TORQUE Monitoring

Improves **Process** and **Predictive Maintenance** Strategies

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Effective non-contact torque monitoring can help production quality as well as identify machine problems before they happen.

The importance of torque measurement in manufacturing environments is a new concept to some, but an everyday essential to others. Realizing the enormous cost benefits of measuring torque in rotating systems is sometimes not recognized by those tasked with improving profitability. The challenge is to be able to monitor and measure torque as accurately, unobtrusively, and economically as possible. For continuous-manufacturing processes where machines are driven by rotating shafts, machinery failure and subsequent downtime must be avoided in order to maintain profitability as well as consistency of output. The effective use of precision non-contact torque monitoring instrumentation can preemptively identify problems that might affect machinery reliability—extremely important for situations where a single machine failure can lead to costly production losses.

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Installing torque sensors in the rotating drive train of operating machinery can track some of smallest changes in a plant's operating parameters, and diagnose a change in state or viscosity of materials being handled, or the condition of the machinery itself. For instance, measured torque increases on a mixer drive may suggest that contents of a food preparation are thickening exactly as expected for a consistent product result, or that a seal or bearing is sticking and may soon fail. So it can be seen that data collected from a torque sensor can be vital for a control computer to accurately capture and assess manufacturing situations.

A process engineer's job is to be responsible for material mixes being transformed from one condition into another, monitoring both consistent and changing variables at all the various stages of the process. Some parameters can be measured directly and simply, such as temperature, fluid levels, volumes, and others. Other factors, such as chemical bonding reactions or process thickening, can be more challenging to measure. Instead of directly measuring these more difficult parameters, an often-used technique is to instead measure a related parameter—typically one related to the plant or machinery rather than the process material itself—and to infer from this the desired parameter readings. For instance, viscosity may change when a desired chemical reaction is completed.

Significantly, many types of processing equipment—mixers, pumps, conveyors—are motor driven, and measuring motor output characteristics or current consumption will often yield vital process information. For instance, the level of motor torque can be an indicator of the quantity, speed, or viscosity of process material being mixed. Electric motor torque monitoring can be an effective strategy for detecting worn bearings or over-tight shafts on equipment such as fans or blowers, the malfunction of which can significantly increase a plant's overall operating costs.

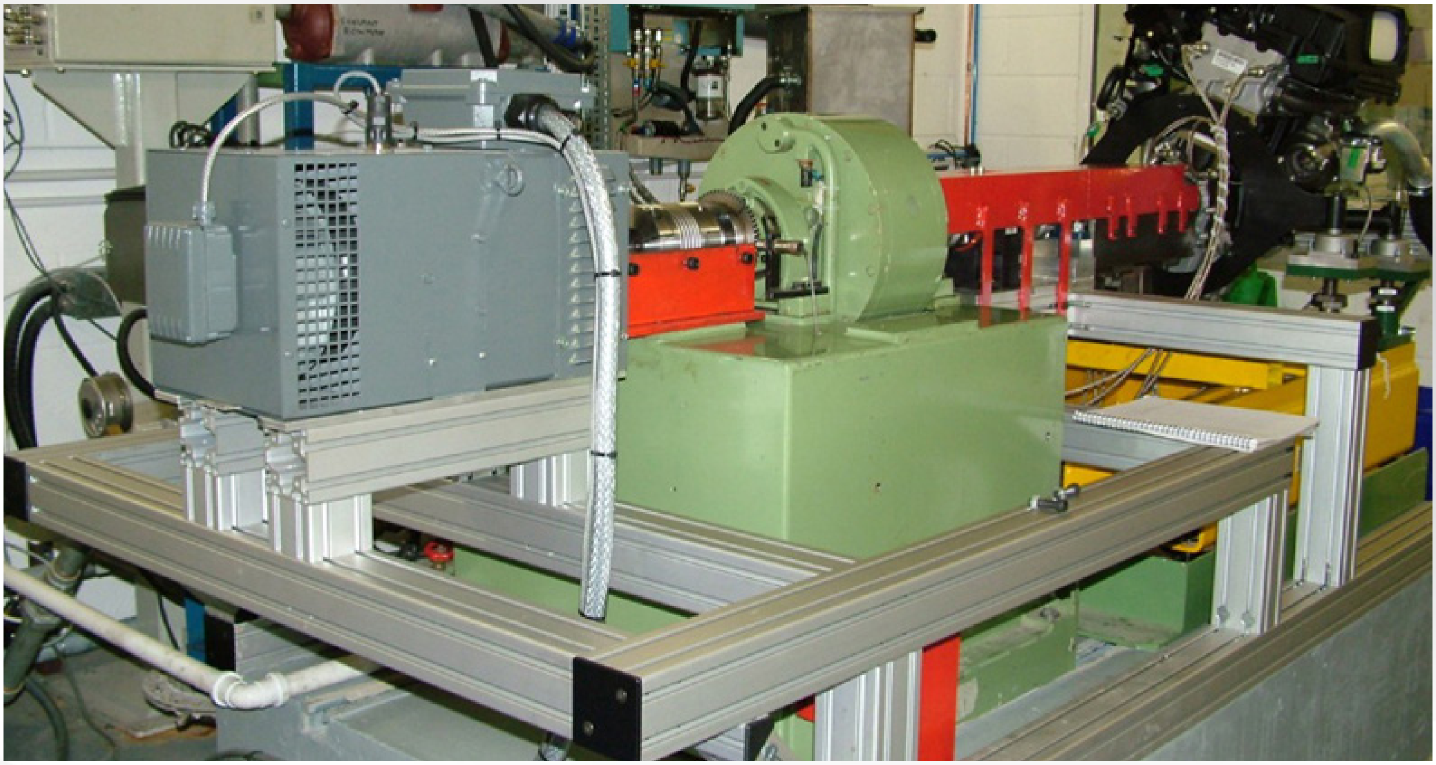
Torque measurement provides an important set of data on machinery performance and condition monitoring. Knowledge of what data parameters to evaluate will provide proactive or early warning of breakdowns, allowing plant operators to schedule appropriate pre-emptive or predictive maintenance, allowing critical machinery to reliably and continuously run with minimal downtime.

Today's torque measurement techniques have become increasingly simpler and user-friendly. Formerly, torque sensors required a fairly complicated and fragile array of slip rings connected to the rotating drive shaft of a machine under test. UK-based Sensor Technology has incorporated surface wave technology in their non-contact method of torque monitoring, known as TorqSense™. The product requires adhesion of several pads on to the side of the driveshaft, supported by an accompanying electronics unit mounted nearby, which monitors the torque, sending readings as a data signal to the control system. These pads are a series of tiny piezoelectric combs, fully encased in plastic. The combs are designed to open or close under torque effects of drive shaft rotational speed. A low-power radio frequency signal is emitted toward the combs, feeding back signals to unit's integral internal electronics. The reflected signal is returned at a different frequency, with the change proportional to the distortion of the combs, and hence also proportional to drive shaft torque.

Diverse Non-Contact Torque Monitoring Applications

Regenerative Energy/Windmills and Nuclear Industries

Precision gearboxes supplied to the regenerative energy and nuclear industries must be 100% guaranteed to reliably operate without premature failure, making off-line testing vital. Certain offline test rigs consist of a motor driving a test unit against a load created by an industrial disc brake. Testing generates a performance profile that can be compared with an ideal performance standard. In the



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case of an equipment failure within the nuclear industry, a component or system breakdown could mean longer term shutdown of critical operations, automated/unmanned removal of the faulty parts, sealing into a secure flask and automated replacement installation, potentially costing millions of dollars.

Chemical Processing, Plastics and Pharmaceuticals

Implementing a precision torque sensor in recipe mixing applications can reduce development costs in the chemical, food and plastics industries, and help nanotechnology advances with in pharmaceuticals. Incorporating instruments, which monitor the properties of materials as they are being mixed, capturing torque output to a PC for analysis and real-time control, allows instantaneous reaction to mixer conditions. Often a key parameter is the mix torque itself, which can settle at a constant level once mixing is complete. During process development, many batches may be required before a "recipe" is finalized, so the cost and time involved can be considerable. It is easy to see how quickly torque equipment costs can be recouped by enabling reproducible experiment variations to be constructed, as well as minimizing a resultant consistent process time.

Appliances: Washing Goes Green

High performance non-contact torque measurement can also improve the energy efficiency of industrial and domestic washing machines. Process plant manufacturers are redesigning machines to reduce power consumption. In horizontal-axis, front-loading washers, the load (wet laundry) is lifted onto one side of the axis, and falls on the other side. In this scenario, regenerative energy recovery is desirable, if it can be practically achieved. A critical element in designing such systems is the capability to make continuous, non-invasive, accurate torque measurements. A precision torque sensor actually allows a design engineer to measure torque change at the exact moment when a drive is ideally switched from power to regeneration, to make the most of the falling load potential energy release. Since a drive motor within this application could be rotating at up to 1500rpm, accurate data collection and

equally responsive control software are essential, and may be built into next-generation washing machines. For industrial-sized loads, torque sensors can assist appliance manufacturers in achieving energy savings of up to 20-30 percent, providing a significant competitive edge in the marketplace.

Aerospace and Defense: Unmanned Aerial Vehicle Design

The development of low-cost, flexible search and surveillance unmanned aerial vehicles (UAV) for military, homeland security and environmental monitoring can benefit from torque monitoring. Vectored-thrust propulsion system developers are using torque measurement technology as a key technology for the design and implementation of propulsion systems.

Hybrid Vehicle Design

Vehicle designers around the world know that torque measurement in invaluable in mapping the characteristics of combined motor-generator developments in hybrid cars designed to reduce vehicle emissions. The benefits provided by non-contact sensing technology include easy data capture, intelligent calibration, and advanced analysis capabilities.

Intelligent Lubrication

Car designers are constantly working on competitive improvements in their vehicles. Intelligent lubrication systems analyze engine friction and parasitic losses to provide optimal lubrication. Accurate and repeatable measurement of small changes in drive torque is a critical requirement during the development phase. Controlled oil pumps, each capable of supplying individual engine parts with oil under conditions unique to that part of the engine, react to signals that sense the vehicle operating conditions. For example, the engine head may be fed with oil at pressures different to the engine block, and bearings may need more oil when an engine is under heavy load. Profiling engine performance under various lubrication conditions can derive optimum performance configurations for future intelligent engine systems. Both gas and diesel engines run much cleaner than years ago. The required need for efficient operation under a wide range speeds and loads, and environmental conditions from -40 to +40 °C, poses a huge challenge.

Intelligent lubrication systems analyze engine friction and parasitic losses to provide optimal lubrication.

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Intelligent lubrication has the potential to improve performance enormously, but quantifying the best configuration is a lengthy and complex task. Torque sensing is critical to measuring friction effects of a range of different oil supply and formulation strategies.

Research and Development/ Test Lab Applications

With regard to research experiments, there is often an inordinate amount of dismantling and reassembling of test equipment. This can be time-consuming and therefore expensive, but choosing a non-contact torque sensing method is ideal for this kind of application since it does not need to be dismantled. A non-contact coupling between the shaft and the controller eliminates any issues of mechanical compliance. Easily embedded within servo drive systems, the best torque transducers can withstand heat, dirt and mechanical vibration. The potential of servo drive trains, for instance, that are 'intelligently rigid' and so free from torsional losses could result in commercial servo products that deliver improved performance and vastly superior system dynamics with even the most demanding mechanical loads. Ongoing research around the world is focused on developing control algorithms that improve the efficiency of servo controllers that maximize the use of torque feedback.

Conclusion

The application of precision torque sensing presents many opportunities for developing improved efficiencies in performance, production and maintenance in a wide variety of industries. Optimal sensing transducers require minimal shaft length, have low inertia, no physical contact between shaft and housing, while offering wide bandwidth, high resolution, high accuracy and good magnetic/ RF noise immunity. And they pay for themselves rather quickly! EE

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