An Oil Company Used Dual-modality ECT and ERT to Study the Flow of Multi-phase Oil-water-gas Systems Reducing Energy Costs and Improving Plant Yields

Emeline Bodard, Industrial Tomography Systems
Email: marketing@itoms.com

Electrical tomography techniques provide the capability for flow visualisation, regardless of material opacity, to enhance the understanding of such complex flow processes.

Industry challenges

The petrochemical sector has invested a considerable amount of resources over the last decades trying to understand more about flow conditions, multiphase flow being one of the most challenging processes for the industry.

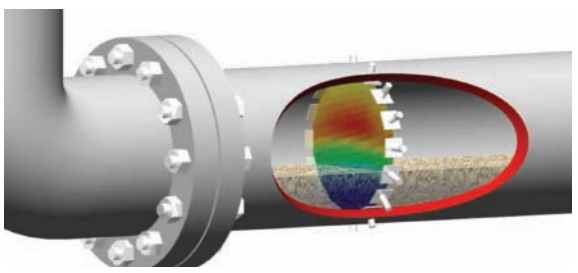
Multiphase flow occurs when two or more phases are flowing along a closed or open pipe. The phases may be gas, liquid or solid and two or three phase flow are common (as well as multiple component flow due to immiscibility in the liquids more that one liquid phase may exist). Hence in the "fluid" flowing down the pipe, the phases may be fully mixed, fully separated and anything in between depending on the nature and densities of the phases, the degree of turbulence induced in the mixture and the physical geometry of the pipe. Add to this the boundary layer effect at the pipe walls and it is a very complex measurement challenge.

Most of the current research and measurement systems rely on flow regime pre-determination, assumption or computational models.

There is a well defined need in knowing process conditions with certainty to improve efficiency and quality as well as reducing processing costs. It would be highly beneficial to measure the flow of each phase in the pipe, ideally mass, volume, phase inversion and the degree of mixing within the pipe.

Oil & gas companies are particularly interested in knowing which flow regimes (stratified, bubble flows, etc) they are working under at a certain time of their process. There is also growing academic and industrial interest in oil sands research where once again visibility is reduced due to stainless steel equipment or opaque material (sand in heavy oil). Additionally there is a need to learn more about wet gas flow behavior to improve understanding of meter performance.

Organisations from the mining and environmental sectors are involved in water based slurry research looking at the concentration, settlement and velocity of solids transported down a pipe by the liquid phase. This also provides a better understanding of corrosion effects.



Solution: Electrical Tomography

Background

In the mid-1980s work started that led to the present generation of Process Tomography systems. At Manchester University there began a project on Electrical Capacitance Tomography for imaging multi-component flows from oil wells. A relatively new technology, Electrical tomography has developed into robust technique for the characterisation of complex chemical processes. Tomography allows chemical process users to estimate the spatial distribution of phases and chemicals inside their processing vessels or pipelines, giving instant feedback on reaction processes, or efficiency of transport.

Technology principles

Industrial Tomography Systems plc (ITS), a spin-off of the University of Manchester was founded in 1997 to commercialise electrical tomography systems. ITS is today the leading supplier of Electrical Resistance Tomography (ERT) solutions. The company also supplies Electrical Capacitance Tomography (ECT) and ultrasound spectroscopy instruments.

Pipeline monitoring

ERT measures the distribution of electrical resistance (or conductivity) in a cross-sectional plane of a pipe or vessel: applicable to water/gas or water/solid flow. ECT is used where the bulk medium does not conduct electricity: applicable to oil/gas flow. Multiple modalities (of capacitance and resistance electrical tomography) have been fused to provide information on multi-phase flows.

Sensor expertise

ITS has wide experience in developing electrical tomography sensors for a range of applications. 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.

Electrical capacitance sensors have the advantage that they can be made in such a way that they are both non-invasive and non-intrusive. ITS can manufacture sensors in a variety of materials ranging from acrylic to PTFE.

For the measurement of 3-phase systems including air, oil and water, ITS has developed a dual modality pipeline sensor, which combine Electrical Resistance and Electrical Capacitance tomography measurements. This combination makes it possible to measure both conducting and non-conducting phases in a process.

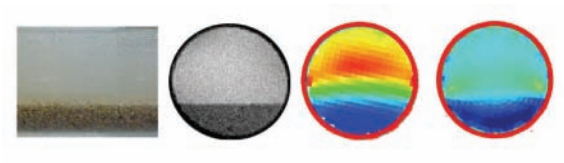
ITS have developed polymer lined stainless steel pipeline ECT sensors for more demanding conditions. The electrodes are contained within a resin filled cavity between the polymer pipe linear and the external stainless steel pipe. The external stainless steel pipe ensures the pressure integrity, which is key in many petrochemical processes.

ITS is committed to the development of its range of sensors and is continually exploring novel techniques to deploy the technology in challenging operating conditions.

Applications

Water and sand flow visualisation:

CSIRO (Melbourne, Australia) required a measurement technique to measure the particle and fluid properties in solid-liquid flows for both research and industrial application. Measurements were performed on a 100 mm diameter flow loop with closely graded 2 mm silica sand suspended in clear shear thinning polymer suspensions. These 'model' suspensions mimic the behaviour of bimodal suspensions of particles containing a large fraction of fine theologically active particles that would form a non-Newtonian carrier in which would be suspended the coarser fractions such as those found on mining co-disposal lines.



Comparison of a photograph, an MRI picture, an ITS p2000 online tomogram and ITS SCG offline tomogram

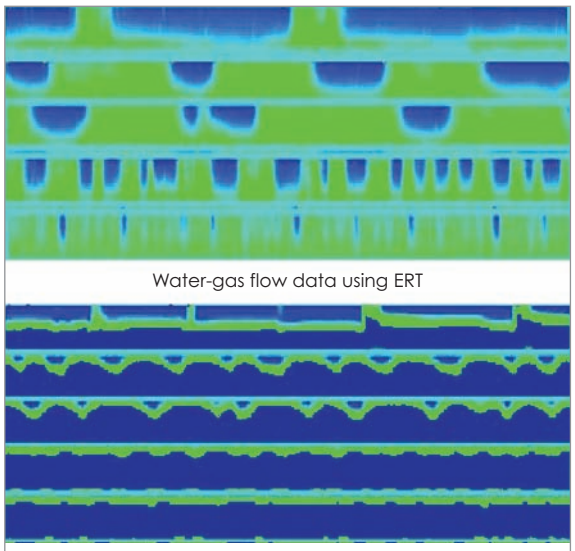
Robust sensors have also been deployed in marine (dredging) and mining application to provide information on solids flowing down a pipe.

Sand/Water online visualisation using ERT

Oil & Gas flow visualisation

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 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



Air-oil-water three phase flow visualisation

with temperature sensors, pressure transducers and viscometers. Experiments were conducted on water-gas and oil-gas systems for a range of flow conditions.

Recent developments

Rapid Flow z8000 system

Recently ITS has developed a fast resistance system for the measurement of rapid flows. The instrument was developed in conjunction with BP Chemicals, BHR Group and University of Leeds. The z8000 can capture data 1,000 dual frames per second, which enables it to measure rapid flows of up to 10 m/s. The z8000 platform measures impedance, which can give information on the real and imaginary part which gives another set of data to understand complex materials and how they are distributed in the course of a process. The instrument is suitable for multi-phase systems such as the measurement of flowing oil water systems and hydraulic conveying of slurries.

Conclusion

The measurement principals of electrical tomography are applicable to many processes within the oil and gas sector. The simplicity of the technique offers a unique and valuable insight into complicated and very often little understood processes such as multiphase flow. It should be noted that electrical tomography systems have not been tested on every flow regime, but are one of the few technologies which can measure flow of opaque fluids in real time. However the ITS m3000 dual modality system is currently under evaluation as part of the NEL Flow Programme at their facilities in East Kilbride

Remote Level Sensing for Any Application

HWM's (France) SonicSens is a versatile ultrasonic level sensor with a 5 year battery life, designed for easy installation and ready to output results either locally or via a range of telemetry options. The SonicSens combines precise ultrasonic measurement with a connected MultiLog data logger to store, interpret and transmit results, making it suitable for a wide variety of level-sensing and flow monitoring situations. The option of cellular wireless telemetry and the long battery life mean that the device is ideal for remote installations where constant access is difficult and traditional communications unsuitable.

Open channel flow or level monitoring for any liquid is made easy by the non-contact ultrasonic sensor, taking instant and accurate readings of targeted surface levels. Fluid levels in tanks, reservoirs or storage containers can also be remotely checked, with easy mounting options allowing for temporary survey type operations. Data from the SonicSens can also be used as a control for other processes, allowing varying levels or alerts to have different effects. The system is available in four different configurations to suit varying installation requirements and networking preferences. It can be non-ATEX cable linked, ATEX cable linked with a Barrier box, ATEX radio linked to the logger outside the ATEX zone, or the sensor, logger and cable all ATEX rated with total protection for completely below-ground installations.

SonicSens can communicate via GSM, GPRS, PSTN radio or satellite, and the communication module can be sited separately from the sensor itself to maximise signal.

Reader Reply Card No 166

Differential Pressure Transmitter for Static Pressure Up to 1035 Bar

Oil and gas producers are drilling to new depths to keep up with demand. Traditional differential pressure transmitters that are not designed to operate above 6000PSI (414 bar) are challenged by the need to operate at high pressure. This challenging application needs a solution that is specifically designed to cope with higher static pressures, aggressive process and environmental conditions.

Based on extensive experience of supplying transmitters for this demanding application, **Fuji Electric** (France) is proud to announce the release of its latest, ATEX approved, Differential Pressure Transmitter as a direct response to their customers' requirement in high pressure applications that are traditionally found in oil and gas flow measurement. The experience and technical capability that Fuji built into the new transmitter enables it to measure differential pressures of 130mbar at static pressures of up to 1035 bar (15 000 Psi), typically found in top side and subsea applications.

Reader Reply Card No 167

New Differential Pressure Transmitter Ideal for Level and Flow Measurement

A range of smart differential pressure transmitters for process industry applications has been launched, which can be used for level measurement of closed, pressurised tanks, pump and filter control, or for closed pipe flow measurement in conjunction with an orifice plate, Venturi or nozzle.

The XMD range from **Impress Sensors and Systems Ltd** (UK) is ideal for flow applications due to the device's ability to switch the output from a standard linear output to a square root extraction where flow rate can be output. Target industries include chemicals, paper and pulp, petrochemicals, energy & power, food and dairy, and pharmaceuticals.

The XMD has a differential pressure range from 75mbar up to 2 bar and with a static over-pressure capable of 130 bar line pressures. The calibrated pressure range can also be turned down 10:1 times, which means that a 75mbar range can give a full scale output at 7.5mbar, whilst still maintaining the 130 bar line pressure. A 5:1 turn down ratio maintains the accuracy of the transmitter, which is ±0.1% FSO.

Outputs available are 4-20mA as standard with the option of having HART® communication. If this option is selected, the XMD is ATEX-approved as standard. The device is intrinsically safe for Zone 0/1 and an Ex d version is available with a flameproof enclosure for Zone 1 applications.

The XMD range is designed for harsh process manufacturing environments and so the electrical enclosure is a two-chamber aluminium die cast, powder coated with the option to include an integrated smart display. As Sam Drury, Sales & Marketing Director at Impress Sensors & Systems comments: "The integrated display enables the user to programme the device, including electronic damping of the signal, offset adjustment [of up to 90 per cent of full scale] and a turndown ratio of 10 to 1. The two-chamber aluminium die cast housing is prepared for chemical seals to extend the application possibilities even further."

Reader Reply Card No 168

Flow Measurement Distribution Agreement for Canada

In September, **AW-Lake Company** (USA) inked a distribution agreement with Peacock, a division of Kinecor, to stock, distribute and support flow measurement systems from the AW-Lake brands AW Gear Meters and Sabre Flow Turbines. The agreement unifies AW-Lake's Canadian market and provides more localized support. The two companies are working together to target oil and gas, HVAC, food & beverage, water and pharmaceutical markets. Although this is an exclusive distribution agreement, it is non-exclusive for the province of Quebec. Peacock will offer both of AW-Lake's new products, the TW series turbine flow meter specifically designed for the oil & gas market, and the MicroFlow PD gear meter, which is ideal for low flow rate applications, such as chemical injection.

"We are very proud to align with Peacock, a key player and leading source of instrumentation and industrial products," stated Curt Foreman, Director of Sales & Marketing for AW-Lake Company. "We are confident that Peacock is equipped with the talent and experience necessary to accelerate the growth of our flow measurement products in the Canadian markets." Simon Bennington, Peacock's VP & General Manger agrees, "We feel the AW-Lake products as well as the technical support and new product development program will provide Peacock with a strong product offering, allowing Peacock to use our technical sales and service expertise and Canada-wide presence to mutually benefit both companies."

Reader Reply Card No 169