*It can be difficult for operators of pressure filtration systems to know what is going on inside the filter cake during filtration, washng and drying, and any miscalculation can result in wastage of time, effort and money. However, this may be about to change. Thanks to a UK government funded project, Industrial Tomography Systems has been able to test its novel sensing technique – electrical resistance tomography – for pressure filtration on a commercial scale. Peter Varey, freelance writer for Filtration+Separation, presents the major findings of the project.*

# ERT: tracking the progress of pressure filtration

In the process industry "suck it and see" may be an occasional last resort when facing unknowns in vacuum filtration. But it's no use at all in pressure filtration, where in extremis "push it and pray" might be a better maxim. The problem is that most pressure filters do not have the instrumentation to help an operator judge, for instance, whether the filter cake has "rat holes" or whether wet patches remain. As a result, the determination of the end-point can be a very hit and miss affair. Operators can find themselves pressurising batches first during filtration and then during washing and drying for long hours, spending – and almost certainly wasting – precious time and energy. If one batch takes 100 hours instead of 50 hours, the integrity of batches following on behind and the planning of asset use can be compromised.

All this may be about to change. Industrial Tomography Systems (ITS), based in Manchester, UK, has just completed a four-year Government-funded LINK project to test its novel sensing technology, i.e. electrical resistance tomography (ERT) on pressure filtration at commercial scale. Major filter manufacturer Rosenmund, bio-processing company Syngenta Agribusiness and academics at Glasgow Caledonian University and the University of Manchester Institute of Science and Technology (UMIST) have supported and played important roles in the project.

ERT visualizes the contents of vessels and pipelines containing multi-phase mixtures without disturbing the flow. In the context of pressure filtration – and this is but one of many potential process applications – it lets the filter operator see what is going on inside the filter cake. The information produced is graphic. For instance, a typical conductivity read-out against time (Figure 1) illustrates filtration and four washing cycles followed by drying. Armed with the information that ERT supplies, the operator can make changes to process conditions and watch as filtration performance improves. But first, how does ERT work?

## ERT in action

The form ERT takes depends on the application. For pressure filtration, an array of 16 electrodes, for example, can be placed on a mesh in the plane of the filter cloth and on top of the filter cloth hold down bars. They are therefore in contact with the process fluid, but do not disturb the process flow pattern. The next step is to apply a small AC current between electrode pairs and make voltage measurements between the remaining electrodes pairs according to a pre-defined measurement strategy. A 16-electrode sensor delivers over 100 independent measurements in approximately 25 milliseconds, the exact number depending on measurement strategy. An image reconstruction algorithm, the heart of the technology, generates pictures of the distribution of materials within the sensing zone.

Thus operators get a picture of the filter cake during filtration, washing and drying. The technology shows how moisture content varies throughout the filter cake, and when an end point has been reached. The Glasgow Caledonian team (experts in electrochemistry) has been checking that the electrical pulses do not affect product integrity and has found no problems to date.

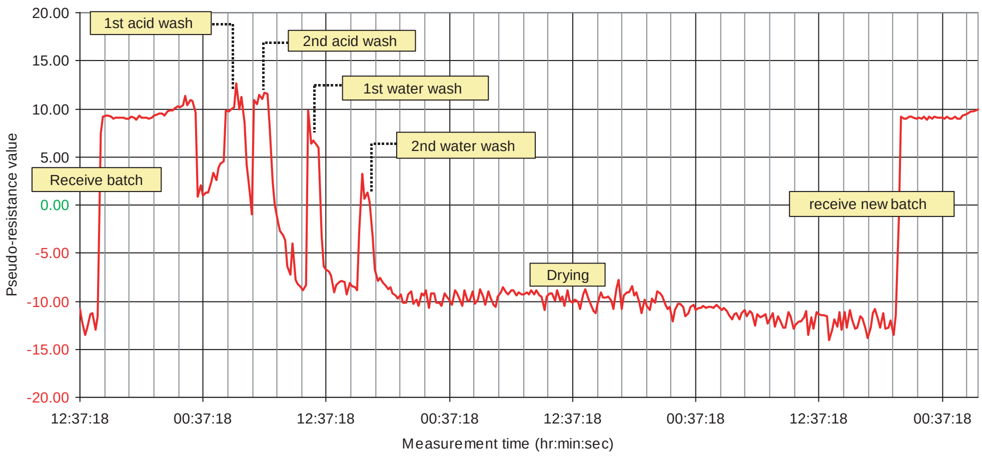



**Figure 1: Typical data from electrical resistance tomography.**

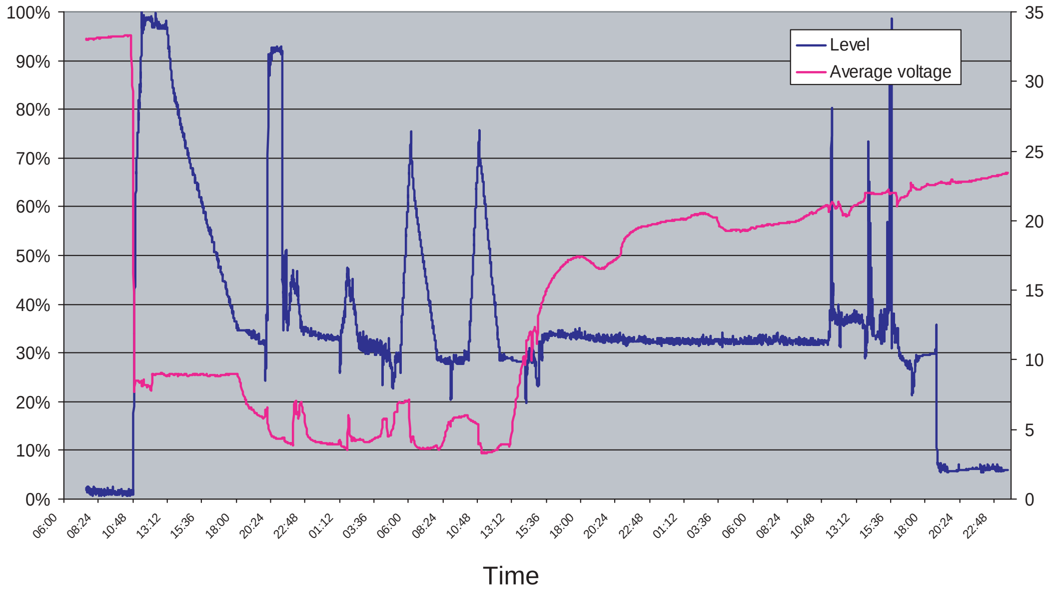

ISSN 0015-1882/04 

## Early work

Before the LINK project began in 2001, Syngenta had already scaled up the application of ERT to a 36 m$^3$ production pressure filtration vessel at its agrochemicals manufacturing site in Huddersfield, UK. The purpose of the work was to provide real time information on the end-point of filtration and drying, imperfections in the filter cake and solvent displacement of the mother liquor.

Located in a flammable atmosphere, the pressure filter handled chemically aggressive material, so retrofitting an ERT sensor to the unit presented a number of challenges. The first, was to design a system that met the requirements of intrinsic safety (IS) certification. This was achieved by using zener barriers to limit the power that could be delivered to the electrodes located in the hazardous area. Other challenges included, the electrode materials and design, cable routing and exit detail, and some operational constraints.

The study showed that an ERT sensor could be retrofitted to a large pressure filter without the need to modify the internal structure of the unit. It also demonstrated that ERT could be certified to comply with intrinsic safety regulations, making the technology suitable for the most hazardous of flammable atmospheres. Electrode design initially suffered from a number of weaknesses, but they were resolved through design iterations.




**Figue 2: Match between the level of and voltage across the filter cake.**

## LINK project results

The LINK study cross-checked ERT results against several factors often used to judge the progress of pressure filtration, such as the variations of level, pressure, load on the agitator and air temperature in and out. Figure 2 shows how the mean of over 100 different voltage measurements through the filter cake varies with level over time. The various wash cycles are indicated by step increases and decreases in voltage during the early stages of each batch, and the drying cycle by a steady increase in voltage. ERT and level data match well.

As each data point on these trends is a mean of the 100 or so individual voltage measurements taken from different regions within the filter, the data sets are amenable to statistical analysis.

The long-term aim is to use this information to improve fundamental understanding leading to minimization of product variability and improvement in product quality. Any unexpected hold-up in pressure filtration is a serious matter, i.e. holding the next batch of material longer than planned in a crystalliser, for example, can result in adverse changes in quality.

ERT also makes available other previously inaccessible

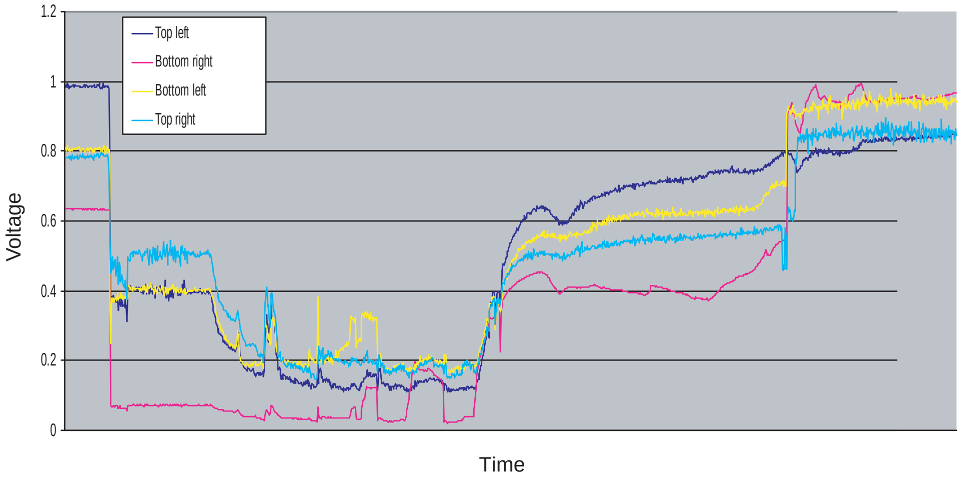



**Figure 3: ERT data on four segments of a filter cake.**

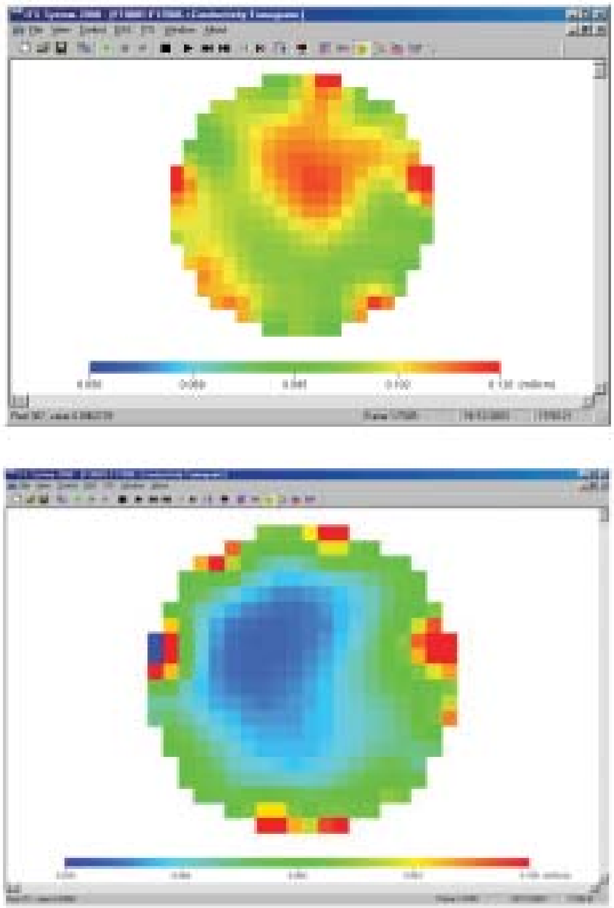


**Figure 4: Tomographic images across the plane of the filter cake during (a) filtration and (b) drying (red = high moisture; green = moderate moisture; blue = low moisture)**

information. For example, data from four segments of the filter cake can be compared (Figure 3) to see whether performance varies, or is identical, in each. Often it is not, and this asks questions about the process materials and conditions. It helps plan process strategy and allows simple comparison of the performance of different batches.

Sampling strategy can also be validated. A tomographic image of the conductivity distribution through a horizontal section of a pressure filter (Figure 4a) shows that the area below the feed pipe has a higher moisture content (the red area at one o'clock) than elsewhere. In order to determine level of dryness (LOD) of the filter cake, the sample point may be located in the area under the feed pipe. The results from ERT in the LINK project vindicate the assumption that if the cake is dry in that area, it should be dry everywhere. The image during drying (Figure 4b) gives a clear indication of which sections of the cake are dry and which still wet.

## Benefits of ERT

According to ITS, the benefits of the technology revealed so far by this project are opportunities to:

- Improve yield and quality
- Reduce use of raw materials like wash solvent
- Operate more safely because there is less need for sampling
- Reduce capital cost because optimizing means that a smaller pressure filter will do the job of a larger one

Syngenta has been testing the technology thoroughly on a chosen manufacturing process requiring intrinsically safe operation and use of polytetraethylene (PTFE) and Hastelloy parts to counter aggressive media.

ERT can also be used on pipework and reactors, with useful insights into what otherwise would be unseen. Users have compared using ERT to a whole body scan in hospital, i.e. the doctor uses it to spot disease, while a process operator uses it to spot process imperfections.

Among various companies, GlaxoSmithKline is considering ERT as a possible process tool to reveal what is going on inside its reactors, British Nuclear Group is mid-way through a project to equip one of its processing stages with ERT and Johnson Matthey Catalysts (previously Synetix) has used it to validate computational fluid dynamics data on flow through a catalyst bed in the design of a more efficient reactor. Letting the operator see what is going on inside the metal walls of processing vessels is a potentially powerful tool in many areas of process optimization.

## About the author

Peter Varey has been a freelance for six years. Previously he was editor of The Chemical Engineer, the Institute of Chemical Engineer (IChemE) magazine, and then publisher of it, together with books and learned journals.

ITS was established in 1997 as a spin-off company from research conducted at UMIST. For more information on ERT contact ITS directly on Tel: +44 161 233 1970, or visit its website (www.itoms.com).