NEW LEVELS OF EFFICIENCY

Tony Ingham, Sensor Technology Ltd, UK, illustrates how newly developed technology that monitors the handling of dry bulk cargo can improve performance and optimise maintenance planning.

Dry bulk cargos have to be loaded and unloaded quickly, efficiently, cost-effectively and safely, if shipping operations are to be profitable. The processes have long been mechanised, but by harnessing the power of computers to monitor the handling equipment, operational performance can be improved, scheduling for maintenance can be optimised and billing of customers can become automated.

50 years ago, ships were loaded and unloaded manually, so each port employed a small army of strong men who worked long and hard as soon as a ship came in. But, nevertheless, the handling operations protracted, and so the ships were in harbour for extended

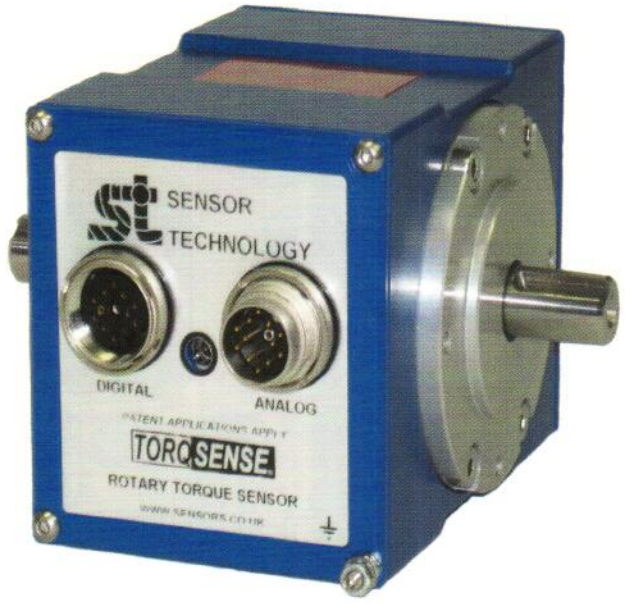

Figure 1. Sensor Technology's TorqSense.

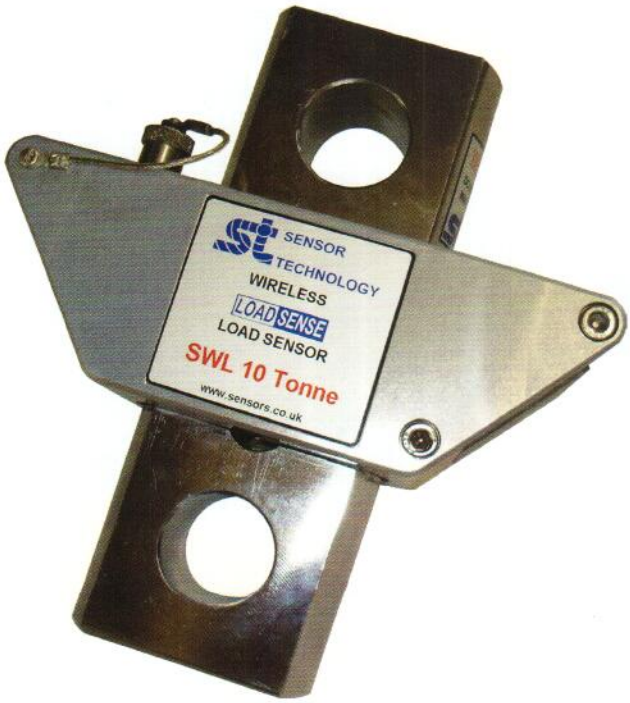

Figure 2. Sensor Technology's LoadSense.

periods. It is also worth noting that, back then, health and safety legislation was virtually unknown and it was practically impossible to accurately account for the whole cargo.

However, dockside operations have long since changed for the better and, even in developing countries, harbours now bristle with cranes, elevators and loaders.

There is a simple rule that drives the development of such technologies: a ship at sea is earning its owners money; a ship in port is costing its owners money. Therefore, shipping companies drive harbour operators to constantly improve their services and will transfer their loyalty to new docks if necessary. Quite simply, rapid loading and unloading are critical to the success of a shipping company, and so dockside technology continues to develop to provide evermore speed and efficiency.

In order to enhance manual operations, cranes, elevators, augers and loaders were developed – each one suited to handling a different product, such as grain, coal, gravel or chemicals. While these were motor driven, they were controlled by human operators and, no matter how skilled the operators became, they had no real way of telling if they were optimising processing and working efficiently. Then computers were brought in to automate the calculations and decision making, and efficiency took a turn for the better. Further, the computers could automatically collect operational data and convert it into commercial information for billing customers.

Today, another new generation of technologies is emerging and it is taking bulk cargo handling operations to new levels of efficiency, accuracy and flexibility. Put simply, robustly built sensors are being installed on dockside handling equipment; these constantly measure operational parameters of the machinery in 'real time' and feed live information back to a controlling computer, which can adjust operations on the fly so that efficiency is maintained. All this data can be collated to provide billing information and analysed to determine how much work the machinery has done, so that pre-emptive maintenance can be scheduled for minimal disruption to normal operations.

Unloaders come in a number of different designs, each suited to different materials. The core technologies include bucket wheels, flighted vertical conveyors and elevators, augers, horizontal belt conveyors and pneumatic systems. The mechanical principles of each of these are self-explanatory, but it is essential that control and monitoring of this equipment is maintained at all times to both ensure trouble-free operation and to calculate the weight of cargo being unloaded.

New sensors

The fundamental parameter to be measured is load (which can also be called weight or mass). The weighing scale was invented in ancient times, but is of no use in modern bulk handling operations; a load cell is required. This is an electronic sensor (in a robust housing, if it is to be used in a harsh working environment) that constantly sends a signal to a remote computer proportional to the load being experienced at every moment in time.

As such, it is simple to see that a load sensor is very useful on a crane: each load is weighed and the figures added up to give the total amount of cargo lifted.

However, a load cell is not appropriate on a conveyor, auger or other equipment that works by constantly having a quantity of cargo 'in flight'. The

amount in flight will be approximately constant and the duration of the operation will determine the total amount of material handled. For this type of handling system, the torque of the motor's drive shaft is measured first.

Torque is, in effect, a measure of the amount of power being transmitted in a rotational direction. A simple example that aids understanding is riding a bike: to accelerate or go uphill, one needs to pedal harder – or apply more torque via their leg muscles. The same principle applies to conveyors and augers: the more heavily loaded they are, the more power the drive motor needs to supply and, therefore, the total amount of power supplied over time is proportional to the total load handled.

It is increasingly common to fit torque and/or load sensors to handling equipment to obtain a real time measurement of their performance. They constantly feed information to the control computer, which can then adjust machine setting to optimise operations. The computer also collects the data for commercial purposes and maintenance planning.

As noted earlier, these sensors are mounted inside strong housing so that they can withstand the rigours of dockside life. Significantly, they must transmit their data back to the control computers; the normal way to do this would be with electrical wiring, but that could not be expected to last long in the demanding environment of a busy port. One solution would be to use armoured cable and to route via the most benign areas; however a better solution is wireless transmission of the signals.

Now, with over 20 years of R&D into digital non-contact torque monitoring, Sensor Technology is at the forefront of an important enabling technology. Its TorqSense transducer is based on the patented technology of measuring the resonant frequency change of surface acoustic waves (SAWs) generated by rotating shafts. It is a proven technology that has solved torque measuring challenges in a host of industries.

TorqSense torque sensors use two small SAW detectors made of ceramic piezoelectric material containing frequency resonating combs. These are securely mounted onto the drive shaft at a 90° angle to one another. As the torque increases, the rotating shaft twists very slightly along its length and this causes one comb to expand and the other to contract in proportion to the torque being experienced.

An adjacent pickup device emits radio waves, using the unrestricted 2.4 GHz waveband, towards the SAWs. The combs reflect them back, but, because one comb is expanded and the other is contracted, they return at two different frequencies. The difference in frequency of the reflected waves is proportional to the torque at any moment in time. This arrangement means there is no need to supply power to the SAWs, so the sensor is non-contact and wireless.

In reality, TorqSense measurement, together with the digital outputs it offers, is often the only practical way to measure torque in a demanding working environment. And once torque data is being collected this way and fed into a computer, one is well on the way to sophisticated real time control of complex processes.

Originally developed to solve a particular challenge in the automotive industry, TorqSense is now widely used throughout a range of industries, including many bulk solid handling operations, liquid pumping applications, mixers, the nuclear industry, for testing aerospace components, and running drug trials. It is applicable to all sizes of torque measurement tasks, from dispensing minute amounts of active pharmaceutical ingredients, through stirring industrial quantities of cook-chilled curries, to modelling storm and flood water

flows and, indeed, monitoring the tonnage of bulk solid cargo loading and unloading.

This innovative method of measuring torque is bringing distinct advantages to handling dry bulk products. A process that was once regarded as very difficult to monitor can now reap the same benefits as many other industrial processes, enabling operations to be optimised, so that the highest levels of productivity can be achieved at the lowest cost.

Torque and load

Once TorqSense was fully developed, Sensor Technology found itself very busy working on project after project. Because torque is a fundamental parameter, it is used in many situations across the full spectrum of industrial sectors. So, the company could spend one day talking to bakers about dough mixing, the next at a pharmaceutical plant dispensing active ingredients to microgram levels of accuracy, the third day working on a quarry conveyor or a dredger, and then move onto a dockside crane application, a robot arm or an electric vehicle drive.

In fact, the company was so busy that it could not find time to develop its next idea until about five years ago. It was only logical to adapt the RF technique for use with straight-line load monitoring, such as is required by cranes and hoists as they lift cargo to and from ships. This would bring the wireless advantages to all types of bulk solid handling plants and allow all cargo handling techniques used in any given situation to be monitored by the same system, which would lead to significant savings in management time and costs, as multiple reports do not have to be integrated.

It is notable that while LoadSense can measure any straight line load, can be scaled to work with any size of force, and works horizontally, diagonally and vertically, it was actually developed for a bulk minerals application (of sorts). In fact, it was first used to weigh multiple loads of stone being carried as an underslung cargo by helicopter. The stone was being used to build hikers' paths in the UK's most visited National Park: the Peak District. For airborne applications, LoadSense is integrated with a GPS for pinpointing drop zones and totalising flight distances.

Conclusion

Back in the world of dry bulk handling, it can be concluded that the modern world requires rapid and efficient transportation of goods from continent to continent. Speed of handling and accurate records are also essential. TorqSense, and its sister product LoadSense, allow real time data to be collected, constantly updated and instantly converted into the critical information required for efficient logistics. DB