Torque about a nightmare!

Measuring the torque of a rotating shaft has always been a bit of a nightmare because the necessary slip rings tend to be rather fragile and unreliable. To make matters worse, they add to the load on the shaft so alter the torque. But, such problems are rapidly becoming history as Oxon-based **Sensor Technology** introduces its non-contact torque sensor

The technology community in the UK and further afield have found a 21st Century solution to the age old problem of monitoring torque in a rotating shaft. It is a new low cost, non-contact, rotary torque transducer -Torqsense - from Sensor Technology that is proving as robust and simple to use as a photoswitch or temperature gauge.

Previously, torque measurement was a delicate and fiddly operation and was therefore confined to labs, test rigs and gentler industrial environments. Now, Torqsense is able to withstand the rigours of much more hostile locations, so is extending the benefits of torque monitoring to a far wider field. The latest version of the sensor, the RTW 310/320, is designed for serial manufacture, easy installation and robust performance. Not surprisingly it is in great demand – mainly from first-time users.

Torqsense operates by using Surface Acoustic Wave (SAW) effects, the properties of which were demonstrated in 1885 by English physicist Lord John William Strutt Rayleigh. His original interest in them was based on the fact that he thought they were a major component of earthquake vibrations and this was confirmed in the 1920s with the advent of seismic recordings. Some 45 years later, Voltner and White of the University of California generated SAWs on the free surface of quartz.

In the early 1990s, news leaked out that, as part of a DTI LINK scheme, Sensor Technology was developing a low cost torque sensor based on SAW technology. The programme showed much early promise, with a prime example of its potential demonstrated in its use in the development of an all-electric power steering system for small 'city' cars, where heavy bulky hydraulic power steering would have been impractical.

Now, having worked through two or three generations of the technology, the new Torqsense RTW310/320 is opening up rotary torque measurement to a diverse spread of applications.

The Torqsense rotary torque transducer

Applications

In many fields a knowledge of torque is critical. These include: variable speed drive systems where direct transmission torque feedback can be measured to minimise torsional oscillations, mechanical resonance and fatigue; condition monitoring, for example on CNC machine tools; highly automated and torque critical tightening processes; and monitoring and control of viscosity during mixing processes. The take-up of the new technology has been impressive, with Torqsense products replacing existing types of rotary torque transducers by providing better performance at a far lower cost while offering the great advantage of not having to physically contact the shaft being monitored.

'Torqsense is able to withstand the rigours of hostile locations so is extending the benefits of torque monitoring to a far wider field'

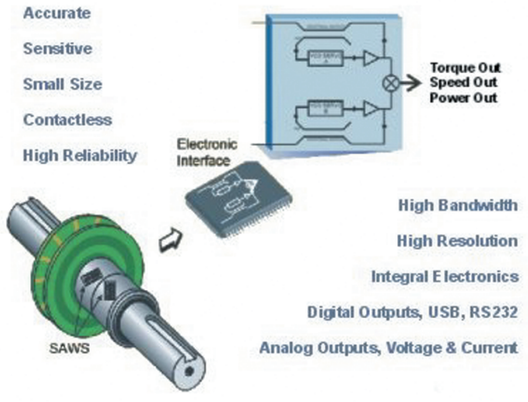
Rotary torque has historically been difficult and expensive to measure because traditional techniques are invasive to the mechanical systems being measured, i.e. they have to be mechanically coupled to the test piece through slip rings and thus introduce drag.

Torqsense overcomes these problems in a novel way: by using a radio connection rather than a mechanical one. It's sensing head is essentially a 'frequency dependent' strain gauge that measures the change in resonant frequency caused by strain induced in the shaft by its rotation.

In use, two SAW devices are embedded onto a shaft to form part of a high frequency oscillator circuit; one device is angled at +45º to the axis of the shaft, the other at -45º. When the shaft rotates under load it deforms by twisting: this compresses one device and stretches the other, creating a frequency difference between them. The difference in the two signals is a measure of the induced strain due to the twisting moment, and from this the torque can be derived. (Interestingly, the sum of the signals is a measure of the shaft temperature.)

Transmission of the signals is via an electromagnetic coupling operating at radio frequency (RF) levels, allowing non-contact, intrinsically safe torque measurement. Significantly the SAWs are piezoelectric so have minuscule power requirements. This power is delivered over the RF link simultaneously with the transmission of the output signals. Thus Torqsense is completely non-contact with the shaft being monitored.

The primary frequency of oscillation can be chosen anywhere from 100 to 1000MHz, with the difference frequency varying up to 1MHz. Operating at such high frequencies, the transducers are much less susceptible to electrical interference than conventional torque sensors. The high immunity to magnetic fields makes them eminently suitable for use in motors, for example.



The diagram shows how the transducer works

Key characteristics of the SAW based transducer include a resolution to one part in 10 million, an extremely linear

> 28

response (better than 0.1%) and a bandwidth in the order of 1MHz.

Integration

The Torqsense transducers are designed to operate direct from a PLC or a PC, removing the need for conventional instrumentation, and will interface with standard DPMs. They require only a minimum shaft length, have low inertia, no physical contact between shaft and housing, wide bandwidth, high resolution, high accuracy and magnetic/RF noise immunity.

With so many advantages over the traditional rotary torque measurement solutions, it is easy to see why the technology is generating so much interest in general industry.

The units are mechanically straightforward and as such they stand to completely redefine the expectations of machine builders, control engineers and OEMs, who to date have had to put considerable time and expense into obtaining the accurate torque readings essential for modern machine control and production monitoring requirements.

At the same time, the technology is providing a key tool in the development of higher efficiency rotating machines, where development engineers rely on accurate knowledge of torque and rotational speed.

The RWT series features integral electronics with outputs for torque, speed, power and angle. The RWT 310 provides analog outputs and the RWT 320 both analog and digital outputs, the latter being directly compatible with PC Interfaces such as serial and USB and are easily programmable for signal levels. Other features include built-in peak torque sampling, storage and torque averaging, and a self-diagnostics test package. Both the RWT 310 and RWT 320 can operate from a wide range of supply voltages.

Torqsense in use

The benefits offered by non-contact torque transducers has led to their adoption in a range of fields. One example of this was its use by Mindready Solutions of Belfast. When building a replacement rig for a global seatbelt manufacturer, the company used a highly sensitive transducer which highlighted previously undetected large torque oscillations within the spring retractor mechanism.

"The oscillations were so massive that at first we thought there was something wrong with our rig," recalls Mindready's Nick Beckett, "but we went through everything with a fine toothed comb several times and our results were proven valid. Further tests on the seatbelts themselves then established that they are actually more reliable than they were thought to be."

The test rig is quite simple. A motor rotates the reel spindle through 15 turns and back, simulating the extraction and retraction of a standard belt to its full extent, and the transducer records the changes in torque or 'force curve' throughout the motion. The spring force generated is expected to remain more or less constant throughout the travel excepting a critical ramp section where the force rapidly changes over less than one turn. The rest of the equipment is concerned with control, data logging and analysis. During tests, changes in speed from 15rpm to 400rpm were investigated and the Torqsense output proved to be consistent over this range.

"The results show that the Torqsense delivered higher levels of accuracy and sophistication than had previously been applied to product design verification and test," explains Beckett.

Sensor Technology's Torqsense rotary torque transducer was also chosen by scientists who wanted a way of measuring the key parameters for mapping the performance of vertical axis turbines.

The wind turbines are said to offer a number of advantages over the more conventional propeller-type horizontal axis generators. They tend to be quieter and safer, do not need to be turned to face into the wind, and their design and construction is relatively simple because there are few unbalanced loads.

Roy Wirachai of the University of Northumberland is undertaking a programme to analyse the performance of various types of vertical axis turbines. Data is generated via the RPM pick up of a Torqsense transducer and recorded using the related Sensor Technology measurement devices. Torque was also measured by the transducer, while other data such as wind speed was logged by suitable instruments.

In food manufacture, the torque on the mixer's shaft is measured

In another example, real time process control for food manufacture has come a significant step closer following research at University College Dublin into viscosity measurement techniques for characterising the flow and mixability of highly non-Newtonian fluids.

While many foods are presented in a sauce and can be produced in a process-type environment, real time control has been virtually impossible due to the non-uniform nature of the food - which can contain particulates, fibres, vegetables, meat, nuts etc.

PJ Cullen of the research team commented: "Real time process control is vital if food processors are to achieve the ultimate in product quality. To achieve this the sensor, a Torqsense, has to be pretty special to detect the changes with sufficient sensitivity, yet be robust enough for regular washdowns and general industrial abuse."

Cullen and his colleagues have simulated food processing techniques and the key requirement is often to mix sufficiently to achieve a uniform dish, but not to waste time and energy by over-mixing. To meet the requirements, they monitor the torque on the mixer's shaft as it will move to a steady state once uniformity is achieved, explained Cullen.

These are only a few examples of where Torqsense rotary torque transducers have been used, but the benefits offered by the technology will ensure its adoption is widespread across many different areas.

The use of the transducer by seat belt manufacturer, Mindready Solutions, highlighted previously undetected torque oscillations within the spring retractor mechanism