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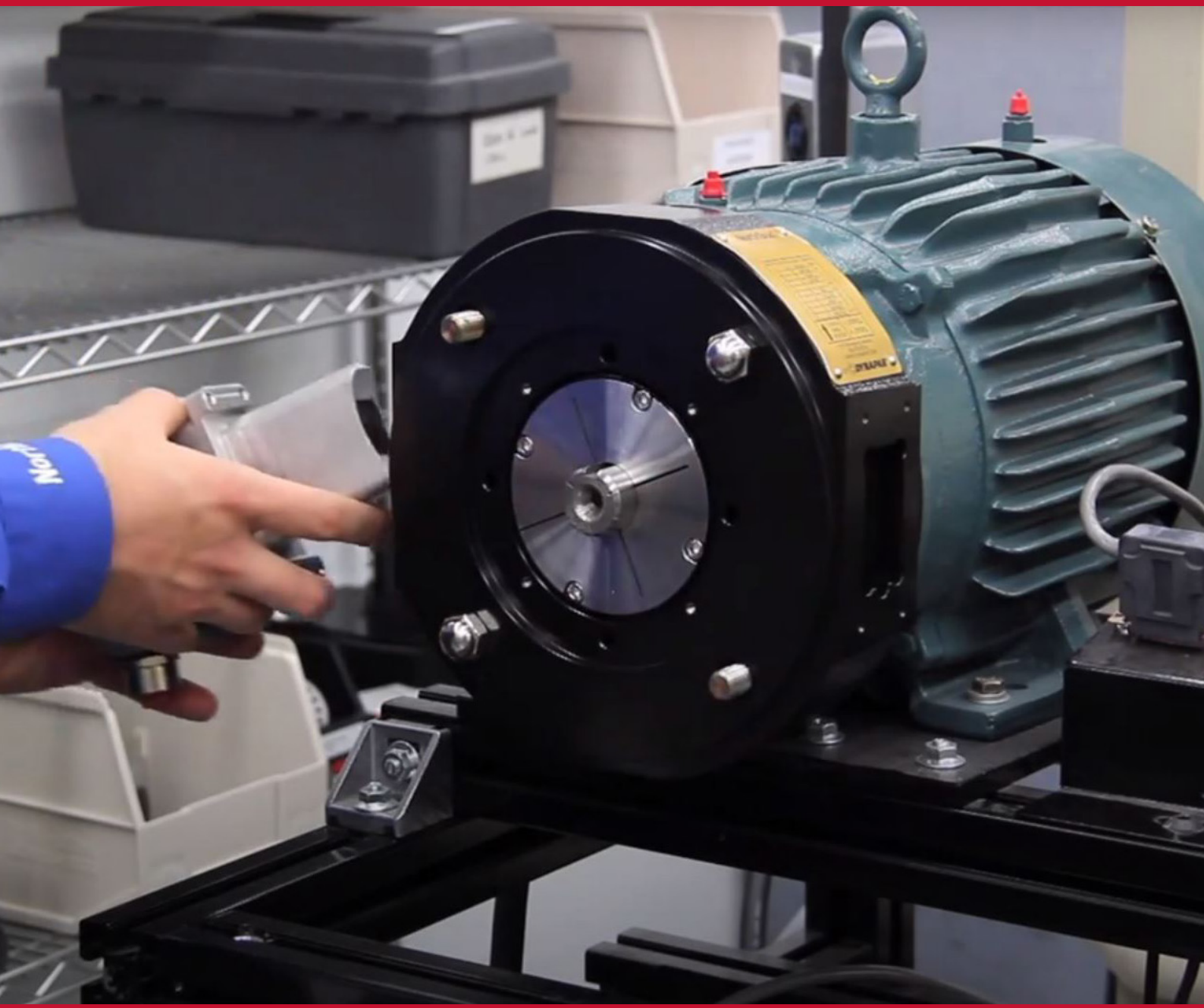
The Benefits
of Closed Loop Motion Feedback

Learn about how today's encoders and resolvers can increase throughput, decrease downtime, enhance safety, and increase performance. Rotary speed and position feedback introduce competitive advantages in a surprising array of applications.



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Rotary speed and position feedback introduce competitive advantages in a surprising array of applications.

When you hear of encoders and resolvers, you probably think of high-performance applications like hundred-axis printing lines and 300-part-per-minute bottlers. You might be surprised to learn that they can also deliver an important competitive edge to OEMs and end-users across a variety of nontraditional markets ranging from dockside loading to oil drilling to construction. Today's encoders and resolvers can increase throughput, decrease downtime, enhance safety, and boost performance while providing significant savings over the lifetime of a machine or device. Let's take a closer look at some surprising applications for the technology and recent advances that make closed-loop feedback an essential solution for your thorniest problem.

The basics of feedback

Closed-loop feedback devices can be broadly divided into resolvers and encoders. A resolver is a trigonometric function generator, which means that it simultaneously generates a sine and cosine wave to determine position or speed. It's a robust, simple, analog device that provides essentially infinite resolution. Because it does not require onboard electronics, a resolver can survive extreme heat, radiation, contamination, and shock and vibration. Some application areas include aerospace & defense, steel manufacturing, and glass fabrication.

Encoders generate digital data as the load turns or translates. They're typically based on optical or magnetic sensor engines, although capacitive designs also exist. In an optical encoder, a code disk modulates an optical beam to generate a pulse train; electronics elsewhere in the system convert that information to position or velocity. Magnetic encoders are analogous, except that instead of a modulated optical beam, they use a perturbed field. Optical encoders deliver ultrahigh performance but can be fragile, whereas magnetic encoders are quite robust and deliver plenty of resolution for many applications.

Magnetic encoders can operate effectively even when covered in dust and oil.

Within these two broad divisions, a variety of options exist. Incremental encoders offer a simple and economical solution but they require homing at startup or after a fault, which can be time-consuming or even hazardous in some applications. Absolute encoders maintain constant record of their location, but they can be more expensive. In the case of both optical and magnetic encoders, state-of-the-art array-based designs deliver top performance in robust components suitable for high-reliability operation in the harshest of conditions. If you think encoders are too fragile for your toughest application, think again.

What to know before you call

1. What are the specifics of your operating environment (e.g. temperature, shock and vibration, contamination, radiation, etc.)?
2. What are you trying to measure (e.g., speed or position)
3. What are the special constraints of the application (e.g., space, resolution, etc.)?
4. What are your biggest pain points?

Why closed loop?

There was a time design teams chose the simplest, cheapest solution that got the job done. Cooling fans for large HVAC applications, for example, traditionally used fixed-speed AC brushless motors, which were robust and economical. A few years back, however, a funny thing started happening: OEMs and end-users began to explore the use of variable-speed motors and discovered that over the lifetime of a system, the more sophisticated technology actually saved money and optimized operations. By taking the long view and considering alternative solutions, those early innovators gained a competitive advantage in their market. If your rationale for running open loop is that your company has always done it that way, you, too, could be in a position to expand your market share by switching to closed-loop feedback.

Improved speed control

For many process industries, speed control plays an essential role in the quality of the product. Whether a plant is making paper, tires, rolling sheet steel, or pressing gypsum board, better control of speed not only improves the product but boosts throughput, allowing manufacturers to both differentiate themselves and save money in the long term. Especially given the lifetime of many industrial machines, the decreased cost of operation will dwarf the capital outlay required for the upgrade.

It's important to understand what speed control really means. Better speed control requires accurate and sometimes higher-resolution feedback, but that doesn't necessarily imply high-speed operation. In reality, the slower your motion, the more resolution you typically need. A higher number of data points per revolution allows your controller or drive to minimize effects like cogging that can cause problems. The right encoder/drive feedback can actually extract higher torque at low speeds, allowing smaller motors to be used. Good low-speed operation is especially important for electrically-powered off-highway vehicles like the automated cars used in underground mining. There, tight control enhances starting and stopping performance, reducing wear. High-resolution feedback also improves speed control in elevators to ensure that cars don't jerk when starting and stopping, improving passenger experience.

Reduced downtime

When it comes to manufacturing, time is money. Depending on the industry, an hour of downtime can cost hundreds of thousands of dollars. Closed-loop feedback devices with on-board sensor-health monitoring provide another diagnostic for drives and controllers, allowing them to detect system problems early. Particularly if the machine is networked, the components can send alerts to the HMI or even direct to the desktop of maintenance departments, allowing repairs to be scheduled and reducing the chance of costly stoppages.

A bus approach can also help in on-site applications. Take logging, for example. If a branch catches the wire on a mobile harvester and an intermittent fault develops, you could have a loose connection, a damaged wire, or you could have lost the encoder altogether.

With a standalone device, it's not easy to know, and that's not a problem you want to troubleshoot in the middle of a sub-zero forest. With a bus-level component, the encoder can send regular or periodic health updates. That can provide huge savings in terms of maintenance and uptime, not to mention troubleshooting time.

Damage prevention

In many applications, motion control is as much about where the load should not go as where it should go. For example, a mobile crane or lift vehicle may be designed for deploying one side of the outrigger, a method known as short jacking. In this case, the boom can only move through a certain specific range. If it swings to the other side, the entire vehicle becomes unstable, putting every person and object around it at risk.

Historically, these vehicles have used potentiometers to monitor the swivel or the slew position of the crane. The problem is that potentiometers are contact devices, so they wear. They're inherently susceptible to electronic noise and also susceptible to damage, for example from welding arcs. Harsh-duty absolute encoders provide a more rugged alternative. They're noncontact, so they eliminate wear points while providing EMI-resistant performance. Even more valuable, encoders are available as digital devices that are compatible with the CANbus networks typically used on smart off-highway vehicles. This ties sensors into a single bus, providing built-in real-time diagnostic capability.

Balanced performance

For more than a century, an excavator was only as good as operator running it. Today, highly automated machines use GPS feedback to excavate sites to within inches of the desired level and provide "return-to-dig" functionality that allows the excavator to command the bucket to some designated location at any time. All of that automation comes at a price, however, which is hard to justify with today's tight budgets.

The trend now is to bridge the gap between these automated designs and their more traditional manual versions. The question is how. Sure, a limit switch could provide more functionality compared to an open loop system, but only by a small margin controller whether the bucket is low or high, but little else.

An encoder allows the machine to pinpoint the location of the bucket during its sweep and even monitor its speed. Once again, the excavator can offer return-to-dig functionality but with more precision. The approach can also be used with concrete pumpers building complex, 3-D structures, allowing operators to pour concrete exactly where they want it.

Decreased wear

Detailed feedback provides much more than just control over the excavation process. Abrupt hard stops abuse hydraulic systems, increasing wear and making them more likely to fail. Higher resolution feedback allows the system to slow down gradually, softening the stops to reduce shock and vibration.

The mining industry can also see big savings from the use of closed-loop feedback. Traditionally, the motors pumping slurry operate at a fixed speed and the system controls the flow using a valve. Certainly, it's a tried and true approach that minimizes parts, but that takes the short view. When a valve closes abruptly, or deadheads, the sudden jump in pressure can trigger extreme localized heating that will vaporize any water in the system. The sudden expansion can damage the pump or even cause catastrophic failure. Not only do you have to replace the part, you have to replace pipes and fittings, and worst of all, lose hours of production time. Closed-loop feedback makes it easy to adjust motor speed to minimize that pressure differential. There's less pressure on the pump and less stress on the valve, which makes both components last longer.

Running a motor at high speed shortens time to failure, putting us back into that vicious cycle of replacement parts, maintenance hours, and downtime. Varying motor speed reduces wear, prolonging motor life. It also saves energy, an important issue in today's economy. It's easy to focus on cost of acquisition when you're trying to get a request through purchasing, but for assets that can run a decade or more, cost of operation can have a far bigger impact. That's where closed-loop feedback can make a significant difference.

Not your grandfather's encoder

Not your grandfather's encoder
Now at this point, you might be thinking that these examples cover some of your problems, but deep down, you just don't think an encoder can do the job in your application. After all, aren't they fragile and expensive? As Mark Twain once said, it ain't what you don't know that's the problem, it's what you know for sure that just ain't so. Today's encoders are highly rugged devices that incorporate chip-level integration to deliver better performance with fewer vulnerabilities. Properly equipped, optical array encoders, for example, can tolerate up to 400 Gs of shock. Semiconductor technology allows us to manufacture reliable devices that significantly outperform previous models at the same cost because of the economies of scale involved.

Meanwhile, design improvements give engineers new degrees of freedom. Shaftless encoders, for example, are non-contact components that enable a gap of several millimeters between the sensor and the rotating device without affecting performance. Absolute encoders can be networked together on a communications bus, which enables customer-programmable parameters like scaling and output limits. Their zero position can even be reset from the factory setting, but unlike incremental encoders, the device will retain that setting even when powered off.

As we move out of the recession, the market is going to become more competitive than ever. Whether you're trying to cut operating costs, make your system last longer, improve performance, or all of the above, closed-loop feedback can help. Modern feedback devices deliver ever more functionality in the most robust package possible. As manufacturers, we're taking advantage of every possible design and fabrication advance to fine-tune our offerings. The result is that you can probably buy an encoder or resolver for a price far lower than you think. If you're looking to improve your product or gain a competitive advantage in your market, you owe it to yourself and your company to explore the use of closed-loop feedback

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