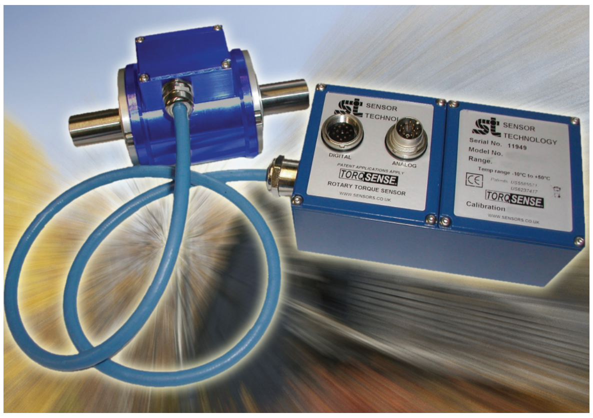
Torqing sense for process plant control

Plant monitoring and control is particularly vital in the continuous process industries, where multiple machines must act in harmony day after day and failure of a single machine can lead to massive consequential losses of production. With most machines driven through a rotating shaft, torque monitoring can identify problems before they become critical. **Tony Ingham** of **Sensor Technology** considers the techniques involved



TorqSense from Sensor Technology provides a digital, non-contact means for taking the torque readings

Say 'process control' and most people automatically think of monster-sized central computers running barely-fathomable SCADA software in a control room that would not be out of place at Cape Canaveral. But out on the plant floor, there may be literally thousands of simple sensors and switches, collecting data and feeding it back to the behemoth.

These sensors are tracking every little change in the plant's operating parameters, indictative of either the state the materials being worked or of the state of the machinery itself. For instance an increase in torque on a mixer drive may suggest that a mixture has thickened up as expected, or alternatively that a seal or bearing is failing, either way this is vital information for the central computer to capture and assess.

Ultimately, process engineers want to transform material from one state to another, and to monitor variables indicative of the various stages of the process. Some parameters can be measured directly and simply, such as temperature for example. Others are more difficult to measure, so an often-used technique is to measure a related parameter (typically one related to the plant or machinery rather then the process material) and interpolate from this.

Significantly many types of process plant - mixers, pumps, conveyors - are motor driven, and measuring the motor output characteristics will often provide process information. For instance, the torque of a motor could suggest the quantity, speed or viscosity of the process material being worked.

Obviously, measuring the processing is the primary concern of the production engineers, but torque measurement has a second, equally important function. Because you are actually measuring plant performance, you get to see how the machinery is holding up. Knowing what to look for will give you early warning of breakdowns, allowing you to schedule pre-emptive maintenance. For a continuous process where downtime can cost thousands of pounds an hour in lost production, this can be critical, ultimately the difference between a healthy profit and a catastrophic loss.

This all sounds very useful, and actually measuring torque can be very simple. Not so long ago torque sensors required a fairly complicated and fragile array of slip rings connected to the rotating drive shaft of the machine under test. But now TorqSense provides a digital, non-contact means for taking the readings. In use, a couple of 'pads' are fixed to the shaft of the sensor and a digital TorqSense electronics module unit mounted close by. The TorqSense then starts monitoring torque, and feeding it as a data signal to the SCADA control system.

Technology principles

The 'pads' contain in fact tiny piezoelectric acoustic wave combs. The spacing of these combs are designed to open or close under the torque being applied to the drive shaft. The greater the applied torque, the more the distortion.

The digital TorqSense unit then emits a low powered radio frequency signal towards the combs, which are reflected back to the TorqSense unit. The reflected signal returns as a changed frequency, the change being proportional to the distortion of the combs, and thus to the applied torque on the drive shaft.

In use, the Torq Sense unit monitors torque and feeds it back to the SCADA control system as a data signal

The physical phenomenon which deforms the combs is called Surface Acoustic Wave (SAW), a property first noted in 1885 by gentleman-scientist Lord John William Strutt Rayleigh. He postulated many possible uses for SAWs, but was unable to realise any practical use for his theories. It was not until the 1920s that SAWs were shown to be generated by the moving edges of earthquakes and avalanches, the recording of which using low frequency vibration monitors formed the basis of modern seismology and volcanology.

By the mid 20th century scientists were creating SAWs devices in laboratories and developing new ideas for their use. As the century closed Sensor Technology was using the phenomenon to develop a new method of digital torque measurement and monitoring, the non-contact nature of which promised to be very attractive to working engineers.

Sensor applications

Charles Austen Pumps (CAP) has recently upgraded its test facilities with Surface Acoustic Wave (SAW) TorqSense equipment from Sensor Technology.

Charles Austen Pumps manufactures pumps individually designed to meet specific customer requirements that cannot be satisfied by off-the-shelf units. 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 pumps in home and office installations, or the guaranteed extra long life of pump in inaccessible locations.

TorqSense transducers are used to monitor the constantly changing flow characteristics of materials as diverse as tomato ketchup, chocolate, pasta sauce and chicken tikka massala as they are mixed

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

CAP has recently built a new test station based on Sensor Technology's TorqSense sensors, and it is proving it's worth time and time again. Advantages of SAW techniques include a broader signal bandwidth than other analogue based technologies and elimination of electronic interference. As CAP found, it often also proves far lower cost, simpler to use, is more reliable and has a wider operating than contact alternatives.

Curryin g flavour

Real time process control for food manufacture involves characterising the flow and mixability of highly non-Newtonian fluids. TorqSense transducers are used to monitor the constantly changing flow characteristics of materials as diverse as tomato ketchup, chocolate, pasta sauce and chicken tikka massala as they are mixed.

Many manufactured foods are presented in a sauce or as what physicists could describe as a neo-liquid and can be produced in a process-type environment. But to date real time control has been virtually impossible due to the non-uniform nature of the food, which may contain particulates, fibres, vegetables, meat, nuts, raisins, biscuits etc.

To achieve real time control the TorqSense has to be able to detect the changes with sufficient sensitivity, yet be robust enough for general industrial abuse. Of course it must not compromise hygiene standards and regimes either. TorqSense has been found to meet all these requirements and is being used in by a number of food processors.

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 applied torque on the mixer's shaft, as it will move to a steady state (within the characteristics of the given recipe) once fluid uniformity is achieved.

Nuclear safety

Precision gearboxes supplied to the nuclear industry have to be guaranteed to never fail prematurely, so testing them off-line is a vital function for Centa Transmissions. A test rig has been developed in which a motor drives the test unit against a load created by an industrial disc brake. The test runs initially for three hours at the full working load, and is then increased to 300 percent load for another hour. At the heart of the rig is a TorqSense that constantly monitors the torque in the gearbox, generating a performance profile that can be compared with the ideal performance standard.

The duty the gearboxes are destined for takes place in an environment where reliability has to be 100 percent. They are used in completely automated scoop mechanisms that collect small amounts of 'high-activity liquor' from the reactor cooling systems. This is sealed into thick-walled ceramic flasks for long-term storage until the radioactivity has decayed to safe levels.

This is at the very core of the nuclear plant where a component or system breakdown would mean shutting down all operations for months, automated/unmanned removal of the faulty parts, sealing into a secure flask and automated installation of a replacement. The cost would be millions of pounds, at the very least. To avoid this everything has to be lifetime guaranteed to demanding criteria.

Miniature mixing

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

Research and development is being carried out at the University of Bradford to develop a miniature mixer (5-25 grams 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 and their output is 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 that offers the development team the great advantage of not requiring complex and delicate slip rings, making the mixer easier to build (and rebuild between trials) and far 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 say 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, so the cost and time involved can be considerable.

Clearly 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.

Washing goes green

High performance torque measurement is helping to improve the energy efficiency of industrial (and domestic) washing machines. Process plant manufactures are redesigning their machines to reduce power consumption.

In horizontal axis washers (front loaders in domestic parlance), the load, i.e. 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 is planned to build into the next generation washing machines. With industrial sized loads, it is possible that energy savings of 20-30 percent could be achieved.

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