

m3000 Dual



Electrical Capacitance Tomography:

Parameter	Permittivity
Process Environment	Dry (air/oil)
Typical Processes	Powder flow; fluidized beds
Sensor	External
Reference	Dual (max; min)
Also sensitive to	Moisture

Electrical Resistance Tomography

Parameter:	Conductivity
Process Environment :	Conducting (solutions)
Typical Processes:	Mixing, flow of slurries
Sensor:	Internal
Reference:	Single (mean)
Also sensitive to:	Temperature

m3000

The m3000 instrument is the only commercial tomography system that provides dual capacitance and resistance modality. This allows users to visualize multi-component systems such as air / oil / water in real time. Using its dual modality function, the m3000 can monitor processes which move from conducting to non-conducting in the continuous medium.

In contrast to many systems-based measurement techniques, tomography sensors are able to rapidly sense throughout a volume. Thus providing a dynamic picture of what is going on inside a pipe or vessel, e.g. whether a system is homogeneous.

Product Characteristics

m3000c (ECT)

- Max 24 electrodes arranged in 1,2,3 planes

m3000 dual (ECT & ERT)

- Max 24 electrodes arranged in 1,2,3 planes
- Max 32 electrodes arranged in 1,2,4 planes

Sensor Geometry:

- Circular

Applications

- Multiphase flow characterisation
- CFD Validation
- Filtration
- Fluidised Beds
- Packed Beds
- Pneumatic Conveying
- Extrusion

Industries:

- Oil & Gas
- Pharmaceuticals & Chemicals
- Nuclear
- Biotech
- FMCG
- Mining
- Environmental
- Pulp & Paper
- Others...

Benefits to users are:

- Measurement of multiphase flow
- Increased process understanding
- More effective process development
- Improved and more consistent product quality

m3000c



Operation

Measurement Principals: ECT
Number of electrodes: 24; either 12 x 2 planes, 8 x 3 planes or 24 x 1 plane
Image reconstruction algorithm: Linear back projection

System performance

Accuracy: $\approx 0.01-1$ pF with one plane sensor
Stability: $< 1\%$ deviation (@10 kHz, 2 hours)
Frame acquisition speed: 20 ms/frame
Spatial resolution: 5%-10%
Online measurement speed: 4 frames/ S @ 12 electrodes

Hardware

Input injection method: 18 V
Injection frequency: 1 MHz
Output: 0.001 +10 V (pp)
Memory : 1MB EPROM, 80KB RAM
Max no. measurement frame: Programmable
Mode of measurement: Sequential

Power Supply

Power input: 100-240 V a/c, 50/60 Hz 1.5A
Consumption: DC 24 V 45W

Software

GUI: VC++ Class
Data display: Online view and manage tomography data
Tomograms images
Output: P2k file, which can be analysed using the ITS toolsuite

Computer Requirements

CPU: Pentium 4 (1.6 GHz or higher) or equivalent
RAM: 512MB
Operating System: Windows 2000/ XP / Vista
Serial Ports: USB 2

m3000r



Operation

Measurement Principals: ERT
Number of electrodes: 32; either 16 x 2 planes, 8 x 4 planes or 32 x 1 plane
Image reconstruction algorithm: Linear back projection

System performance

Accuracy: $\pm 1\%$ (@10 kHz)
Repeatability: < 1% deviation
Frame acquisition speed: 25 ms/frame
Spatial resolution: 5%
Online measurement speed: 2 frames/ S @ 16 electrodes and 8 frames/S @ 8 electrodes

Hardware

Input: Current
Non- conducting
Adjacent
Range: Up to 40 mA (ad-ad)
Injection frequency: Programmable up to 15KHz
Output: -10 V (pp) to +10 V (pp)
Memory : 1MB EPROM, 80KB RAM
Max no. measurement frame: Programmable
Mode of measurement: Sequential

Power Supply

Power input: 100-240 V a/c, 50/60 Hz 1.5A
Consumption: DC 24 V 45W

Software

GUI: VC++ Class
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Polimeri (Eni S.p.A.)

Multi-phase Flow

The Challenge

Polimeri a subsidiary of Eni S.p.A. sought a measurement system capable of multiphase flow visualisation in a pilot scale flow loop at their Novara Research Centre in Italy. The primary goal is to enhance understanding of multi-phase flows comprising oil-water-gas for the optimisation of existing mathematical models of hydraulic transportation processes.

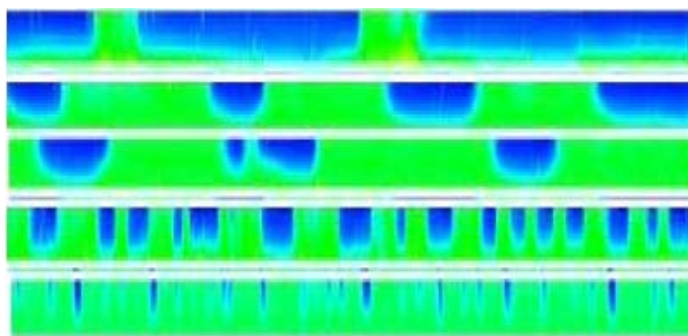
The Solution

The ITS m3000 dual-modality Electrical Resistance Tomography (ERT) and Electrical Capacitance Tomography (ECT) system has been developed to do on-line monitoring of multi-phase flow by providing detailed information such as multi-phase flow pattern, flow regime, composition and velocity. The m3000 ERT and ECT modules produce conductivity and permittivity maps from multi-electrode sensors arranged around the pipe.

The Polimeri flow loop consists of a feed tank (which also acts as a liquid-gas separator), pump, 2" diameter pipe and a gas injection system. It is instrumented with temperature sensors, pressure transducers and viscometers.

Experiments were conducted on water-gas and oil-gas systems for a range of flow conditions. Measurements were collected at a rate of 20 Hz. Figure 1 shows an example of the ERT results for 5 different operating conditions for water-gas flow in the form of a time series of the central vertical slice of the conductivity image.

The operating conditions in terms of the gas and liquid superficial velocities (V_G and V_L) are shown in the table to the side of the figure.

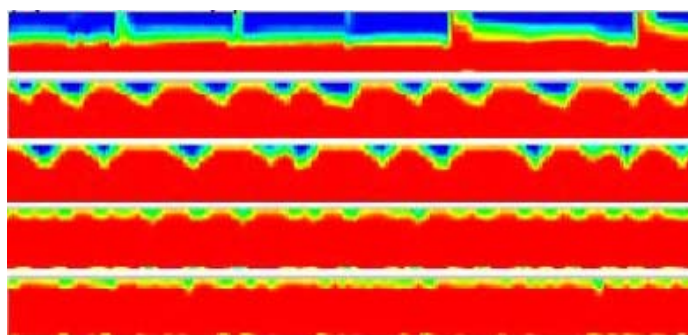


$V_G \text{ ms}^{-1}$	$V_L \text{ ms}^{-1}$
3	0.2
0.3	0.2
0.07	0.2
0.07	0.3
0.07	1.0

Figure 1: Water-gas flow data

A colour scale is used to represent conductivity. In this case green corresponds to liquid and blue corresponds to gas.

Results for the same operating conditions but for oil-gas are shown in Figure 2. In this case the results are based on the permittivity images generated by the ECT module. The colour red indicates the higher permittivity oil and blue indicates the lower permittivity gas.



$V_G \text{ ms}^{-1}$	$V_L \text{ ms}^{-1}$
3	0.2
0.3	0.2
0.07	0.2
0.07	0.3
0.07	1.0

Figure 2: Oil-gas flow data

Polimeri (Eni S.p.A.)

Multi-phase Flow

In addition to visualising the flow regime Polimeri were interested in measuring the composition of the multi-phase mixtures. Further experiments were performed for the oil-gas system using the m3000 ECT module with a high-speed digital video camera for comparison. The m3000 system is calibrated with the pipe sensor full of gas and full of oil. A linear relationship is used to determine the concentration of oil-gas mixtures. Image analysis software was used to determine the composition from the high-speed video camera data independently from the m3000.

Good agreement between the m3000 and high-speed video camera were obtained for the composition measurements thus paving the way for electrical tomography to be used to measure the composition of multi-phase flows. Electrical tomography has the benefit that it does not require optical access as the high-speed video camera does.

Customer Benefits

The ITS m3000 dual-modality electrical tomography system has been successfully applied to multi-phase flows by Polimeri. The combination of ERT and ECT allows the full range of flow conditions to be explored from 100% water to 100% oil and all intermediate conditions.

The customer benefits are:-

1. Optimisation of existing mathematical models of hydraulic transportation processes
2. Much greater confidence when sizing pipes and reactors with capital cost savings
3. Increased plant yields and capacity
4. Reduced energy consumption

Further Reading

Qiu, C, Bagatin, R, Palmery, S, Bolton, GT, On- line visualization of asymmetric multi-phase flow in an industrial flow loop applying multi-modality process tomography system, 5th World Congress on Industrial Process Tomography, 3-6 September 2007, Bergen, Norway

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