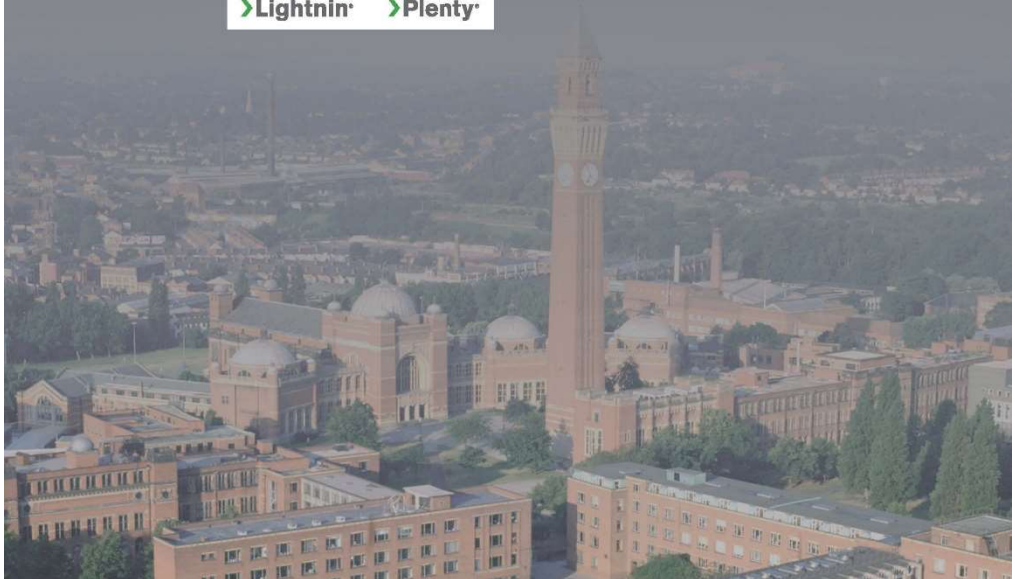
UNIVERSITY OF BIRMINGHAM

# ISMIP9

## International Symposium on Mixing in Industrial Processes 9

**25–28 JUNE 2017,**
**HYATT REGENCY**
**BIRMINGHAM**



# Welcome

The inaugural International Symposium on Mixing in Industrial Processes (ISMIP) was held in Quebec City, Canada in 1995. Since then the symposium has been held in countries around the world including Australia, Canada, China, Spain, France, Japan and Mexico.

ISMIP brings together the global mixing community across academia, industry and research institutions to share and discuss the most recent developments in research and in processing. The symposium is unique in its blend of academic and industrial interest within the mixing community. For this symposium, the ninth in the series, we will particularly focus on the following topics

- Mixing of fluids with complex rheology - single or multiphase fluids from dilute suspensions to slurries, formulated liquid products;
- Mixing for manufacturability – from laboratory to process scale in batch and continuous processes;
- Mixing within biological processes – effects of local conditions on cells and bioreactor performance;
- Mixing in microfluidic systems – chemical and bio-processing driven by microscale mixing;
- Simulations – different computational techniques used for mixing processes such as CFD

Our symposium is hosted by the School of Chemical Engineering at the University of Birmingham. Birmingham is a city which was at the forefront of the industrial revolution in the 18th Century; by 1791 it was hailed as the “first manufacturing town in the world”. Today, the city is a major international commercial centre; its metropolitan economy is the second largest in the United Kingdom and its six universities make it the largest centre of higher education in the country outside London.

We are delighted to have keynote lectures given by distinguished academics and industrialists working in the mixing field, namely Prof. Jonathan Seville, Prof. Alvin Nienow, Prof. Richard Calabrese, Prof. Suzanne Kresta, Prof. Hugh Stitt, Prof. Adam Kowalski and Prof. Jerzy Baldyga – three of whom have travelled from afar to join our meeting and contribute their insights.

Part of the conference includes an industrial exhibition and we are most pleased to welcome ITS Ltd., NOV, M-Star, TSI Ltd and SPXFLOW. You will have the opportunity to find out more about the work of these companies during the conference.

We will also be arranging a call for invited papers for a special issue of **Chemical Engineering Research and Design** following the conference

On behalf of the ISMIP9 organizing committee, scientific committee, exhibitors and the School of Chemical Engineering at the University of Birmingham, it is our pleasure to welcome you to this event; many of you have travelled from all parts of the world to be with us. I am sure you will thoroughly enjoy the symposium program, the associated activities and the engaging environment of ISMIP9.

**Mark Simmons**, Head of Chemical Engineering
University of Birmingham, UK

**Gul Ozcan-Taskin**, Department of Chemical Engineering, Loughborough University, UK

**Symposium Co-Chairs, ISMIP9**

WWW.ITOMS.COM

# SEE INSIDE YOUR PROCESS

Industrial Tomography Systems (ITS) is the world leader in measurement solutions using process tomography, a technique that works by taking volumetric, in-line electrical measurements to give real time 3D images and data on what is going on inside pipes and vessels.

## LIQUID-LIQUID MIXING

Process tomography is an effective technique for monitoring conditions at multiple positions throughout a vessel. As such it provides an ideal tool for optimizing the mixing of non-Newtonian fluids.

ITS' MIX-ITOMETER system was recently put to the test to monitor the production of fizzy drinks. The aim of the research was to establish if the system could monitor the mixing of carbonated water and syrup.

A two-plane sensor was used throughout the experiment; data taken directly from the trial is displayed in figure 1. The tomograms on the top row display the untouched carbonated water lying dormant in the mixing cavern.

The second phase displays the syrup entering the vessel. Immediately the change in concentration is registered on the tomogram, disrupting the once blue image.

Lastly, the final tomogram displays the end of the mixing process. The engineers were able to process to endpoint due to the real-time imagery. The fully homogenous, orange, tomogram informs us that the mixing is over as the syrup and carbonated water have been thoroughly blended together.

The results from the trial were overwhelming positive, as the tomograms in figure 1 display accurate readings of the foreign substance entering the mixing vessel whilst also displaying real time mixing homogeneity.

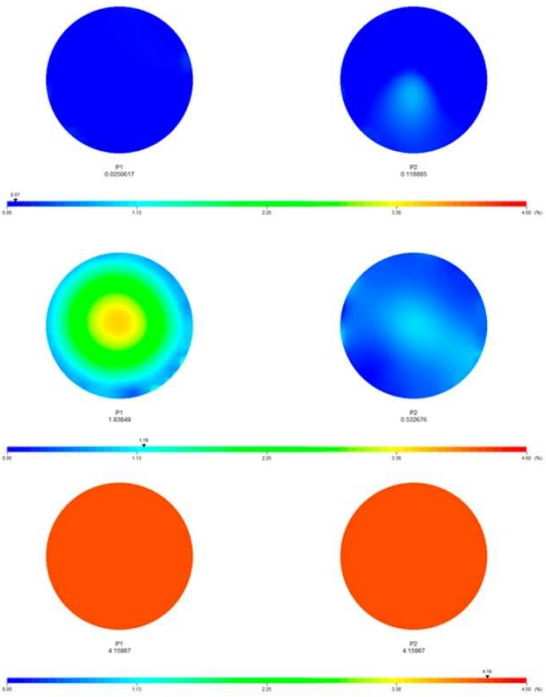


**Figure 1:** Tomograms displaying each stage of liquid-liquid mixing

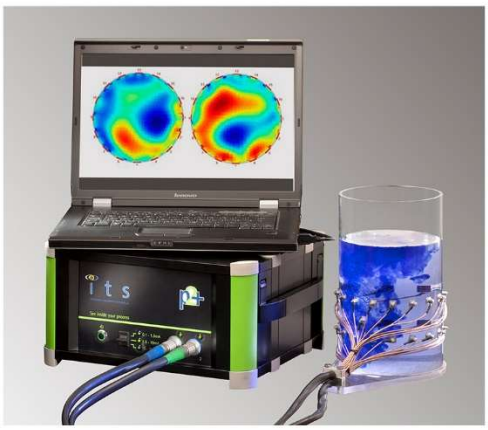


**Figure 2:** MIX-ITOMETER system and sensor

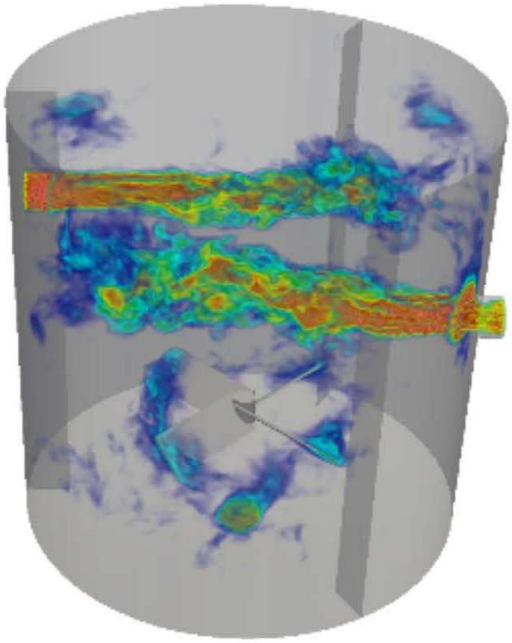
INDUSTRIAL TOMOGRAPHY SYSTEMS PLC
Registered in England No.04139271

Sunlight House, 85 Quay Street
Manchester, M3 3JZ, United Kingdom

T: +44 (0) 161 832 9297
F: +44 (0) 161 839 5195

E: sales.support@itoms.com
www.itoms.com


Bringing you excellence in mixing equipment for more than 65 years.
Chemineer™ rotating mixers | Prochem™ belt driven mixers
Kenics™ static mixers | Greerco™ high shear mixers
Learn more about our mixing solutions at nov.com/mixing.
©2017 National Oilwell Varco | All rights reserved
NOV

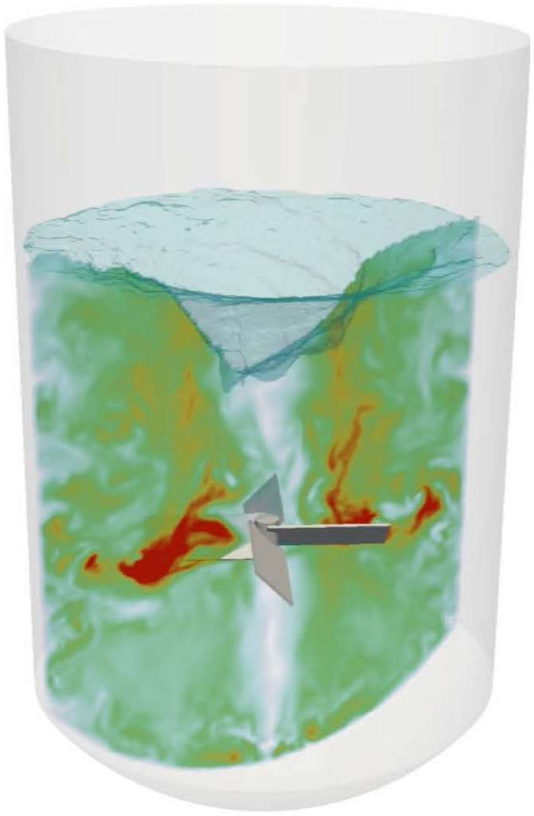


# Insights with Impact

Use the DMT to evaluate process design, throughput, and production consistency. Analyze the time development of surfaces and particles.

Improve reactor design before fabrication or scale-up.

Visualize and assess the coupling between reactions, heat transfer, and fluid flow to optimize process yield.



# A Better Foundation

The DMT uses direct numerical simulations (DNS) for laminar and transitional systems, and large eddy simulation (LES) for turbulent systems. The robustness of these time-accurate approaches eliminates the ambiguity associated with traditional turbulence models.

The DMT captures transient flow patterns that cannot be resolved using conventional RANS tools. Superior turbulence models in the DMT make complex fluids easy to model, including: Power law fluids, Carreau fluids, Custom constitutive relationships, Yield-stress fluids (coming 2017).

# Build Models Quickly

Import your existing CAD files or quickly generate notional geometry within the DMT. Specify system parameters and execute. No meshing required.

Execute the DMT on your local resources or send your simulation for processing in the cloud seamlessly.

M-Star

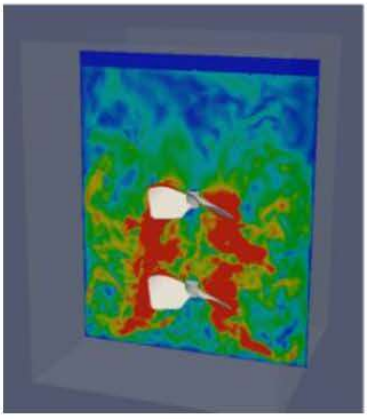
mstarcfd.com

sales@mstarcfd.com

SPXFLOW

›Lightnin® ›Plenty®

# A Global Leader in Providing Solutions For All of Your Fluid Mixing Applications




- Full range of modeling capabilities (CFD, Experimental, Mobile Lab)
- Dedicated R&D Group, providing Process Consulting Services

- Full range of mixer and impeller designs available for a wide range of applications (top entry, side entry, portable, laboratory mixers)
- Global network of manufacturing and service solutions (spare parts, mixer repairs and service, commissioning services)

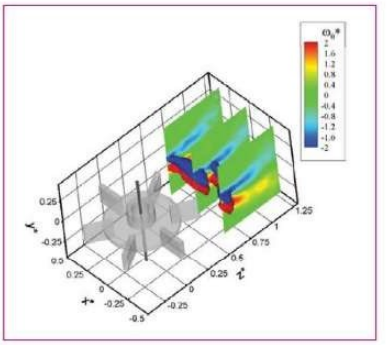
For more information, please contact your local sales office
http://www.spxflow.com/en/lightnin/where-to-buy/

# VISIT TSI AT ISMIP 2017

## BOOTH #8

## COME TO OUR BOOTH AND LEARN MORE ABOUT TSI SYSTEMS FOR MIXING STUDIES

+ Volumetric PIV for velocity measurement
+ Planar Laser Induced Fluorescence (PLIF) for mixing time studies
+ LDV for velocity and sheer studies
+ Simultaneous PIV and PLIF for velocity and dye concentration measurements



TSI®

UNDERSTANDING, ACCELERATED

## Keynote Speakers

**Jonathan Seville** is FIChemE FREng recently re-joined the University of Birmingham after five years as Dean of Engineering and Physical Sciences at the University of Surrey. He has degrees in Chemical Engineering from the Universities of Cambridge and Surrey and has held visiting appointments at the University of British Columbia and the Technical University of Denmark. He was President of the Institution of Chemical Engineers 2016-17 and is a Trustee of the Engineering Council, for whom he chairs the Registration Standards Committee.

His research is aimed at understanding and improving manufacturing processes involving granular materials such as detergents, pharmaceuticals and foodstuffs. His achievements include patented inventions for supercritical route particle formation, the first full experimental validation of discrete element codes in solids mixing, development of a continuous pharmaceutical granulation process and the first large scale use of mobile positron imaging on an industrial site. He is technical advisor to Recycling Technologies, a company he helped to start, which is devoted to recycling waste plastic back to oil feedstocks.

While Head of Chemical Engineering at the University of Birmingham, he established the UK's first research centre in Formulation Engineering and co-founded the Positron Imaging Centre, which has pioneered the use of positron-emitting radioactive tracers in engineering studies.

**Alvin W Nienow** is Emeritus Professor of Biochemical Engineering at the University of Birmingham (UK) and a Visiting Professor at Aston University (UK), and a Fellow of the Royal Academy of Engineering. He has a PhD and DSc from University College London and an Honorary Doctorate from West Pomeranian University of Technology (Poland) and Loughborough University, where he is also a Visiting Professor. Alvin was the founding Chairman of the Institution of Chemical Engineers Fluid Mixing Processes Special Interest Group (1978) and was one of the founders in Quebec (1995) of the ISMIP series.

The Institution of Chemical Engineers awarded him the Moulton Medal (best research paper) and the Donald Medal (Lifetime award for biochemical engineering). He has also received the Lifetime Award of the European Federation of Chemical Engineers Mixing Working Party and the Jan E Purkyne Medal (Czech Academy of Sciences). His research has been largely experimental, particularly related to the fluid dynamics of stirred tank (bio)reactors and the use of this knowledge in their design and operation for a broad range of processes such as crystallization, hydrogenation and particularly to biosystems: the fermentation of bacterial and filamentous organisms and yeast (brewing), the culture of animal and insect cells in free suspension, and of stem cells on microcarriers.

In addition, he has a patent related to a cell lysis bioreactor for plasmid recovery. Dr Nienow taught mixing at undergraduate and master course level from 1972 till 2004 and still directs short courses for industry. He has been a consultant for the BHRG's Industrial Mixing Consortium since its inception in 1983 and also consults widely in the US and mainland Europe.

**Richard V. Calabrese** is Professor of Chemical & Biomolecular Engineering at the University of Maryland, College Park, MD USA. Before joining Maryland in 1981, he worked for Pickard, Lowe & Garrick and Stevens Institute of Technology. He received his BS degree from the University of Rochester and his MS and PhD degrees from the University of Massachusetts.

Rich's expertise is in turbulent mixing and multiphase flow, with emphasis on drop dispersion & coalescence, prediction & measurement of particle size distribution, and measurement & CFD simulation of velocity fields in stirred contactors. He is the author of more than 75 publications, has given more than 300 presentations, and is a consultant to numerous chemical and pharmaceutical companies. He is director of the High Shear Mixing Research Program, founded in 1997.

Prof. Calabrese is a Fellow of the AIChE and has received the NAMF Award for Sustained Contributions to Mixing Research & Practice. He was Fulbright Senior Scholar and SERC Visiting Fellow at the University of Birmingham, a Visiting Scientist in Particle Science & Technology at the DuPont Experimental Station, and a Technical Adviser in the Office of the Assistant Secretary for Fossil Energy at the US Department of Energy. He has provided input to DOE and its subcontractors on design matters related to slurry transport and mixing in the Hanford (nuclear) Waste Treatment Plant since 2001.

Rich has served as chair of AIChE's Chemical Technology Operating Council and is a member of several national committees. He is a founding member, past Treasurer and Past President of the North American Mixing Forum, and has served as national programming chair and as the Chair of MIXING XV. Rich has contributed to NAMF's Handbook of Industrial Mixing and has also served as an Editor for ChERD.

**Suzanne Kresta** joined the University of Alberta in 1992, after completing a doctorate at McMaster University. She is a co-editor of the Handbook of Industrial Mixing (Wiley, 2004) and Advances Volume (Wiley, 2015) and has served as President of the North American Mixing Forum. She was awarded the Engineers Canada Medal for Distinction in Engineering Education (2014), the APEGA Summit Award for Excellence in Education (2013), the Rutherford Award for Excellence in Undergraduate Education (2011), the Senior Moulton Medal from IChemE (2005), the NAMF Award for Excellence and Sustained Contributions in Mixing Research and Practice (2004), and was named a Killam Annual Professor at the University of Alberta (2012). She teaches process design, mass + and energy balances, fluid mechanics, process data analysis, and mixing and served on APEGA Council from 2010-13.

Her research is on characterizing turbulence in a stirred tank to develop design and testing methods for mixing sensitive processes. She has collaborated with industrial colleagues to solve mixing problems in over 20 industries. Two of her papers were named among the 21 Most Influential Contributions to Mixing Research (2011), as was the Handbook of Industrial Mixing (2004).

Her teaching interests focus on two objectives: integrating engineering design into the core chemical engineering curriculum, and designing courses to accelerate student learning past routine problem solving and into critical thinking and process evaluation. She has been involved with faculty development at the University of Alberta since 1996, leading the (New) Faculty Forums, serving as a Peer Consultant across the university, and leading the Teaching Enhancement Committee in the Department of Chemical and Materials Engineering. She served as Acting Associate Dean, Research and Planning for the Faculty of Engineering from January-July, 2014 and is currently serving a term as Associate Dean in the Faculty of Graduate Studies and Research.


**Adam Kowalski** is Principal Engineer in Unilever's Strategic Science Group responsible for developing strategy for Virtual Process Engineering with a track record in Open Innovation working with academics, SMEs, and other global companies to develop and exploit advances in process engineering. He has >30 papers focused on developing a scale-up methodology including new analytical expressions and the building of highly instrumented rigs for validation.

Other papers include work on 3D printing, structure characterisation of formulated products and use of high throughput techniques for early process evaluation. He holds >15 patents including the design of an innovative new mixer and its application to make new products. In addition to the Innovate UK EMFORMR project which is the subject of this keynote he secured >£5M worth of collaboratively funded projects in recent year.

**Hugh Stitt** is a Scientific Consultant with Johnson Matthey based at Billingham, UK. He has over 25 years of industrial research and development experience across a variety of themes related to catalyst manufacture (fluid mixing, particle technology etc) and catalytic reaction engineering including experimental and modelling approaches.

He has over 100 refereed publications. He is a Visiting Professor at the University of Birmingham, UK, and at Queen's University Belfast, Fellow of the Institution of Chemical Engineers and a Fellow of the Royal Academy of Engineering.

**Jerzy Bałdyga,** PhD; DSc, has been since 1997 a Professor of Chemical Engineering at the Warsaw University of Technology, Warsaw Poland. He has received his MSc in 1974, PhD in 1981, and DSc in 1989, all from Warsaw University of Technology. In 1997 he has got the Chair of Mechanical Engineering and Process Dynamics at the Chemical Engineering Faculty, Warsaw University of Technology. Since 2012 he has been a chair of Working Party on Mixing of European Federation of Chemical Engineering, since 2015 member of executive board of European Federation of Chemical Engineering. Research of Professor Bałdyga can be characterized as application of fluid mechanics to problems of chemical engineering including chemical reaction engineering, micromixing, problems of drop breakage and coalescence, relations between secondary processes (aggregation, breakage) and structure of suspension and its rheology.

He promoted 16 Doctors, 13 at Warsaw University of Technology, 3 at ETH Zürich (as co-referee). He is an author of 135 papers, 3 books and several book chapters published by Wiley, Marcel Dekker, Elsevier and Warsaw University of Technology, and editor of 2 books containing conference proceedings.

# General Information

***Symposium Co-Chairs***

**Professor Mark Simmons**, Head of Chemical Engineering University of Birmingham

**Dr Gul Ozcan-Taskin**, Department of Chemical Engineering, Loughborough University

***Organizing Committee***

**Miss Sarah Fleming**, School of Chemical Engineering, University of Birmingham

**Dr Federico Alberini**, School of Chemical Engineering, University of Birmingham

***Registration Desk Opening Hours***

| | |
|---|---|
| Sunday 25th June | 16:00 – 18:30 |
| Monday 26th June | 08:00 – 17:00 |
| Tuesday 27th June | 08:00- 17:00 |
| Wednesday 28th June | 08:30 – 14:00 |

***Symposium Venue***

**Hyatt Regency Birmingham,** 2 Bridge Street, Birmingham, United Kingdom, B1 2JZ.

Tel: +44 121 643 1234

Conference Website www.ismip9.org

***Wi-Fi Access***

Complementary Wi-Fi is available throughout the symposium.

***Speaker Preparation***

Staff will be on hand to assist with uploading your presentation; presentations should be provided on a USB stick. **Speakers are required to load their presentation in the break prior to their session**. Please arrive 15 minutes prior to the start of your session to meet your session chair. It is not intended for the presentations to be made available after the conference.

***Symposium Proceedings***

Symposium proceedings are available online only via the conference website. Abstracts are also available on the USB memory sticks supplied.

***Symposium Dress Code***

The dress code for the symposium events and dinner is business casual.

***Waiver of Liability***

We accept no liability to any persons or body for any loss, injury or damaged caused, promoted or sponsored by this event.

***Welcome Reception***

Begin ISMIP9 with a evening networking event!

| | |
|---|---|
| Date: | Sunday 25th June 2017 |
| Time: | **18:00- 21:00** |
| Venue: | Sonata Room, Hyatt Regency Birmingham |
| Cost: | Complementary for all delegates |

***Symposium Name Badges***

All participants will be issued with a name badge at registration. Please wear it at all times. Lost badges can be replaced at the registration desk.

***Symposium Dinner***

| | |
|---|---|
| Date: | Tuesday 27th June 2017 |
| Time: | **19:30- 23:00** |
| Venue: | The Council House, 1 Victoria Square Birmingham B1 1BB |
| Cost: | Complementary for all delegates |

The Symposium Dinner will be held in the banqueting suite of the imposing Council House, a grade II* listed building dating from the 1870's.

Join your colleagues to sample some excellent food and music at the social highlight of the symposium.

**Your name badge acts as an entry pass for the dinner, please bring it with you!**

***Special Requirements***

Every effort is made to ensure people with special requirements are catered for. Should you require specific assistance or dietary requirements please advise venue staff.

## Scientific Committee

### UK:

Professor Mostafa Barigou (University of Birmingham)

Professor Jos Derksen (University of Aberdeen)

Dr. Andrea Ducci (University College London)

Dr. Gustavo Padron (BHR Group)

Professor Adam Kowalski (Unilever Port Sunlight)

Professor Alvin Nienow (University of Birmingham and Loughborough University)

Professor Andrzej Pacek (University of Birmingham)

Professor Chris Rielly (Loughborough University)

Professor Hugh Stitt (Johnson Matthey)

Professor Michael Yianneskis (University College London)

Dr. Thomas Rodgers (University of Manchester)

### Europe:

Professor Rufat Abiev (St. Petersburg State Institute of Technology)

Dr. Joelle Aubin (University of Toulouse)

Professor Jerzy Baldyga (Warsaw University of Technology)

Professor Joel Bertrand (CNRS)

Professor Alberto Brucato (University of Palermo)

Professor. Matthias Kraume (Technical University of Berlin)

Professor Alain Line (INSA, Toulouse)

Professor Jose Carlos Lopes (University of Porto)

Dr. Giuseppina Montante (University of Bologna)

Professor Harry van den Akker (University of Limerick)

Professor Serafim Vlaev (Bulgarian Academy of Sciences)

### The Americas:

Professor Richard Calabrese (University of Maryland)

Dr. Art W. Etchells III (Rowan University)

Professor Enrique Galindo (National Autonomous University of Mexico)

Dr. Richard Grenville (Philadelphia Mixing Solutions)

Professor Suzanne Kresta (University of Alberta)

### Asia:

Professor Zhenming Gao (Bejing University of Chemical Technology)

Professor Yushi Hirata (Osaka University)

Professor Shaliza Ibrahim (University of Malaya)

Professor Koji Takahashi (National Institute of Technology)

### Australia:

Professor Raj Parthasararthy (RMIT University)

Dr. Jie Wu (CSIRO)

| ISMIP9 SCHEDULE: HYATT REGENCY, BIRMINGHAM | | | |
|---|---|---|---|
| **Day 1** | | **Sunday 25th June** | |
| 16:00 | 18:30 | ***Registration desk*** | |
| 18:00 | 21:00 | ***Welcome reception: Sonata Room*** | |
| **Day 2** | | **Monday 26th June** | |
| 08:45 | 09:00 | Conference opening and welcome, Symphony Ballroom | |
| 09:00 | 09:30 | **Keynote 1: Prof J. Seville<br>University of Surrey** | **Following mixing in real time at industrial scales using positron emission** Chair: M. Simmons |
| **Session 1: Mixing for microstructure in formulated products – advanced measurement techniques<br>Session Chairs: Prof Mark Simmons and Dr Gul Ozcan Taskin** | | | |
| 09:30 | 09:50 | Cazacliu, B<br>IFSTTAR | Forces on an intruder during the mixing of granular pastes : insights on rheology and mixture evolution |
| 09:50 | 10:10 | Al-Sharify, Z.<br>University of Birmingham | PEPT measurements of solid–liquid flow field of floating particles in a stirred vessel |
| 10:10 | 10:30 | Hohl, L.<br>Technical University of Berlin | Modelling of drop sizes and drop interactions in liquid three phase systems |
| 10:30 | 11:10 | **Coffee and drinks** | |
| 11:10 | 11:40 | **Keynote 2: Prof. A. Nienow<br>University of Birmingham** | **Academic mixing research applied to some industrial bioprocessing problems; a reflection** Chair: G.Ozcan-Taskin |
| 11:40 | 12:00 | Celani, A., University of Birmingham & Johnson Matthey | Effect of mixing conditions on the wet preparation of ceramic foams |
| 12:00 | 12:20 | Forte, G., University of Birmingham & Johnson Matthey | Towards increased quantification of electrical resistance tomography using linear probes in fluid mixing diagnosis |
| 12:20 | 12:40 | Hayashi, H.<br>Yokohama National University | Evaluation by image analysis of time evolution of the crystal particle aggregation state during batch cooling crystallization |
| 12:40 | 13:50 | **Lunch** | |
| **Session 2: Biochemical processes – gas liquid flows and mass transfer<br>Session Chairs: Prof Zhengming Gao and Prof Enrico Galindo** | | | |
| 13:50 | 14:10 | Wang, S<br>Newcastle University | Trapping of Inertial Particles: from Fundamentals to Applications |
| 14:10 | 14:30 | Galindo, E<br>Instituto de Biotecnología Unam | Local $k_La$ in a three phase system, including mycelial biomass, in a pilot stirred tank at constant gassed power drawn |
| 14:30 | 14:50 | Brucato, A<br>Università di Palermo | Scale-up and viscosity effects on gas-liquid mass transfer in unbaffled stirred tanks |
| 14:50 | 15:10 | Jamshed, A<br>University of Manchester | Gas-liquid multiphase mixing in dual axial radial agitated vessel in heterogeneous regime |
| 15:10 | 15:30 | Tervasmäki, P<br>University of Oulu | Applicability of a bottom agitated draft tube reactor to microbial processes - the effect of agitation power distribution and hydrostatic pressure on gas-liquid mass transfer |
| 15:30 | 16:00 | **Coffee and drinks** | |
| 16:00 | 16:30 | **Keynote 3: Prof. R. Calabrese<br>University of Maryland** | **Crystal wet milling and particle attrition in high shear mixers** Chair: G.Ozcan-Taskin |
| **Session 3: Bioreactors - hydrodynamics, cells and suspension dynamics<br>Session Chairs: Prof Alvin Nienow and Dr Giuseppina Montante** | | | |
| 16:30 | 16:50 | Li, Y<br>University College London | Study on mixing and suspension characteristics in shaken microwell systems |
| 16:50 | 17:10 | Quedeville, V<br>LISBP - INSA de Toulouse | Interactions between mixing and bioreactions: a matter of cell uptake |
| 17:10 | 17:30 | Annas, S, Münster University of Applied Sciences | Influence of the viscosity and speed on the fluid flow of a paddle agitator |
| 17:30 | 17:50 | Rodiguez, G<br>University College London | Appraisal of microcarrier suspension dynamics in a shaken bioreactor with conical bottom |
| 17:50 | 18:10 | Stamatopoulos, K<br>University of Birmingham | Understanding flow and mixing process in human colon using a biomechanical Dynamic Colon Model |
| 18:10 | 18:35 | **Exhibitors 5 minutes talks<br>Session Chair: Dr Federico Alberini** | |
| 19:00 | 21:30 | ***Poster session and drinks: Sonata Room*** | |

| Day 3 | | Tuesday 27th June | |
|---|---|---|---|
| **Session 4: High shear mixing - emulsification and deagglomeration**<br>**Session Chairs: Dr Tom Rodgers and Prof Richard Calabrese** | | | |
| 08:30 | 08:50 | Padron, G.<br>BHR Group | Particle de-agglomeration with an in-line rotor-stator mixer at different solids loadings |
| 08:50 | 09:10 | Ozcan-Taskin, G.<br>Loughborough University | Breakup of nanoparticle clusters using a microfluidizer |
| 09:10 | 09:30 | Espinoza, C.<br>University of Birmingham | Flow studies in an in-line silverson 150/250 high shear mixer using piv |
| 09:30 | 09:50 | Carrillo De Hert, S.<br>University of Manchester | Effect of viscosity on the emulsification kinetics using an in-line rotor-stator |
| 09:50 | 10:10 | Casugbo, C.,<br>Unilever | Flow rate constraints on the selection of in-line dynamic mixers |
| 10:10 | 10:40 | **Coffee and drinks** | |
| 10:40 | 11:10 | **Keynote 4: Prof. S. Kresta**<br>**University of Alberta** | **Liquid draw-down and dispersion: scaling-down to a CIST**<br>**Chair: M Simmons** |
| **Session 5: Solid-liquid mixing**<br>**Session Chairs: Prof Mos Barigou and Dr Richard Grenville** | | | |
| 11:10 | 11:30 | Etchells, A., Rowan University | A Correlation for Cloud Height in Liquid – Solid Agitated Vessels |
| 11:30 | 11:50 | Gao, Z., Beijing Uni of Chemical Technology | Characteristics and mechanism of the just drawdown of floating particles in laminar STR |
| 11:50 | 12:10 | Mao, Z., Chinese Academy of Sciences | Simulation of mixing and crystallization in a non-submerged impinging jet mixer |
| 12:10 | 12:30 | Thomas, J<br>M-Star | Comparing experimental observations, literature correlations and CFD predictions; minimum speed required for particle suspension, $N_{JS}$, using Rushton turbines and other radial flow impellers |
| 12:30 | 12:50 | Wood, T. Uni. Birmingham &<br>Johnson Matthey | Incorporation of floating solids into high solid content slurries |
| 12:50 | 13:50 | **Lunch** | |
| 13:50 | 14:20 | **Keynote 5: Prof. H. Stitt**<br>**Johnson Matthey & Prof. A. Kowalski, Unilever** | **Embedding manufacturing development in formulation research**<br>**Chair: M. Simmons** |
| **Session 6: Mixing of complex rheology and high viscosity fluids**<br>**Session Chairs: Prof Art Etchells III and Prof Alberto Brucato** | | | |
| 14:20 | 14:40 | Dawson, M.<br>BHR Group | Influence of additive to bulk viscosity ratio on inline blending in laminar and transitional flow |
| 14:40 | 15:00 | Kolano, M., Technical<br>University of Berlin | Influence of viscoelastic flow properties on cavern formation in stirred tanks – an experimental and numerical study |
| 15:00 | 15:20 | Garcia, M.<br>University College London | Experimental and computational fluid dynamic studies of mixing of complex oral health products |
| 15:20 | 15:50 | **Coffee Break** | |
| 15:50 | 16:10 | Esteves, L.P.<br>University of Porto | Mixing of fluids with very dissimilar viscosities in CIJs |
| 16:10 | 16:30 | Grenville, R., Philadelphia<br>Mixing Solutions, Ltd. | Validation of the wall shear stress model for blending shear-thinning fluids |
| **Session 7: Single phase laminar and turbulent mixing**<br>**Session Chairs: Dr Andrea Ducci and Dr Joelle Aubin** | | | |
| 16:30 | 16:50 | Brown, D<br>BHR Group | De-stratification of cylindrical storage vessels using a bottom mounted horizontal jet |
| 16:50 | 17:10 | Line A,<br>LISBP - INSA de Toulouse | Local hydrodynamic investigation by PIV within a dynamic filtration unit under laminar flow |
| 17:10 | 17:30 | Kehn, R<br>SPXFlow | The effect of impeller type on dip pipe design forces in stirred vessels |
| 17:30 | 17:50 | Montante, G<br>University of Bologna | Turbulent flow and scalar mixing in a continuous stirred tank |
| 17:50 | 18:10 | Mendoza, F<br>University of Toulouse | Experimental study of the hydrodynamics of the flow in a stirred tank in the transitional flow regime using the POD technique |
| 19:30 | 23:00 | ***Conference Dinner at Council House*** | |

| Day 4 | | Wednesday 28th June | |
|---|---|---|---|
| 09:00 | 09:30 | **Keynote 6: Prof. J. Baldyga**<br>**Warsaw University of Technology** | **Chemical product design including effects of mixing** Chair: G.Ozcan-Taskin |
| | | **Session 8: Simulations and Computational Fluid Dynamics**<br>**Session Chairs: Prof Chris Rielly and Dr Federico Alberini** | |
| 09:30 | 09:50 | Liu, L<br>Johnson Matthey | Effects of input rheology model parameters on the CFD modelling of non-Newtonian fluid mixing |
| 09:50 | 10:10 | Giacomelli, J<br>Philadelphia Mixing Solutions, Ltd. | Measurement and analysis of local turbulence properties by using large eddy simulations |
| 10:10 | 10:30 | Mihailova, O<br>Unilever | Optimisation of helical ribbon mixers using HEEDS |
| 10:30 | 10:50 | Aubin, J<br>University of Toulouse | CFD studies of transitional flow in mixing vessels |
| 10:50 | 11:10 | O'Byrnes, N<br>Bernal Institute | A direct numerical simulation of a turbulent stirred vessel driven by a Rushton turbine |
| 11:10 | 11:40 | **Coffee and drinks** | |
| | | **Session 9: Microfluidics and micromixing**<br>**Session Chairs: Dr Gustavo Padron and Prof Suzanne Kresta** | |
| 11:40 | 12:00 | Kretzschmar, T<br>Fraunhofer ICT-IMM | Evaluation of micromixer performance |
| 12:00 | 12:20 | Roumpea, E<br>University College London | Mixing during plug flow of shear-thinning liquids in microchannels |
| 12:20 | 12:40 | Kovalchuk, N<br>University of Birmingham | Drops coalescence and mixing in microchannel |
| 12:40 | 13:00 | Vigolo, D<br>University of Birmingham | Flow visualization of the trapping induced by vortex breakdown at a junction |
| 13:00 | 13:20 | Ejim, L<br>University of Loughborough | A design of experiment (DoE) approach to optimize liquid-solid plug flows in meso-scale tubes operating with oscillatory flow mixing |
| 13:20 | 13:30 | ***Conference Close*** | |
| 13:30 | 14:00 | **Lunch and departure** | |

**List of Oral Presentations by Session with Full Authorship (see schedule above)**

| O # | Authors | Abstract title | Affiliation |
|---|---|---|---|
| O_1.1 | R. Artoni, J. Moreno Juez, P. Richard, J. M. Paul, B. Cazacliu | Forces on an intruder during the mixing of granular pastes : insights on rheology and mixture evolution | IFSTTAR |
| O_1.2 | Z. T. Al-Sharify, M. Barigou | PEPT Measurements of Solid–Liquid Flow Field of Floating Particles in a Stirred Vessel | University of Birmingham |
| O_1.3 | L. Hohl, M. Kraume | Modeling of drop sizes and drop interactions in liquid three phase systems | TU Berlin |
| O_1.4 | Andrea Celani, Stuart Blackburn, Mark Simmons, Hugh Stitt | Effect of Mixing Conditions on the Wet Preparation of Ceramic Foams | University of Birmingham, Johnson Matthey |
| O_1.5 | G. Forte, P.J. Clark, O. Wale, J.F. Hall, N. Zumaeta, M.J.H. Simmons, E.H. Stitt | Towards Increased Quantification of Electrical Resistance Tomography using Linear Probes in Fluid Mixing Diagnosis | University of Birmingham, Johnson Matthey |
| O_1.6 | H. Hayashi, R. Misumi, M. Kaminoyama, K. Nishi, B. Harjo | Evaluation by image analysis of time evolution of the crystal particle aggregation state during batch cooling crystallization | Yokohama National University, MCHC R&D Synergy Center |
| O_2.1 | S Wang, S Frey, M Meyer, U Gülan, Y Murai, E Windhab | Trapping of Inertial Particles: from Fundamentals to Applications | Newcastle University, ETH Zurich |
| O_2.2 | S. García-Cerna, A. Holguín-Salas, E. Galindo | Local kLa in a three phases system, including mycelial biomass, in a pilot stirred tank at constant gassed power drawn | Instituto Tecnológico de Zacatepec, Universidad Nacional Autónoma de México |
| O_2.3 | F. Scargiali, L. Labik, F. Grisafi, T. Moucha, A. Brucato | Scale-up and viscosity effects on gas-liquid mass transfer in unbaffled stirred tanks | Università degli Studi di Palermo, University of Chemistry and Technology Prague |
| O_2.4 | A.Jamshed, M.Cooke, Z. Ren T.Rodgers | Gas-Liquid Multiphase Mixing in dual axial radial agitated vessel in Heterogeneous Regime | University of Manchester |
| O_2.5 | P. Tervasmäki, M. Latva-Kokko, S. Taskila, J. Tanskanen | Applicability of a bottom agitated draft tube reactor to microbial processes – the effect of agitation power distribution and hydrostatic pressure on gas-liquid mass transfer | University of Oulu, Outotec |
| O_3.1 | Y. Li, A. Ducci, M. Micheletti | Study on mixing and suspension characteristics in shaken microwell systems | UCL |
| O_3.2 | V. Quedeville, J. Morchain | Interactions between mixing and bioreactions: a matter of cell uptake | Université de Toulouse |
| O_3.3 | S. Annas, H. Czajka, H.-A. Jantzen, U. Janoske | Influence of the viscosity and speed on the fluid flow of a paddle agitator | Münster University of Applied Sciences, University of Wuppertal |
| O_3.4 | G. Rodriguez, A. Ducci, M. Micheletti | Appraisal of microcarrier suspension dynamics in a shaken bioreactor with conical bottom | UCL |
| O_3.5 | K. Stamatopoulos, H.K. Batchelor, M.J.H Simmons | Understanding flow and mixing process in human colon using an biomechanical Dynamic Colon Model | University of Birmingham |
| O_4.1 | Gustavo A Padron, N. Gül Özcan-Taşkın | Particle De-agglomeration with an In-Line Rotor-Stator Mixer at Different Solids Loadings | BHR Group, Loughborough University |
| O_4.2 | Emmanuela Gavi, Dominik Kubicki, Gustavo A. Padron, N. Gül Özcan-Taşkın | Breakup of nanoparticle clusters using a Microfluidizer | F. Hoffmann- La Roche, t Engineering Design Center Al. Krakowska, Loughborough University |
| O_4.3 | C.J.U. Espinoza, F. Alberini, | Flow Studies in an In-Line Silverson | University of Birmingham, |

| O # | Authors | Abstract title | Affiliation |
|---|---|---|---|
| | A.J. Kowalski, O.Mihailova, M.J.H. Simmons | 150/250 High Shear Mixer Using PIV | Unilever |
| O_4.4 | S. Carrillo De Hert, T.L. Rodgers | Effect of Viscosity on the Emulsification Kinetics using an In-Line Rotor-Stator | University of Manchester |
| O_4.5 | C. Casugbo, M. R. Baker | Flowrate Constraints on the Selection of In-line Dynamic Mixers | Unilever |
| O_5.1 | A. W.Etchells III, R.P.Hesketh | A Correlation for Cloud Height in Liquid – Solid Agitated Vessels | Rowan University |
| O_5.2 | He Gong, Fenglei Huang, Yafei Li, Zhipeng Li, Zhengming Gao | Characteristics and mechanism of the just drawdown of floating particles in laminar stirred tanks | Beijing University |
| O_5.3 | Jingcai Cheng, Chao Yang, Zai-Sha Mao | Simulation of mixing and crystallization in a non-submerged impinging jet mixer | Key Laboratory of Green Process and Engineering, University of Chinese Academy of Sciences |
| O_5.4 | John Thomas, Federico Alberini, Alvin W Nienow | Comparing Experimental Observations, Literature Correlations and CFD Predictions; Minimum Speed Required for Particle Suspension, NJS, Using Rushton Turbines and Other Radial Flow Impellers | M-Star Simulations, University of Birmingham |
| O_5.5 | Thomas Wood, Richard W. Greenwood, Mark J. H. Simmons, E. Hugh Stitt | Incorporation of Floating Solids Into High Solid Content Slurries | University of Birmingham, Johnson Matthey |
| O_6.1 | Michael K. Dawson, Ignacio Aparicio | Influence of Additive to Bulk Viscosity Ratio on Inline Blending in Laminar and Transitional Flow | BHR Group |
| O_6.2 | M. Kolano, M. Kraume | Influence of viscoelastic flow properties on cavern formation in stirred tanks – an experimental and numerical study | Technische Universität Berlin |
| O_6.3 | M. Cortada-Garcia, W.H. Weheliye, L. Mazzei, P. Angeli | Experimental and computational fluid dynamic studies of mixing of complex oral health products | UCL |
| O_6.4 | L.P. Esteves, H.M. Salvador, N.D. Gonçalves, C.P. Fonte, M.M. Dias, J.C.B. Lopes, R.J. Santos | Mixing of fluids with very dissimilar viscosities in CIJs | Universidade do Porto, University of Manchester |
| O_6.5 | R. K. Grenville, J. J. Giacomelli, A. J. Horvath | Validation of the wall shear stress model for blending shearthinning fluids | Philadelphia Mixing Solutions Ltd, Rowan University |
| O_7.1 | D. A. R. Brown | De-Stratification of Cylindrical Storage Vessels Using a Bottom Mounted Horizontal Jet | BHR Group |
| O_7.2 | X. Xie, N. Dietrich, L. Fillaudeau, P. Schmitz, A. Liné | Local Hydrodynamic Investigation by PIV within a Dynamic Filtration Unit under Laminar Flow | Université de Toulouse |
| O_7.3 | Joel Berg, Evan Burley, Richard Kehn, Brian Santhany | The Effect of Impeller Type on Dip Pipe Design Forces in Stirred Vessels | SPX Flow, The Dow Chemical Company |
| O_7.4 | G. Montante, A. Busciglio, A. Paglianti | Turbulent flow and scalar mixing in a continuous stirred tank | University of Bologna |
| O_7.5 | F. Mendoza, A.Lopes Banales, E.Cid, C.Xuereb, M.Poux, J.Aubin | Experimental study of the hydrodynamics of the flow in a stirred tank in the transitional flow regime using the POD technique | Université de Toulouse |
| O_8.1 | L. Liu, S.K. Wilkinson, S. Cauffman, T.A. Wood, E.H. Stitt | Effects of input rheology model parameters on the CFD modelling of nonNewtonian fluid mixing | University of Birmingham, Johnson Matthey |
| O_8.2 | Jason J. Giacomelli, John | Measurement and Analysis of Local | Philadelphia Mixing Solutions, |

| O # | Authors | Abstract title | Affiliation |
|---|---|---|---|
| | Thomas, Harry E.A. Van den Akker | Turbulence Properties By Using Large Eddy Simulations | Ltd., University of Limerick, M-Star Simulations |
| O_8.3 | O. Mihailova, T. Mothersdale, T. Rodgers, Z. Ren, S. Watson, V. Lister, A. Kowalski | Optimisation of helical ribbon mixers using HEEDS and STAR-CCM+ | Unilever, University of Manchester, Siemens PLM software |
| O_8.4 | J. Aubin, D.F. Fletcher | CFD Studies of Transitional Flow in Mixing Vessels | Université de Toulouse, University of Sydney |
| O_8.5 | N.O'Byrnes, B. Bavelaar, H.E.A. Van den Akker | A direct numerical simulation of a turbulent stirred vessel driven by a Rushton turbine | University of Limerick |
| O_9.1 | Thomas Kretzschmar, Klaus Stephan Drese | Evaluation of micromixer performance | Fraunhofer ICT-IMM, University of Applied Sciences Coburg |
| O_9.2 | Evangelia Roumpea, Maxime Chinaud, Panagiota Angeli | Mixing during plug flow of shear-thinning liquids in microchannels | UCL |
| O_9.3 | N.M.Kovalchuk, E. Nowak, Z.Schofield, D. Vigolo, M.J.H. Simmons | Drops coalescence and mixing in microchannel | University of Birmingham, Massey University |
| O_9.4 | D. Vigolo, M. Riccomi, F. Alberini, E. Brunazzi, J. T. Ault, H. A. Stone | Flow visualization of the trapping induced by vortex breakdown at a junction | University of Birmingham, Università di Pisa, Princeton University |
| O_9.5 | Louisa N. Ejim, Stephanie Yerdelen, Thomas McGlone, C.D Rielly, Nuno M. Reis | A design of experiment (DoE) approach to optimize liquid-solid plug flows in meso-scale tubes operating with oscillatory flow mixing | Loughborough University, University of Strathclyde, University of Bath |

**Monday 26th June 2017**

***Poster session and drinks: Sonata Room***

***Alphabetical list by first author.***

| P # | Authors, | Abstract title | Affiliation |
|---|---|---|---|
| P1 | Alberini, F., Stamatopoulos, K | Use of super-hydrophobic surfaces to enhance mixing in a stirred vessel | University of Birmingham |
| P2 | Algave, R., Straw, M., Eppinger, T., Baran, O. | Simulating Solid Suspension in Stirred Vessels with a Fully Coupled CDF-DEM Algorithm | Siemens PLM Software |
| P3 | Al-Najjar, S., Barigou, M. | On The Error in Mass Transfer in a Stirred Vessel Predicted by Frössling-Type Correlations Based on Particle Settling Velocity | University of Birmingham |
| P4 | Brito, M.A., Gonçalves, N. D., Fonte, C.P., Dias, M.M., Santos, R.J., Lopes, J.C.B. | Formulation Screening in Rotational Shear Flow Devices | University of Porto |
| P5 | Bach C., Albaek M. O., Krühne U., Gernaey K. V. | A novel in situ measurement method of bubble sizes in bioreactors using a high speed camera | Technical University of Denmark |
| P6 | Cao, Z., Jiaying, C., Gao, Z. | The Numerical Simulation of a Single Bubble Breakup in Jet Flow | Beijing University of Chemical Technology |
| P7 | Cardus, J., Alberini, F., Ingram, A., Simmons, M.J.H. | The Potential Of Reactive PLIF For The Evaluation Of Micromixing And Reaction Yield In Stirred Vessels | University of Birmingham |
| P8 | Chekroun, A., Lebaz, N., Thibault, D., Cockx, A., Morchain, J., Cagnac, O., Griffith, H. | Lagrangian particle tracking in an industrial photobioreactor | LISBP - INSA de Toulouse |
| P9 | Cunliffe, C., Baker, M.R., Martin, P.J., Martin, P.A., Mihailova, O. | Tracking compositional evolution during batch manufacturing using spectroscopic methods | Unilever/University of Manchester |
| P10 | Date, T., Komod, Y., Suzuki, H., Hidema, R. | Fluid deformation induced by a rotationally reciprocating anchor Impeller | Kobe University |
| P11 | Parthasarathy, R., Daoody, M., Graham, L.,Youn.,Wu, J., Raman, A. | Optimum design for the mitigation of scale in mixing tanks | RMIT University |
| P12 | Fujiwara, M., Misumi, R., Kaminoyama, M., Taniguchi, K., Katai, Y., Nishi, K. | Quantification by image analysis of mixing of two fluids with large viscosity ratio in static mixers having elements of two types | Yokohama National University |
| P13 | Ghorbanian, S. | Effect of Thixotropy on Fluid Mixing in a Stirred Tank | University of Birmingham |
| P14 | Nadal Rey, G., Grundtvig, I., Hybschmann, T., Gernaey, K., Svendsen, T.,Krühne, U. | Shape optimization of a gas-inducing impeller | Technical University of Denmark |
| P15 | Hayashi, H.,Misumi, R., Kaminoyama, M., Nishi, K., Harjo, B. | Evaluation by image analysis of time evolution of the crystal particle aggregation state during batch cooling crystallization | Yokohama National University |
| P16 | Hirata, Y. | Mixing Processes in SAR Plate Static Mixers Combined with 180°-Rotation of Fluid Interface under Reversed Flow Operation | Osaka University |
| P17 | Ifachsyad, D. | Influence of Water Phase Temperature on Emulsion Produced with High Shear Mixer | PT. Tetra Pak Stainless Equipment |
| P18 | Kanazawa, K., Kamiya, H. | Energy Efficiency Improvement of a Cylindrical-Wall Revolving Mixer | Primix corporation |
| P19 | Komoda, Y., Date, T., Suzuki, H., Hidema R. | Power characteristics of a rotationally reciprocating anchor impeller | Kobe University |
| P20 | Machin, T.,Simmons, M.J.H., Greenwood, R.W., Wei, K. | Characterisation of Complex Multiphase Fluids Using Process Tomography | University of Birmingham/ITS |

| P # | Authors, | Abstract title | Affiliation |
|---|---|---|---|
| P21 | Montante, G., Maluta, F., Paglianti, A. | CFD modelling of biohydrogen production in a self-ingesting stirred tank | University of Bologna |
| P22 | Masuda, H., Yoshida, S., Horie, N., Ohmura, T., Shimoyamada, M. | Mixing and heat transfer characteristics of Taylor-Couette flow with thermal instability | University of Shizuoka |
| P23 | Migliozzi, S., Mazzei, L., Angeli, P. | Experimental and computational fluid dynamic studies of continuous mixing of highly-viscous non-Newtonian mixtures | University College London |
| P24 | Murasieiwcz, H., Pacek, A.W. | Application of aqueous/aqueous and organic/aqueous dispersions for stem cell expansion in a stirred bioreactor | University of Birmingham |
| P25 | Nagatomo, D., Yajima, T., Esaki, K., Ohmura, N. | A study for slurry wear patterns of Maxblend® | Sumitomo Heavy Industries Process Equipment |
| P26 | Nishi, K., Saito, S | Power consumption and mixing performance of an eccentrically located large type impeller in a laminar region | Chiba Institute of Technology |
| P27 | Ramsay, J., Archer, R., Mellsop, S., Brown, C. | Effect of specific mechanical energy input on viscoelastic properties of a model cheese | Massey University |
| P28 | Riccomi, M., Alberini, F., Brunazzi, E., Vigolo, D. | Ghost Particle Velocimetry implementation in millimetres devices and comparison with µPIV | University of Birmingham |
| P29 | Rodiguez, G., Micheletti, M. Ducci, A. | Planar induced measurements in a shaken bioreactor for different fluid viscosity | University College London |
| P30 | Scargiali, F., Tamburini, A., Cipollina, A., Micale, G., Brucato, A. | Power consumption for particle suspention and liquid aeration of unbaffled bioslurry reactors | University of Palermo |
| P31 | Fukunaga, S.,Toba, Y., Horie, T., Sugiyama, H., Kanda, A. Y., Hsu, T., Chen, T.H., Tung, K. L., Ohmura, N. | Effect of disk turbine impeller on lignin decomposition in a sonochemical vessel reactor | Kobe University |
| P32 | Umair, A., Prosser, R., Kowalski, A | An energy transport based evolving rheology | Unilever/University of Manchester |
| P33 | Vikhansky, A., Eskin, D. | Formation of liquid/liquid dispersion in a Couette device | cd-adapco.com (Siemens) |
| P34 | Vipin, M., Bagkeris, I., Prosser, R., Kowalski, A. | Modelling turbulent emulsification in an inline high shear static mixer | Unilever/University of Manchester |
| P35 | Vlaev, S., Tsibranska, I., Atanasova, D. | Hydrodynamic Characterization of a Dual Impeller Submerged Membrane Bioreactor (SMBR) Relevant to Single-Use Bioreactor (SUB) Options | Bulgarian Academy of Sciences |
| P36 | Yajima, T., Esaki, K | Fluid Analysis for NANOVisK by MPS method | Sumitomo Heavy Industries Process Equipment |
| P37 | Wang, Y D.,Ye, Y S.,Tang, Q. | Optimisation of structural and operational parameters of a settler via CFD simulation in a mixer-settler | Tsinghua University |
| P38 | Zhang, C., Winterburn, J., Rodgers T. | Environmentally Friendly Personal Care Products | University of Manchester |
| P39 | Zhang, J., Gao, Z., Yating, C., Ziqi, C.,Bao Y. | Power consumption and mass transfer in a gas-liquid-solid stirred tank reactor with various triple-impeller combinations | Beijing University of Chemical Technology |