The non-contact measurement process

Non-contact torque technology from Sensor Technology is being used across the process industries where monitoring and control are vital. **Tony Ingham** from the company explains why

Within a process environment, monitoring and control are vital and, as such, there can be thousands of sensors and switches collecting data and feeding it back. These sensors track changes in the plant's operating parameters, enabling the engineers to monitor variables indicative of the various stages of the process as, after all, they want to transform material from one state to another.

While some parameters such as temperature are easy to measure, others are more difficult – so a technique is to measure a related parameter (typically one related to the plant or machinery rather than the process material) and interpolate from this.

Many types of process plant, such as mixers, pumps and conveyors, are motor driven. Measuring the motor output characteristics will often provide process information – the torque of the motor, for instance, could suggest the quantity, speed or viscosity of the material being worked. When monitoring a mixer drive, for example, an increase in torque could be suggesting that a mixture is thickening up as expected. Alternatively it could be indicating that a seal or bearing is sticking and may fail. Early warning of breakdowns will enable pre-emptive maintenance, which can be critical in continuous processes where downtime can cost thousands of pounds an hour in lost production.

Sensor Technology's TorqSense unit

Measuring the torque can be simple. TorqSense from Sensor Technology, for example, provides a non-contact means of taking the readings. In use, a couple of 'pads' are glued to the side of the driveshaft and a TorqSense unit mounted close by. This then monitors the torque and feeds it as a data signal to the SCADA control system.

The pads are tiny piezoelectric combs encased in plastic. These open or close under the torque effect of their rotational speed on the drive shift – the greater the torque, the more the distortion. The Torqsense unit emits a low powered frequency signal towards the comb, which reflect it back to the Torqsense at changed frequency, the change being proportional to the distortion of the combs, and thus the torque in the drive shaft. The physical phenomenon which deforms the combs is called the Surface Acoustic Wave (SAW).

The advantages of SAW equipment have been seen by many companies. Pump manufacturer, Charles Austen Pumps, for example, has recently upgraded its test facilities with SAW equipment from Sensor Technology.

SAW advantages

The company manufactures pumps to customer specifications. Much of its work comes down to optimising drive dynamics to produce the desired characteristics, be it a smooth flow in a critical medical situation, ultra low noise for home and office installations, or versions for inaccessible locations which need a long life.

The cyclic nature typical in the operation of many pumps tends to induce torsional oscillations in the drive shaft, which can have an adverse effect on performance if unchecked.

Charles Austen Pumps has seen many benefits of the new test station based on SAW sensors, including a broader signal bandwidth and elimination of electronic interference, but it has also been lower cost, simpler to use and more reliable.

Monitoring

In food manufacture, real time process control involves characterising the flow and mixability of non-Newtonian fluids, with TorqSense transducers monitoring the constantly changing flow characteristics of materials as they are mixed. This can range from tomato sauce or chocolate, to pasta sauces and chicken tikka massala.

Many foods are presented in a sauce – or a 'neo-liquid' to physicists. To date, however, real time control has been virtually impossible due to the nature of the food which may contain particulates, fibres, vegetables, etc.

As a solution, TorqSense has been able to detect the changes with sufficient sensitivity, while being robust enough to suit the industrial environment, suitable for washdowns and capable of meeting the hygiene standards.

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Accessing traveller fares with Hall Effect sensors

Access gates are designed to collect traveller's electronic fares using high speed ticket encoding from magnetic strip or contactless smart cards. So when looking to reduce maintenance and reliability of its access control gates, Cubic Transportation Systems worked with Variohm Eurosensor to use the Contelec Vert-X 13 series non-contact Hall Effect sensor.

Cubic's Universal Gate range has been designed to adapt to the diverse requirements of ticketing and gate siting as an integral part of complete software, hardware and communications systems that have revolutionised mass transportation ticketing. These feature two paddles to provide dual opening. Each gate flap is independently driven via a motor gearbox with a fixed rotation of up to 180˚, controlled using a feedback voltage set between an upper and lower value from the directly coupled angular position sensor. High traveller throughput rates requires rapid accelerations and fast settling times which place high demands on all the components used.

The Vert-X 13 series sensor is a two part Hall Effect and magnet design. As it can be delivered with a pre-programmed angular range between 5% and 95% of rotation, Variohm was able to supply the replacement sensor with exactly the same output characteristics as the original potentiometer version. Of additional benefit, its small size (13mm in diameter and 20mm nominal length) enabled it to fit into the existing space and its durable stainless steel housing and integral ball bearing system meant the sensor would satisfy the environmental specifications required.

A further benefit was its true linear output and improved accuracy – Cubic engineers found they could achieve almost pin-point accuracy which considerably improved in-position stability and the superior linearity also enhanced the control system smoothness.

"The Vert-X solution was trialled during 2007 at a new rapid transit system project in Atlanta-Georgia and quickly proved successful," says Colin Peacock of Cubic's Redhill UK engineering department. "The reliability gains and improved life time of the non-contact solution has considerably reduced the Universal Gate maintenance burden and it is now the design choice for new and retrofitted access gates worldwide."

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Often the key requirement is to mix sufficiently to achieve a uniform dish, but not to waste time and energy by over-mixing. This can be done by monitoring the torque on the mixer's shaft, as it will move to a steady state (within the characteristics of a given recipe) once fluid uniformity is achieved.

A TorqSense is also helping to analyse the mixing properties of recipes in a project that could slash development costs in the food and plastics industry and help nanotechnology advances in the pharmaceuticals world.

For this, the University of Bradford is carrying out research to develop a miniature mixer (5-25g batch) that incorporates a set of integral instruments to monitor the properties of materials as they are being mixed.

The instruments work in real time during the mixing process, with their output captured to a PC for analysis. Software is being written so that the analysis can be performed simultaneously with the mixing and perhaps even used to interactively control the mixer itself.

One of the key parameters to be measured is the torque of the mixing element, as this will become constant once mixing is complete. This is measured by a TorqSense non-contact sensor which means the development team doesn't require complex and delicate slip rings, making the mixer easier to build (and rebuild between trials) and more robust in operation.

The Mini Mixer development and validation is the result of a three year EPSRC sponsored programme of research. The results of this research are expected to have a major impact on formulation of viscous mixes and scale-up of extruders. Traditionally, recipes for formulating, for example, specific coloured plastics for consumer products, are developed in 25 to 50kg batches, mixed in an industrial scale twin screw compounder. Several batches may be required before the recipe is finalised. The development of a smaller mixer is advantageous, but the laboratory device must be able to duplicate mixing in the larger scale and guide design and operation of large machines – and that is what the research programme has achieved. That fact that the technology will transfer to the plastic industry and other soft solid sectors means it is likely to rapidly recoup development costs.

Torque measurement is also being used in a move towards energy efficiency. In horizontal axis washers (front loaders in domestic parlance), the load (the wet laundry) is lifted on one side of the axis and falls on the other side. This is a dynamic where regenerative energy recovery is very attractive if it can be practically achieved.

A test rig has been built which subjects washing machine systems to extensive tests using an industry standard inverter to simulate the various washing cycles, etc. A critical element of the programme was the ability to make continuous accurate torque measurements and, for this, TorqSense is ideal. The time saving in setting the transducer, compared to installing a slip ring based sensor, over a big project is measurable and significant.

By measuring the torque change, the exact moment when to switch the drive from power to regeneration and make the most of the potential energy released by the falling load could be defined. Given that the motor could be rotating at up to 1500rpm, this called for very accurate data collection and equally responsive control programmes.

This technique has proved so worthwhile that it will be built into next generation washing machines. With industrial sized loads, energy savings of 20-30% may be achievable.

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