See inside your process

Mixing

Throughout industry components are mixed in stirred vessels. The challenge is to determine exactly how well the ingredients are being mixed. Factors such as the composition and nature of the ingredients, the position, speed and design of the stirrer and the structure of the vessel all contribute to mixing effectiveness. Often the structure is complex and the nature of the ingredients and the operating conditions make visual inspection either impossible or hazardous.

Liquid-liquid mixing

In liquid-liquid mixing a stirred tank can be fitted with 8 x 16-electrodes is used as shown in Figure 1:

These are connected to an Industrial Tomography Systems (ITS) p2000 instrument designed to measure and display Electrical Resistance Tomography (ERT) data. Each 16-electrode ring of electrodes generates a conductivity map of the cross-section at that plane as shown in Figure 2.

P1 to P8 represent the 8 measurement planes from the top to the bottom of the vessel. Mixing patterns and times can be determined by injecting a high conductivity tracer into the base of the mixer.

Figure 1: Multiple electrodes fitted to a stir tank

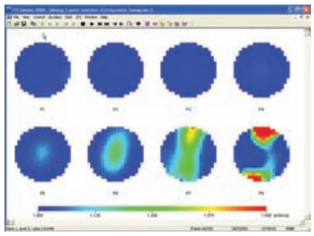

Figure 2: Instantaneous conductivity maps after high conductivity injection at two positions

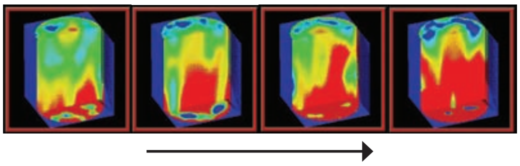

Figure 3: Effect of sparging rate on gas distribution. Red regions indicate gas concentrations greater than 15% v/v

Gas-liquid Mixing

In gas-liquid mixing a stirred tank fitted with an 8 x 16-electrode array which is connected to an ITS p2000 instrument designed and established to measure and display ERT data. Each 16-electrode ring of electrodes generates a conductivity map of the cross-section at that point as shown in Figure 3. In these circumstances gas is injected into the base of the mixer. Figure 3 shows an example of three-dimensional images for different gas injection rates into the liquid.

Solid-liquid Mixing

Solid-liquid mixing is common in many process industries and recurring issues are the suspension of denser solids in a fluid and dispersion of dry powders into solution. Electrical tomography can identify the axial solids distribution in a stirred tank and the just suspension speed. In these cases ITS uses its linear probe as shown in Figure 4.

This is inserted into the mixing vessel from the top and connected to an Industrial Tomography Systems p2000 instrument designed and established to measure and display ERT data. The linear probe produces a conductivity map of an orthogonal slide perpendicular to the probe. This information can be reduced to show the axial conductivity profile through the height of the vessel. Again, concentration of the dispersed phase, in this case solids, can be determined from the conductivity data by applying Maxwell's equation. The axial solid concentration profiles for a range of agitation rates are shown in Figure 5.

This plots the % solids in the mixture as a function of tank height and allows quantification of the degree of mixing throughout the vessel.

Figure 4: ITS linear probe

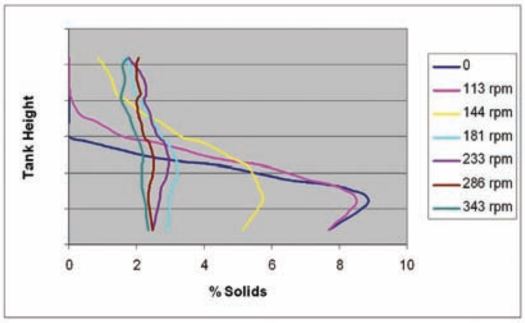

Figure 5: Axial solids concentration for range of agitation speeds

Key Benefits

Improved process understanding

Determine level of homogeneity, mixing time and process start/end points

Validation of CFD Models

Higher yields through improved mixing with shorter mixing time and less energy consumption

INDUSTRIAL TOMOGRAPHY SYSTEMS plc

Lisco Analytical ApS
Naverland 2 · DK-2600 Glostrup
Tel.: 3990 3905 · www.Liscotech.dk

Industrial Tomography Systems plc
Speakers House | 39 Deansgate
Manchester | M3 2BA
Tel: +44 (0) 161 832 9297 | Fax: +44 (0) 161 839 5195
E-mail: sales.support@itoms.com

See **inside** your process

Case Study: Cavern Mixing Size

The Challenge

Cavern formation can occur in the mixing of thick / viscous fluids. Examples of such fluids range from consumer products such as shampoos, pastes and sauces; to a wide range of industrial products and processes. Caverns form when non-Newtonian fluids are mixed and a region around the impeller becomes agitated, whilst the surrounding process fluids remain stagnant. These poorly mixed regions give rise to poor heat and mass transfer and thus inefficient processes.

The Solution

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. Figure 1 shows an example of a typical tomography rig used to investigate mixing.

A number of papers detailing the use of the ITS p2000 ERT system were presented at the International Symposium on Mixing in Industrial Processes 6 at Niagara Falls, Ontario, Canada, 17-21 August 2008 and key points are described below.

Dr. Farhad Ein-Mozaffari from Ryerson University, Toronto, Canada investigated the shape and size of the cavern formation in mixing a non-Newtonian fluid (xanthan gum) using Electrical Resistance Tomography (ERT).

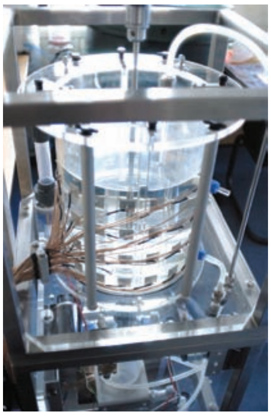

Figure 1: Mixing rig

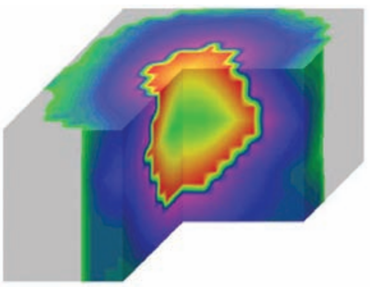

Figure 2: Cavern in the centre of a 50 liter vessel which was stirred with a Scaba 6SRGT impeller. The image shows that the cavern formed did not reach the sides of the tank or fill the complete volume of the fluid.

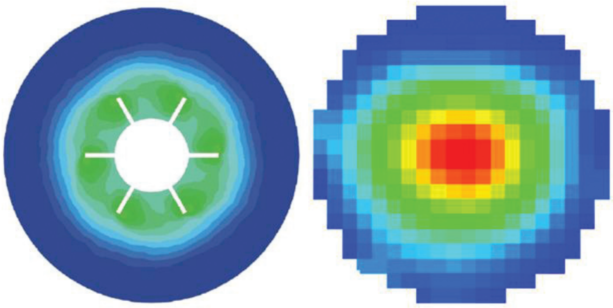

Figure 3: Comparison between CFD (computational fluid dynamics) simulation of cavern size and ERT measurements

A second paper, presented by Dr Mark Simmons from the University of Birmingham reported on work performed with Johnson Matthey Catalysts. As above, ERT was used to visualize cavern formation. However in this case, Positron Emission Projection Imaging (PEPI) and visual measurements using a dye tracer were used to validate the tomography data.

The figures show the comparison of cavern size obtained from the different techniques confirming the effectiveness of ERT. This has provided Johnson Matthey with confidence in the application of ERT to optimize mixing conditions at a number of their plants.

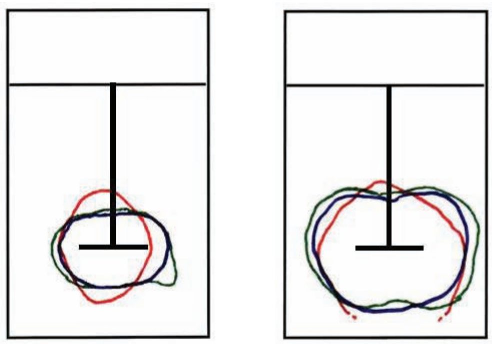

Figure 4: Comparison of cavern size obtained from the different techniques confirming the effectiveness of ERT

Customer Benefits

The use of ERT is able to determine the development of caverns and the effectiveness of different mixing configurations. This information improves product consistency and reduce energy consumption.

References

"Analysis of Cavern Formation in Mixing Yield Stress Fluids using Tomography and CFD Modelling" Dr. Farhad Ein-Mozaffari Ryerson University ISMIP VI

"Techniques For Visualisation of Cavern Boundaries in Opaque Industrial Mixing Systems" Dr Mark Simmons University of Birmingham/Johnson Matthey Technology Centre ISMIP VIIChemE, Volume 80, Part A, 903-909

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INDUSTRIAL TOMOGRAPHY SYSTEMS plc

LISCO Analytical
Lisco Analytical ApS
Naverland 2 · DK-2600 Glostrup
Tel.: 3990 3905 · www.Liscotech.dk

Industrial Tomography Systems plc
Speakers House | 39 Deansgate
Manchester | M3 2BA
Tel: +44 (0) 161 832 9297 | Fax: +44 (0) 161 839 5195
E-mail: sales.support@itoms.com