See inside your process

Case Study: Understanding Mixing Times

The Challenge

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.

The Solution

This technical note compares mixing times calculated from the Industrial Tomography Systems (ITS) fast impedance z8000 instrument to those obtained by the ITS p2000 instrument.

The mixing time is a quantitative criterion for assessing the mixing performance of an agitated vessel. To determine this using tomography a conductive tracer was added to a continuously stirred mixing vessel with tap water as the continuous phase. The vessel was fitted with two planes of 16 electrodes to allow analysis of how fast the tracer reaches the bottom of the vessel

The mixing time was then determined by monitoring the normalised conductivity values from the time the tracer was injected to the time where the recorded conductivity fluctuations were in the limits of -5% and +5%, known as the t90 mixing time.

Normally mixing times are calculated by using point-conductivity probes in different areas of the vessel and using these to determine when mixing is complete.

ITS has developed an electrical tomography technique that allows 104 unique data points to be taken from throughout the process in multiple cross sections. In this manner the mixing performance can be monitored much more effectively in various different zones of the vessel.

The provision of measurements in two dimension images at sampling rates can vary from a few frames per second with the p2000 to 1000 frames per second with the z8000 instrument. The mixing information can be expressed for the total volume of the vessel as a function of time.

The present approach consists of expressing the conductivity values within the cross section of the mixing vessel by means of dividing the tomography data in a zone scheme containing four distinct zones (see figure 1.0). However, different arrangements are also available to choose in order to meet different process demands.

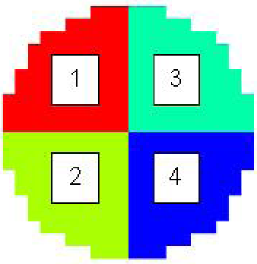

Figure 1: Zone average scheme

The above schematic representation was used for tracking the spatial location of the tracer with ITS software. The ITS software can also export the experimental data in a comma separated variable (.csv) file which is fully compatible with Microsoft Excel.

The resulting tomography data was acquired using both block and the on-line mode of the z8000 which permitted capturing around 1000 and 40 frames per second, respectively. The plots for the block tomography data per sensing plane are shown in figures 2 and figure 3.

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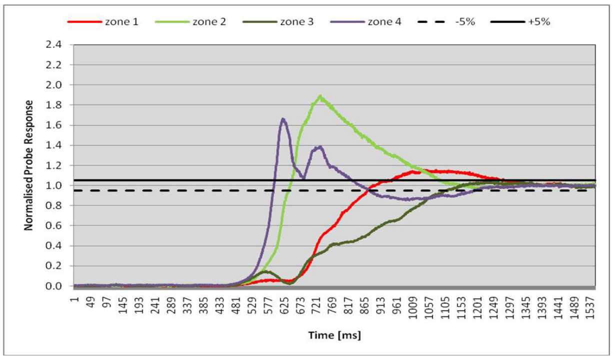

Figure 2: Data taken as block data from P1

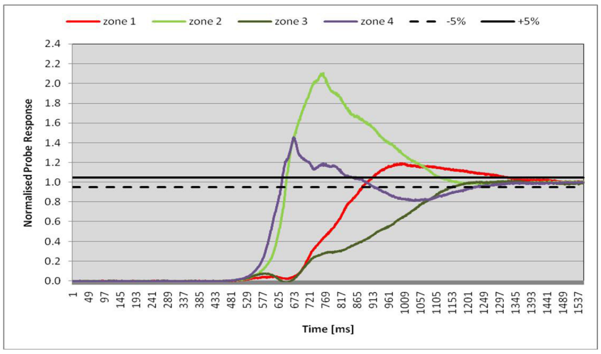

Figure 3: Data taken as block data from P2

The cross-sectional spatial position of the tracer was monitored as a function of the experimental mixing time in figure 2 and figure 3 and the following observations were made. The largest scalar fluctuations were initially monitored by P1 due to its proximity to the injection of the tracer, which was added close to the impeller and an adjacent zone. Soon afterwards, P2 was able to detect the tracer, which indicated an evolving mixing pattern across the vessel.

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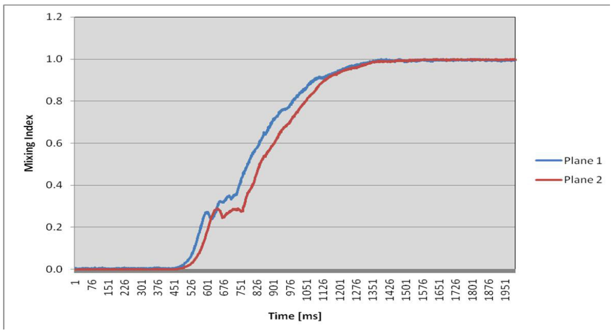

Figure 4: Block data from both planes

In addition, the mixing index obtained from the averaged statistical variance of the electrical conductivity from P1 and P2 was used as criterion of determining the mixing time. This was from the time when the tracer was firstly added to the time dissolution reached the desired homogeneity within the vessel (see figure 4).

Customer Benefits

The t90 mixing time for this experiment was found to be 1.8s by the p2000 whereas the z8000 found it more accurately to be 0.88s due to its much higher sampling rate.

Electrical tomography has been demonstrated as a highly effective way of monitoring mixing due to its 104 data points per plane compared with single data points from other measurement strategies..

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