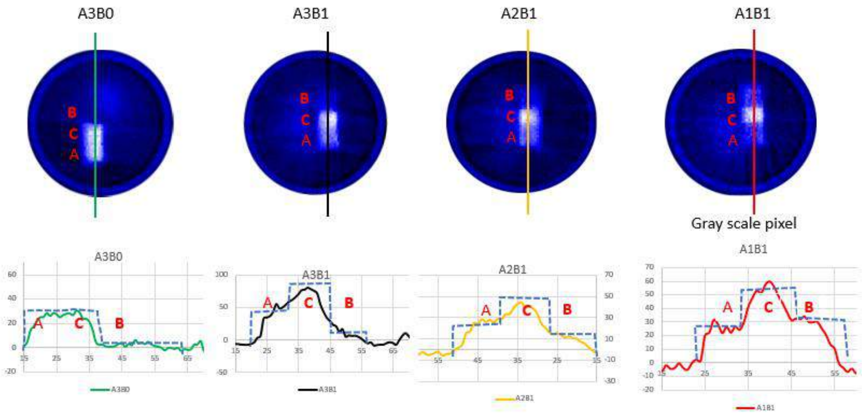

Figure 2. Pixel value that represent each position

KEYWORDS

Gamma-ray, industry, dynamic object, paraffin, tomography

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Gamma Scanning Technique for Investigating De-Ethanizer Column: On Field Experimental at NGL Plant

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INTRODUCTION

Natural gas is often liquefied for efficient transportation, and liquefaction is a high energy consumption process [1]. A natural gas liquid (NGL) plant consists of a series of fractionators such as de-methanizer, de-ethanizer, de-propanizer, de-butanizer, and butane splitter. De-ethanizer column aims to remove ethane from product fed by de-methanizer. There are several problems that ussualy occur during de-ethanization process such as low recovery of propane and propylene, refrigeration problems, CO_2 removal problems, and caryover problems [2]. The problems can cause by inappropriate process parameters or the malfunction of process column. Gamma scanning technique is best technique to investigate the internal structure of industrial process columns. In comparison to other non-destructive control techniques used in practice, gamma scanning provides real time, the clearest vision of the production conditions inside a reservoir of process [3]. Shahabinejad et al. have been conducted several lab-scale gamma column scanning experimets [4,5]. They were studied about the application of gamma scanning in trayed column. We used gamma scanning technique to examine the 01-C-3401 De-Ethanizer column of NGL company in north Sumatera, Indonesia. This unit is trayed column having inside diameter of 1900 mm at lower segment, 3200 mm at upper segment, and total height of 36710 mm (TL to TL). Number of the trays are 38 with 30 trays in the lower segment and 8 trays in the upper segment.

METHODS

The scanning has been conducted using 2.59 GBq of Co-60 as the transmitter and NaI(Tl) scintillation detector as the receiver. The gamma source and detector were collimated using lead. For the effectiveness of applications in the field, panoramic collimators with window height of 20 mm were used. They were moved parallely each 50 mm and counting the radiation that penetrating the column. Scanning time is 3 seconds every step. The scans were separated into upper and lower segment scans. There were two scans orientation for each segment as shown in Figure 1.

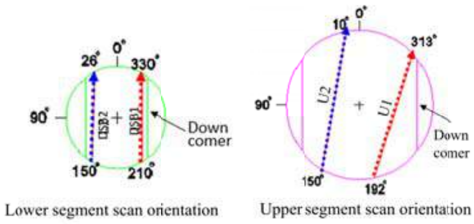

Figure 1. Scan setup and orientation.

The lower scans were started from 750 mm below the TL until 27210 mm, while the upper scans were started from 27210 mm to 36710 mm. The difference in the diameter of the upper and lower segments and limited number of platforms to do the work in the column were another challenge when conducting set up process.The scanning process was performed automatically. The scanning system were consisted of mechanical wincher with 25 W AC motor, arduino module as controller module, gamma counting system, and personal computer with LabVIEW as the graphical user interface.

RESULTS

The scan data was compared to the CAD drawing as shown in Figure 2. The results show mechanical structure of tray #1 until tray #38 were in good condition. There were no collapsed or flooded trays in the column. The demister was in its position. Chimneys above tray #38 and tray #8 were observed exist. The liquid level during the scanning process were in normal liquid level (NLL) approaching to high liquid level (HLL).

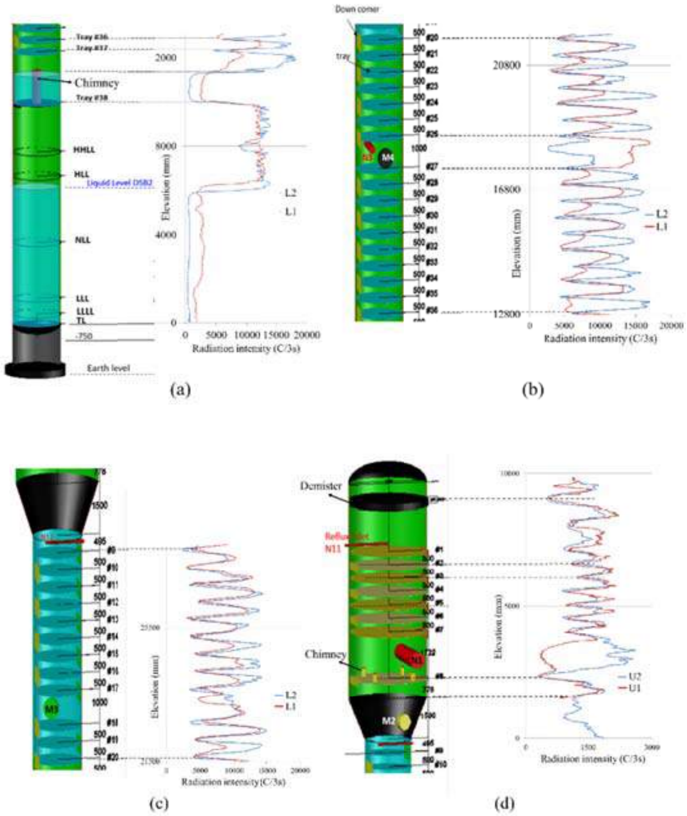

Figure 2. Scan data, (a) lower segment TL-tray #36, (b) lower segment tray #36-#20, (c) lower segment tray #20-#9, and (d) upper segment tray #8-demister.

CONCLUSIONS

The gamma scanning technique has been succesfull to provide the internal structure condition information of the column. Automatic scanning reduces potential of human error compared to manual method. Overall, mechanical structure of De-Ethanizer column were in good condition. The flow rate and the process were in normal condition during the scan.

KEYWORDS:

field experiment; gamma scanning; industry; NGL; process column

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Liquid Level Measurement in Distillation Column Simulator by Neutron Backscattering Technique

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ABSTRACT

Water levels on the trays and in the downcomers in distillation column simulator have been investigated by neutron backscattering technique. The on-line measurements of two scan lines have been carried out for single trays and double trays using the portable neutron backscattering gauge including 0.25 mCi Am-Be neutron source and ^{3}H detector. LUDLUM Model 375 data acquisition system was used for neutron counting. The measurements were carried out by moving the measuring head up along the column wall using a wincher. From the scan curves, the measured water levels on the tray #2 to tray #12 except tray #7 are approximately 30 mm and that on the tray #1 is less than 10 mm. The water level on the tray #7 is a little higher than others.

INTRODUCTION

Accurate level measurement increases process efficiency of the industry. The neutron backscatter technique is used to provide non-invasive level measurements not obtained by other methods. This technique involves the use of a fast neutron emitting radioactive source. Neutrons are the same size as hydrogen molecules. They will penetrate lagging and steel, but if any hydrogenous liquid is present within a vessel, the neutrons are scattered back by the hydrogen out of the vessel as slow neutrons, and can be detected as they do so by a slow neutron detector. The source and detector are located within a small portable instrument that can be moved up and down the vessel walls to quickly and accurately locate levels and interfaces. The experiment on the measurements of water levels on the tray and in downcomers in distillation column simulator were conducted using neutron backscattering gauge at the Radioisotope Techniques Laboratory in the Division of Atomic Energy.

MATERIAL AND METHOD

Distillation Column Simulator

Distillation Column Simulator was constructed with a transparent acrylic tube for the demonstration and practice in the radioisotope techniques for the industrial applications. The tube is 300 mm in diameter and 2000 mm in height and placed on a steel tank used as a water reservoir. It contains 12 trays and one packed bed which is 120 mm height and situated between fifth and sixth trays. Trays #1 to #5 are double pass trays and trays #6 to #12 are single pass trays. The distance between the trays is 120 mm. The water in the distillation column was circulating through PVC pipe installed outside the column by the water-proof pump placed in the steel tank.

Portable Neutron Backscattering Gauge

The neutron backscattering gauge for industrial applications is designed to be portable device and used for level and interface measurement. The system is composed of a measurement head and electronic module for acquisition of measurement. The measurement head includes ^{3}H thermal neutron detector and source holder for neutron source. LUDLUM Model 375 radiation monitor controller is used as the data acquisition (DAQ) system. The measurement head and DAQ system are connected with a cable about 2 m length.

During the experiment, the measurement head was mounted on the surface of the distillation column and ensure good contact between the measurement head and the surface Refer to the mechanical drawing of the column, the point at elevation of 500 mm was assigned as starting point of the scan and it was notified as 0 mm. After installation of Am-Be fast neutron source in source holder, the measurement head moved up along the column wall increasing 10 mm in each step using the wincher Two scan lines were conducted for the single pass trays and the double pass trays from the starting point to 2100 mm.The data from the display of LUDLUM 375 were recorded manually for each predetermined level point.

RESULTS

The results obtained during the measurements were shown graphically in Figure 1. According to the scan orientations, the scan line 1 identified all single trays except collapsed tray #6 but two double trays. The scan line 2 identified three single trays and two other double trays. Scan profiles showed the levels of water on the trays. From the scan curves, the measured water levels on the tray #2 to tray #12 except tray #7 are approximately 30 mm and that on the tray #1 is less than 10 mm. The water level on the tray #7 is a little higher than others because of the tray #6 collapsing.

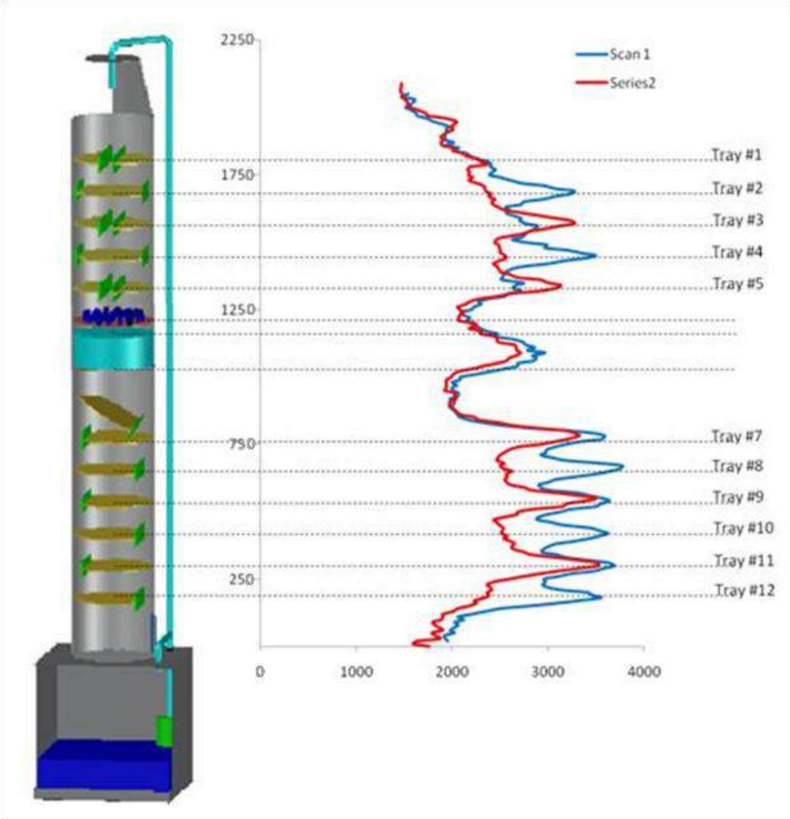

Figure 1. Scan profiles obtained on distillation column simulator

CONCLUSION

The neutron backscattering technique facilitated the rapid identification of the problems. The experiments provided complementary data for accurate level measurements of water in the distillation column simulator and exactly pointed out the position of trays in the column. The results obtained from the measurements can be verified seeing the transparent acrylic column.

KEYWORDS

Neutron backscattering technique, distillation column, level measurement, on-line measurement

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Gamma Scanning Application in Column Scanning

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ABSTRACT

Gamma scanning is a very effective and well-established troubleshooting technique in distillation columns. The technique is widely applied in various chemical and allied industries during product separation stage. These industries include oil and gas industries (crude oil columns) as well as breweries companies' (rectification of alcohol). The quality of the products in these industries depends almost entirely on the performance of the columns, thus any malfunction (such as liquid entrainment, flooding, foaming, weeping and collapsed trays) in the columns can lead to undesirable consequences to the plant operation. The gamma scanning technique can provide a powerful tool to monitor in real time the performance of an operating column which can help improve on the operating efficiency. In addition, the technique can reduce production down-time, thus saving money, since it can provide information on whether a column can be kept running even when the schedule indicate it should be shut down for inspection. In this work, gamma scanning will be carried out on a laboratory scale distillation column using a ^{60}Co sealed source with an activity of 10 mCi, a NaI scintillation detector using Nibras software data logger. Various distillation columns malfunctions will be simulated in the setup, data will be treated for various corrections and the scan profiles recorded. The experimental results will be presented at the ICARST-2018 conference to demonstrate the effectiveness of the gamma scanning technique in troubleshooting the malfunction of a distillation column.

We acknowledge training support on tracers by International Atomic Energy Agency and research capacity support at University of Nairobi by International Science Programme, Uppsala University, Sweden.

KEYWORDS

^{60}Co isotope, sealed sources, crude oil columns, distillation columns, oil and gas industries

Using the Gamma Scan Technique for Diagnostic and Troubleshooting in Industrial Plants

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ABSTRACT

Among a number of applications carried out by CANTI, this paper gives the typical case studies of use of gamma scanning to detect damages, blockages in pipeline and to investigate of malfunction in process columns in the petroleum refinery which provided the technical evidences for engineers in planning the troubleshooting. Gamma column scanning was used to determine the malfunction in the flue gas absorber tower of Dung Quat Refinery. The scanning results showed the heavy foam occurred in many trays that help the operator adjusting the operational parameters to recover the normal performance. In pipeline, gamma scanning technique was used to detect the blockage inside flare pipeline, to inspect the damage of refractory inside the withdrawing well and to detect the part of steel valve dropped and stuck inside the steam pipeline. In many cases, gamma scanning showed as the only technique to solve problem owing to the high penetration capability of gamma ray through the thick steel wall of components that allows to “see” inside the object; and implementation of the online inspection without shutting down the process.

KEYWORDS

gamma scan, gamma column scan, refractory investigation

Radiographic Examination of Local Fabricated Products ("Jua Kali") in Kenya

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ABSTRACT
This study sought to establish the integrity of welded joints in selected locally fabricated products ("Jua Kali") in Kenya; Pull type Hoes and Tee type Hinges for ISO 5817 standard compliance. Lack of fusion and underfill, emerged as the most prevalent defects evaluated at 83% and at 70% respectively, of the welds examined in this study. Other defects observed include; porosity, undercut, burn through, slag and crack. In general, more than 86% of the welds inspected in this study failed to comply with ISO 5817 standard requirements. These results reflect poor quality welds largely attributed to lack of use of standards and procedures in fabrication processes. The study recommends for training of personnel and adherence to standards in the welding operations.

INTRODUCTION
The presence of weld defects in any engineering component affects mechanical and chemical properties of the material. Common weld defects include; cracks, lack of fusion, incomplete penetration, porosities and inclusions.

This study sought to establish the integrity of weld quality of locally fabricated products in Kenya, commonly referred to as "*Jua Kali*" products, which contributes significantly to the economy ; employment and for income. In Kenya, "*Jua Kali*" products are widely used in the informal sector ; agricultural and build . Some of these products include local fabricated; hoes, door and windows hinges, wheel barrows, cooking utensils, metal doors and windows etc. Specifically, we have examined welded joints for Hoes and Hinges products using radiography testing method for ISO 5817 standard compliance [1,2,3].

MATERIALS AND METHODS
Thirty (30) samples each for Pull Hoes and Hinge were randomly sourced from open air markets (Figures 1 and 2). Weld sizes of these products varied between 7 mm to 16 mm. In addition, we have evaluated thirty (30) other standard based welded joints as a controls.

The test specimens were radiographed and analyzed for defects at the Kenya Bureau of Standards NDT laboratory, Nairobi. A Portable X-ray machine, Model SMART HP 300 and control unit Model 583 was used in this study. Radiographic exposure was done in accordance to ISO 17636 standard, while classification of defects was done in accordance to ISO 5817 standard. Kodak industrex AA400 films were used in radiographic exposure. For sensitivity check of radiographic technique, a 10FE EN wire penetrameter was used and with a Lead intensifying screens of 0.1 mm thick placed on both sides of the film. Film optical density, were measured by DDS2 digital densitometer.

ISO 5817 is a general standard that defines dimensions of typical imperfections expected in normal fabrication and provides quality levels for imperfections in fusion welded joints in all types of steel, nickel, titanium and their alloys; designated with symbols B, C and D [4,5,6,7]

RESULTS AND DISCUSSIONS

Table 1 shows a summary of testes for compliance against ISO 5817. Of the sixty welded samples inspected, fifty-two (87%) had lack of fusion defect, thirty-five (58%) showed underfill defects and eight (13%) had burnthrough defect. Other defects of concern included; porosity and undercut, slag inclusion and crack.

Fig 1. Pull Hoe and Hinge with a welded joint

Table 1: Summary of specimen tests compliance

SPECIMEN	Number of samples evaluated	Non compliant samples	
		Number of samples	percentage
Standard weld	30	3	10%
Hoe weld	30	25	86.7%
Hinge weld	30	30	100%

In general, of the ninety samples evaluated, fifty-eight were non-compliant with ISO 5817 standard, represented by the following; three or (10%) of standard welded joints, thirty (100%) of Hinge welded joints, and twenty-five (83%) of Hoe welded joints. The high compliance of standard welded joints can be attributed to application of standards and the expertise of the welders.

CONCLUSION

This study has demonstrated that 86.6% to 100 % of welds investigated did not comply with the minimum requirements of quality level D of ISO 5817 standard, due in part to ; poor weld preparation, lack of welding skills and poor working environment. We recommend for application and adherence to welding standards and procedures and training of artisans.

KEYWORDS:

radiographic testing method, welds, defects, Jua Kali (fabricated) products.

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Hydrodynamics of Binary Fluidized Bed Employing Radioactive Particle Tracking

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INTRODUCTION

Fluidized bed reactors, with its widespread application in the energy sector, still remains technically challenging in operation and elusive to scale up. One of the impediments has been the usage of a wide gamut of solids with underlying hydrodynamics spanning over multitudes of scales. However, the key to unraveling this challenge may possibly lie in developing robust modeling framework through CFD supplemented with suitable constitutive equations. In particular, determination of hydrodynamic effects such as phase holdups and velocities may pave the path for superior closures. Further, for studying practically relevant systems, one must resort to studying beds with multi-particle systems [1]. In order to circumvent this issue, a simplification would estimate velocity fields in binary beds with known effective densities and particle properties. To this end, our goal here is to determine velocity fields of solids beds through Radioactive Particle Tracking (RPT) in both unary and binary fluidized beds.

In spite of several techniques implemented in the past, based on the principle of tracing the path of a single radiotracer particle, RPT remains a popular velocimetry technique [2]. However, it is noteworthy that in almost most of the previous explorations in gas-solid systems, RPT has been employed in rather idealized situations. Specifically, the studies focused on tracking mono dispersed particles. Thus, in this communication, we explore the implementation of RPT for poly dispersed systems. The wider objective is to establish the RPT technique for bed mixtures with wide properties. In order to effect such a study it is planned to conduct RPT measurements in a mixture of particles of known distributions. Further, for a comparable analysis the mean particle diameter is kept identical. The system chosen for the present study is a mixture of glass beads and alumina of various proportions so as to explore a wide gamut of solids. As such systems were never attempted to be studied using RPT, we plan to implement the methodology in two phases: the former phase involves tracking with a bed with a single radiotracer, which essentially assumes the bed to be unary; whereas, the latter phase involves study using two radiotracers, thus considering a binary bed. However, in view of the limitation of abstract, in the sections to follow, we elucidate the detailed experimental technique adopted and their findings for binary beds.

METHODS

Fluidization experiments were performed on a laboratory scale cylindrical fluidized bed of 10 cm ID employing dry air as a fluidizing medium. Two-bed compositions of bed material with glass beads were used as inventory – Composition I with 70% of 0.5 mm and 30% of 2 mm (by weight) and Composition II with 90% of 0.5 mm and 10% of 2 mm by weight. For every composition, experiments were conducted at three superficial velocities of 2.54, 3.82, and 4.24 m/s. For the present study, 46Sc tracer was used as a solid tracer.. Figure 1 below shows a typical solids trace and velocity field for a case in which the bed was operated at 4.24 m/s.

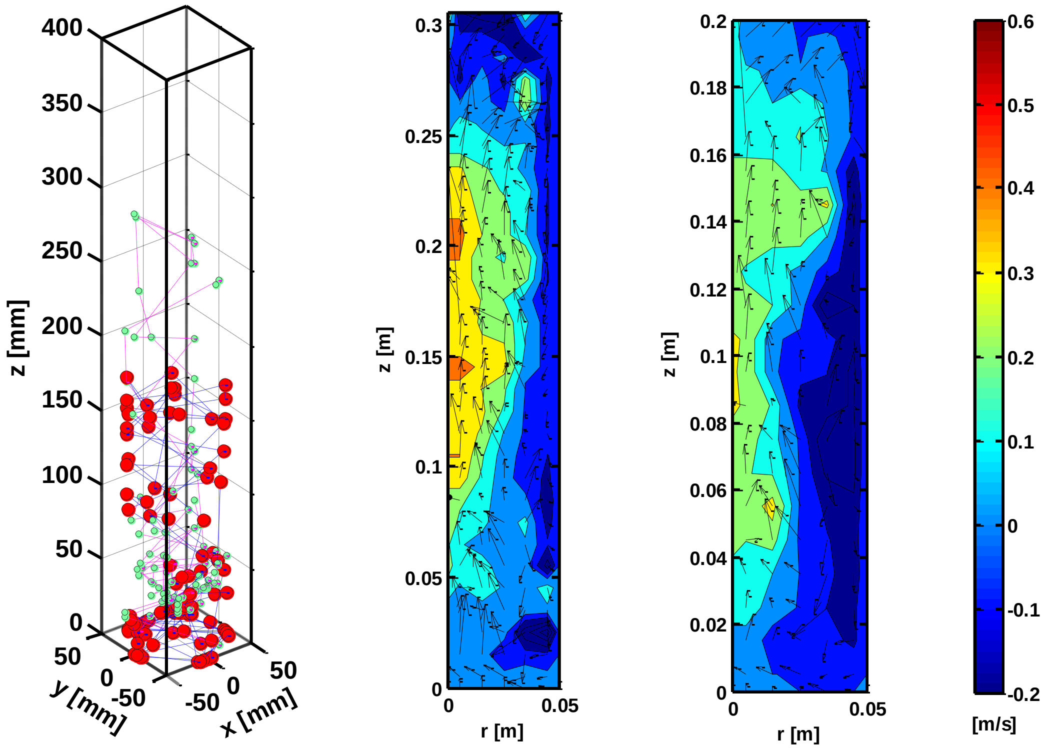

Figure 1: Binary fluidization of glass beads (a) Instantaneous position of solids (b) Velocity field of 0. 5 mm and (c) 2 mm glass beads

CONCLUSIONS

This study reports velocity measurements in binary beds particle employing RPT. Instantaneous tracer locations showed that it ensured an unbiased scanning of the entire test section. Also, the mean velocities revealed two distinctive zones – a high-velocity region around core while relatively lower velocity towards the wall. Detailed analysis of the results will be discussed in the final presentation.

KEYWORDS: *Binary Fluidized Bed, Radioactive Particle Tracking (RPT)*

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Neutron backscatter gauge for the measurement of different phases: scans and modélisation

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ABSTRACT

The tanks used in the chemical, petroleum and petrochemical processing plants, contain a various types of liquid hydrocarbures Crude oil, petroleum products, chemicals, water.etc. Since the tanks are subjected to tremendous stress due to the different activities. Fusioned or new layers may developed into the tank; the neutron backscatter technique can be used to measure and detect interfaces between different levels (liquids, solids, vapor) without affecting the process reliable.

Fast neutrons, in the range 0.5-11 MeV, lose their energy by scattering process. The concentration of thermal neutrons near the fast-neutron source is increased by the presence of hydrogen in the medium.

The practical work were carried out using the portable neutron backscatter gauge for level and interface measurement (NBS-3 MK1) to inspect the interface between water and different liquid into the tank (oil, foam…) and performed a simulation studies using a MCNP code, so as to compare the experimental and theorical results.

KEYWORDS:

Neutron back scattering, Nucleonic control system, Tanks, Interface water/liquid. Simulation, MCNP code

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Imaging deposits and corrosion by tomography

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ABSTRACT

The use of pipes is a necessity for transporting raw materials and end products to their destination in several industries. Presented in several physical forms (gas, liquid and solid) these different products, because of several parameters contribute to degrade the internal state of the pipes by the appearance of corrosion and internal deposits decreasing the effective sections of the pipes. Therefore the quality of the products is affected as well as the production process.
The detection of these abnormalities by imaging techniques such as tomography is of high importance, since tomography does not only detect the existence of abnormalities but the dimensions of the latter become measurable.
In this study we will give an overview about the tomography principles and tomographic images of corrosion and deposits will be shown using the eGorbit tomography system. Finally, we will conclude at what end the tomography can detect the internal anomalies.

KEYWORDS:

Imaging, tomography, pipes, corrosion, deposits, section

Malfunction Investigation in Catalyst Column Using Industrial Gamma Scanning

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ABSTRACT

Many problems in the industrial process, for instance production disruptions often occured where a non-destructive test (NDT) without influencing production process is highly needed. Gamma scanning technique is one of NDT method which widely developed to predict abnormal process without interfering the operation. Inspection of methanator vessel has been carried out to identify configuration system malfunction which caused by overheating. Based on mechanical drawing, measurement was done by scanning the column from bottom to top position, also by hanging 80 mCi Co-60 as gamma source and NaI(Tl) as scintillator detector. The measurement results showed catalyst condition was changed. Material density changed at top section of column, exactly found odd density volume with radius 40 cm, depth 100 cm.

There are numerous process advantages that can be realized by using column scanning technique in various application [1]. Some paper explained the effectiveness of utilizing Monte Carlo simulation to demonstrate in analyzing troubleshooting of the column [2]. For instance, the density profiles generated in scans can identify damaged trays and packing, liquid maldistribution, flowrate-related problems such as weeping or entrainment, and process problems such as fouling or foaming. Thus periodic scanning of critical equipment by using gamma-ray source can improve the efficiency and also reduce the possible down time of the plant for unidentified problem [3].

MEASUREMENT METHOD

Measurement technique depends on mechanical drawing of the object / column. The configuration of scanning system consists of NaI(Tl) detector with 5 cm diameter and encapsulated source 80 mCi Co-60, was hanging outside column. Source and detector was placed oppositely and separated 3 m distance.

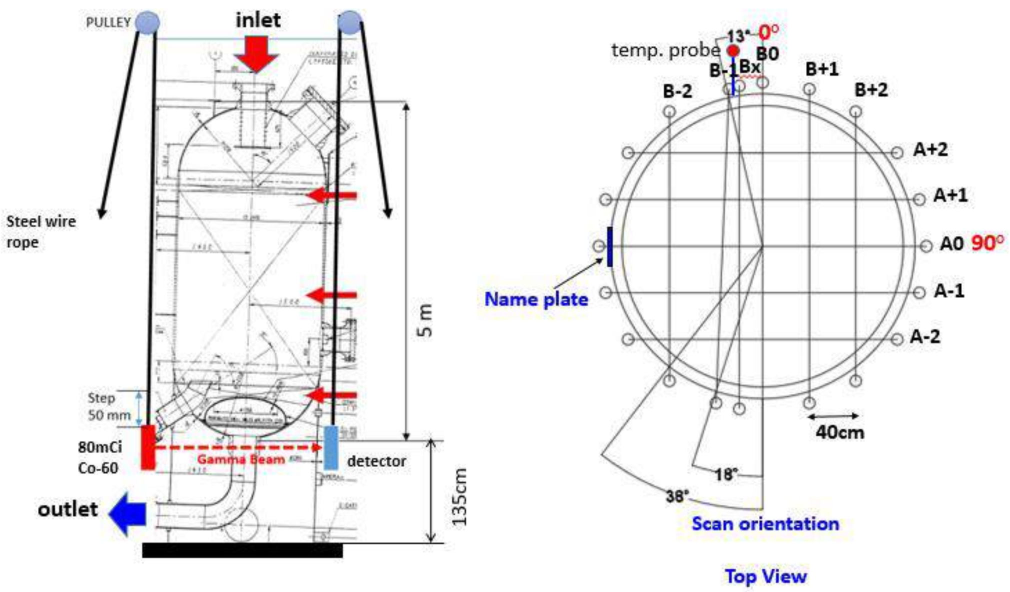

Figure 1. Scan orientation based on mechanical drawing

Grid orientation is determined by 2 x 5 scans, from 0° to 180° orientation and next five scans from 90° to 270°. It's expected to find abnormal configuration of catalyst in every 400 mm apart (top view). Movement of gamma source and detector automatically controled. Radiation intensity measurement is carried out every 50 mm height in each orientation and each segment. Scan code consists of A+2, A+1, A0, A+1, and A+2. Serial codes of B are B-2, B-1, B0, B+1, B+2 and Bx as an extra scan. For detail information, shown in figure 1.

RESULT AND DISCUSSION

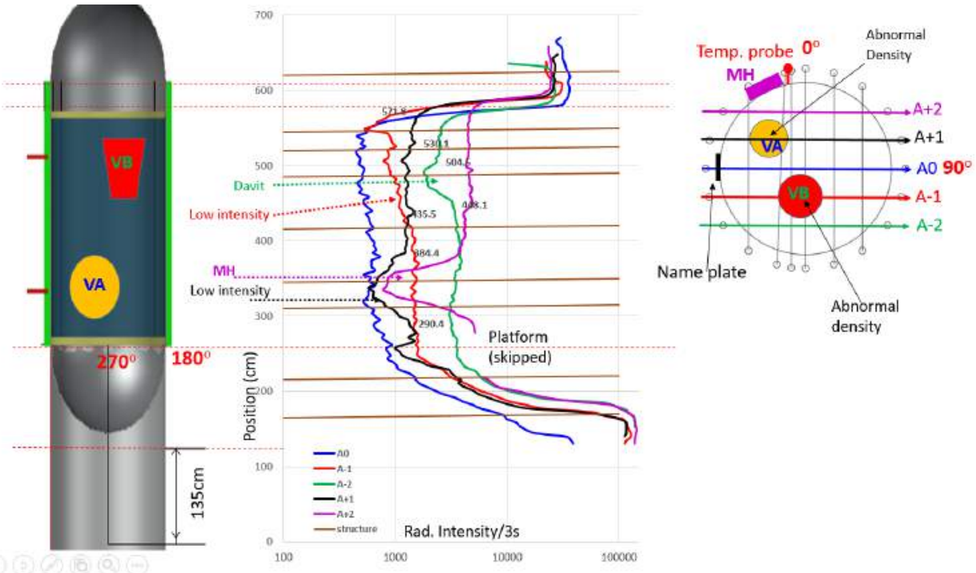

Figure 2. Result of scan profile A

Scan profile A+1 colored by black, decreased in position 290 cm to 384 cm or approximately 100 cm. Based on mechanical drawing on A+1 path did not indicate the existence of an internal structure. External structure main hole (MH) was far enough from A+1 track. This data interpreted that material absorbed gamma rays much more. Catalysts in this area assumed having abnormal density (VA code as seen in figure 2). This suspected area in catalyst could not identified at A0 scan and couldn't be interpreted from A+2 because it was blocked by main hole (MH). Some scan profile of A+2 was skipped because scan track blocked with the platform.

KEYWORDS

NDT, gamma scanning, process, industry, methanator

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SESSION 3

RESERVOIR, WELL, INTERWELL, GEOTHERMAL ENERGY, DAM, NUCLEAR WASTE STORAGE

12
ABSTRACTS

Application of radiotracer techniques for geothermal. Reservoir management in Kenya

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ABSTRACT

The injection of additional 280 megawatts produced in Kenya to the national grid in December 2017 has lifted Kenya's global ranking as the eighth largest producer of geothermal energy. Currently, Kenya tops in Africa with 700 megawatts. The Kenya Electricity Generating Company (Kengen), which is 74% state-owned, has built three plants to exploit the Olkaria geothermal resource, Olkaria I (195 MW), Olkaria II (105 MW) and Olkaria IV (150 MW, 75 MW Wellhead generation plants, with a third private plant Olkaria III (139 MW). By 2030 Kenya aims to have 5,530 MW of geothermal power or 26% of total capacity. This will make it Kenya's largest source of electricity clean energy by 2030. However, the geothermal generation will only be sustained if the reservoirs are well managed. Currently there are over 350 production wells in the region, to allow extraction of heated fluid by the natural heat of the earth. Several wells have reported decrease of pressure caused by mass extraction and the heat content. Pressure declines continuously with time in systems that are closed or have limited recharge. Therefore, the production potential of geothermal systems is limited by a lack of water rather than a lack of heat. This has necessitated use of radiotracer technique in Geothermal resource management to allow controlling energy extraction from geothermal systems underground so as to maximize the resulting benefits, without overexploiting the resource. The purpose of interwell tracer test in Kenya in reservoirs is to gain information for improving and understanding of reservoir geology and to optimize production and re-injection using radiotracer technique. This would allow monitoring both qualitatively and quantitatively the injected fluid connections between injection and production wells and mapping of the flow field, reservoir heterogeneities and volumetric sweep (contacted volumes) between wells. The Information gained from tracer testing includes: Diagnostics of the properties of the reservoir, including evidence of direct connections between the tracer injection point (either within or outside the field) and the monitoring wells in the field; Measurement of the direction, speed and MRTs of water movement; Determination of the extent to which groundwater down flows intrude into production wells; Identification of breakthrough or injected water into a field and, when this is detected, quantification of the amount; and Calibration or verification of the physical models. Radiotracer techniques have several advantages in comparison to chemical tracer for geothermal resource management. The advantages include: the detestability of the tracer is not affected by the physico-chemical nature of the environment; capacity to sustain high temperature and high detection sensitivity; the radiation emitted by the radiotracer are easy to detect and can be measured by high precision; The radiation emitted is independent of temperature, pressure, chemical and physical states; the radiation intensities measured furnish direct information concerning the amount of labelled species and no special models are required to draw quantitative conclusions and the detestability of the tracer is not affected by the physico-chemical nature of the environment. Steps for radiotracer investigation: design of tracer strategy together with reservoir engineers; selection of applicable tracers; application to the relevant authorities based on a safety report; tracer mixture preparation, calibration and quality assurance; selection/design of tracer injection and sampling procedures; tracer transportation to injection site; implementation of radiation safety procedures at the injection site; tracer injection; radioactivity contamination survey; injection equipment decontamination and handling of radioactive waste; tracer sampling and sample transportation to analytical laboratory; tracer analysis; data evaluation and simulationr and reporting of results.

Investigation of radiotracer's capability in water flooding system using laboratory sand pack column: A preliminary study

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ABSTRACT

Fluid flow in most reservoirs is anisotropic. The reservoir structures are usually layered and frequently contain significant heterogeneities leading to directional variations in the extent of flow. Hence, the effective fluid movement can be difficult to predict. Moreover, the complex minerology of sandstone reservoirs further complicates the process. Malaysia reservoirs are dominantly sandstone sedimentary layers with shale inter-layers. Hence, there is an immediate need to investigate and understand the behavior of reservoir during waterflooding specifically the fluid flow and transport behavior using radiotracer and CFD simulation technique. Radioactive tracers play an important role in oilfield study because of their advantages, such as high sensitivity, stability and selectivity. Most of the information given by the tracer response curves cannot be obtained by means of other techniques.

Thus, a lab scale of sand pack has been set up to investigate the compatibility of radiotracer technique in assisting the behavior of sandstone reservoir in Malaysia. A full packed of sandstone with grain size of 800-900μm has been occupying a 20cm diameter and 20 cm height of the lab scale reservoir. The sand pack is then connected to water reservoir which is located at height of 45.5cm from ground to enable the flow of water to push the trapped oil using gravitational force. Prior the known amount of local crude oil injection, the water has to be saturating the reservoir and the water breakthrough is recorded at 64s where the tracer is recorded by DAS at the outlet.The radiotracer used is Br-82 with activity of approximately 1mCi. The irradiation of NH4Br is carried out at RTP Nuclear Malaysia using *Pneumatic Transfer System* (PTS) facility for 3 minutes. Five (5) NaI scintillation detectors are also located at various places outside the reservoir to look at the anisotropic effect, the property of being directionally dependent, which implies different properties in different directions of Br-82.

The optimization of RTD model from radiotracer experiments will present the characterization of the reservoir such as unexpected anomalies in flow and verify suspected geological barrier or flow channels as well as provide information on sweep changes due to injection of various type of EOR flooding agents (polymer, chemical, surfactant) later.This is important knowledge in order to optimize the oil recovery. The present study shows that, the laboratory porous media represents perfect mixers in parallel model. The selection of this model is due to the minimum value of root mean square RMS which is $0.217e^{-8}$. The optimized parameters of the respective model are $\tau_{1=}$ 848, $\tau_{2\,=}$ 145, J_1 = 3.14, J2 = 3.18 and Q1/Q2 = 0.952. of This study is to leverage the potential of radiotracing technique, a method that is scarcely utilized in laboratory-scale waterflooding studies. It is able to analyze the reservoir behavior and the informations can be set and optimize a development plan for increasing the oil recovery efficiency for EOR application.

Keywords: radiotracer, water flooding, Enhanced Oil Recovery (EOR), sandstone reservoir

Natural Stable Isotopes To Detect Leakage In Mining Tailings Dams

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ABSTRACT

There is always some degree of leakage in all kinds of dam structures. If not surveilled these leaks may develop into larger channels and cause a severe risk to the environment downstream. In case the dam contains mining tailings, sludge or any other kind of solid waste, the damages that may be caused by an eventual rupture of the dam would be catastrophic, long reaching and lasting. A recent accident of large magnitude at an iron mining area in southeast Brazil has impacted the watershed down to 700 km away from the dam. It is estimated that over 100 tailings dams in the Brazilian province of Minas Gerais are liable to such accidents.

Artificial tracers, both radioactive and dyes have been used to detect leakage in dams, but they are subject to limitations; they may pinpoint the leak inside the dam but fail to estimate the amount as well as tell where and when to control the seeping locations downstream. Besides they require manipulation of radioactive stuff or chemicals in area of frequently difficult access.

The stable isotope technique for diagnosing dam leakage is based on the isotope fractionation attending water evaporation inside a dam. As water evaporates the isotope ratio of both hydrogen $\left({}^{2}\mathrm{H}/{}^{1}\mathrm{H}\right)$ and oxygen $\left({}^{18}\mathrm{O}/{}^{16}\mathrm{O}\right)$ is increased in the remaining water and deceases in the produced vapour. Given that the water pool retained inside tailings dam is characterized by large surface to volume ratios, evaporation is markedly enriched in both deuterium and ${}^{18}\mathrm{O}$ as compared to surface and groundwaters in the adjency of the dam. An increase in the above mentioned isotope ratios measured in water samples collected in the surroundings of the dam is an indication of leakage. The relative amount of enrichment in these samples indicates the magnitude of leakage. Due to the sensitivity of te measurements leaks can be detected at early stages and corrective actions can be implemented.

Isotope ratio measurements in water samples collected inside and around an abandoned gold mining tailings dam near the above mentioned ruptured dam. Samples were evaluated by both isotope ratio mass spectrometry (IRMS) and conventional chemical and geochemical water analyses. IRMS results show that the dam presents no leaks. The combined analysis of isotopic and hydrogeochemical parameters have revealed interesting interactions between the dam and the microwatershed in which it is inserted. It has also disclosed some of the alterations that the insertion of the dam has caused to the pristine water flow patterns in the watershed.

Tracer Class Combination for Interwell Tracer Tests – Joining Cost-effective Robustness to State-of-the-Art Selectivity

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ABSTRACT

Interwell tracer testing has been increasingly used in the oil and gas industry in the last years. Especially the requirement for multiple tracer tests within single reservoir and wells has led to the deployment of different classes of tracers. Mostly, halogenated, i.e. fluorinated or chlorinated, benzoic acids are used for this purpose, necessitating enhanced analytical strategies for accurate quantification. As a consequence of the involved multi-step sample pretreatment analytical accuracy is in many cases reduced while analysis costs per sample have increased.

The presented work describes the use of different tracer classes in single tracer injections to join the advantages of robust analytics to the required selectiveness. Besides the analytical capabilities of this approach its commercial impact is described and presented on the basis of an exhaustively tested oil reservoir, the 8. Tortonian horizon of the Matzen oil field in Austria.

INTRODUCTION

Interwell tracer testing in the oil and gas industry has been successfully used in the last decades and has significantly enhanced the quality of reservoir description and simulation [1]. Especially the rise of EOR techniques, which may lead to changes flow patterns as well as differing flow behavior, tracer testing has gained significance for project design and evaluation. This includes optimization of alkali surfactant floods [2] and evaluation of polymer flooding effects in heterogeneous reservoirs [3].

The increased demand for interwell tracer testing has necessitated the deployment of different tracer substances to permit simultaneous testing within interconnected patterns or even layer specific test evaluation. While tracer testing with halides or the pseudohalide thiocyanate (SCN^-) was widespread, the limited number of differing tracer substances in this tracer class led to the increasing deployment of halogenated benzoic acids (HBAs) as water tracers [4].

The application of HBAs dramatically increased the variety of applicable tracers and fulfilled the abovementioned requirements. The achievable detection limits are at least 3 orders of magnitude lower as for e.g. ion chromatography analysis of SCN^-. On the other hand, the required sample preparation routine for HBA quantification in produced oilfield waters leads to an overall decrease of accuracy, especially if compared to classic ion chromatography preceded solely by dilution to reduce matrix interference. In addition, the time consuming sample preparation leads to a significant increase in cost per analysis.

This presentation delineates the advantage of the approach to combine both mentioned classes, i.e. SCN^- and HBAs, to maintain the accuracy of ion chromatographic quantification while allowing to selectively assess different source wells or layers as tracer origin. Overall analysis cost could be significantly reduced compared to a benzoic acid approach, since usually the majority of samples need only to be analyzed for SCN^--content, respectively its absence.

ANALYTICAL STRATEGIES

Thiocyanate via ion chromatography

Thiocyanate can be reliably detected in produced oilfield waters by ion chromatography. The required sample preparation consists of filtration for removal of residual (free) oil and dilution for matrix adaption. By employing matrix matched standard solution for calibration, detection levels of 0.1 mg/l can be reliably achieved. The required sample amount for a measurement is usually around 0.5 ml, depending on vessel size for the ion chromatography.

Analysis of halogenated benzoic acid

Quantification of HBAs, which are usually deployed and quantified at concentrations levels three orders of magnitude lower than SCN^-, require a multi-step sample preparation protocol. The sample is de-oiled by filtration and adjusted to the required pH by addition of HCl. An aliquot (usually 100 to 500 ml, volume dependent on required preconcentration factor) is spiked with an internal standard for yield correction and subjected to a solid phase extraction procedure. This automatized step is required for analyte preconcentration and matrix elimination. To the resulting solution of analytes in organic solvent a derivatization agent is added and the mixture is heated for 1 h. The derivatized analytes are separated by gas chromatography and selectively quantified by mass spectrometric detection.

METHOD COMPARISON

In comparison with SCN^- analysis, HBA quantification yields limits of detection (LOD) approximately 3 orders of magnitude lower and appropriately reduced quantities employed. Accordingly, the resulting detected quantities, when related to the respective LOD, are similar. The significantly more sophisticated HBA analysis method, as described above, leads to higher analysis cost per sample and, due to the multi-step sample preparation procedure, higher result uncertainty. Especially the effectivities of the preconcentration and derivatization depend on the concentration of interfering residual organic compounds and may cause underestimation of HBA content or even false negatives. The application of an internal standard may remedy the situation, but introduces an additional handling step and potential error source. Overall, HBA tracer curves show a distinctly higher scattering than SCN^- based results.

Further to be considered are the analysis cost per sample, as, especially in course of interwell tracer tests in oil reservoirs, a part of the monitored wells may not show any tracer response. Accordingly, a significant amount of analyzed samples yields a negative result.

In summary, SCN^- based tracer tests yield results of reduced uncertainty at lower analysis cost, but lack the nowadays required capability for simultaneous application in a single reservoir or even different layers of single wells.

The presented dual approach combines the high accuracy of SCN^- analytics with the multi-tracer capability of HBA tracer testing, since the analytical variations of HBA quantification usually impacts all target analytes in a similar way. Thus, the assignment of the quantified SCN^- -fractions to different origins via HBA ratio yields lower result uncertainty than direct HBA analysis.

COMMERCIAL IMPACT OF DUAL APPROACH

Additional SCN^- injection in an HBA based tracer test has commercial impact at several stages of the project:

- The costs for chemicals are increased by the additionally required substance
- Injection costs may increase due to the additional volume, depending on available equipment
- Sampling costs are usually not affected, since SCN^- analysis does not require an additional vessel
- Analysis costs are decreased due to decreased per sample costs. Depending on the test layout, especially monitoring costs for of additional wells with uncertain response are significantly reduced.

FIELD STUDY: 8.TORTONIAN HORIZON, MATZEN FIELD, AUSTRIA

The impact of the dual tracer approach will be highlighted using data from the 8. Tortonian horizon in Matzen field, where in course of the last years multiple tracers were applied to determine changes in flow patterns. In course of these tests, single tracer applications of SCN- and HBA, as well as multi-tracer tests were applied.

KEYWORDS:

interwell tracer test, halides, halogenated benzoic acids

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Application of Tracer Techniques in Investigation of Leakage in Earthen Dam

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ABSTRACT

Dam is a construction work to store water in hydropower and irrigation reservoirs. Statistical reports on 900 cases of dam failures in the world (except China) of the International Commission on Large Dams showed that 66% of the failures occurred in earthen dams, in which almost a half (46%) was due to internal erosion. Although the monitoring systems were installed on the dams, from traditional techniques to modern techniques like using piezo tubes, or sensors of pressure, resistance and temperature, most of the leak cases were discovered by direct observation because to the initial leakage occurred in relatively narrow range compared with the control of the monitoring network. When the percolation leakage is founded, besides monitoring the progress of seepage flow by the measurement of flowrate and sediment load, the parameters such as permeability or hydraulic conductivity of the leakage and infiltration progresses over time are actually requirements to help assess the impact of the leakage phenomenon to the safety of the dam.

This paper presents the preliminary results of tracer technique applications in Ham Thuan Hydropower Dam to locate the leak point in the reservoir; to determine the transit time of leak flow, which are the important data for validation of numerical leakage model in assessment of dam safety in accordance to the National Standards.

Leaching of Oil/Water Partitioning Compounds from Immobile and Bypassed Oil in Porous Media

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ABSTRACT

The leaching process of Alkyl Phenols as oil/water partitioning compounds from immobile and bypassed oil to water phase in porous media was studied by theoretical and numerical models, as well as experimental studies to validate the method using natural partitioning compounds as tracers to estimate remaining oil in reservoir during water flooding recovery. The results of studies showed the reduction rate of Alkyl Phenols concentration in produced water depends on partitioning coefficients, remaining oil saturation, diffusion coefficients in oil and water phases and velocity of water in porous space. And, by using combination of the set of 3 Alkyl Phenols having different partitioning coefficients, the remaining oil saturation can be determined.

Tracer for determination of dispersion coefficient of water in core sample

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ABSTRACT

Dispersivity is one of rock characteristics which is useful for evaluation of mass transport of fluids in porous media. In oil and gas exploration, dispersivity is used in enhanced oil recovery calculations as well as in reservoir simulation models. Tracer technique is well known as the appropriate approach to evaluation of dispersivity in both field scale as well as in laboratory scale. The report presents the results of applying tracer technique to determine the longitudinal dispersivity of water in Kuwait core samples. A series of tracer experiments in pulse mode with different flow rates were conducted on core samples using HTO and FBAs as tracers. The dispersivity of water in core samples was then determined by matching the tracer concentration curve with the analytical solution of the solute transport equation.

Investigation of Structural Properties of Barrier Materials for Nuclear Waste Storage using Non-radioactive Tracers

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ABSTRACT

Non-radioactive tracers was used to investigate of structural behaviours of amino pyridine sulphonamide resin as a barrier material for nuclear waste deposition areas. The adsorption capacity of the barrier material differs for monovalent and divalent ions. Adsorption capacity for monovalent and divalent ions was found as 0.12g and 4.30g, respectively. Sorption isotherm models were applied to experimental equilibrium data to provide sufficient physicochemical information about mechanism properties. Dubinin-Radushkevich isotherm model were the best fit for the adsorption equilibrium data. Thermodynamic parameters, such as enthalpy of adsorption ΔH, free energy change ΔG and entropy change ΔS have been also calculated and interpreted. The positive value of enthalpy for cesium ions indicates that the interaction is an endothermic reaction which consumes energy and a negative enthalpy value for strontium ions indicates an exothermic nature which needs energy.

INTRODUCTION

Since the chemical behaviour of radioactive isotopes is almost the same as that of their natural stable counterparts, non-radioactive stable isotopes may be used to explain the interaction of some important barrier materials in nuclear waste management with radioactive waste and to examine their structural behaviour against such wastes. In this way, the effects of interaction between temperature and time-dependent nuclear waste and barrier materials can be examined (Putman, 1956).

Cesium and strontium radionuclides in radioactive waste are considered to be dangerous pollutants and their migration by groundwater is strongly affected by their adsorption on the geologic materials of nuclear waste deposition areas. Considering that cesium ($t_{1/2}$:30.1 y) and strontium ($t_{1/2}$:28.8 y) radionuclides have long half-lives, presence of radionuclides and toxic metals in wastes is a major environmental concern. Sorption processes of radionuclides help to understand prediction of their mobility (Ararem et al., 2013; Chen et al., 2016).

This work aims to investigate the ability of man-made barrier material to predict Cs and Sr mobility in aqueous solutions by testing the isotherm models, thermodynamic parameters and the diffusion parameters.

MATERIALS AND METHODS

Amino pyridine sulfonamide resin was used as a barrier material for simulated nuclear waste deposition area. Pure cesium nitrate and strontium nitrate (Merck) was used for adsorption experiments. Solutions of cesium and strontium were prepared by dissolving known quantities of cesium nitrate and strontium nitrate in distilled water. For pH adjustment of cesium and strontium solutions, the buffers of pH 4 and 8 were used for the calibration of pH meter. Solutions of HNO_3 and Na_2CO_3–$NaHCO_3$ were added for pH adjustment. 0.1 g barrier material in a polyethylene tube was interacted with 25 mL of non-radioactive tracer solution of known concentration in a flask at ambient temperature in a thermostated shaker water bath for a known period of time. After equilibration, solid and solution phases were separated by filtration using Whatman No. 40 filter paper. The cesium and strontium concentrations in solution were determined by ICP-OES (Perkin Elmer). The results are the average of at least duplicate independent measurements. Adsorption efficiencies (%) were calculated using mass balance equation.

RESULTS

According to the results, the adsorption of monovalent ions in the barrier material showed a low concentration and the adsorption efficiency remained constant with the increase in concentration. It has been observed that the adsorption capacity of the barrier material against monovalent ions is low. For the divalent ions of the same barrier material, a very high adsorption capacity is reached. Adsorption capacity for monovalent and divalent ions was found as 0.12 g and 4.30 g, respectively.

Sorption isotherms provide sufficient physicochemical information about mechanism properties and tendency of the adsorbent for target species by analysis of the experimental equilibrium data between the ion and solid surface. Adsorption equilibrium data were adapted to different adsorption isotherm models such as Langmuir, Freundlich, Dubinin-Radushkevich (D-R) and Temkin. The correlation coefficients (R^2) indicate the suitability of the adsorption data to the isotherms. According to the results, Dubinin-Radushkevich (D-R) (R^2=0.99) and Temkin (R^2=0.90) isotherms were found to be in good agreement for monovalent ions. For divalent ions, the regression coefficients obtained for all isotherm models were compared with the adsorption data of Langmuir (R^2 = 0.90) and Dubinin-Radushkevich (R^2 = 0.99) isotherm models.

Thermodynamic considerations of an adsorption process are necessary to conclude whether the process is spontaneous or not. Gibb's free energy change, ΔG°, is the fundamental criterion of spontaneity. Thermodynamic parameters such as enthalpy change (ΔH°), entropy change (ΔS°) and free energy change (ΔG°) were estimated using the related equations. The positive value of enthalpy for cesium ions indicates that the interaction is an endothermic reaction which consumes energy and a negative enthalpy value for strontium ions indicates an exothermic nature.

KEYWORDS:

nuclear waste, barrier material, sorption, isotherms, cesium, strontium.

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Thermodynamic Behaviors of Selenium Ions onto Barrier Material using Radiotracer Technique

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ABSTRACT

In this study, modified bentonite was used as man-made barrier systems to investigate occurring reactions with interaction of ^{79}Se with barrier material systems. Thermodynamic parameters of interaction between dominant ion species of selenium and modified bentonite depending on contact time were investigated. In the interaction between modified bentonite and selenium, enthalpy (ΔH), entropy (ΔS) and Gibbs free energy (ΔG) were found to have different behaviours depending on the contact time. The adsorption enthalpy changed from endothermic reaction to the exothermic reaction one hour after the interaction and endothermic reaction occurs after two hours interaction.

INTRODUCTION

For long-term storage of high level nuclear waste in geological repositories besides natural geologic barriers human made multiple-barrier systems are used to prevent dispersion of long-lived radioactive elements in waste to the surrounding environment in a probable accidental or unexpected situation. This type of barrier systems can stop long-lived radionuclides in waste before they arrive to earth’s surface even if they disperse to the environment and prevent reaching of groundwater to waste. Therefore, it is necessary to have good knowledge about probable reactions in material after interaction of radionuclides with human made barrier materials (Bruggeman et al., 2005; Grambow, 2008).

Selenium (Se) is a very long-lived fission products and is one of the important redox sensitive elements in nuclear waste. There is not so much information about interaction of ^{79}Se which are very long-lived fission products with barrier materials (Jordan et al., 2009; Chen et al., 1999).

This study was aimed to determine thermodynamic behaviours of ^{79}Se on a modified bentonite material. Thermodynamic parameters such as enthalpy ΔH, free energy change ΔG and entropy change ΔS of selenium adsorption were investigated from equilibrium adsorption data depending on contact time.

MATERIALS AND METHODS

The original selenium dioxide compound was irradiated in central irradiation tube of TRIGA Mark II nuclear reactor at Istanbul Technical University at 250 kW in 1 h. The stock solution of selenium(IV) (1780 mg/L) was prepared by dissolving appropriate amounts of irradiated selenium dioxide compound (SeO_2, Fluka, 99% purity) and used as radiotracer.

Batch experiments were carried out by using radioactive selenium solution satisfying liquid/solid ratio at different temperature and contact time. Data for thermodynamic studies were obtained by determination of ^{75}Se radioactivity at high resolution gamma spectrometry system. In the measurements, adjusting the statistical confidence level to 1σ raises the accuracy of results. Counting time can be applied as 30 min related to the expected activity. The area of the peak in a gamma spectrum is a measure of the interested isotope resulting from interaction of gamma-radiation of corresponding energy in the radiation detector. Peak areas of ^{75}Se at 136 keV gamma-rays in the spectrums are determined by using nuclear analysis software programs.

Calibration of gamma detection system is based on the rightly determination of net peak areas in the gamma-ray spectrum to the amounts of the elements present in the sample under studied experimental conditions. A standard point source such as ^{152}Eu is used in energy calibrations of the spectra.

In the adsorption process, the variation in thermodynamic parameters (ΔH, ΔS and ΔG) are very important to determine the spontaneity of adsorption process. ΔH, ΔS and ΔG parameters were obtained from adsorption experiment data in the temperature range of 273–323 K depending on time from 15 min to 240 min.

RESULTS

To investigate the effect of temperature, the sorption of Se(IV) ions onto modified bentonite was studied in the temperature range of 273–323 K. The adsorption of Se(IV) on modified bentonite increased with increasing temperature till one hour of contact time. This downtrend can be explained by the endothermic spontaneity of the Se(IV) adsorption. After one hour of contact time, the adsorption of Se(IV) on modified bentonite was decreased with increasing temperature by the exothermic spontaneity. Uptrend changed after 2 h of contact time which indicate that the Se(IV) adsorption process was endothermic.

A similar trend was observed for Gibbs free energy. The Gibbs free energy values, which are positive for short periods of time, turn to negative Gibbs free energy values as a result of the contact time of 45 min. After 3 hours of contact time, the Gibbs free energy value changes again to positive values.

KEYWORDS:

nuclear wastes, man-made barriers, modified bentonite, selenium, thermodynamic parameters.

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Non Target Monitoring Tracers and Emerging Tracers for Enhanced Reservoir, Well Integrity and Risk Management

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ABSTRACT

Since several decades, there is strong evidence that the climate and anthropogenic factors are responsible for the evolution of the components on Earth. Our resources are precious and limited. Especially in the case relative to the availability / the access, the treatment and the quality of waters are critical and submit to new regulations and social acceptance. New innovations and strategic developments in analytical sciences are commonly accepted as a perpetual source of innovations in order to provide reliable and useful research data and to address new challenge. For the present and future generations, the collection of a full high quality and representative data are the key of success to address any global and comprehensive resources management and risk assessment study linked to the environment quality decay. The current status of water quality strategy monitoring does not allow it.

The hot topic and last update research related to surface, sea, ballast, ground and produced waters are mainly focused on a few set of contaminants. But emerging contaminants, their relative byproducts, metabolites, natural trace element, their isotopes, nanoplastic/materials are all part of the memory and the history of water media. Unfortunately, there are any synergic approach, which is mixing high-end resolution mass spectrometry and elemental mass spectrometry. Our subject here, « having a nonspecific monitoring » is almost unique and even more if we are adding the specificity of Ion Mobility and HRMS technology and the quantitative selectivity of single particle ICPMS. The Challenge is real and it is offering a tremendous field of opportunities and new frontiers to discover at the ppt level. The objective is also to prevent any further trouble and to minimize the risk of missing and critical information. Direct and Real Time analysis will be now possible, and the sensitivity with adequate and automated sample preparation will solve the problems of transport or exportation of sensitive fluids.

CHEMICAL TRACERS

In the current tracing tests of oil reservoirs chemical tracers, such as fluorinated benzoic acids (FBAs), are broadly used as chemical water tracers to obtain a better description, model and understanding of the reservoir (fluid movements, velocities and heterogeneities), and inter-well connectivity before any EOR design. As an alternative to methods currently used by oil companies or sub-contractors, a direct and sensitive technique using a 2D UHPLC-HRIMS method was developed. The separation of all family of produced water tracers was achieved within 8 min using 10 to less than 125µl sample aliquot. A direct injection of salty reservoir water is either possible. The detection limit achieved here, is below 10 pg/mL.

If necessary and in case of high matrix or ultra-high salinity (above 40g/L) online or offline desalting and preconcentration could be added to the process for a cost of a couple of additional minutes and less than 1mL sample consumption. This novel method is more sensitive and efficient than the other available methods. Moreover, it does not require any chemical modification, large sample volumes or sample pre-concentration/purification as are currently used by sub-contractors. It is sufficiently robust to meet the requirements of chemical tracer campaigns and can minimize environmental impacts and operational costs. The novelty of such an approach is the high potential to achieve, in parallel, a complete non-specific screening of produced or condensate water with additional qualitative raw data for the reservoir engineer. A high quality and accurate set of data could be easily stored in silico. Then after critical events or for further studies, we will be able to re-extract data to explore new frontiers in time and within the chemical water memory.

The following part of this research work deals with emerging applications for the screening of tracers or biomarkers from producing wells such as fluorescent molecules or nanoparticles, direct analysis in real-time and identification and detection of ions from completion. A short overview will be provided of how state-of-the-art analytical chemistry leads the production optimization with a minimum water footprint and the understanding of inter-well integrity, connectivity and production allocation. In a multi-well tracing test, one of the key parameters is the selection of an appropriate tracer molecule and its relative analytical process regarding the local environmental and operational constraints. Many tests in the past have been unsuccessful due to improper tracer selection. The first part of this research work provides guideline and advices on to select or to define the best compromise in terms of tracers and its relative analytical methods.

TRENDS and NATURAL TRACERS

Since several decades, there is strong evidence that the climate and anthropogenic factors are responsible for the evolution of the components on Earth. Especially in the case relative to the availability / access, the treatment and the quality of waters are critical. New innovations and strategic developments in analytical sciences are commonly accepted as a perpetual source of innovations in order to provide reliable and useful research data and to address new challenge. For the present and future generation, the collection of a full high quality and representative data are the key of success to address any global and comprehensive risk assessment study linked to the environment quality decay. The current status of water monitoring strategy does not allow it.

Here, we will introduce an innovative and comprehensive study on water characterization with special focus on extreme high salinity media. We will introduce also accurate data and information on organic and inorganic natural or emerging tracers and their byproducts.

1, Non Target Monitoring Strategy of Natural Tracers, byproducts or other contaminants

2, Monitoring of Biomarkers in case of Fluid Allocation or Natural Attenuation in Geological Storage

3. Trends for Nano(material) and Single Particle Tracers Quantitative Monitoring

KEYWORDS: *Chemical & Natural Tracers, Biomarkers, Non Target Monitoring, Ion Mobility & High Resolution Mass Spectrometry, Water, High Salinity, Isotopic Dilution, SP-ICPMS.*

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Using Tracer Tests in the Management of Reinjection into Geothermal Systems

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ABSTRACT

Geothermal reinjection, which involves injecting energy-depleted fluid back into geothermal systems, is an integral part of modern, sustainable and environmentally friendly geothermal utilization projects. Reinjection counteracts production induced pressure draw-down and extracts more thermal energy from reservoir rocks, thus increasing production capacity of the geothermal systems involved, in most cases. Reinjection is essential for sustainable utilization of geothermal systems that are virtually closed, with limited natural fluid recharge. Cooling of production wells is one of the problems/obstacles associated with geothermal reinjection. This danger can be minimised through careful testing and research. Tracer testing, which plays an important role in geothermal research and management, in particular concerning heat-transfer efficiency in reinjection operations and EGS development, is the most important tool for this purpose. The methodology involves comprehensive interpretation and cooling predictions, which in turn are based on tracer-flow and reinjection modelling. Advances have been made in the introduction of new tracers, which both add to the multiplicity of high-sensitivity tracers available as well as being increasingly temperature tolerant. But the geothermal industry also needs to follow advances in other disciplines utilizing tracer technology.

INTRODUCTION

Geothermal resources are distributed throughout the Earth's crust with the greatest energy concentration associated with hydrothermal systems in volcanic regions at crustal plate boundaries. Yet exploitable geothermal resources may be found in most countries. Shallow thermal energy suitable for ground-source heat-pump utilization is available worldwide and attempts are underway at developing EGS-systems (enhanced, or engineered, geothermal systems) in places where limited permeability precludes natural hydrothermal activity. Geothermal systems are classified based on their nature and geological setting, in addition to classifications based on physical conditions (temperature, pressure, steam fraction) and energy content (fluid enthalpy). The three most common types of systems are [1]: volcanic systems, where heat sources are hot magma intrusions, convective fracture-controlled systems, where the heat source is hot crust at depth in tectonically active areas, and sedimentary systems that owe their existence to permeable sedimentary layers at great depths.

The energy production capacity of geothermal systems is predominantly determined by the pressure decline caused by production [2]. This is in turn mainly controlled by the production rate, the size of a system, its permeability structure, its boundary conditions and reinjection management adopted. The production capacity is also determined by the available energy content of the systems. Natural geothermal reservoirs can often be classified as either open or closed, depending on their boundary conditions, with drastically different long-term behaviour. Pressure declines continuously with time in systems that are closed, and their production capacity is limited by lack of water rather than lack of thermal energy. Most sedimentary geothermal systems are examples of this. Pressure stabilizes, however, in open systems as recharge eventually equilibrates with mass extraction. Reinjection is essential for the sustainable management of closed geothermal systems during utilization.

GEOTHERMAL REINJECTION

Geothermal reinjection involves returning some, or all, of the water produced from a geothermal reservoir back into the geothermal system, after energy has been extracted from it. In some instances, water of a different origin is even injected. Reinjection started out as a method of waste-water disposal in a few geothermal operations (ca. 1970) but it has slowly become widespread the last two decades. By now reinjection is considered an important part of comprehensive geothermal resource management as well as an essential part of sustainable and environmentally friendly geothermal utilisation [3]. Reinjection provides an additional recharge to geothermal reservoirs and as such counteracts pressure draw-down due to production and extracts more of the thermal energy from reservoir rocks than conventional utilization. Reinjection will, therefore, in most cases increase the production capacity of geothermal reservoirs. Without reinjection, the mass extraction, and hence energy production, would only be a part of what it is now in many geothermal fields. Reinjection is also a key part of all EGS operations.

Some operational dangers and problems are associated with reinjection. These include the possible cooling of production wells, often because of short-circuiting and cold-front breakthrough, and scaling in surface equipment and injection wells because of the precipitation of chemicals in the water. Injection into sandstone reservoirs has, furthermore, turned out to be problematic (due to well clogging). Because of this extensive testing and research are prerequisites to successful reinjection operations, including tracer testing.

TRACER TESTING IN GEOTHERMAL RESOURCE MANAGEMENT

Tracer testing has become a highly important tool in geothermal research and resource management, with its role being most significant in reinjection studies. This is because tracer tests provide information on the nature and properties of connections between reinjection and production wells, connections that control heat-transfer efficiency and the danger/rate of cooling of production wells during long-term reinjection. Enabling such cooling predictions is what distinguishes tracer tests in geothermal applications from tracer tests in ground water hydrology and related disciplines (surface hydrology, pollution studies, petroleum reservoir engineering and nuclear-waste studies). The power of tracer tests in reinjection studies lies in the fact that the thermal breakthrough time is usually several orders of magnitude (2–4) greater than the tracer breakthrough time, bestowing tracer tests with a predictive power.

Comprehensive interpretation of geothermal tracer test data, and consequent modelling for management purposes (production well cooling predictions), has been rather limited, even though tracer tests have been used extensively. Their interpretation has mostly been qualitative. A simple and efficient method has been developed for this purpose, based on the assumption of specific one-dimensional flow channels connecting injection and production wells [4]. The interpretation method involves simulating (inverting) tracer return data with the simulation yielding information on the flow channel cross-sectional area and dispersivity, as well as the mass of tracer recovered through a given channel (0–100%). Consequently the model is used to predict thermal breakthrough and temperature decline during long-term reinjection. Yet, the properties of the flow-channels involved are not uniquely determined by the flow-path pore-space volume, as the heat transfer (cooling/heating) mainly depends on the surface area and porosity of the flow-channels, requiring some additional constraints.

Advances have been made in the introduction of new tracers for geothermal applications, which both add to the multiplicity of high-sensitivity tracers available as well as being increasingly temperature tolerant. But the geothermal industry needs to follow advances in other disciplines and adopt those beneficial. This applies, in particular, to advances in modelling of tracer return data, which has been limited so far, especially modelling of reactive tracer data, which can yield information on flow-channel surface areas in addition to their volumes.

KEYWORDS:

geothermal, reinjection, cooling, tracer test, modelling

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Use of radioactive tracers and nucleonic gauges to solve problems related to sediment transport in dam's channels and the origin of stagnant water in some dam's plots faced by the INGA site.

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ABSTRACT

The site of INGA offers the opportunity of construction of a series of connected dams capable to produce 45.050 MW. Till today only two connected dams have been constructed namely Inga I and II. Inga III project is still in progress. This paper presents the challenge of sediment transport in channels of intakes water for turning turbines and stagnant water in some dam's plots faced by INGA site and the use of radiotracers and nucleonic gauges to solve those problems.

KEYWORDS:

sediment transport, stagnant water, radiotracers, nucleonic gauges

SESSION 4

METHODOLOGY, THEORY, MODELING, SIMULATION

15

ABSTRACTS

Performance Assessment of Dynamic Systems using Analytic Solution

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ABSTRACT

This paper focuses on residence time distribution (RTD) radiation signal modeling and treatment. Therefore, implicit solutions of RTD radiation models are proposed by Maple 18. Also, explicit analysis is introduced. Thus, block diagram modeling of RTD through Matlab Simulink is implemented. These models are perfect mixers in series, perfect mixers in series with exchange and perfect mixers in parallel models. The proposed models are used to implement the behavior of the RTD with different values of performance parameters such as Peklet number, mean residence time, total volume, flow rate and number of mixers. The parameters tuning are of primary concern to enhance the performance of the RTD. Efficiency measurements algorithms are studied and evaluated. Hence, the geometric efficiency and total intrinsic photopeak efficiency are considered. Furthermore, the RTD signal de-noising of 99Mo is performed by complex wavelet transform. Moreover, I-moment of RTD radiation signal is determined. Thus, the mean residence time is evaluated. Consequently, the mean residence time is simply calculated. The accuracy of the underlined algorithm is evaluated through statistical measurements. The obtained results confirm the applicability of RTD measurements for industrial purposes.

THE PROPOSED RTD MODELING

The perfect mixer model has been extensively used to characterize and simulate grinding processes. This is due to its simple conceptual representation and suitable mathematical treatment [20]. Here, two different mathematical models are introduced. The first model depends on the analytic solution of this model differential equation. The perfect mixers in series model are composed of perfect mixing tanks connected in series as shown in Fig. 1 [2]. This model can be described by [4]

$$\frac{dC}{dt} = \frac{JQ}{V}\left(C_p - C\right) \qquad (1)$$

where J, Q, V, C_p denote the number of mixers, flow rate, tank volume and previous concentration in the tank, respectively. The solution of previous equation represents the tracer at the system output. The solution of Eq. 1 is based on Laplace transform. Therefore, the laplace transform method was applied. Then, the following equation as a function in s-domain is stated as

$$C = \frac{QJC_p}{s\left(Vs + QJ\right)} \qquad (2)$$

Then, inverse Laplace is applied that leads to the following RTD function in time domain.

$$C = 2C_p e^{-\frac{QJt}{2V}} \sinh\left(\frac{QJt}{2V}\right) \qquad (3)$$

However, the second model depends on general integration mathematical solution. This solution leads to the following RTD function in time domain at the output of the system.

$$C = C_p\left(1 - e^{-\frac{QJt}{V}}\right) \qquad (4)$$

This equation describes the radiotracer at the output of the system. However, an implicit solution describing the RTD at the output of the system is introduced. This solution depends on Matlab Simulink. It is a graphical user interface (GUI) model that helps in understanding the physical behaviors of RTD signal. This model methodology helps user and scientists to optimize their work. Therefore, block diagram model for perfect mixers in series is introduced as shown in Fig. 2. This model has the advantage of its simplicity and can be compared to the IAEA software.

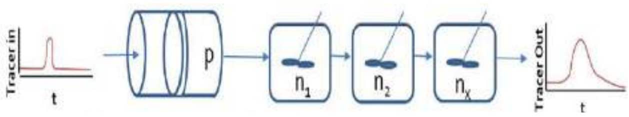

Fig. 1 Perfect mixers in series model [2]

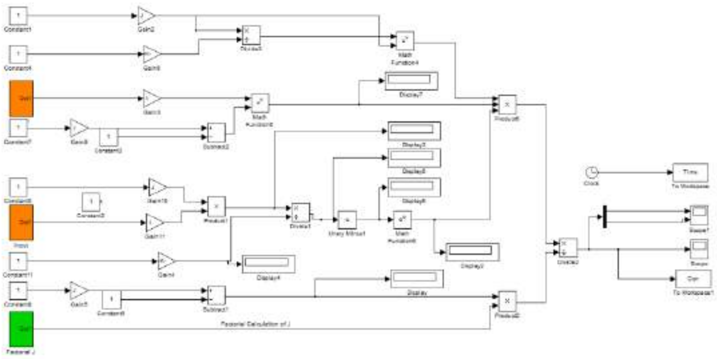

Fig. 2 The proposed block diagram model of perfect mixers in series model

EFFICIENCY MEASUREMENT OF ACQUIRED RADIATION SIGNAL

The intrinsic photopeak efficiency is related to full energy peak region of interest. An algorithm for intrinsic photopeak efficiency is illustrated in Fig. 3. The intrinsic photopeak efficiency is described by

$$\varepsilon_p = \frac{C_p}{N_\gamma} \times 100\% \qquad (12)$$

where C_p and N_γ denote the number of counts in the photopeak corresponding to energy per unit time and the fractional number of γ-rays emitted per disintegration, respectively. However, this efficiency derived from the standard absorption formula.

$$\varepsilon_{\text{int}} = 1\text{-}e^{\mu\rho x} \qquad (13)$$

where μ, ρ and x are photoelectric mass attenuation coefficient, the density and thickness of the sensitive detector material, respectively.

- **Acquire Radiation Signal From Radioisotopes**
- **Analyze the Input Signals**
- **Count Total Number of Counts at the Full Peak**
- **Determine the Emission Probability Constant of the Isotope**
- **Count Total Number of Counts from the Isotope**
- **Compute Photopeak Efficiency**

Fig. 3 Intrinsic photopeak efficiency algorithm

RESULTS AND conclusion

This paper presents the analysis of RTD radiation signal. Hence, the evaluation of radiotracer concentration based on explicit and implicit solution is presented. Explicit solution by Maple 18 is introduced. Therefore, a closed form expression for radiotracer concentration is introduced. Moreover, an implicit solution through Matlab Simulink is investigated. These proposed models describe the perfect mixers in series, perfect mixers in series with exchange and perfect mixers in parallel models. We observed that flow rate, number of mixers and tank volume changes the behaviors of radiotracer concentration. Also, efficiency measurement of detection system is computed. It is based on the detection geometry efficiency and total intrinsic efficiency. Furthermore, the handling of RTD radiation signal is considered. The RTD signal de-noising by CWT is studied. Evaluation of this method is considered by statistical measurements. Also, the moment calculation using both probability of weighted moments and coefficients of shifted Legendre polynomial is introduced. The first moment calculation is found to be 193.5895. On other hand, the mean residence time is equivalent to the first moment. It is found to be 193.5895sec. The obtained results confirm the accuracy of proposed models for analysis and evaluation of RTD signal.

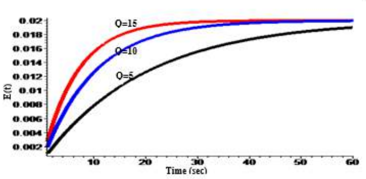

Fig. 12 The radiotracer concentration with time at different flow rate with J=10 and V=1000L

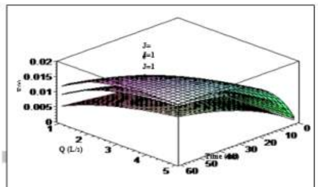

Fig. 13 The radiotracer concentration with time and flow rate at different mixers numbers with V=1000L

Keywords: Perfect mixers, plug flow, mineral processing, RTD Modelling

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Some thermodynamic aspects of tracer plumes evolving in natural streams at "dynamic equilibrium"

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ABSTRACT

The tracer injections, evolving into the natural channels for the effects of fluvial studies, are open thermodynamic systems, developing in complex and irreversible environments, and therefore participating in certain general and specific characteristics of this type of phenomena. The author has previously presented the definition of a function of state, Φ *(t)* that guides the physical evolution of this type of phenomena, so it is interesting to advance a discussion on the thermodynamic characteristics of the process from this function.

On the other hand, the tracer plume is itself a disturbance that advances in a larger environment which is the section of the channel under study, which can be considered for practical purposes that is in a "stable state" (i.e: "dynamic equilibrium"). If geometry and geomorphology do not show appreciable changes. In this way, since thermodynamics is a science of the general, there must be a certain coupling between what the function Φ (t) expresses, and the probabilistic conditions of the channel section. This approach can provide new information both to the evolution of the tracer, and to the evolution of the channel itself.

This article briefly reviews some characteristics of turbulence that are applicable to the subject under discussion, especially those defined in the extensive study conducted by I. Prigogine and L. Leopold in Europe and the USA. [1][2]

1 A MODERN VIEW OF TURBULENCE

Turbulence has been stated as one of the great challenges of all times, this in that, although its transition from the laminar movement (regular movement) to more heterogeneous states is well known, the mathematical description of the latter has been extraordinarily complex and diverse. It has long been known that turbulence begins when the kinetic effect of the flow exceeds the action of viscosity (instability), and from there it was assumed that there was a harmonic coupling (sum) of frequencies indefinitely, but experiments in 1970 showed that the effect disappeared very soon and the power spectrum became chaotic. [3] The truth is that the turbulence appears if the average speed of the fluid increases to a certain value, and from there it develops completely.
Although many relationships have subsequently been proposed that explain isolated facets of the turbulent movement, a plausible explanation of the very background of the problem has been posed from the thermodynamics of non-equilibrium, especially by I. Prigogine. [4]

An unequivocal aspect of the turbulence is that from a human perspective (macroscopic) appear "ordered" movements - not random in the traditional sense - consisting of unrepeatable fillets that meander at all levels, which implies a certain physical coherence of large amounts of particles. This type of formation is explained as "long-range fluctuations" (and of short duration) that appear in irreversible processes close to equilibrium. Its effect is measured by the so-called "exponent of Liapunov", λ, which measures how fast two trajectories that start at the same point diverge drastically (which is the so-called "butterfly effect" or critical sensitivity to initial conditions). This exponent depends on the magnitude of irreversible production of entropy, σ. [5]

$$\lambda \sim \sigma = \frac{dSi}{dt} \qquad (1)$$

Prigogine thus explains the appearance of turbulence as a general, observable, macroscopic phenomenon. However, the same effect of chaotic divergence appears with equal or greater preponderance at the microscopic level, while the potential forces (non-integrable) that bind the particles are degraded (causing the molecular correlations to be destroyed) destroying the concept of "trajectory" ", That is, making them diverge until they lose their own identity. This effect is mathematically described by means of a quadratic diffusion operator, that is, by a kind of Brownian movement. [6]

$$\lambda \sim \frac{\partial^2}{\partial X^2} \tag{2}$$

2 BROWNIAN MOTION AS A FRACTAL

Einstein defined in his pioneering work on the Brownian movement the mean longitudinal displacement, Δ of a few molecules that through a totally arbitrary effect (thermal motion) transgress a given limit in a time, τ, resulting from a process of counting the particles that pass through the limit.

$$\Delta \approx \sqrt{2 * D * \tau} \tag{3}$$

These displacements are, by the nature of the author's analysis, thermal (microscopic). However, this type of movement is a fractal, that is, it is self-similar at larger scales. One of these scales is, of course, that of a human observer looking at the tracer pen. In this case equation (3) is therefore valid but with different meaning. Δ and τ will be macroscopic measurements, estimated on the inflection points of the Fickian curve and will be due not to a thermal effect but to a chemical imbalance.

In this way, the thermodynamics of the non-equilibrium gives a macroscopic and microscopic view of the Brownian movement, compatible with each other, and congruent with a single effect of divergence.

$$\lambda \sim \frac{\partial^2}{\partial X^2} \sim \sqrt{2 * D * \tau} \tag{4}$$

3 A STATE FUNCTION THAT GUIDES THE TRACER DYNAMICS.

A tracer injection to a turbulent flow will generate a sudden increase in concentration, inducing a Le Chatelier-Braun reaction. This effect can be seen as the mutual distancing tendency of the particles, which is attenuated once the lost chemical equilibrium is restored. You can define a function that reflects this effect by the ratio of two speeds: The speed of mutual separation of the particles and the average speed of the flow

$$\Phi(t) = \frac{Vsep}{U} \approx \frac{\left(\frac{\Delta}{\tau}\right)}{U} \approx \frac{\left(\frac{\sqrt{2*D*\tau}}{\tau}\right)}{U} \tag{5}$$

It can be verified that this function describes the thermodynamic state of the pen, because:

$$\oint d\Phi = 0 \tag{6}$$

But you can also establish that:

$$\lambda \sim f(\Phi) \tag{7}$$

And, in “stable state” of the stream, this relationship may be applied to *all* flow.

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Utilization of Efficient Signal Processing Techniques for Sealed Sources Radioisotopes Identification

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BACKGROUND

For multi-phase system analysis, more than one radioisotope can be used and the result is a mixture of radioisotopes signals. The problem is in such cases is how to separate these signals from each other. Before, we presented a successful separation method based on the principle component analysis for separating Tc^{99m} and Ba^{137m} mixed two radiotracers [1]. In this work we proposed an approach for identification of some sealed sources radioisotopes using signal processing techniques-based algorithm. The objective of this paper is the determination of the number and energy of the photons emitted by the source in order to identify the unknown radioisotopes.

METHODOLOGY

This paper proposed an approach for discriminating the gamma radiation pulses in order to identify the unknown radioisotopes. Gamma ray spectrometer with NAI detector and gamma spectroscopy multichannel analyzer have been used for collecting the gamma signals. A set of radioisotopes point source contains Co^{60}, Co^{57}, Ba^{133}, Cs^{137}, Mn^{54}, Na^{22} and Cd^{109} have been used for training and testing the proposed approach. Survey meter and calibration tool kit have been used for manual reporting the exposure and the activity of each source. The output gamma pulse has been applied on a signal processing technique for extracting a the most important features. The extracted features fed the Artificial Neural Network (ANN) classifiers for the identification purpose.

RESULTS

The below table shows the overall identification rate for each radioisotope. The results confirm the ability of the proposed method in discriminating gamma signals and it achieved high identification rates.

Source	Activity (Bq)	Exposure (μSv/h)	Identification Rate (%)
Co^{60}	3300	13	99.17
Co^{57}	230	0.6	98.25
Ba^{133}	721	721	98.78
Cd^{109}	325	0.1	97.94
Cs^{137}	1025	2.2	98.75
Mn^{54}	355	7.5	99.03
Na^{22}	2500	7.5	99.11

CONCLUSION

This work has been carried out for the purpose of sealed sources radioisotopes identification using signal processing techniques and ANN. The results show that high identification rates can be obtained for different radioisotopes sources.

KEYWORDS:

Sealed Sources, Radioisotopes Identification, Artificial Neural Network

ACKNOWLEDGMENTS

This work supported by Egyptian Atomic Energy Authority and International Atomic Energy Agency

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Review of the International Standard ISO 2975 on Tracer methods for the measurement of single-phase flows in closed conduits.

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ABSTRACT

Flow rate measurement is the most applied radiotracer method for online calibration and mass balance control in industrial processing. Better than 1-2% accuracy is achievable.

ISO Standards for measurements of fluid flows with tracer methods drafted years ago have been as follows:

- ISO 2975 Measurement of water flow in closed conduits-Tracer methods, which consists of 7 parts, some of them never applied and others became obsolete.
- ISO 4053 Measurement of gas flow in conduits -Tracer methods, which has been withdrawn for unknown reasons in 2003 leaving a void on this subject.

It is due time to review the existing ISO 2975, in the light of new development in radiotracer methods and industrial processing market.

The Sub Committee (SC) 5 of Technical Committee (TC) 30 of International Standardization Organization (ISO) - shortly: ISO/TC 30/SC 5 - is responsible for periodically reviewing ISO standard in the field of fluid flow measurements. Currently, the SC5 consists of 25 P member states and 11 observing member states (O-members).

Every five years the ISO TC30 SC5 initiates a so-called systematic review of each ISO standard. The last one for the ISO 2975 standard was carried out in 2018.

American Society of Mechanical Engineers (ASME) has adopted the American National Standard MFC-13M – 2006, which merges both ISO 2975 and ISO 4035. This Standard defines the terms and principles needed for intelligent consideration of tracer methods for any application, it can be serving as a good model for reviewing the ISO 2975.

The International Atomic Energy Agency (IAEA) and the International Society of Tracer and Radiation Applications (ISTRA) invites experts from all over the world to participate in the reviewing process of the existing ISO standards, formulating a more comprehensive, simple and universal ISO standard in this field. The new Standard on tracer methods for the measurement of single-phase fluid (gas or liquid) flows in closed conduits, will respond to the demand of industrial end-users.

Recent status of Industrial Application using radioisotope in Korea

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ABSTRACT

Today radioisotope techniques are used extensively throughout the world for troubleshooting an optimization of industrial process plants. Radioisotope techniques are very competitive and they are largely applied for troubleshooting and a process analysis of technical complexes, for continuously operating industrial plants. The success of this application is attributed to its unique ability to provide information which otherwise cannot be obtained by alternate techniques. The radioisotope techniques includes radiotracer and sealed sources application for process diagnosis. Traditionally, radioisotopes in an industrial sector have played a unique role as a tracer, helping engineers diagnose their process plants without posing any interference. This is very important because tracers are the only way to obtain information regarding dynamic details on process units. Most of the radiotracers emit gamma radiation that is intensive enough to penetrate steel walls and insulators of process units under study. Their chemical and physical status should be compatible with those of the process flow to be traced because tracers are supposed to represent the movement of process materials as its definition. Radioisotopes to be used as tracers can be produced from research nuclear reactors or particle accelerators, but when no facilities are available for production, radiopharmaceutical portable radionuclide generators can be good alternatives.

Recently, radiotracer experiments have been carried out to measure the residence time distribution of fuel and raw material mixers in sintering process of steelworks. The mixer is 4 meters in diameter and 18 meters in length, and about 160 tons of fuel and raw material remain inside. As a radiotracer, Ga-68 was eluted from the Ge/Ga generator. 2 inch NaI detectors were installed at the input and output of the mixers. The residence time was measured while changing the feed rate of fuel and raw material. Mean residence time of 1^{st} mixer and 2^{nd} mixer is 165sec and 185 sec, respectively. However, no change was observed with feed rate.

One of the most widely used sealed source application is column scanning. This is a technique used to carry out an internal inspection of any process equipment, without interrupting its production. A collimated beam of penetrating gamma rays is allowed to pass through the shell of a column, which is then modified by the column internals and emitted out the other side. By measuring the intensity of the transmitted radiation, valuable information can be obtained about the densities of the materials present inside the column. The higher the density of the material, the lesser the amount of radiation that gets through.

A new automatic column scanner has been developed for more precise measurement. By replacing the single channel analyzer based radiation measurement board with a multi channel analyzer based measurement board, the spectral measurement of gamma radiation is possible. In addition, the positions of source and detector can be corrected in real time by changing the step motors to servo motors. In order to evaluate the performance of the newly developed column scanner, the vertical density distribution was measured on a 50 meter of tray column of an oil refinery. 90mCi of Co-60 was used as the radiation source. The vertical scan interval was 5cm and the counting time was 5 sec each step. The positions of source and detector were strategically determined in such a way that downcomers were not placed in the passage of the radiation in order to get straightforward interpretation from the measurements. The minimum values at each tray were almost consistence over the scan ranges, which means the source and the detector were kept at the same levels throughout the scanning. Every tray was identified simply by comparing with the drawing of the column.

KEYWORDS:

Radioisotope, column scanning, radioactive tracer

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Simulations for Industrial Radiotracers Experiments

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ABSTRACT

Computer simulations offer great advantages to industrial radiotracer technology. Simulations can be used to assess radiation safety by calculating the radiation dose distribution before performing a radiotracer investigation. Another valuable use of the simulations is that they can be used to understand the expected behaviour of the radiotracer in a certain experiment to enhance the practice and result in more reliable results. The simulations give a sense to the user of how each parameter of the experiment could affect the results; giving them the ability to optimize the current methods and evaluate new approaches and methods.

Moreover, computer simulations can be used to train the practitioners or educate the students where the radioactive materials are not available or an acceptable understanding of safe practice still to be reached. In this work, simulation setups for industrial radiotracers are developed and the name Virtual Laboratory is used to describe the simulation workspace.

GATE (Geant4 Application for Tomographic Emission) is an open source Monte Carlo simulation toolkit that was developed in 2004 for the use of simulating tomographic emission imagining devices. Since then it has been updated and new packages were added to it increasing the field of application where it can be used. GATE uses a macro language to write the codes instead of C++, the build language for Geant4. The macro language makes GATE easier to use without the knowledge of C++. The current use of GATE is in the medical imaging field (both using an external and internal source) [1,2], dosimetry [3,4,5], radiotherapy (using photons and charged particles) and newly added feature of optical imaging.

Using GATE, we developed a predefined experiment setup within the simulation toolkit that will be used for two important experiments used in the industry that require radioactive tracers namely, detection efficiency and flow rate measurement. In each experiment there are few parameters that can be changed. To ensure the simulation is user-friendly, for each experiment the parameters will be in a separate file where the user can edit it while keeping the simplicity of the overall simulations.

The first simulation was built to calculate the detector's sensitivity. The experiment setup was built by placing a detector 5 cm away from a pipe that contains a flow with a radiotracer. The detector is left for a specific time to collect counts from which it would be possible to calculate the detector's sensitivity. In this experiment, the user can change the radioactive tracer, the fluid within the pipe, the pipe properties, and detector material.

The second simulation is made for calculating the flow rate. A radioactive tracer is injected into the pipe and two detectors are placed on the surface of the pipe with a given distance apart. As the fluid with the radioactive tracer passes through the pipe, the first detector will start collecting counts while the other detector

receiving little to no signal. When the fluid moves towards the second detector, the first detector will start losing counts while the second detector starts accumulating counts. By plotting the results against time, two peaks will be visible; one when the radioactive tracer was at the first detector and the second when the tracer was at the second detector. From the signal peaks, the times at which the tracer arrived at each detector will be calculated, which will be used with cross-sectional flow area and the distance between the detectors to calculate the flow rate.

The radiotracer experiments simulations in the developed virtual laboratory gave robust results that are encouraging to use the laboratory in the education of undergraduate students at the Department of Nuclear Engineering. The work is ongoing to improve the workspace and simulate more advanced experiments.

KEYWORDS:

gate, simulation, industrial-radiotracer.

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Significance of Quality Management Systems in Tracer Services to Industry

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ABSTRACT

Tracer applications (radiotracer and sealed sources technology) have gained wide interest as non-destructive and non-invasive tools for online diagnosis of process malfunctioning, optimization and predictive maintenance for industrial processes. The services offered to industry are, at present, provide by organizations and individuals that are not accredited and certified respectively. This has tended to decrease the trust that companies have in the providers. In order to enhance the confidence by industry on the use this technology (product), both service providers are required to establish a quality management system and adhere to set standards. For organizations, accreditation to ISO/IEC 17020 standard by a competent body is key. For individuals, certification in a scheme managed by an ISO/IEC 17024 accredited certifier would suffice. Both elements are aimed at demonstrating the technical competence and promoting confidence in the results of their work. A quality management system (QMS) is a collection of business processes focused on consistently meeting customer requirements and enhancing their satisfaction. It is aligned with an organization's purpose and strategic direction. Quality management methods have a common goal - to deliver a high quality product or service. Quality management is essential to create superior quality products which not only meet but also exceed customer satisfaction. Accreditation is a formal means of determining the technical competence of inspection organizations to perform specific types of inspection. Accreditation provides a ready means for customers to identify and select reliable inspection services, suitable for their needs. Therefore, the need for inspection bodies applying the technology to establish quality management systems and the means of achieving this is discussed in this paper. It also provides a guide on how personnel certification by an accredited certification body can be implemented. It is imperative that the International Society for Tracers and Radiation Applications (ISTRA) is accredited as a certifier based on ISO/IEC 17024 international Standards. Global competition and more demanding customers forced enterprises to continuously improve the quality of operations and business. For this reason quality is indispensable issue of theory and practice

KEYWORDS

quality management, accreditation, certification, competitiveness, tracers.

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Numerical RTD as a tool for compartmental modeling of water basin

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ABSTRACT

The settling of particles in water basin occurs in numerous industrial systems working with impaired, waste or natural (surface or sea) waters. This settling phenomenon could either be beneficial or detrimental depending on the industrial process (stabilization pond, feed and rejection channels, water treatment plants, industrial cooling circuits, etc.). Since hydrodynamic conditions strongly impact physical-chemical phenomena such as suspended matter sedimentation and deposition or precipitation, an accurate evaluation of hydrodynamic behavior is required to apprehend and mitigate industrial depositions.

This study aims at presenting the construction method of a compartmental modeling approach of settling phenomenon in water basins and particularly the influence of hydrodynamics in the suspended matters deposition. Information about the reactor from both systemic and local approach allows providing a complete hybrid model. One of the most useful tools for compartmental model construction is the Residence Time Distribution (RTD). Tracing and RTD curves allow systemic scale characterization of the system and validation of the final compartmental model.

MODELING APPROACH

The modeling of all the phenomena in complex reactors is a scientific and numerical challenge. Two ways are commonly used to model hydrodynamics in industrial systems: on one hand the systemic approach [1], on the other hand the local approach; i.e. Computational Fluid Dynamics (CFD) [2]. A most recent one called compartmental approach combines information from both local and systemic approach to spatially divide the complex reactor into a network of compartments [3]. Compartmental modeling approach facilitates the simulation of complex coupled phenomena. The compartment network is representative of the system geometry and the spatial distributions of occurring phenomena such as: fluid dynamics, chemical reactions, biological reactions, transport phenomena, transfer phenomena, shear-induced physical processes (e.g. agglomeration, breakage, coalescence), etc. Compartmental approaches are based on a multi-scale description of the system fluid dynamics behavior. They aggregate local information about fluid dynamics from CFD simulations and local measurements. They also use data from system scale calculation and system scale experimental characterizations. The system division into compartments is done considering chosen compartment construction criterion.

The developed methodology consists in applying an iterative approach starting with phenomena analysis (determination of characteristics times and lengths) in order to select the relevant hydrodynamics quantities to studied phenomena. Thanks to a preliminary study, model objectives and phenomena of interest are identified. Then, the model construction parameters can be selected to define the different compartments. Geometry meshing and CFD simulations provide fields and scalar analysis of such quantities in order to refine calculations if required. For example, the Residence Time Distribution (RTD) gives information on the overall particles and chemical compounds residence time in the system, the turbulence intensity on the local mixing, or the influence of shear rate on the mass-transfer with interfaces, either gas-liquid (water surface) or solid-liquid (walls).

In this study, the methodology is applied on a cooling tower basin, with a focus on the modeling hypotheses (e.g. turbulence model, characteristics lengths) and the way to evaluate the RTD, for example using scalar transport or particle tracking. Finally, the obtained compartmental model network is reproduced in DTS® software to compare and validate the DTS curves.

RESULTS

The local study of particles settling in the water basin can be done by calculating local parameters. Using the equations of the motion of a single particle in a fluid, it is possible to calculate the vertical component of a settling particle. The vertical component of the particle velocity can be compared with the horizontal component of the horizontal flow velocity to infer the intensity of the settling phenomenon: the settling number Sn is set as the ratio between these two velocities.

Using CFD simulations of the hydraulics quantities, it is possible to divide the water basin in different zones according to the settling number values: the mains central zone where the particle is driven by the flow and two recirculation zones, at the opposite of the outlet harnessing and behind the access arm to the basin, where the particle could settle.

The computation of numerical RTD gives systemic information of the basin. The analysis of the RTD curve shape leads to the proposition of a network of ideal reactors to complete the compartments definition. Each zone can be divided in a network of well-known reactors and it allows the calculation of the different fluxes between the compartments.

Finally the obtained compartmental model RTD is computed with RTD software (DTS Pro 4.5) and compared with the RTD curve simulated by CFD method in order to validate the model.

The compartmental model structure is finally obtained by coupling the information from local and systemic approach. The *Figure 1* presents a possible division in compartments of a horizontal slice of basin.

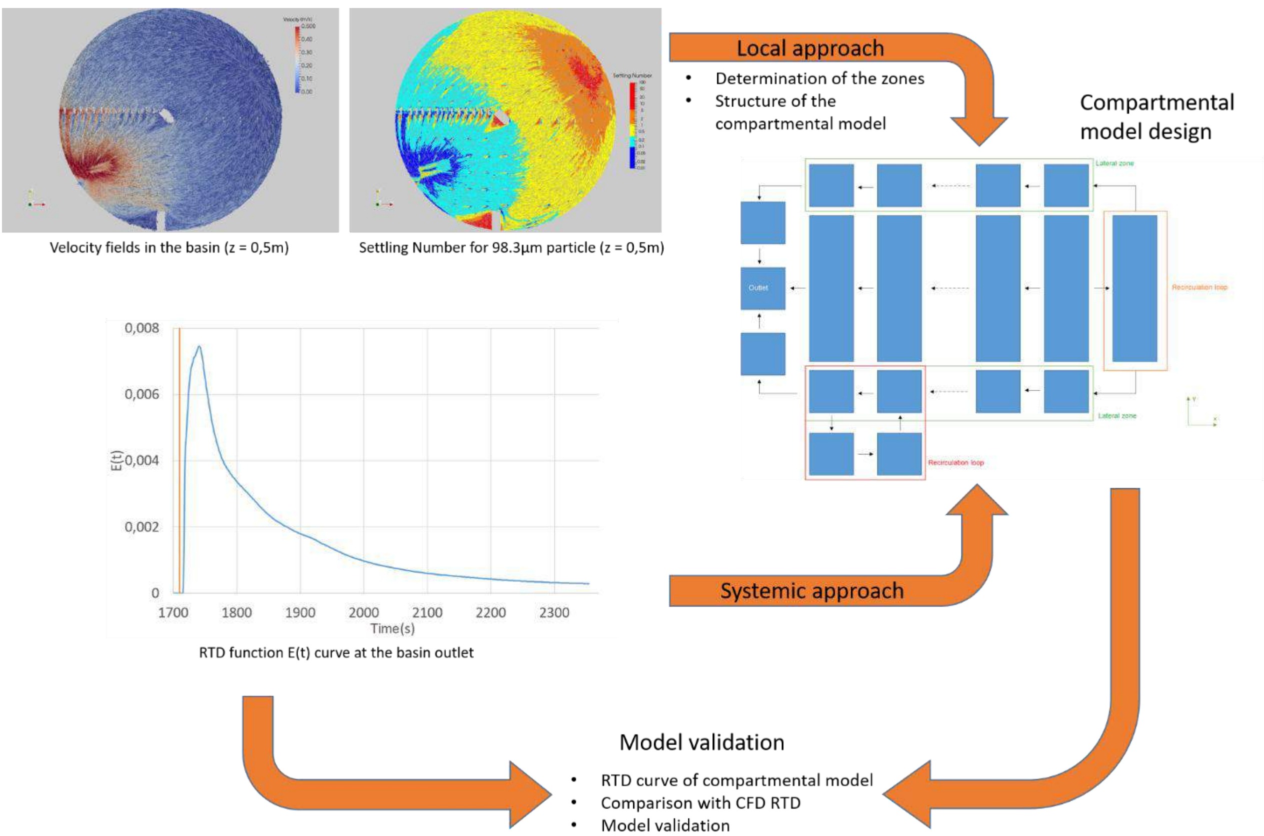

Figure 1: Construction of the compartmental model

KEYWORDS:

Compartmental modeling, settling, water basin, Computational Fluid Dynamics, Residence Time Distribution

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Comparison between Potassium Bromide and Lithium Chloride as feasible tracer for assessing hydraulic performance in anaerobic digesters

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ABSTRACT

The understanding of the hydrodynamic behaviour of the municipal anaerobic digesters presents difficulties related to the large reaction volumes and therefore, limitations on its accessibility, instrumentation and control operation. For this reason, tracer tests applied to digesters have more interest than in other process unit. The optimization of mixing for its correct performance raises some questions among which stands: how can we quantify the mixing degree? What is the most appropriate way to quantify dead volumes? A full-scale tracer test was carried out using two commercial products as tracers, Lithium Chloride (LiCl) and potassium Bromide (KBr), to characterize the hydraulic performance inside an anaerobic digester tank of the wastewater treatment plant and to validate a full-scale CFD model. An exhaustive sampling campaign was conducted specially during the initial time of the experiment where defects of the fluid behavior such us short-circuiting, mixing or stratification can be detected easier. Moreover, a tracer adsorption test was carried out for 21 days under different conditions to ensure the suitability of the tracers. The Residence Time Distribution (RTD) was obtained for 76 days where the mean residence time and the dead volume of the digester tank was calculated from both tracers. They presented very similar results. The study revealed that KBr is a reliable tracer for assessing hydraulic performance which allows validating CFD models in anaerobic digesters and it is more cost-effective than LiCl. Once validated, CFD is a sophisticated simulation tool that allows to reproduce the fluid behavior inside large volumes.

INTRODUCTION

Anaerobic digestion has become one of the most profitable treatments for the stabilization of the sludge in the past years. Mostly, the hydraulic retention time (HRT) and the state of the mixture inside the tank are relatively poorly understood in the daily operation, being complicated to propose improvements in the design as well as in the operation. In wastewater treatment plants, the major concern regarding to this process unit is to quantify dead volumes inside the tank. Tracer tests allow obtaining the global fluid behaviour in real-scale by means of the Residence Time Distribution (RTD) and it is also being used increasingly to validate hydraulic models such us Computational Fluid Dynamics models [1]. However, this experimental technique often presents limitations for wastewater operators because it might be not cost-effective due to it is still a tedious and expensive work due to the large volumes where the anaerobic digestion takes place in municipal WWTP [2]. The purpose of this work is to apply the tracer technique for the hydraulic assessment of a full-scale anaerobic digester tank comparing different tracers and to validate a Computational Fluid Dynamics (CFD) model.

CFD techniques can successfully address these hydraulic issues in order to enhance fluid behaviour and therefore the biochemical processes. In this work, CFD models performed to reproduce the fluid behaviour and to characterize the mixing system of the process unit were validated through Residence Time Distributions (RTD) obtained from two well-known tracers. In addition, a comparative study between tracers was conducted to determine their technical-economic feasibility.

MATERIALS AND METHODS

Initially, in a previous work, a first tracer test was performed in a full-scale anaerobic digester tank of 3,400 m3 with an external pumping mixing system in mesophilic conditions, to obtain the dead volume and the hydraulic performance as well as to validate a CFD model. As a result of this first study, an intrinsic dead volume was determined, and the fluorescent tracer used resulted not suitable for anaerobic digestion applications.

Numerical simulations were accomplished using the commercial CFD code ANSYS® Academic Research Release 17.2. Three-dimensional Eulerian non-Newtonian single-phase simulations were performed to reproduce accurately hydrodynamics [3]. Two different scenarios (with and without propeller) and different recirculation flows, ranging from 50 to 200% of maximum recirculation flow rate, were studied to evaluate dead volume according to different criteria in literature.

Finally, with the purpose to find a feasibility of well-known tracer materials, a pulse injection tracer test was carried out using Potassium Bromide and Lithium Chloride over a retrofitted full-scale anaerobic digester tank with the same configuration. More than 300 samples were taken during 76 days at the outlet and at different sampling points located at several heights of the digester. An adsorption experiment under different conditions was performed in order to ensure and compare the suitability of both tracers and the no-interaction between them during the full-scale tracer test.

RESULTS AND CONCLUSIONS

The global hydrodynamic behavior was correctly validated by means of RTD for 76 days. RTD was calculated by CFD and compared to both tracers at the outlet which presented similar results. Other measuring points showed similar results between tracers according to the mixing performance inside the digester. The concentration of tracer reached was equalized in less than 1 day at different measuring points within the digester showing a CSTR hydraulic performance. LiCl presented higher recovery at the full-scale test; this was confirmed by means of the separate sorption tests.

With respect to the sorption test, after 21 days of exposure to digester sludge under anaerobic conditions, approximately 100% of both Li^+ and Br^- were recovered for all the concentrations tested. The results of this experiment gave us confidence of the zero-interaction between the tracers.

RTD was obtained at the outlet for both tracers validating the experiment [4]. From this, the mean residence time was calculated resulting very close to the theoretical (about 17 days). It exhibited a very similar performance for both tracers. The dead volume resulted almost near-zero meaning that the retroffiting of the configuration was effective, it consisted on a propeller working 6 hours/week) to avoid the dead volume generation. The RTD obtained after 76 days allowed to verify the simulation and revealed a more recovery degree for the LiCl. However, KBr can be considered a reliable tracer and more cost-effective because it is significantly cheaper than LiCl due to the total mass of the product required for the tracer test is 66% lower.

Potassium Bromide is a low-cost and a reliable tracer for assessing hydraulic performance in anaerobic digesters

KEYWORDS:

Tracer; RTD; anaerobic digestion; Lithium; Bromide

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Tracer techniques for validating CFD modelling of open channel UV disinfection systems

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ABSTRACT

Hydrodynamics is one of the main principles that influences the performance of UV systems and presents a major difficulty when proposing improvements or new designs for water treatment. It is known that UV open channel systems tend to have a poorer hydraulic behavior than closed reactors, due to defects in the flow behavior, among which one can highlight the phenomena of shortcircuiting, the presence of dead zones inside the reactor and the irregular velocity profiles that affect the contact time.

In this work, several three-dimensional computational fluid dynamics (CFD) models were developed to improve the performance of a full-scale UV open channel installed in the tertiary treatment in a WWTP. These allowed to study in detail the hydraulic behavior and reproduce the fluid dynamics phenomena under different working conditions. In addition, the main disinfection phenomena of wastewater have been considered through the implementation of the Montecarlo radiation model.

Finally, an extensive experimental work through tracer tests has been developed to assess the modifications proposed over the configuration to optimize the efficiency of the process unit. Fluorescein sodium salt was used as a reactive trace to evaluate the disinfection efficiency while sodium bromide was used as inert tracer to evaluate the hydrodynamics. Moreover, fluid velocity measurements were carried out before and after the modification to reinforce both the experimental tracer tests and the simulations.

INTRODUCTION

Disinfection is defined as the mechanism for the deactivation or destruction of pathogenic organisms in order to prevent the spread of diseases transmitted through water, both to users and the environment. In the last decade there has been a growing interest in the application of ultraviolet (UV) radiation to disinfect wastewater. It has been seen that UV radiation has important germicidal properties, which has not contributed to the formation of secondary compounds.

The use of UV radiation systems in wastetreatment plants (WWTP) is today one of the most effective systems for disinfection processes [1] and a very good alternative to chlorination systems and / u ozonation that are usually used but it is expensive, it is around 20% of the total energy cost of a WWTP. The effectiveness of the disinfection system with ultraviolet light depends on the characteristics of the wastewater, the intensity of the radiation, the exposure time of the microorganisms to the radiation and the configuration of the reactor. This study is focused on this last aspect.

Hydrodynamics is one of the main factors to consider in the performance of the UV disinfection systems. The effectiveness of the disinfection and the cost of the operation depends on the geometry and the configuration of the UV channel [2,3]. On the one hand, Computational Fluid Dynamics (CFD) techniques can successfully address these hydraulics issues in order to enhance fluid behaviour and therefore the biochemical processes. On the other hand, since the mean residence time of the standard operation is low (less than 1 minute), a small improvement on hydrodynamics may provide an enhancement of the quality of the water.

The main object of this study is to investigate how to change the configuration of the open channel through geometry modifications to achieve a better performance of the fluid behaviour and therefore, to increase the disinfection efficiency under the same operational conditions.

MATERIALS AND METHODS

Several CFD models were developed to propose new designs and to develop new configurations over the UV system considering the implementation of internal elements and changing the position of the UV lamps inside the channel, all to study the modifications on the hydraulics through simulation. From this tool, it was possible to carry out experiments by minimizing the work done in the field. For these simulations, the commercial code ANSYS® Academic Research Release 17.2 was used. As a noticeable improvement over other CFD models, the Montecarlo radiation submodel [4] was implemented in the three-dimensional Eulerian non-Newtonian single-phase simulation to reproduce in detail the boundary conditions of the lamps and the UV diffuse absorbance in the fluid.

Secondly, the implementation of a perforated baffle was selected as the best option to increase the UV open channel efficiency among all the modifications studied by CFD.

Tracer tests were carried out to study the fluid behaviour and to validate the CFD models. On the one hand, Sodium Bromide was introduced following a "pulse" to evaluate Hydrodynamics [5] after changes over the configuration. On the other hand, several tracer tests were performed using a "step" over the same system using fluorescein sodium salt.

Finally, the Vectrino Nortek® high-resolution acoustic Doppler velocimeter was used to measure the fluid velocity components, to validate the CFD model and to characterise the effect of the perforated baffle over the mixing.

RESULTS AND CONCLUSIONS

A novel CFD model of an UV open channel has been developed with the implementation of a 3D radiation model. From this, we have explored different conceptual models to carry out a comparative study to quantify the efficiency in the UV channel under different configurations according to the disposition of the UV-lamps and the internal elements in the channel. The implementation of the perforated plate type baffle was carried out as the best option simulated.

An extensive tracer test campaign was carried out using different tracers. Bromide allowed the hydraulics to be studied and the Fluorescein sodium salt was successfully used as a reactive tracer to evaluate the UV open channel performance. It is more feasible than using E-coli as a bio tracer.

This work demonstrates that a modification over the hydrodynamics changes the efficiency of the process units, and the combination of simulation with tracer experiments is a technological solution to assess the modifications of the process unit configuration such an UV open channels for wastewater disinfection.

KEYWORDS:

UV lamps; water disinfection; tracer; open channel; CFD

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Challenges in the Applications of Radioisotopes in Nigerian Industries

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ABSTRACT

Owing to the importance of Radioisotope technology for industrial applications, the Centre for Energy Research and Training began the process of building capacity for this technology in the early 2000s. Experts from the International Atomic Energy Agency (IAEA) visited the Centre over many years and in cooperation with the National Oil Companies, (Nigerian National Petroleum Corporation) we attempted to introduce the technology to the oil industry in Nigeria. There has been some technology transfer via international trainings of staff and acquisition of equipment which should enable application. Unfortunately, this technology has not found its use in the relevant Nigerian Industries despite a number of attempts. This trend must not be allowed to continue and hence the need to review and consider new options to forge ahead with the introduction of the technology into the relevant Industries in Nigeria. The problem of not being able to penetrate the relevant industries with the above technology may be due mainly to the politics of the day to day running of these industries. New approaches may be needed to combat the challenge where we have the equipment and capacity to apply the technology, but no access to the people that should benefit from it. This paper highlights some of the challenges over the years and attempts to proffer some solutions.

Data Fusion Approach for Improving the Reliability of Radiographic Testing and other Complementary NDT Techniques

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ABSTRACT

Non-negligible uncertainty and imprecision in defect detection and defect sizing exist when only using one single Non Destructive Testing (NDT) technique. To increase the reliability and reduce the uncertainty of defect detection and defect sizing, the complementarity and redundancy of radiographic and ultrasonic testing data is exploited. The reliable concept to improve the detection and characterization of defects is by combining the data sets of these NDT techniques. This goal is achieved by employing mathematical Data Fusion techniques [1][2]. These are techniques allowing for simultaneously taking into account heterogeneous data coming from different sources in order to get an optimal estimation and evaluation of defects under investigation. The present study focuses on the development of a data fusion approach based on the evidence theory (Dempster-Shafer theory) [3][4] in order to merge a large number of data sets, in a suitable manner, and obtain more reliable results of localization and characterization of defects inside a component. The proposed method is validated by a real ultrasonic and radiographic NDT data of different industrial components.

KEYWORDS:

Non Destructive Testing, Data Fusion techniques, Dempster-Shafer theory.

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Numerical Tracer Simulation in Algal Raceway Pond using Momentum Source and Dynamic Mesh Methods

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INTRODUCTION

High rate algal pond (HRAP) is usually considered as a proper method for producing microalgae biomass. It is the most widely used technique at both lab and full-scale [3, 4, 6]. The main reason behind the broader acceptance of this technique is its low operational cost and simplicity to build and operate the system. However, an optimum hydrodynamic mixing is always required within the pond for the algal cell to grow and perform their photosynthetic activity. Proper mixing will ensure recurring light exposure to algal cell, reduce settling and sedimentation of cells, and enable uniform distribution of nutrients and carbon dioxide in the culture [1].

Computational Fluid Dynamics (CFD) modelling has proven itself to offer the possibilities of capturing a wide range of parameters even in multiphase simulation with a high degree of accuracy including complex pond hydrodynamics [2, 4, 5]. One of the challenges is the representation of the momentum induced by the paddle wheel that is usually in charge of inducing mixing and liquid velocity in such systems.

Simulation of this rotating element could be performed using different approaches. The most comprehensive one is the dynamic mesh that considers rotation of the paddle-wheel geometry and simulate the momentum transferred to the fluid thanks to this movement [4]. However, this approach could be computationally intensive. According to the modelling objective, one can consider simplifying the model using cyclic inlet and outlet boundaries with a momentum source of constant inlet velocity [3]. This method assumes a steady state flow and therefore flow fields are calculated from a steady state solution.

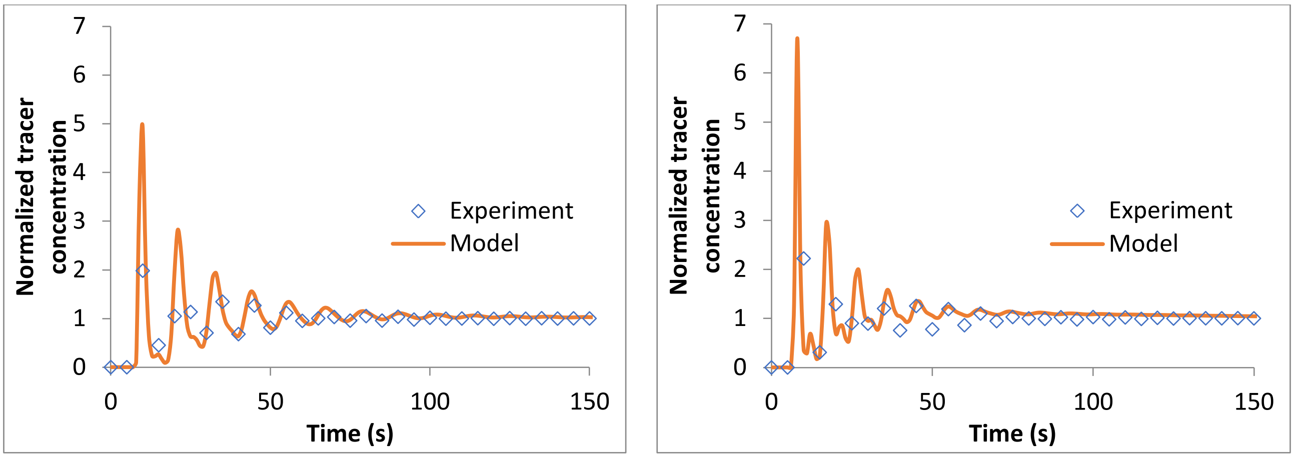
In this study, results from experimental tracer studies are used to estimate overall performance of a CFD model built for further evaluation and optimization of HRAP. Two different approaches are used and compared in terms of reproduction of tracer experiments: the momentum source method (fixed velocity) and dynamic mesh. The impact of turbulent Schmidt number *Sc* is also discussed. The open-source platform is used for simulations.

A lab-scale pilot pond having central length, including the two curves, of 3.228m and channel width of 0.2m is used to perform the experimental tracer tests. The CFD model was built according to the actual geometry and structured mesh is used. For simulating pulse tracer injection, an equivalent spherical volume of numerical tracer element is introduced at the centre of flow depth exactly where the actual tracer experiment used to inject the sodium chloride solution.

Tracer transport is represented by the passive scalar transport method. The original solver in OpenFOAM didn't consider turbulence effect in mixing to solve the equation for scalar transport of tracer material. Due to this reason the equation is modified by adding a ratio of turbulent viscosity (μ_t) to Schmidt Number (S_c) to the diffusion coefficient. Turbulent viscosity is calculated from the known flow parameters and universal Schmidt Number (0.7) was used at the start.

Simulations with dynamic mesh method are currently running on the High-Performance Cluster of the University of Strasbourg. Results will be presented at the conference.

Concerning the momentum-source method, first results show that the simulated pick concentrations were substantially higher than the experimental pick values and have slight deviation in the pulse position. *Sc* was then reduced by a half to increase the diffusivity due to turbulence. Though the pick difference still exists, the result is improved in both depths of flow as shown in the figure 1 (a) and (b).



(a) (b)

Figure 1 - Experimental vs simulated tracer plot for **(a)** 0.2m and **(b)** 0.15m depth of flow

KEYWORDS

High rate algal pond; mixing; CFD; Momentum Source; Dynamic Mesh

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Development of "compartmental modelling" methodology of flowing systems with or without chemical reaction using tracing experiments and computational fluids dynamics simulations.

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INTRODUCTION

This paper deals with the modelling of chemical reactors using the "compartmental" approach, which consists in dividing the system into a network of a dozen to several hundreds of interconnected volumes, called compartments [1]. The structure of the network is deduced from tracer experiments, technical information about the chemical reactor and computational fluid dynamics simulations. When they are properly set-up, compartmental models give similar predictions of chemical reactions as CFD simulations with a shorter calculation time and a simpler visualization of the reactor behavior. Several applications of this principal can be found in the literature, but each one of them is devoted to a specific reactor with a particular approach that cannot be straightforwardly transposed to other reactors. [2] have studied a bubble column. Their network is composed of three vertical tanks in series (zone rich in gas, zone poor in gas and down flow). Convective fluxes between compartments represent the main recirculation loops whereas turbulent fluxes are used in order to describe gas dispersion in the riser. [3] have studied a mechanically agitated reactor in order to predict the effect of mixing on the performance of the reactor. Different kinetics have been tested and the cutting criteria is obtained with consistent time scales between reaction and hydrodynamics. [4] have studied a biological reactor of wastewater treatment. The network is based on several vertical slices, each slice is composed of three zones (a high gas concentration zone, a low velocity zone and a recirculation zone). [5] have studied mixing inside a mechanically agitated batch reactor. Compartmental network is built mainly on a geometric analysis of reactor and phases distribution. [6] have studied a bubble column photobioreactor in order to study algae growth. Flow field and light availability are taken into account. The aim of our work is to provide a contribution to the development of the most general possible methodology and to develop an automatic tool of generation and resolution of the differential equations system which must be solved. A versatile approach is proposed, consisting in dividing the reactor into identical slices.

SCOPE OF THE STUDY

The "compartmental modeling" relies upon the description of the reactor by a structural and functional subdivision of around a few hundred compartments. The proposed method is based on generalizing and establishing rules for the division [7]. Symmetrical and geometrical analysis of the reactor is performed in order to divide the reactor into several slices of similar apparent behavior. Inside each slice (or inside the entire volume of the system), a compartmental network is defined by relevant compilation and integration of CFD flow simulations, including the most preponderant parameters (for instance flow velocities, turbulence, gas fraction, temperature…). The number of slices is adjusted by fitting RTD curves based on compartmental model with the experimental ones. The analysis of the time constants of the preponderant processes (hydrodynamics, heat/mass transfer and/or chemical reaction) allows to refine locally the network. Finally, exchanges between compartments are based both on convective fluxes (deduced from velocity field) but also on the turbulence exchanges. This methodology has been included in a new version of DTS pro [8].

The proposed methodology has been applied to the simulation of the dispersion of a chemical compound in an aquaculture pond. This application has been chosen because of the strong heterogeneity of the flow field in order to validate the approach in a non-favorable case. A compartmental model of 98 compartments has been built from the identical slice cutting methodology as shown in Figure 1. RTD and numerical simulations of the dispersion at several points of the pond have been successfully compared to experimental data.

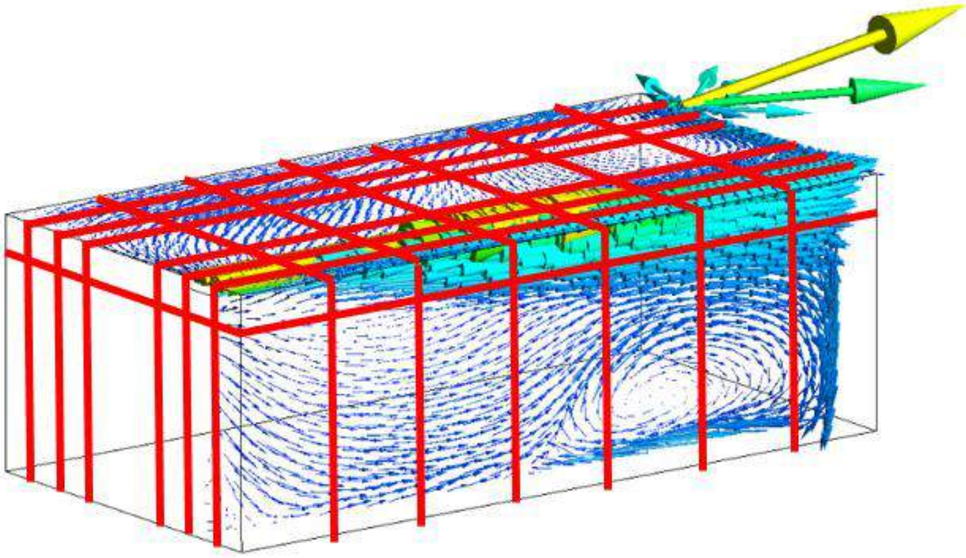

Figure 1: Aquaculture pilot scale pond with representation of velocity field and the structure of the compartmental model.

KEYWORDS [HEADING 1 STYLE]:

compartmental modelling, tracing experiment, slice cutting, turbulent exchanges

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Turbulent Schmidt Number: a necessary tool but also a trap for CFD simulation of tracing experiments or reactions

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ABSTRACT

In chemical engineering, process simulation is a very useful tool, notably for reactor design. These models need to integrate different phenomena such as hydrodynamics and reactions. Computational Fluid Dynamics (CFD) is one of these tools: to simulate a reaction, it is necessary to couple fluid mechanics equations with substances transport and reactions kinetics. Reactants and products concentrations are usually considered as scalars. Transport of these scalars is calculated from both velocity (advection) and turbulence (eddy diffusivity) fields by the means of the use of the Turbulent Schmidt Number. This dimensionless number corresponds to the ratio of kinematic turbulent viscosity to diffusion coefficient. Classically, CFD results allow computation of turbulent viscosity in every cell of the mesh. The corresponding dispersion term can then be derived thanks to the turbulent Schmidt number (Sc), which is a constant. Most studies do not consider calibrating Sc, assuming it has a neglectable impact on simulation results. A default value (often Sc=1, or 0.8 in water treatment, or 0.7 for some CFD software) is used without proper justification. The purpose of this presentation is to demonstrate that the choice of Sc value has a strong influence on the reactant/product transport, and ultimately on the validity of the simulation. A given simulation could be very good from the hydraulic point of view and nevertheless give wrong results from the reactant/product transport point of view. In this presentation, an activated sludge reactor used for water treatment is simulated. In CFD, since the transport of a reactant/product scalar is calculated with the same method than a conservative scalar, it is possible to compare the influence of the Schmidt Number by use of virtual tracing carried out from the CFD model. Our simulations show that changing the value of the Schmidt number induces variation of virtual tracing results; i.e. the Residence Time Distribution is different. Moreover, there is an effect of the turbulence model used for the CFD simulation.

In conclusion, the turbulence model should be chosen with caution. In water treatment for instance, the bubble–induced turbulence is an important phenomenon. The calibration of the Schmidt Number should be done for every situation and also when only the turbulence model is changed. There is no reliable method to identify a priori the best Schmidt Number value, and experimental tracings show their necessity for its calibration.

SESSION 5

TRACING FOR INDUSTRY

22

ABSTRACTS

Investigation of the cause of Decrease in PTA Production

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ABSTRACT

Applications of radioisotopes in industries are the best techniques to carry out online dynamic internal inspection of reactor vessels, columns and pipelines without interrupting the process. Clear insight of the process conditions and operating parameters can be acquired using sealed source and radiotracer techniques. Level measurements, column scanning, blockage detection, flow rate measurements and calibration of flow meters, leak detection and RTD studies are few of the online diagnostic investigations that can be accomplished using radioisotope techniques.

In an oxidation reactor of pure ter-phthalic acid (PTA) plant, the process used to become unstable at the designed production rate of about 150 tons per hour. Hence, it was compelled to run the plant at lower rate of about 120 tons per hour rendering the huge loss of production. Purified ter-phthalic acid (PTA) is produced in this plant by oxidation of paraxylene using air and acetic acid in presence of a catalyst. The feed line to the reactor was bifurcated into east and west header and the feed mix was introduced into the reactor from both sides. Vapours from the top of the reactor are condensed in a series of heat exchangers and recycled to the feed lines through vertical headers.

The vertical headers consisting two phase flow were scanned using gamma ray emitter isotope to locate the liquid vapor interphase. The counts were recorded for a certain period of time at three different angles at each diametrical location after every 150 mm throughout the length of each header. It was found that in three of the pipes, the interphase is not static, but it is oscillating with a certain period. The other two pipes were filled with liquid. These oscillations may be due to the intermittent condensation in the heat exchangers.

Flow rate measurements were carried out in the bifurcated headers by injecting suitable radiotracer and response of each detector were recorded in a multi input data acquisition system. Transit time method of flow rate measurement was used to estimate the flow rate. Mathematical analysis of the data was carried out and it was seen that volumetric flow rate was fluctuating. It could be due to the variation in the throughput delivered by the heat exchangers through the vertical headers. The fluctuation of the flow rate in both the headers could be the cause of level fluctuation in the reactor.

KEYWORDS

radio-isotope, Pure-terephthalic acid, two phase flow, level fluctuation

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Identification of leaky heat exchanger in a series using Mo-99 as radiotracer

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ABSTRACT

For efficient utilisation of heat generated through various processes in a petroleum refinery system of heat exchangers is used. Many of the times, very high pressure fluids flow through shell side and/or tube side of the series of heat exchangers for efficient heat transfer. Hence such heat exchanger series becomes vulnerable for leakages. Identification of leaky heat exchanger/s is a very important task to reduce downtime thereby saving great losses.

In Vacuum Distillation Unit of one of the leading refineries in India, Vacuum Column overhead comprises of two sets of heat exchangers. First set consists of two Pre-condensers (EE-101 A/B: parallel) followed by second set of three numbers of staged ejector condensers (EE-102/103/104: series). Both the sets of exchangers have cooling water on the tube side & hydrocarbon stream on the shell side. The overhead vapor after getting condensed in the above exchangers is routed to a hot well where hydrocarbon and sour water are separated.

Refinery engineers experienced the problem of ingress of cooling water (tube side) in to hydrocarbon (shell side) in one or more heat exchangers in series. Locating the leaky heat exchanger is a difficult task since there are five heat exchangers installed in series and leaky heat exchanger could be identified only by hydro-testing of individual heat exchanger that too during shutdown.

A radiotracer study was performed to identify the leaky heat exchanger during operational conditions of the plant. Radiotracer Mo-99 as sodium molybdate (aqueous solution) was injected in to the cooling water stream (tube side) as a sharp pulse through specially fabricated injection system and its ingress was monitored by placing lead collimated 2” NaI scintillation detectors on the outlet of hydrocarbon stream (shell side). The data was recorded by multi input data acquisition system for certain time interval. Data recorded was mathematically treated and count rate versus time plot were obtained for each of the detectors.

Leakage peaks were identified in heat exchangers EE-101A and EE-102. The leak rate found in the EE-101A & EE-102 was about 2% & 10% respectively.

KEYWORDS

vacuum column, heat exchanger, radiotracer, scintillation detector, leak rate

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Liquid Mixing Behavior in Upflow Moving Bed Hydrotreater Reactor (MBR) Reactor Using Advanced Liquid Tracer Technique

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ABSTRACT

Gas-liquid upflow moving bed reactor are widely used in industries for hydrotreating of feeds with a higher level of contaminants. These reactors are designed with conical bottom support for catalyst bed structure to facilitate the removal of the spent catalyst, and a provision to add fresh catalyst from the top without shutdown, mostly under operating conditions these reactors behaves as upflow packed or slightly expanded bed [1]. The problem associated with these reactors is maldistribution, sintered carbon deposition and reduces expected conversions. To address such issues, detailed studies to enhance the understanding of the hydrodynamics and mixing behavior of liquid in this reactor are still required. We developed scaled down lab scale reactor based on the combination of hydrodynamic and geometrical similarity with the industrial reactor [2]. This reactor consists of plenums and catalyst bed section.

In this work, a methodology based on convolution and regression has been implemented using advanced liquid tracer technique to remove the external dispersion due to additional volume (sampling line, top section of the reactor, plenums) and to deconvolute mixing characteristics of the catalyst bed. The liquid tracer system consists of the conductivity probe, water pump, sampling line and 1.1 M KCl solution as a tracer [3]. As part of the methodology, the KCl solution is injected below the catalyst bed, above the catalyst bed of the reactor and sampled at the top of the reactor. These injection-sampling networks characterize residence time distribution (RTD) of various section of the reactor. The catalyst bed section is modeled using an asymptotic solution of wave model for pulse injection having dispersion coefficient of liquid phase as a parameter. Dispersion parameter estimation is done using the concept of convolution, parameter regression with the experimental data, and liquid holdup determination using RTD data. Dispersion coefficient quantifies the overall mixing characteristics of the liquid phase in catalyst bed section. We focus in this work on the catalyst bed section, which is a plexiglass column of 11 inches (ID) and 30- inch height, filled with catalyst of 3mm diameter till 24-inch height. The measurements were conducted at superficial liquid (water) velocity of 0.017 cm/sec to 1.78 cm/sec and superficial gas (air) velocity of 1.27 cm/sec to 8.8 cm/sec. The bed expands on higher liquid velocity and liquid dispersion coefficient is increasing with the extent of expansion and deviating largely from plug flow. This information is essential for scale-up and performance evaluation of this kind of reactor.

KEYWORDS

packed/ expanded bed reactor, liquid tracer technique, residence time distribution, axial dispersion coefficient, multiphase flow

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Gas Phase Mixing Behavior in Upflow Moving Bed Hydrotreater Reactor (MBR) Using Advanced Gas Tracer Technique

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ABSTRACT

Gas-liquid upflow moving catalytic packed bed reactor are widely used in industries for hydrotreating (hydrodemetallization. hydrocracking, hydrodenitrogenation, hydrodesulfurization, etc.) of feeds with a higher level of contaminants including heavier feeds. In these reactors spent catalyst are replaced periodically by adding fresh catalyst at the top and removing spent catalyst from the conical bottom which supports catalyst bed. While the catalyst moves downwards systematically, gas and liquid phase move upwards. The catalyst is removed in small increments once a week. The other times the reactor operates in up flow packed or expanded bed condition. The problem associated with these reactors is maldistribution, which causes hotspots, sintered carbon deposition and reduces expected conversions. To address such issues, detailed studies to enhance the understanding of the hydrodynamics and mixing behavior of gas in this reactor are still required. We developed scaled down lab scale reactor based on the combination of hydrodynamic and geometrical similarity with the industrial reactor.

This reactor consists of plenums and catalyst bed section [1]. In this work, a methodology based on convolution and regression is implemented using advanced gas tracer technique to remove the external dispersion due to additional volume (sampling line, the top section of the reactor) and to deconvolute mixing characteristics of catalyst bed and plenum. The gas tracer system consists of the gas analyzer (TCD) [2], in-house developed gas-liquid separator, water pump, air pump, sampling line and helium as a tracer. As part of the methodology, the helium is injected at the inlet, below the catalyst bed, above the catalyst bed of the reactor and sampled at the top of the reactor. These injection-sampling networks characterize residence time distribution (RTD) of various section of the reactor. Dispersion coefficient quantifies the mixing characteristics of catalyst bed section and plenums and is obtained using developed model for these parts. The plenums are modeled as ideal CSTR-PFR and catalyst bed as ADM. Dispersion parameter estimation is done using the concept of convolution and parameter regression with the experimental data. We focus in this work on the catalyst bed section, which is a plexiglass column of 11 inches (ID) and 30-inch height, filled with extrudate catalyst of 3mm diameter till 24-inch height. The measurements were conducted at superficial liquid (water) velocity of 0.017 cm/sec to 1.78 cm/sec and superficial gas (air) velocity of 1.27 cm/sec to 8.8 cm/sec. At low liquid superficial velocity, it is seen that the bed behaves as packed bed or slightly expanded bed and dispersion coefficient (Dg) increases with increasing gas superficial velocity. At higher liquid superficial velocity the bed acts as extended bed and Dg decreases with increasing gas superficial velocity. The Dg decreases with increasing liquid superficial velocity at constant gas superficial velocity. These kind of information are essential at industrial scale, to improve the performance of the real plant reactor. In this presentation, results and findings are discussed.

KEYWORD

packed/ expanded bed reactor, gas tracer technique, residence time distribution, axial dispersion coefficient, Multiphase flow.

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Axial dispersion and mixing of coolant gas within a separate-effect prismatic modular reactor

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ABSTRACT

Multiphase Reactors Engineering and Applications Laboratory performed gas phase dispersion experiments in a separate-effect cold-flow experimental setup for coolant flow within heated channels of the prismatic modular reactor under accident scenario using gaseous tracer technique. The prismatic modular reactor (PMR) is a promising candidate of the next generation nuclear plants (NGNPs). One of the prismatic modular reactor (PMR) advantages is its capability to passively remove the decay heat from the reactor core through natural circulation under the loss of flow accidents (LOFA) scenario [1]. In the scenario of the loss of flow accident (LOFA), the natural circulation, due to large temperature variations and consequently density differences, is initiated to remove the decay heat from the reactor core. Furthermore, during the LOFA event, the direction of the coolant flows within the reactor core is reversed, and there are two different possibilities for the direction of the flow may occur inside the coolant flow channels due to large densities variations.

The separate-effect experimental setup was designed on light of local velocity measurements obtained by using hot wire anemometry. The measurements consist of pulse- response of gas tracer that is flowing through the mimicked riser channel using air as a carrier. The dispersion of the gas phase within the separate-effect riser channel was described using one- dimensional axial dispersion model [2]. The axial dispersion coefficient and Peclet number of the coolant gas phase and their residence time distribution within were measured. Effect of heating intensities in terms of heat fluxes on the coolant gas dispersion along riser channels were mimicked

in the current study by a certain range of volumetric air flow rate ranging from 0.0015 to 0.0034 m^3/s which corresponding to heating intensity range from 200 to 1400 W/m^2. Results confirm a reduction in the response curve spreads is achieved by increasing the volumetric air velocity (representing heating intensity). Also, the results reveal a reduction in values of axial dispersion coefficient with increasing the air volumetric flow rate.

KEYWORDS

Prismatic modular reactor; gaseous tracer technique; axial dispersion coefficient; Peclet number.

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Identification of flow abnormalities in pulp digesters using radiotracers

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ABSTRACT

^{99m}Tc and ^{82}Br were used as the radiotracer to identify the flow abnormalities in two tubes and three tube pulp digesters at industrial scale by measuring the residence time distribution (RTD). The investigations were carried out at the extreme operating conditions of two digesters. The obtained RTD data were analyzed to obtain the reactors performance and deviation from ideal/design performance. The wheat straw and white liquor are the feeds of pulping digesters to obtain the cellulose fiber in the form of pulp for paper production. The liquid phase of the digesters was traced using gamma detectors. The non-ideal flow behavior of the digesters was approximated using available RTD models as a function of operating conditions. The pretreated obtained RTD data was used to extract the model parameters and mean residence time. The axial dispersion model (ADM) and tank in series with the back-mixing model (TIBM) were found equally suitable to represent the behavior of the digesters. The number of tanks in TIBM was found almost double as the value of Peclet number (Pe) for each case. High Back-mixing was observed inside the first tube of both digesters whereas, plug flow behavior was observed inside the last tube of both digesters.

INTRODUCTION

It is always observed that no system can behave ideally and shows the deviation from the ideal state/ designed values. The reasons for these deviations include improper design, fluctuating operating conditions, scale-up effects, different raw material sources, non-uniform heating/cooling, etc. As results, the system shows malfunctioning or failure of the process and may lead to poor quality product [1]. The residence time distribution (RTD) measurement is one of the tools to evaluate the performance of continuous reactors. The RTD predict the non-ideal flow behavior of the system/ process as the probability distribution function of the material flowing inside the system/ reactor. Furthermore, the application of radiotracer facilitates us to perform online RTD measurement even in an opaque system without disturbing the normal operation of the reactor/process equipment [1]. In this technique, a small amount of radiotracer is injected in one of the phases of the reactor at the inlet and concentration of the radiotracer was measured at the outlet as a function of time using gamma-ray detectors [2]. The obtained RTD data has to be pretreated for background correction, starting point correction, radioactive decay correction, data smoothing, and tail correction. The RTD modeling has a number of benefits such as prediction of flow behavior or any type of flow abnormality like bypassing, recycling, stagnant zone etc.

The continuous pulp digester (two tubes or three tubes) is the multiphase reactor used to produce pulp from the non-wood fibrous raw material such as wheat straw, rice straw, bagasse, etc. [2]. The pulping process involves the removal of lignin from lingo-cellulosic material from plant origin and this process is known as the delignification process. Pulping process is classified as mechanical and chemical pulping process. Whereas, the high-quality paper is being produced by chemical pulping because of low residual lignin, more brightness, and higher strength. The chemical pulping process for wheat straw (agro-residue raw material) is being carried out in the tubular continuous pulping digester (two tubes or three tubes). The delignification process starts at the inlet and progresses throughout the length of the digester. During delignification process, the white liquor is diffused into the biomass and the lignin dissolves in white liquor. So, high dispersion of white liquor is desirable for better delignification. The delignification process depends on the process variables as raw material flow rate (biomass feeder screw rpm), white liquor feed rate, operating temperature, and pressure, etc. The obtained pulp quality is being measured by the Kappa no. (extent of delignification) and residual alkali. The high liquor flow rate as compared to biomass feeder screw rpm results in poor delignification which leads to high residual alkali and Kappa no., whereas, low white liquor flow rate results in ineffective delignification. So, it is required to maintain the optimum ratio of white liquor flow rate and biomass feeder screw rpm [2].

In the present work, the radiotracer experiments have been carried out in two tubes and three tube continuous horizontal pulp digesters at extreme operating conditions to optimize the operating parameters. The flow behavior is predicted using RTD modeling and flow abnormalities have been identified.

MATERIAL AND METHOD

Wheat straw and white liquor were the key components for the pulping process. ^{99m}Tc (half-life: 6 hours, gamma energy: 0.14 MeV) in the form of sodium pertechnatate and ^{82}Br (half-life: 36 h, gamma energy: 0.55 MeV) in the form of ammonium bromide were used to trace the liquid phase of two tube and three tube pulp digester respectively. The concentration of radiotracer was monitored at different locations using NaI detectors and RTD data was recorded by common data acquisition system (DAS).

RESULTS AND DISCUSSION

RTD modeling for both digesters have been completed using ADM and TIBM models both connected with a plug flow component in series. Plug flow component has been kept constant, hence there are only two parameters for ADM which are optimized, i.e. Pe and MRT component for the model. In case of TIBM, second parameter is N (number of tanks) and third parameter is the back-mixing ratio α. TIBM gave the better result than the ADM.

It was observed that the very high dispersion or very low dispersion is not desirable during pulping process. White liquor flow rate should be optimum in correspondence with the wheat straw feed rate. High white liquor flow rate as compared with wheat straw feed rate resulted in recycling and low white liquor feed rate as compared to wheat straw feed rate resulted in improper delignification.

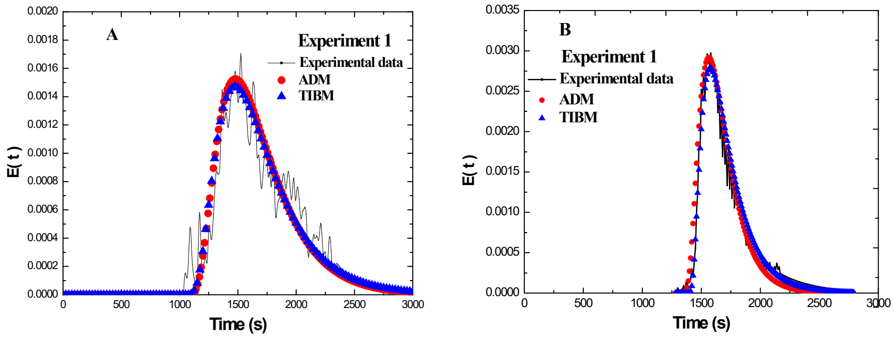

Figure 1 RTD model representing the experimental data for two tube (A) and three tube (B) digester

CONCLUSIONS

^{99m}Tc and ^{82}Br are found suitable as the radiotracer to trace the liquid phase of the continuous pulp digesters. Based on the obtained RTD data, high Back-mixing was observed inside the first tube of both digesters and plug flow behavior was observed inside the last tube of both digesters. The axial dispersion model and tank in series with the back-mixing model are found equally suitable to represent the behavior of the pulp digester.

KEYWORDS:

Pulp digester, radiotracer, residence time distribution, mean residence time.

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Solvent Extraction Process for the Recovery of Copper from Flotation Tailings Investigated Using Radiotracer

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ABSTRACT

The copper industry is one of the most profitable branches of the Polish economy. The technology commonly used is based on pyrometallurgy process. One step of the process is concentration of the metals by flotation of the copper ore. Flotation tailings after copper processing still contain significant quantities of metals. For recovery of these metals a hydrometallurgy process has been investigated. At first step acidic leaching has been applied. Up to 75% of the Cu was recovered by nitric acid. Next step was solvent extraction process with oximes highly selective for Cu, as an extractant. Several parameters, such as oxsime concentrations were chosen in order to determine efficient state for Cu separation. Standard solvent extraction tests for the recovery and separation of Cu were conducted with equal volume of aqueous and organic phases in batch experiments. Laboratory mixer-settler equipment was used. The process was carried out using ^{64}Cu as a radiotracer. Optimal parameters were identified. Up to 99% of the Cu was selectively extracted to the organic phase.

KEYWORDS

cooper, extraction process, radiotracer, hydrometallurgy

Acknowledgements

The study is being performed in the frame of IAEA CRP F22065 “Radiometric Methods Applied in Hydrometallurgical Processes Development and Optimization” and Polish Ministry of Science and Higher Education co-financing grant “Rozwój radiometrycznych i radioznacznikowych technik dla procesu hydrometalurgicznego odzysku metali deficytowych”.

Monitoring of Copper Recovery from Flotation Tailings by Leaching Process Using Radiotracer

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ABSTRACT

Radioactive tracer monitoring was applied for characterization of copper recovery in leaching process of flotation waste. A sample of waste and standard (high purity copper) were irradiated by thermal neutron flux in *MARIA* Research Reactor in Świerk. The activated sample was followed mixed with an inactive portion of flotation tailings in laboratory reactor vessel filled with acid. Atmospheric leach were performed using a sulphuric acid(IV) and (VI) with and without ozone stream. The experiments were carried out in a closed loop unit, which included the reactor, pump and filter. The spectra were recorded using a gamma spectrometer equipped with a scintillation detector with a 3-inch NaI(Tl) crystal. The shielded detector was installed at the outlet of the reactor and placed on a silicon hose. In the investigation the Cu-64 isotope was treated as tracer. A comparative method was used for determination an amount of copper in acid solution and was calculated on the basis of ratio of areas under photopeaks in a gamma-ray spectrum derived from the sample and standard. In the tests a copper leaching at the level of up to 40% was obtained.

Acknowledgements

The study has been performed in the frame of IAEA CRP F22065 “Radiometric Methods Applied in Hydrometallurgical Processes Development and Optimization” and Polish Ministry of Science and Higher Education co-financing grant “Rozwój radiometrycznych i radioznacznikowych technik dla procesu hydrometalurgicznego odzysku metali deficytowych”.

KEYWORDS:

Copper leaching, flotation tailings, radiotracer

FLOW RATE MEASUREMENT IN WATER PIPELINES USING RADIOTRACER TECHNIQUE

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ABSTRACT

One of the most important applications of radioisotope in industry is the flow measurement in the pipes. This paper presents flow rate measurements using radiotracer technology using Tc-^{99m} radiotracer inside petrochemical company in Egypt. The Main objective of this paper is to check and investigate two different types of data acquisition systems (DAS). The flow rate measurement has been obtained based on recording the signals that was collected and measured by two DAS's. The first DAS is a 12-channel ALTIX module running CAESAR 12 software designed by ALTIX Company, the second DAS is a 12-channel Ludlum Model 4612 DAS running MIDASII data acquisition software. Two sodium iodide scintillation detectors are connected to each DAS via coaxial cables and are located overlapped on the surface of pipeline to monitor and record the radiotracer. The flow rate measurement is determined by each DAS with different methods of calculations. The obtained results indicate that there is no significant difference between two DAS's, but the accuracy of flow rate measurements is basically depending on the methods of calculations.

REAL FIELD EXPERIMENT

The idea of using radiotracers for troubleshooting and to investigate flow phenomena in chemical process equipment has always attracted attention of engineers and scientists because of their specific advantages over conventional tracers[1] [2] . this work presents real field experiments are carried out in petrochemical company to measure the flow rate inside pipeline. Tc-99m (about 300 m Ci from Tc99m) radiotracer was used because it has a short half life time equal 6 hours. Two data acquisition system was used, two sodium scintillation detectors are used for each DAS, but the dimension and model of each detector are different. The detectors are overlapped mounted and supported over the surface of pipeline to keep the same conditions and parameters that used for measuring the flow rate. All details about the real field experiment and problem formulation is exist in [2]. Two different data acquisition systems (DASs) have been used to monitor and record the radiotracer along the pipeline, with each one being connected to two detectors. The first DAS is a 12-channel ALTIX module running CAESAR 12 software designed by ALTIX Company, which was used to record the signals from sodium iodide scintillation detectors connected to it via coaxial cables. The second DAS is a 12-channel Ludlum Model 4612 DAS running MIDASII data acquisition software, which was used to collect the signals from sodium iodide scintillation detectors connected to it via coaxial cables. These detectors were fixed firmly to touch the surface of the pipeline under investigation after cleaning and polishing the surface. Experiments were carried out using several different injections with different activities, we choose one injection where the detectors of two DAS's are overlapped on the surface of pipeline under investigation. In our injections, two DASs with four detectors were used, so one section were covered during our injection of this stage. The ALTIX DAS with two detectors was used and named D1 and D2, as the Ludlum DAS was used with two detectors named D3 and D4. The measurement was covered 28.8 m of the pipeline.

RESULTS AND DISCUSSION

Figures 2 and 3 presents the obtained signals that were measured by ALATIX and LADLUM DAS's respectively, while figures 4 ,5,6 and 7 shows the modelling of obtained RTD using RTD software with choosing the perfect mixer in series. Table 1 Comparison between Flow rate measurements calculation that measured by two DAS's. The results show that the flow rate that measured by two DAS's is similar and close together.

Fig. 1 location of sodium scintillation detectors on pipeline.

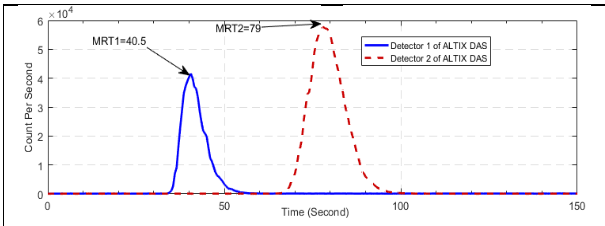

Fig. 2 Data measured by ALTIX DAS

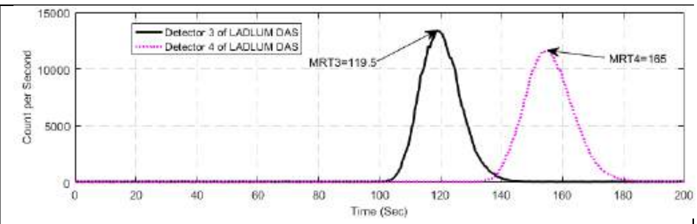

Fig. 3 Data measured by LADLUM DAS

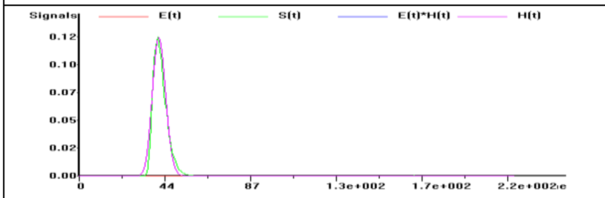

Fig. 4 MRT1 with perfect mixer in series model for D1

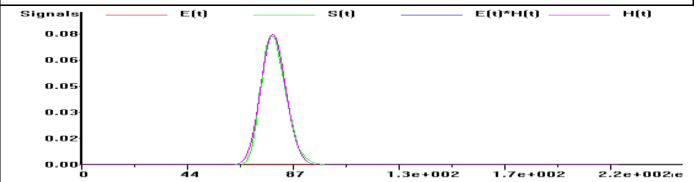

Fig. 5 MRT2 with perfect mixer in series model for D2

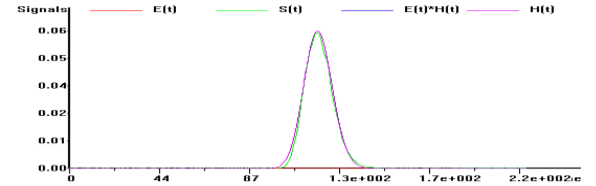

Fig. 6 MRT3 with perfect mixer in series model for D3

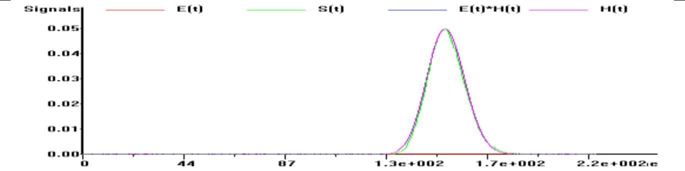

Fig. 7 MRT4 with perfect mixer in series model for D4

Table 1 Comparison between Flow rate measurements calculation that measured by two DAS's. The results show that the flow rate that measured by two DAS's is similar and close together.

Table 1. Comparison between Flow rate measurements calculation that measured by two DAS's

	ALATEX DAS (A)			LADLUM DAS (B)			Flow Rate m3/h	
	MRT of D1	MRT of D2	MRT	MRT of D3	MRT of D4	MRT	ALATEX	LADLUM)
Numerical Calculation	47.1189	80.89069	33.77179	119.7945	153.3732	33.5487	398.2427	400.8909
RTD Software	40.1578	78.019	37.8612	118.87	154.44	35.57	355.2283	378.10991
Visual inspection	40.5	79	38.5	119.5	165	45.5	349.3342	295.59
Mean μ	42.59223	79.30323	36.71099	119.38846	157.6044	38.206233	367.6017	358.19693
Var. σ^2	10.2648	1.42040	4.38747	0.14870338	27.537126	27.280458	475.22448	2046.30984
St. Dev. σ	3.20388	1.19180	2.09463	0.385620	5.247582	5.223069	21.79964	45.23615

CONCLUSION

The paper presented the results of an experiment carried out using Tc^{99} radiotracer to investigate and check the accuracy of two different DAS's via measuring the flow rate in inside a pipeline in petrochemical company in Egypt. The concentration of the radiotracer is monitored using two data acquisition systems and sodium iodide scintillation detectors. The mean residence time has been calculated for each detector by three methods such as; numerical method, RTD software and visual inspection. The results show that there is no significant difference between the accuracy of two different DAS's. moreover; the numerical method for calculating the mean residence time is more accurate and it gives confidence results better than other methods.

KEYWORDS:

Radiotrcer Technology, Flow rate measurements, Data acquisition systems and petrochemical industry.

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Experimental RTD modeling in a Liquid Flow System Using Deconvolved Radiotracer Response Signals

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ABSTRACT

This paper presents radiotracer Residence Time Distribution (RTD) measurement method using the deconvolution and the estimation method of RTD models to determine the structure of the flow in a laboratory water flow-rig. The rig is composed of a tank that consists of four interconnected mixers of total volume 98.5L and a bypass, inside which the water is flowing under pumping effect and entering at the tanks' inlet with rate equal to 12.8 L\min. The experiment was carried out by injecting a short pulse of a radiotracer into the bypass and recording the experimental response signals at three strategic positions (the inlet, the outlet and the mid-point) on the tank. The obtained response signals have been corrected, normalized and deconvolved. The deconvolved signals have been simulated by mathematical RTD models to represent the flow structures in the flow-rig. The results were compared to those obtained by simulating the RTD curves of the tank. The study concluded that the systemic analysis can be enhanced when deconvolution is used.

METHODOLOGY

The tank was filled with water and the flow-rig was operated under the full capacities of the water pump and the mixers. The flow rate was measured by calibrated flow meter (installed in the external bypass of the flow-rig) to be 12.8 L\min. Then ^{99m}Tc radiotracer (1ml, 37MBq as $NaTcO_4$) was instantaneously injected into the bypass using shielded hypodyrmic syringe. The passage of the radiotracer inside the tank was continuously monitored by detecting gamma radiation emitted from the tracer by three scintillation detectors oriented around the flow-rig. Detectors one and three were placed at the inlet and the outlet of the tank, while detector two was positioned at the middle of the tanks' wall. The response signals were transmitted and stored by PC based data acquisition system (ALTAIX SYSTEMS). The signals were corrected to decrease the error arising from the background radiation and the counting statistics. The correct signals values were normalized, deconvolved and simulated by RTD models formulations in the Laplace domain, with numerical inversion by Fast Fourier Transform (FFT), using RTD software developed by the International Atomic Energy Agency (IAEA). Six RTD models were investigated; the axial dispersion plug flow, axially dispersed plug flow with exchange, perfect mixers in series, perfect mixers in series with exchange, perfect mixers in parallel and perfect mixers with recycle. The parameters of the models were optimized by the least-squares curve fitting method and the best model was chosen to minimize the Mean Square Error (MSE) between the model and the processed response. Consequently the RTD models for the upper and the lower portion of the tank and for the whole tank were obtained. The normalized signals values of detector two and three were plotted against time to represent the RTD curves for the upper portion of the tank and for the whole tank respectively. The RTD curves were simulated by the RTD models using the Dirac "delta" function and the best models were determined. The results of the RTD modeling using the deconvolved signals and the RTD curves were compared and used to provide detailed systemic modeling for the tank.

RESULTS

The results of modeling the RTD curve of the tank revealed that the best model which can be used to describe the bulk of the liquid in the tank was the perfect mixers in parallel and the effective volume was estimated to be 83.5%. Modeling of the deconvolved signals revealed that the liquid in the upper portion of the tank can be expressed by the perfect mixers in parallel model too. However, the bulk of the liquid in the tank can be described by the perfect mixers in series model and the effective volume was estimated to be 77.9%. The reduction of the tanks' effective volume was accounted by the presence of a small stagnant zone in the vicinity of the lower portion of the tank. The study concluded that the use of the deconvolved radiotracer signals permitted the appropriate RTD modeling; therefore they can be used in modeling industrial scale reactors by RTD models.

KEYWORDS

radiotracer, residence time distribution, deconvolution.

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Use of radioactive tracers for measurement of flowrate distribution in industrial flotation circuits

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ABSTRACT

The distribution of flowrates to two or more parallel flotation circuits is typically unknown, which is a constraint for calculating reliable mass balances. Under these conditions an even distribution is often assumed between the parallel process lines, thus affecting metallurgical performance as well as the proper implementation of automatic control systems and strategies of predictive control.

In most cases where the installation of flow meters is not possible due to technical or economic limitations, the residence time distribution measurement using radioactive tracers has many advantages, because is a non-invasive technique and has been developed and applied at industrial scale in different concentrators in Chile, including the testing of flotation and grinding processes [1]. Depending on the type of radioactive material selected, liquid and solid flowrates can be determined independently, as well as solids per different particle size classes and mineral characteristics. This methodology consists of the tracer injection in some point of the flotation circuit, while the inlet and outlet tracer signals are measured on-line by means of non-invasive sensors under normal operating conditions [2][3].

The main aim of this work is the identification and quantification of the pulp distribution problems under the typical plant operating conditions (baseline), in order to carry on operational or design changes to enhance the pulp distribution in flotation circuits, e.g. changes in the opening of feed valves located at the distributor tank, for feed regulation to flotation rows, or changes in the circuit layout. For example, under normal operating conditions, the valve setting (e.g. 100% open) for the pulp distribution to the scavenger rows A and B of Los Pelambres concentrator showed an unbalanced condition (40% vs 60%). This kind of unbalanced flowrate distribution has been also observed for the feed flowrate distribution in parallel rows of rougher circuits and cleaning operations where flotation columns are installed in parallel.

A detailed case of study is presented, where radioactive tracer experiments were conducted to determine the pulp flowrate distribution in the parallel flotation Rougher rows A and B at Los Pelambres concentrator [4]. The pulp distribution was evaluated under the typical plant condition (baseline) and some operational changes were performed to enhance the pulp distribution. The distribution was estimated from the mean residence times, which were directly measured by using the radioactive tracer technique.

Figure 1 shows the injection point and the sensors location in the rougher rows A and B at the plant. Tracers were injected in the feed distributor tank and sensors were located at the input and output streams of cells 1 and 2 of each rougher row. The arrangement of these sensors allowed to decrease the time of measurements.

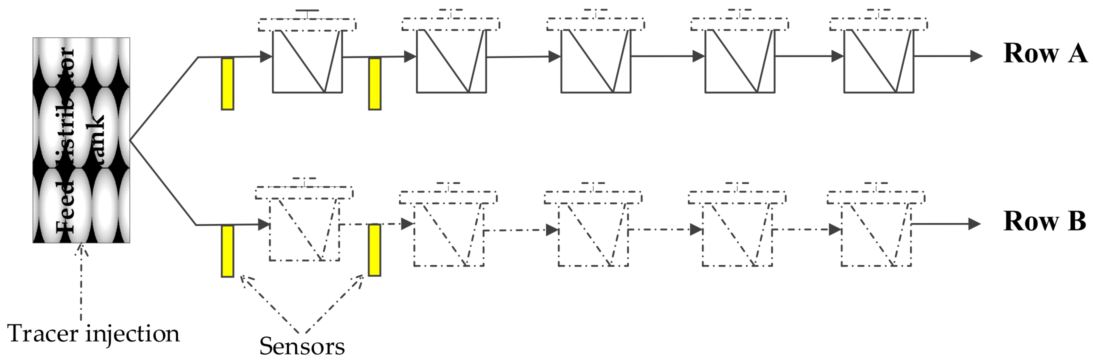

Figure 1. Sensors location in rougher rows A and B.

Table 1 summarizes the operational conditions in the feed distributor tank during three radioactive tracer tests, where the first corresponds to the typical plant condition (baseline) and tests 1 and 2 refer to the operational changes performed to enhance the pulp distribution. It should be noted that the residence time of circuit C was not significantly affected due to the operational conditions of tests 1 and 2.

Table 1. Operational conditions in the feed distributor tank during the radioactive tracer tests.

Tests	Operational condition
Baseline	Two open valves to each of rougher circuits A and B.
Test 1	Two open valves to each rougher circuit A and B. One open valve to rougher circuit C.
Test 2	Two open valves to each rougher circuit A and C. One open valve to rougher circuit B.

Table 2 shows the average pulp distribution to the rougher rows A and B from the feed distributor tank. Under the typical valve setting (baseline), the pulp distribution to the rows A and B showed an unbalanced condition, with a pulp distribution of A=66% versus B=34%. For test 1, the pulp distribution was slightly enhanced. Finally, results from test 2 presented a significant improvement for the pulp distribution between rows A and B (51% versus 49%). Therefore, this condition allowed reaching a balanced pulp distribution from the feed distributor tank.

Table 2. Pulp flowrate distribution to rougher rows A and B.

Rougher row	Baseline	Test 1	Test 2
7	66.4%	60.4%	50.7%
8	33.6%	39.6%	49.3%

This new approach based on residence time distribution measurements and using radioactive tracers, has been successfully applied for identification of uneven pulp distribution in rougher, scavenger and cleaning circuits in concentrator plants in Chile [5].

KEYWORDS

Radioactive tracer, residence time distribution, flotation circuits, pulp distribution.

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Determination of leaks and passes in vapour generators by the use of proper radiotracer for aqueous and organic phase

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ABSTRACT

Various techniques based on the application of tracers and radiation sources have developed in Peru, to solve problems in hydrocarbon operating facilities.

Radiotracer experiments were performed in a water vapour generator from a FCC Unit heavy liquid hydrocarbon, in order to investigate leaks / passes occurring, either from tubes to shell or from shell to tubes.

For online detection, it was used a tracer technique, by using two radiotracers, depending on the phase to be investigated: oleic acid labeled with Iodine 131 as a radiotracer for the heavy hydrocarbon phase and an aqueous solution of Iodine 131 for the aqueous phase, when necessary. A data acquisition system, as well of a portable PC, and detectors in proper positions, were the main part of the measuring system. Recording values were synchronized as well as ambient background, prior to each injection of radiotracer.

Two determinations were conducted, by two injection of radiotracer, either in tubes or in shell, as applicable.

Limits for leak / pass, of 0,1 %, of one stream to another were achieved.

KEYWORDS:

Tracer, injection, vapour phase, generator, leaks, passes, shell, tubes, FCC Unit.

Residence Time Distribution Measurements in a Pilot-Scale Cross Flow Trickle Bed Reactor Using Radiotracer Technique

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ABSTRACT

A series of radiotracer experiments were successfully carried out in pilot-scale trickle bed reactor to evaluate the hydrodynamic efficiency of the cross flow reactor to used for the hydroprcessing plant in a refinery. Br-82 as ammonium bromide was selected and used as a radiotracer. The experimental data was found to be good in agreement with the axial dispersion with exchange model.

KEYWORDS:
Residence time distribution, Radiotracer, Trickle bed reactor

INTRODUCTION

Hydroprocessing is the most promising secondary refining process wherein heavier feedstocks are treated to produce superior quality fuels. The new reactor that can process this reaction efficiently is cross flow trickle bed reactor. Uniformity of fluid distribution is the critical aspect of design and operation [1]. A residence time distribution (RTD) measurement in a pilot-scale cross flow trickle bed reactor was carried out to investigate fluid flow dynamics.

EXPERIMENTAL SETUP AND RADIOTRACER EXPERIMENT

Table 1: Results of RTD study in two different bio reactor models

S.No.	P (Kg/cm^2)	Q_g(Nm^3/hr)	Q_l(LPM)	$\bar{t}_B^{(S)}$	H_T	τ (S)	Pe	N	Φ
1	1.0	32.2	6.4	314	0.24	300	0.15	1	1
2	1.0	32.2	12	185	0.27	212	0.35	1	1
3	1.0	32.2	19	130	0.30	87	0.78	1.3	1
4	1.0	24.1	6.4	270	0.21	301	1.4	1	0.3
5	1.0	24.1	12	158	0.23	145	2	0.9	0.2
6	1.0	24.1	19	113	0.26	102	5.4	0.7	0.16
7	1.0	16.1	19	118	0.27	75	0.39	0.2	0.2
8	1.0	16.1	12	167	0.24	126	0.42	1	1
9	1.0	16.1	6.4	271	0.21	272	0.6	1	1

P: Pressure in the column; Q_g: Gas flow rate, Q_l: Liquid flow rate, $\bar{t}_B$:MRT of liquid in the bed, H_T: Liquid hold up in the column, τ: Model simulated MRT, Pe: Peclet no., N: No. of exchange unit,Φ :Dynamic liquid holdup

The schematic diagram of the cross-flow reactor (CFR) is shown in Fig. 1. A series of radiotracer experiment was carried using Br-82 (74 MBq each run) as ammonium bromide. The radiotracer was injected as a pulse and radiotracer movement was monitored at nine different locations along the height of the reactor by NaI(Tl) scintillation detectors as shown in Fig. 1.

DATA TREATMENT, MODELING AND RESULTS

The data obtained from the experiments was corrected [2, 3]. The corrected data was plotted and analyze for radial distribution across the bedas shown in Fig.2. To describe the flow of liquid in the reactor axial dispersion model with the dead volume exchange was used. The model simulated data was fitting very well to the experimental curve as shown in Fig. 3. The results of the study are given in Table 1.

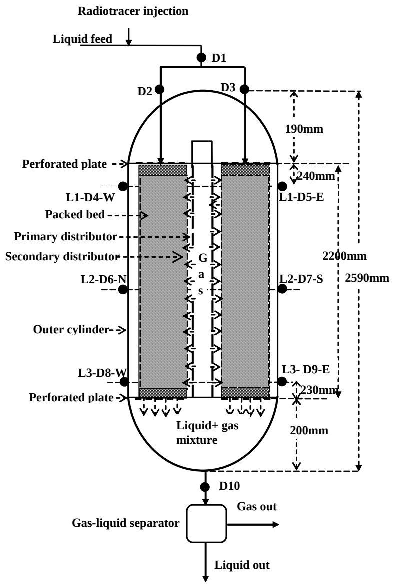

Fig.1. Schematic diagram of the cross-flow reactor and experimental set up

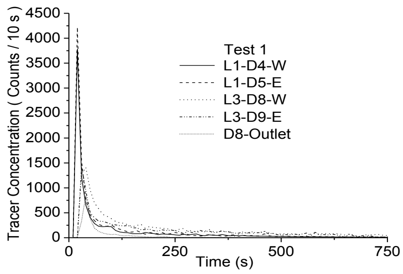

Fig. 2. Treated radiotracer concentration curves

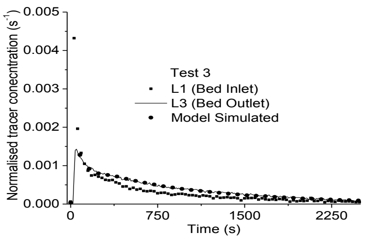

Fig.3. Comparison of experimental and model simulated RTD curves

CONCLUSIONS

The results of the study suggest that the radial distribution of aqueous phase was fairly good across the cross-section of the CFR. The holdup of liquid phase increased with increasing liquid flow rate and was found to be independent of gas flow rate. The axial dispersion with exchange model was found suitable to describe flow in the CFR.

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Radiotracer Investigation of Clinker Milling at East African Portland Cement

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ABSTRACT

Radiotracer technology is an established means of troubleshooting and optimizing industrial processes. Radiotracers enable industrial processes to be studied in-situ, thus avoiding downtime during the investigation. The technology is however new to Kenyan industries with no evidence of its use in troubleshooting and optimizing of industrial processes.

The project aims to carry out radiotracer RTD studies at East African Portland Cement plant. Cement is a key input in the construction sector, a sector that in 2017 contributed to 5.8% of Kenya's GDP. Optimization of cement milling process can lead to significant energy and time savings and the consequent reduction in production costs. The clinker grinding mills of the two plants will be studied using the locally available medical radiotracer technetium-99m.

RTD data generated from the experiment will be analysed to determine the mean residence times and efficiencies of the mills. The RTD will further be used in modelling the system response using IAEA RTD software. The output of the modelling will be used to identify anomalies, if any, present in the flow characteristics of clinker through the mill.

INTRODUCTION

East African Portland Cement Company (EAPCC) is a cement manufacturing plant in Athi River town, Machakos County, Kenya. As of 2017, the plant had a production capacity of 1.3 million tonnes per year (East African Portland Cement, 2018) making it the third largest cement producer in the country.

The plant produces Portland cement, which is a type of cement primarily made up of calcium silicates, calcium aluminate, calcium aluminoferrite, and gypsum, a hydrated calcium sulphate. The production of Portland cement can be summarized in two major steps: First limestone and clay are ground, blended then fed into a kiln where they are heated to produce clinker in form of hard nodules. Secondly, the clinker is ground together with gypsum and pozzolana in a mill to yield cement.

Cement is a key input in the construction sector, a sector that in 2017 contributed to 5.8% of Kenya's GDP (Kenya National Bureau of Statistics, 2018). Kenya is also a major cement exporter in the region having exported 387.6 thousand tonnes in 2017 to countries in Eastern and Central Africa.

The manufacture of cement is an energy intensive process; the clinker production stage consumes the most thermal energy while clinker grinding consumes the most electrical energy (Worrell and Galitsky, 2008). Optimizing these processes to increase their efficiency thus presents a significant cost saving opportunity in the manufacture of cement. Radiotracer studies can be used to expose inefficiencies in these processes due to causes such as the wear and tear of the processing equipment.

In Kenya, the applications of radiotracers are yet to be routinely used in industrial plants. Residence time distribution (RTD) studies have been used before in Kenya to study the efficiency of unit operations; however, this has been done using chemical tracers. In a RTD study on a mill, Makokha et al (2014) used sodium chloride as a chemical tracer. This required them to manually sample and test the mill discharge periodically for tracer concentration. Application of a radiotracer would have enabled in-situ detection and tracer count rates could be measured continuously over the duration of the study.

MATERIALS AND METHODS

EAPCC has four clinker grinding ball mills: mill 1, mill 2, mill 3 and mill 5. Mill 5 is in closed circuit configuration, which means coarse particles leaving the mill are separated from the fine particles and recirculated back to the inlet of the mill for further grinding. This study will be carried out on mill 5.

Technetium-99m (Tc-99m) has been chosen as the radiotracer due to its availability in Kenya as a medical isotope. The tracer is in the form of sodium pertechnetate solution. The radioisotope emits low energy gamma photons when compared to other industrial radioisotopes such as gold-198. However, its most abundant gamma emission, a 140.51 keV photon, has a half value layer of 8.1 mm in steel (Canadian Nuclear Safety Commission, 2016). This will allow the emissions to be detected through the mill inlet and outlet walls, which are made of approximately 10 mm thick steel.

Before introduction of the tracer to the mill, the pertechnetate solution will be mixed with a small amount of clinker to obtain a solid tracer with similar mechanical properties to the clinker. To ascertain how well the clinker absorbs aqueous solutions, 5 ml of potassium permanganate solution was poured on 270 g of clinker. It was observed that the clinker absorbed all of the solution.

The solid tracer will be introduced at the inlet then its flow through the process monitored at four positions using sodium iodide (NaI(Tl)) scintillation detectors. The first detector will be placed at the inlet to the mill, the second detector at the outlet of the mill, the third at the coarse material outlet of the separator and the fourth at the fine material outlet of the separator. The count rates from the detectors will be recorded using an Altaix data acquisition system.

The collected data will be modelled using the International Atomic Energy Agency RTD software to determine the type of flow through the mill. From this model it will be possible identify anomalies in the flow of material through the mill. These anomalies can include dead volumes and bypasses that cause a deviation in the expected flow behaviour. The efficiency of the mill will also be determined by calculating the separation coefficient (Mumuni et al, 2011).

KEYWORDS:

cement, clinker, radiotracer, technetium-99m

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Application of Radiotracer Technology: Laboratory experiments and modelling using Flow Rig

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ABSTRACT

Most industries in the world employ the radiotracer technology as a means of troubleshooting and optimization of their industrial processes. This plays a critical role in enhancing the efficiency of productions to these industries. In Kenya, like in many African states, there is material weakness in industrial process optimization which causes ineffective operating management. This leads to revenue loss and reduced profits or worse still to loss of life when accidents occur. The use of radiotracers can provide high economic benefit and socio-economic development. They can help in reduction of plant shutdown time, improved production efficiency and consolidated working safety as well as conservation of materials and energy which in turn reduce negative environmental impact of industrial processes. A radiotracer injected at the inlet of most industrial systems can be monitored at the outlet to provide the behavior of the system. This work involves carrying out ^{99m}Tc radiotracer injection experiments in water flow rig where flow rate, mixing time and the residence time distribution (RTD) will be assessed. Data from the RTD measurement experiment will be further processed, using MATLAB software, to make corrections for background, decay, starting points, extrapolation and filtering. The preprocessed data will then be used to investigate various models using the International Atomic Energy Agency (IAEA) RTD software and the results will be presented in the ICARST-2018 conference.

We acknowledge training support on tracers by International Atomic Energy Agency and research capacity support at University of Nairobi by International Science Programme, Uppsala University, Sweden.

KEYWORDS

kenya, african states, environmental impact, socioeconomic development, matlab

Determination of residence time and performance of a heat exchanger in a natural gas fractionation plant of liquids

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ABSTRACT

Process involved is the application of radiotracer to determine the residence time and eventual leaks / pass that could exist in a heat exchanger used in different industries, such as petrochemicals, etc. In this case, the radiotracer technique was used for on-line detection, using oleic acid labeled with Iodine 131 as a radiotracer with a total activity of 666 MBq (18 mCi). Some experimental arrangements were necessary to do in order to ease the injection of the radiotracer to the fluid intake lines to the heat exchanger. The radiotracer injection and detection points in the exchanger were implemented according to the work plan previewed prior to the service implementation stage. The data acquisition system, as well as the detectors in their respective positions, were synchronized and recorded environmental radiation background values (baseline) before proceeding to perform each of the three (03) injections of the radiotracer two (02) in shell and one (01) in tubes. Radiation counts were recorded at intervals of 0.5 seconds for each case.

Results obtained by the detectors indicated that the experimental residence time obtained by the passage of the thermal fluid in the shell under the operating conditions given for the flow, Q (P, T) = 178 GPM, was 454.95 seconds, as the average resulting from the two (02) injections performed on the shell; there was thermal fluid pass inside the shell in an estimated fraction of 31%, there was no fluid pass from shell to condensate in tubes. And in the tubes the experimental residence time obtained by passing the condensate in tubes under the operating conditions was 16.2 seconds and there was no condensate pass from tubes to shell fluid.

INTRODUCTION

The application of radiotracer technology is frequent in oil refineries throughout the world, and this industry is one of the main users and beneficiaries of the technology. Radioactive tracers have been used to a large extent in increasing oil production and in petrochemical plants with singular success. The chemical and petrochemical plants in general operate continuously and are technically complex, radiotracer techniques are very competitive and are largely applied to the solution of problems of inspection and analysis of processes. The evaluations with radiotracers take place in situations in which the efficiency of heat exchange, within the units, is affected by distortions of the fluid inside them, mainly due to design deficiencies, defectology of the internal metallic structures, such as baffles, plates, etc., which influence the transfer of heat between the fluids circulating in such units, forcing a longer heating time in the following stages of the process, such as preheating.

PROCEDURE

The heat exchanger was a tubes set type of 6 meter length and 1 meter diameter, in which 8 detectors (NaI scintillation type) connected with the data acquisition system were installed, as Fig. 1 shows:

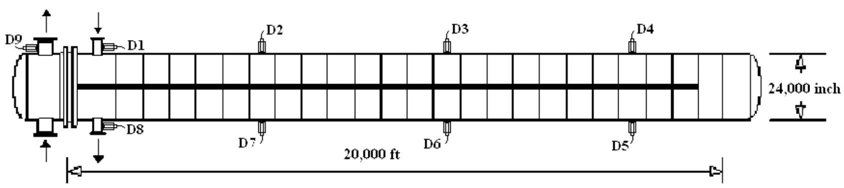

Fig.1 Detectors setting for determination of possible passes/leaks of thermal fluid in heat exchanger

Flowrate of thermal fluid inside the system was 178 GPM. In order to evaluate performance and eventual leaks/passes in the heat exchanger, three injections of radiotracer Oleic acid labeled with Iodine (I-131) were performed for on-line detection by using a pump: two in the shell (one for general behavior evaluation of the thermal fluid in the shell and the other one when, once detector counting anomalies were observed in the lower zone of the heat exchanger, it was necessary to define the exact zone of these anomalies) and one injection in tubes section for evaluating possible leaks/passes to shell.

Results showed that in the shell, experimental residence time obtained was 454.95 seconds, as the average resulting from the two (02) injections performed on it. And there was a thermal fluid pass inside the shell, in an estimated fraction of 31%, as an average resulting from the two (02) injections made in the shell. (Fig. 2)

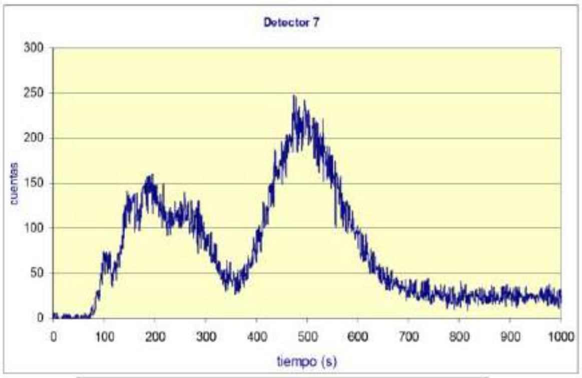

Fig. 2 Radiotracer curve in detector 7 (baffle 7 to 14 lower)

In the case of tubes, there was no condensate pass from tubes to shell fluid. Experimental residence time obtained by passing the condensate in tubes under the operating conditions was 16.2 seconds.

KEYWORDS:

Radiotracer, heat exchanger, leaks, residence time

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Leak Test in Underground Hydrocarbon Pipeline Using Pig-Radiotracer Method

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ABSTRACT

The mileage of underground pipeline has been constructed for transportation of various types of hydrocarbon fluids from one station to another. The pipeline is made of carbon steel with outside diameter of 16 inch. Hydrostatic test on the part of the pipeline which span along 3,4km confirmed that the water pressure inside the pipeline dropped as big as one-third from its initial pressure within 24 hours test. Nuclear-based technology called pig-radiotracer method has been implemented to identify the leak and its location. Around 100 mCi Iodine-131 (^{131}I) was diluted into 1500 liter of canal water in plastic vessels to form radiotracer solution. Prior to injection, five glass vials containing solution of isotope of iodine with concentration varied from 0.5 mCi/cc to 1 mCi/cc were prepared and inserted into holes which was enchased with PVC tubes of 3 inch diameter. The 1 inch scintillation,NaITl, detector and rate meter equipped with data-logger there in was assembled and placed in compartment of pigging device. The injection point was chosen at one end of pipeline located at the control box. The injection and radiation monitoring was carried out by the following steps: (1) the pipeline was emptied first, (2) both ends of pipeline were blinded by flanges with hole for fluids access. (3) the prepared radiotracer solution and water from canal were injected simultaneously such a way that the pipeline was filled with full these mixed solution, (4) high pressure hydro static test was then applied to push the solution to penetrate through leak point(s) for several days, (5) empty the pipeline, the penetrating isotope solution remain around the leak point(s), (6) insert pigging device containing radiation detector and rate meter from one end of pipeline and push this assemblage to let it to move along the pipeline until the another end. During movement, gamma radiation from any iodine sources and background radiation were recorded and saved in data-logger. Plot of retrieved data from data-logger which represent a continuous graph of radiation intensity versus distance showed that the location of leak was at the distance around 1200 m from injection point and leak point at position of 2 o'clock.

KEYWORDS:

leak, pig-radiotracer, iodine-131, pipeline, underground.

The torus photobioreactor: a tool for metabolic flux analysis

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ABSTRACT

Many examples of photobioreactors (PBRs) can be found in literature. But only a few geometries are particularly are well adapted for fundamentals studies under rigorously controlled conditions [1]. Light is the key factor that control the productivity of bioprocesses involving photosynthetic microorganisms. Since cells are absorbing and diffusing materials, light is heterogeneously distributed inside the PBR. Light attenuation prediction is facilitated if the one-dimensional diffusion hypothesis on the radiation-field can be done [2]. A second important parameter is the hydrodynamics applied in the geometry. The culture must be sufficiently mixed to prevent flowing cells from sedimentation and homogenize nutrient concentration. It is important to generate hydrodynamic conditions that promote mixing along the light gradient so as to homogenize light received by each cell with respect of time [3].

In this study, a laboratory-scale torus PBR designed for carrying out metabolic flux analysis under well-defined and controlled conditions is presented and investigated. The set-up allows a simple and accurate determination of the light received by the culture, while providing good mixing conditions thanks to the flat surface of the PBR and the presence of a marine impeller. Light transfer in torus PBR has been studied in a previous work [4], and the assumption of the one-dimensional hypothesis for radiative transfer modeling was verified. Besides, an efficient mixing, macromixing [5] and micromixing [6], is attained, because of Dean vortices involved by the reactor bends, and of the rotation of the marine impeller that generates a three-dimensional swirling motion in the geometry [7]. The combination of these two effects leads to an absence of dead volumes in the reactor.

For carrying out transient isotopic ^{13}C-labeling experiments under photoautotrophic conditions, the PBR has to allow a rapid sampling and quenching procedure and a good mixing throughout the reactor to ensure a sudden step-change in the ^{13}C-labeled feed from liquid label injection without affecting the uptake flux rate [8]. The experimental strategy was to incorporate the labeled carbon into the cultivation system by liquid injection and control the mixing process to get the shortest mixing time. To achieve this objective, a typical control procedure was designed which consists in uniformly injecting labels over a duration close to the circulation time in a torus plug-flow reactor.

The objective of this work was to model the operation of the torus PBR when it is used for isotopic labeling. In a previous article [8], we showed that one criterion to reach a correct analysis of the metabolic behavior of microalgae under photoautotrophic conditions was to inject the isotopic marker in the form of a step, whose duration corresponds to the circulation time in the reactor. The objective is to analyze the curves of residence time distribution obtained after a purge-step tracer injection and to deduce the hydrodynamic.

MAJOR RESULTS

The objective is to reduce the mixing time with the objective to have a mixing time close to the circulation time. To do this, a second agitator was added to improve the mixing between the existing dead zone and the zone where the toroidal flow occurs. Stirring was enhanced by using two marine impellers attached to the same shaft at different heights. Acting on the height of the second propeller allows to reduce the circulation time (t_c) for a speed of 300 rpm, 600 rpm and 900 rpm compared to a circulation time obtained with a single propeller and to define an optimal height for which the circulation time is minimal. The question was to know how the circulation time evolved according to the position of the second propeller whether it was positioned close to the cultivation surface or on the contrary at the level of the dead zone / tore interface. It turned out that this secondary propeller, driving an additional agitation, had a notable influence on the circulation time measured as a function of the height chosen, whatever the agitation speed.

The tracer injection is made in as much time as it corresponds to a "reactor" turn (torus + dead zone, *i.e.* a circulation time). The movement of the stainless steel syringe was perfectly uniform (with a coefficient of determination R^2 of 0.99), and allowed an injection time of 2.03 s to be measured (very close to the circulation time of 2.06 s). Thus, it took a mixing time of 2.84 s from the start of injection for the marker to reach its final concentration of plus or minus 5% (Figure 1). We observe that the tracer concentration oscillates little while remaining within the so-called homogeneous zone. Thus the observed mixing profile is as close as possible to one step. The progression of the injection (green line) allows to measure the injection time while controlling the uniformity of the piston movement. The tracer concentration (blues lines) increases until it reaches its final concentration of plus or minus 5% (so-called homogeneous zone, between the two dashed lines). Simulation result (red line) was found to match closely to measured results.

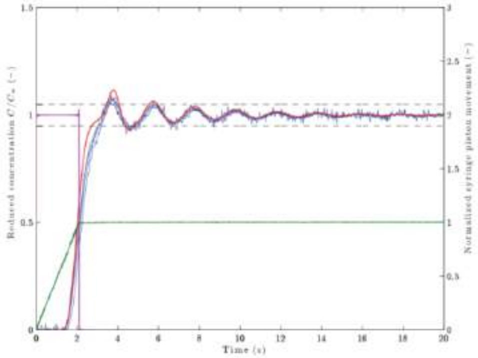

Figure 1: Mixing inside the torus-shaped photobioreactor after a controlled step injection of tracer. Injection progress (green lines) allows measurement of injection time while controlling the uniformity of syringe piston movements. Labeling concentrations (blue lines) reach final concentration within 5% (area between the two dashed lines). Four overlaying assays are presented.

KEYWORDS:

Mixing time, Purge-step injection, RTD, Torus reactor

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Radiometric methods for optimization fo phosphate transport process by "slurry pipe"

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ABSTRACT

Morocco can now lay claim to the largest phosphate slurry pipeline system in the world. The system consists of several pipelines totaling 235 km in length and transports 4400t/h of phosphate. The slurry pipeline represents an efficient transport system, competitive and ecologically profitable.

The pipeline between Khouribga mines to JorfLasfar chemical units, it s built to converge between cost reduction and rationalization of water and energy consumption.

Determination of physical parameters, such as concentration, viscosity, flow rate, etc… of the material inside the pipe becomes a key issue for handling and maintaining the whole system. The current study aim to develop radiotracer methodologies to obtain such information and to contribut to a better understanding the flow conditions at the Slurry Pipe head station. Among the expected results include the characterization of the distribution of the residence time of the pulp in the inlet tanks and the evaluation of the output flow of the latter. The flow measurement in question will be compared with the measurements made using the installed conventual techniques.

The study consists in carrying out of a series of field experiments, aimed flow measurement of pulp phosphates, by using radiotracers (I-131) in various flow conditions. the injection of the radiotracer in the Splitter Box, at the entrance of one of the Slurry pipe feed tanks and its monitoring since outside by means of radiation detectors used to measure the flow of the pulp. The experimental data provided by this study are processed and modeled.

KEYWORDS

Radiotracer, flow rate, Slurry pipe, pulp phosphate, tanks.

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Stability Study of gold -198 Nanoradiotracer in Petroleum Derivatives

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ABSTRACT

Due to the great importance of the petroleum industry in the international economic scenario, the control of petroleum storage and transfer operations is of extreme importance in order to guarantee the efficiency of the processes to optimize the activities pertinent to this industry and thus reduce the inherent costs of such processes.

The use of radiotracer is a tool of great importance because it allows an evaluation of the transfer / transport pipelines of oil and derivatives in a minimally invasive and with high precision. The objective of this work is to evaluate the stability of these particles in the organic medium for their use as nanoradiotracer in petroleum and organic derivatives.

The nanoparticles were synthesized and activated at the Argonauta Reactor located at the Institute of Nuclear Engineering in the city of Rio de Janeiro / Brazil. The research presents a potential grid for the expansion of the use of nanoradiotracer for use in the petroleum industry.

KEYWORDS

Nanoradiotracer; Gold-198; Petroleum Industry

Investigations of Sparger Design Effect on Residence Time Distribution in Bubble Column Reactor Using Industrial Radiotracer Au-198 and Tc-99m

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ABSTRACT

Radiotracer technique is well established assisting tools for troubleshooting and process optimization in process industries. Industrial radiotracer has proved to be a very useful tool to examine and improve the design of pilot-scale systems especially bubble column reactor. Review finds lack of research has been conducted for investigating residence time distribution information for bubble column reactor with different types of sparger plate as gas distributor tools at different gas flow rate using dedicated radiotracer technique. In addition, a primary concern of industrial radiotracer is the capability of tracer to remain stable and intact in the process stream under harsh process reaction condition in processing industries. Thus, the solid nano-sized particle radiotracer $^{198}Au@SiO_2$ has been synthesized and characterized for tracing liquid phase effectively. This study aimed to compare the residence time distribution between different sparger plate designs and gas flow rates in quadrilateral bubble column reactor. This study also introduced an important opportunity to evaluating the potential performance of solid phase $^{198}Au\text{-}SiO_2$ as an effective nanoparticles radiotracer for tracing residence time of liquid phases in multiphase reactor. A series of radiotracer experiments was carried out to measure the volumetric flow rate, residence time distribution, and mixing efficiency of the gas-liquid interaction in the quadrilateral bubble column reactor and evaluate their hydrodynamic performance. Quadrilateral bubble column reactor internal diameter was 200 mm, and the internal diameter of connecting pipe was 18 mm. The reactor was designed to operate with constant water flow rate fixed at 8 liter per hour (lpm). Air is purged into the reactor to create air bubbles for aeration from the bottom by passing through 6 different sparger plate with flow rates fixed between 20 – 100 lpm. All the experiments were carried out at an ambient temperature with normal air and tap water represent as gaseous and liquid phase, respectively. About 4 mCi to 500 mCi radioisotope ^{198}Au and ^{99m}Tc was selected as tracer in this experiment because of its unique characteristics. In a mean time, the performance of the nanoparticles $^{198}Au@SiO_2$ as radioactive tracer for tracing water phase in bubble column was also successfully validated by comparison between nanoparticles ^{198}Au and conventional radiotracer, ^{99m}Tc. This study has applied six recommended IAEA RTD models that successively well fitted the experimental results. The acceptable fitted model for current bubble column study was best described by perfect mixers in series with exchange model (PMSE). It was observed that, increased air flow rates were significantly reduced the mean residence time. The analysis shows that air flow rates factor are highly significant to introduce changes for value of MRT compared to the sparger design. In conclusion, MRT measurement results in bubble column reactor in this study were affected by the presence of high degree of back mixing flow and stagnant volume inside the flow systems.

KEYWORDS

Residence Time Distribution, Industrial Radiotracer, Quadrilateral Bubble Column, Sparger Plate Design.

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Use of I^{123} Radiotracer to Model the Oil Non-Ideal Laminar Flows in Pipelines

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ABSTRACT

Laminar flow is common for viscous fluids in pipelines [1] and the aim of this work was to study the behavior of Lubrax Essencial® oil (density at 20/4ºC : 0,8846 g · cm^{-3}, viscosity at 40ºC :183,7cSt) flow profile in an experimental 2.0" diameter pipeline.

The oil was labeled with I^{123} [2] (159 keV and $T_{1/2}$ 13.2 h). Using iodine monochloride as the radioactive carrier, the radioisotope was extracted from aqueous phase with diethyl ether and after that, mixed with 25 mL of non radioactive oil. The next step was to wash the oil labeled with 50 ml of ultrapure water in order to remove all free iodine ions. This process was repeated three times and in each stage, the total activity of iodine in water phase was evaluated by calibrated scintillator count system and the results show that more than 85% of initial Iodine activity was linked to the oil molecules, it was done to certified that the iodine ions did not interact with the experimental pipeline wall during the flow experiments.

In the non-ideal laminar flow [3] experiments, 25 mL of labeled oil was injected as a fast pulse and radiotracer was monitored by six NaI (1X1) well-collimated scintillator detectors. The first one was positioned 2.0 m from the injection point and 0.8 m downstream of a 90º bend. The others detectors were separated by 0.8 m each one. The steady-state oil flow was maintained by an electronic control device.

The RTD [4] curves were used to diagnostic the correct position of the detectors and they show that for the non-ideal laminar flow, the full developed distance from the bend depends on the Reynolds number [5]. This distance is very importing because, according to RTD curves, the flow profile changes with the distance from the bend and the mathematical models for non-ideal laminar flow only can be used beyond this length because after that the flow velocity profile does not vary.

KEYWORDS

Laminar flow, residence time distribution , flow rate measurement, oil and gas industry.

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