BACK TO THE FUTURE, FORWARD TO THE PAST

Technology and fashion have both come a long way since 1971!

With two moon landings, Britain launching its Prospero satellite, CAT scanners promising to revolutionise medicine, and talk about something called a 'microprocessor', 1971 was a momentous year for science and technology. It also saw a new magazine take off and a giant leap in torque measurement. Mark Ingham, sales manager, Sensor Technology, comments

In 1971 some people were pairing Afghan coats with bell-bottoms and campaigning against the Vietnam war. Others, in suits and ties, were campaigning to join the European Economic Community. Disney World Florida looked set to change Orlando from a torrid swamp into a tourist hotspot, and Qatar gained independence from the United Kingdom (with its new decimal currency).

On the industrial and engineering fronts, Rolls-Royce was nationalised but Upper Clyde Shipbuilders was liquidated; ambitious young engineers signed up with the new Open University – perhaps hoping that one day they would be able to afford a state of the art Morris Marina and drive across that civil engineering marvel Spaghetti Junction; London Underground's Victoria Line was completed; Dennis Gabor won a Nobel Prize for inventing the hologram; and video tape recorders had been miniaturised to the point that they were smaller than stereograms.

Much of this activity was being reported by editor Bob Hersee in his new magazine, OEM Design (the genesis of today's Design Solutions). Had the M40 existed then he would have had an easy trip from Wembley to Banbury to visit Anthony and Bryan Lonsdale at their instrument calibration company, to see their pioneering work in torque measurement.

In fact these twins had had a successful few years working on their clients' need for real-time torque monitoring and were planning to start a new company, Sensor Technology, to commercialise the developments.

Originally, they had worked on refinements to the only real option of that time – fixing multiple strain gauges to rotating shafts and collecting readings from them using a hardwired slip ring arrangement. By standardising on components and procedures they achieved some success, but feedback from the field suggested that nobody liked slip rings as they were fiddly to set up at the start of each test run and so delicate that they often broke or failed in use. So the brothers were soon ready to think out of the box and look for some innovative alternative ideas.

After a good deal of research, they realised that they could replace the slip rings and hard wiring with a radio frequency (RF) transceiver. As the transmission distance was only a few millimetres, the signal did not have to be very powerful, so there were no interference issues to worry about.

A BREAKTHROUGH

By 1971, just as OEM Design was building its readership, they had perfected and were commercialising an optical solution to torque monitoring. The measurement technique they developed was based on two encoder discs mounted on the shaft under test. Each disc is opaque but has a grating, or regular radial lines etched onto it, through which light can pass. Initially the gratings on each disc align so that a light can be shone through them.

However, as the shaft starts rotating the torque causes a slight degree of twist along its length and the gratings move out of alignment. This either reduces or increases the amount of light that can pass through both discs, depending on the direction of the torque applied.

By projecting a light beam of known intensity along the length of the shaft, through both discs to a photoelectric detector, the amount of twist can be measured and the torque in the shaft calculated.

This was a major technological breakthrough and was a boon to machine builders and plant operators who could now monitor and record the torque in their drive shafts in real time. This let them calculate how much power was passing through their drivelines, so that they could optimise designs and profile workloads in order to maximise overall efficiency.

In fact optical torque measurement was so successful that Sensor Technology was kept busy for the next 25 years. However, the company did not rest on its laurels: it built up a research and development team tasked with the dual goals of improving the optical technology and looking for alternatives that could be even better.

NEW IDEAS

By about 1990 Sensor Technology could see that fresh innovations needed to be explored so that boundaries could continue to be pushed. With some demanding projects on the horizon in sectors like defence and aerospace, marine propulsion and medical machinery, the company was granted Link Programme funding to explore a radical new idea.

Whilst conducting research on a separate project using SAW (Surface Acoustic Wave) filters, it had become apparent that these SAW filters were sensitive to strain or torque. When torque is applied to a shaft to which SAWs are fixed, it causes a deformation of the quartz substrate of the SAW device which, in turn, causes a change in its resonant frequency. Essentially the SAWs act as 'frequency dependent' strain gauges.

Thus Sensor Technology had devised a new method of measuring these SAW devices as an indicator of the torque level in a turning shaft. More work was required, but by the middle of the decade they had perfected a surface acoustic wave detector that could be mounted close to a shaft and react to its torque. A new chapter in drive management was beginning.

Once again, Sensor Technology's new SAW sensors collected the signal using a wireless RF rotating couple rather than slip rings, so they had all the ease-of-use of the previous generation sensors. Further, the same electronic processing and calibration was used to generate precise torque measurements and by this time the electronics were highly capable, sophisticated and user-friendly.

SAW devices also proved to have a high immunity to magnetic fields, allowing their use in motors and other electronically-hostile environments. They are bi-directional and provide fast mechanical and electrical responses. As the method is non-contact it has also complete freedom from brushes or complex electronics.

All told, SAW-based torque monitoring advanced the state of the art to a new level that allowed a further widening of its applicability – and another couple of decades of advancement followed.

SENSING INNOVATIONS

By around 2015 the boffins were again worrying about technical limits to their technology and began looking for the next innovation. Their finding was perhaps a bit surprising: they went forward to the past and looked at modern strain gauges.

Sensor Technology's new SGR series torque sensors use a four-element diamond formation strain gauge or Wheatstone bridge, connected to a miniature shaft-mounted analog-to-digital converter and microcontroller. When the shaft rotates two gauges go into tension and two into compression. The microcontroller, mounted as close to the gauges as possible to minimise external noise pick-up, measures these levels and creates a real-time digital data stream. This is transferred wirelessly from the rotating shaft to a second static microcontroller which performs calibration and temperature compensation to produce an accurate torque reading.

The new bridge-based sensors are robust, reliable, highly accurate, and easy to use. Introduced at the end of 2019, they have already created considerable interest amongst users and are fast becoming best sellers.

From a standing start 50 years ago, real time torque measurement has grown and grown. Instead of plateauing, demand has expanded as plant and machinery design has developed. Today, operators need their machines to run at top performance, and use the power of modern computers to constantly assess and reassess all dynamic parameters so that optimised running can be ensured at all times. Naturally these computers need real-time feedback data, principal among which is torque data from the drive systems.

Fifty ago Sensor Technology was building torque sensors for machines that now seem somewhat run of the mill. Today, it is at the current edge of all the developing technologies – from green energy generation to electric, fuel efficient and driverless cars; flood control, irrigation and water management; precision engineering, manufacturing and assembly; medical, surgical and healthcare automation; marine and aerospace propulsion systems.

To express it statistically, the world's population of rotating shafts is growing exponentially, and Sensor Technology has to keep up.

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