Heavy Industry and Smart Technology

Joseph L. Hazelton, Contributing Editor

Heavy industry.

The phrase conjures images of mines and steel mills, of huge caverns underground, of cavern-like factories, of old-line companies operating heavy-duty machines for high-torque work.

That's the image of heavy industry.

Today, though, there's also another image. It's of an operator walking a steel mill's floor, looking at his smartphone or his tablet. He's not on break, though. He's working. He's using his phone to look at real-time data about the mill's machines. He's using the Internet to check that the machines are operating smoothly and to see whether any potential problems have been detected and diagnosed.

With the Internet, he can check without being in a control room or on-site or even in the same state. He can check from anywhere in the world.

Today, in heavy industry, more and more machines can transmit their data in real time to the Internet. This ability comes from smart technology, specifically from sensors that 1) can access complex software to mimic human decision-making and 2) can access the Internet. The smart technology is being added inside the machines to critical components, like power transmission (PT) components (gears, bearings, couplings), to reduce downtime—including unplanned downtime—in order to increase productivity.

Heavy Industry: Continuous Operation

For companies operating in heavy industry, the cost of unplanned downtime is extremely costly. In some cases it can mean the difference between profit and loss for an operation. "To be profitable, they need to minimize their unplanned downtime," says Mike White. "This is why Schaeffler is ac-

VarioSense bearings from Schaeffler make it possible to quickly and easily record and transfer a bearing's operating conditions in order to monitor central machine and process parameters. (Photo courtesy of Schaeffler Group USA, Inc.)

Heavy industries, like the steel industry, are incorporating smart technology into their manufacturing operations. The technology is designed to reduce downtime, including unplanned downtime. The technology uses sensors to obtain data about a machine's operation and analyzes that data using sophisticated software. (Photo courtesy of Bauer Gear Motor GmbH)

tively developing intelligent bearing products. Bearing reliability is often critical to the performance of their operation. By integrating an intelligent sensor to measure temperature, vibration or force, directly into the bearing, valuable data can be obtained — data which can be utilized for early detection of a bearing problem, allowing the customer to proactively schedule and plan for the maintenance." says White.

White is director, regional business unit manager for raw materials with Schaeffler Group USA Inc., Fort Mill, SC. The Schaeffler Group is a global automotive and industrial supplier that develops and manufactures high-precision components and systems for engine, transmission and chassis applications as well as rolling and plain bearing solutions for a wide range of industrial sectors.

Running a factory 24/7/365, though, makes it difficult to maintain machinery. Even regular, preventive maintenance means stopping machines so they can be inspected and possible problems can be addressed. A stoppage may be brief, the time needed to take a machine off the production line and put another machine on the line. Or the stoppage may be comprehensive, bringing the whole line to a halt because there is no other machine.

With smart technology, downtime for maintenance work can be reduced by shifting at least some maintenance from a schedule to as-needed. Also, the case for maintenance work — for a stoppage — can be easier to make.

"You have the data to prove that 'Yes, this is the proper time… to make some inspection,'" says Artur Rdzanek, a global product manager for ABB Ltd., Zurich, Switzerland. Rdzanek's focus is sensors for ABB's Dodge mechanical PT components. ABB's Dodge division makes couplings, enclosed gearing, and bearings and serves many customers in the metals industry, the mining industry, and the oil and gas industry.

Unplanned Downtime: The Real Enemy

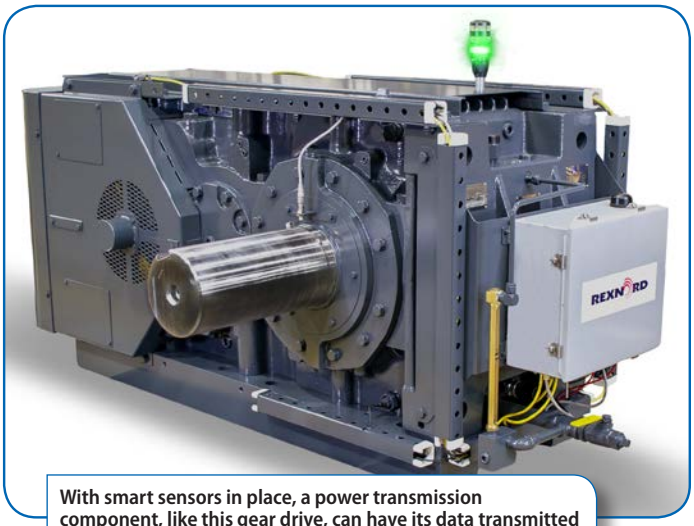
The money effect of unplanned downtime can be stark in heavy industry.

An example is provided by Jason Weber, director, digital solutions for Rexnord Corp., Milwaukee, WI. Rexnord makes bearings, couplings, and gears and also serves the mining industry.

Weber's example is a customer, a Canadian mining company: If it has an unplanned stoppage, with each hour, it loses about $100,000 Canadian.

And unplanned downtime usually doesn't lend itself to a quick fix, like with the mining company. "If they lose a gear drive on one of their main lines at the beginning of a shift, they could be down six, seven hours," Weber says. "The real enemy is unplanned downtime."

Unplanned downtime, however, can be combatted with Industry 4.0. That's a movement to turn factories into smart factories by equipping industrial machines with sensors so their data can be monitored and analyzed by smart software. The sensors and smart software turn PT components into smart PT components with access to smart services.



With smart sensors in place, a power transmission component, like this gear drive, can have its data transmitted to smart services for analysis. The results can then be viewed via a web portal. (Photo courtesy of Rexnord Corp.)

According to Weber, by using smart PT components and services, the Canadian mining company learned about a few pending problems, allowing it to fix them before they led to unplanned downtime. "We have warned them early of pending issues," Weber says.

Also, he estimates that by learning about the problems in advance, the mining company avoided losing some $500,000 Canadian in unplanned downtime.

Smart technology starts with a sensor that can measure operational aspects of a power transmission component. In its white casing, this sensor can collect data on the mounted bearings so the data can be analyzed by smart software. (Photo courtesy of ABB Motors and Mechanical Inc.)

Smart Software

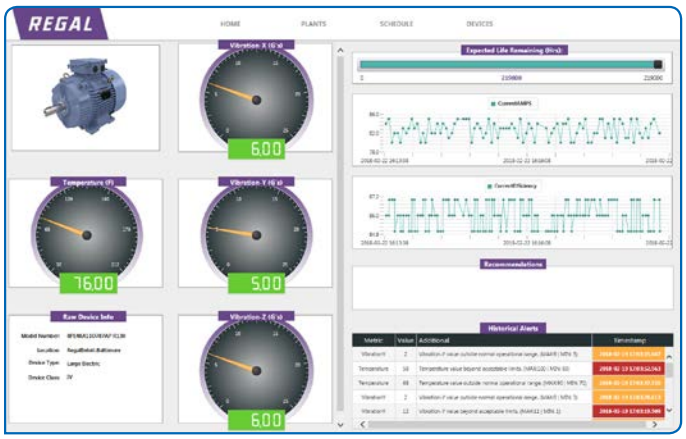
The key to reducing unplanned downtime comes through the PT component's sensor, which has access to smart, predictive software.

The software is predictive because it can take a machine's data — like torque, vibration, temperature, lubrication — can analyze the data, can detect potential problems, and can predict future circumstances, like the remaining useful life of a component. The software can make such predictions by using algorithms.

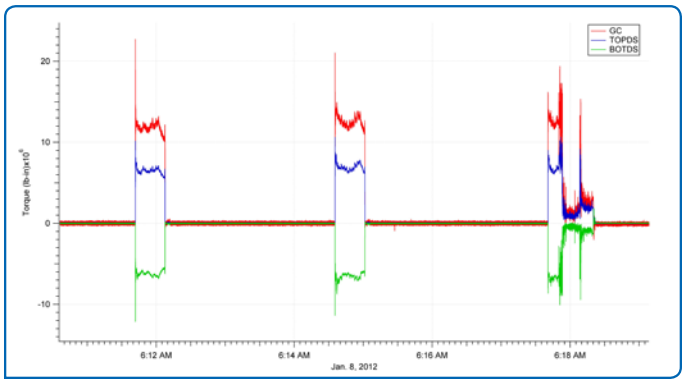
An algorithm is a step-by-step procedure for solving a problem. The procedure uses measured data, like torque and temperature, and is a logical process, so it can be written as software and executed by a computer. Moreover, algorithms can be so sophisticated that they can make decisions like a person would.

Now, an algorithm may be in software that's in a sensor itself, that's in an edge device near the sensor, or that's stored on a server. In all cases, the sensor records data so it can be analyzed by an algorithm.

After analysis, if an algorithm detects a possible problem, it can tell the factory's people about the problem — "Hey, come take a look at this" — so they can fix the problem before it degrades the machine's operation. Moreover, the algorithm can be designed to tell them in an easy-to-understand report that includes actionable information.



Smart monitoring and diagnostic services can collect, analyze, and display various data on a machine's operation, like temperature, vibration, and energy usage; on a component's remaining useful life; and on suggested actions for maintaining the machine's operation. (Photo courtesy of Regal Power Transmission Solutions)



Besides detecting potential problems, smart services can provide real-time data about right-now problems. In this torque graph, the real-time problem is torsional vibration on the drivetrain in a steel rolling mill. After two normal readings, the third reading shows vibration from a failed work roll. (Photo courtesy of Regal Power Transmission Solutions)

An algorithm can also be designed to decide in some cases what should be done to solve the problem, just to get the ball rolling. For example, the algorithm may decide that a component should be replaced, so it will order a new one.

Such smart services and PT components are offered by several companies (see sidebar *Becoming Smart: Products and Services* on page 41).

Now, the ability of a smart PT component to diagnose itself can reduce maintenance costs.

Think of a manufacturing machine as though it were a car. To maintain your car, you have the oil changed regularly, in accord with the automaker's specs: every 3,000 miles or 3 months, for example. Now, imagine your car can tell you when it actually needs to have its oil changed, when the oil is starting to degrade but hasn't yet affected the engine's operation. In that case, you may not need to change the oil for 4,000 miles or 5,000. You can wait until the car tells you to change the oil.

"You can save money just on that," Weber says.

In that case, you were also able to shift your car from one type of maintenance, preventive, to another type, maintenance done only when there's an actual need.

Likewise, a manufacturer using smart technology may be able to shift at least some maintenance from preventive to as-needed. And that shift can lead to another benefit.

Reduced Carrying Costs

Using smart technology, a manufacturer may be able to reduce carrying costs because it can keep a smaller inventory of spare components on-site.

Keeping a smaller inventory may include even customized PT components. No matter the industry, a manufacturer may have to carry custom-made components in stock, laying on shelves in a factory. However, smart technology, may be able to notify a manufacturer of a problem far enough ahead of time that even a customized component can be made and delivered in time for installation before machine failure.

If smart technology is used throughout production, a manufacturer may also be able to manage its consumption of electricity, reducing its energy costs (see sidebar *Reduced Energy Costs* on page 39).

A System of Machines

Of course, machine failure is bad. However, it can be really bad when the machine isn't a stand-alone. The machine may be part of a larger system of machines connected to each other, like by conveyors and robots. In a system, failure in one machine can bring the entire system to a dead stop.

Smart services, however, can be used on a single machine or on a larger system of machines, if the machines are networked by communication technology.

How Smart Services Work

Sensors collect data about their PT components and about the larger machine. The data is analyzed by means of smart services. The services include monitoring and diagnosis and

Smart technology can be used on a single machine or on a larger system of machines, including the equipment that connects those machines, like conveyors and robots. In its gray casing, a sensor monitors the operation of a motor for a conveyor belt. (Photo courtesy of Schaeffler Group USA Inc.)

are offered by the companies that make the smart PT components

The services are offered by the companies that make the smart PT components and include services for monitoring the operation of a machine or system of machines and for detecting and diagnosing problems. While some smart software may be in a component's smart sensor, much is stored on a server, and the server may be an internet one or a private, non-internet one.

After the data is analyzed, the digital services automatically give the end user a report about the PT components or the machine, including specific recommendations for action.

Now, a server is needed because the amount of data to be analyzed and the amount of computing power required can be quite large. In those cases, the data analysis is Big Data Analysis.

And a convenient place for that analysis is the cloud. It already exists—it doesn't need to be set up—and it has abundant computing power for aggregating and analyzing large amounts of data.

"One of the main reasons people use the cloud is for aggregation of data," Eric Huston says.

Huston is vice president, Industry 4.0 applications for Schaeffler Group USA.

He indicates how much data may be aggregated with a hypothetical steel mill with 1,000 machines, each with at least two smart sensors. The total: 2,000 sensors sending information.

Data Security

Naturally, data sent to the Internet for analysis should always be secured. It can be encrypted before transmission. Once on the Internet, it can be secured with measures meant to prevent unauthorized people from accessing it, to restrict authorized people to only data relevant to them, and to store data on only authorized devices.

Also, if the smart services are on the Internet, an end user may be able to solve a problem faster through online help from support people with the company that provided the smart components and services. Those people would be able to remotely access the Internet-based services too in order to help with the problem.

Security measures and remote support notwithstanding, data can be analyzed and problems detected and diagnosed with non-internet servers too, like local ones physically separated from access to the Internet.

"In this world of smart, not everything requires cloud," Huston says. "Some customers, particularly those concerned with data security, are actually requesting non-cloud through edge-processing directly within the smart device."

Retrofitting

Now, a factory can be turned into a smart factory through new industrial machines that were equipped with smart PT components during design and construction, long before the machines were installed in factories. However, a manufacturer may not want to replace installed machines with new ones in order to benefit from smart technology.

For those manufacturers, retrofitting may be an option.

In Huston's experience, the option is available to many companies. "The market—in my mind—is about 50/50," he says, describing the split between 1) machines outfitted with smart PT components during construction and 2) machines retrofitted with them after installation.

Reduced Energy Costs

Another possible benefit of smart PT components and services: reduced energy costs.

This benefit is explained by Karl-Peter Simon, managing director and president, Bauer Gearmotor GmbH, Esslingen, Germany. Bauer manufactures geared motors and serves the metals industry and the material-handling industry.

If a smart sensor can monitor and record aspects of power consumption, that data could then be processed centrally to forecast energy demand.

A manufacturer could then manage its consumption to keep its energy costs down. To do that, the manufacturer has to avoid a peak load. That can be done by turning off some equipment when a peak load is expected. For example, a manufacturer may be able to turn off some fans for a short time.

The reason for avoiding a peak load is straightforward. If a manufacturer gets its electricity via an energy contract, the electricity is supplied at a quoted price based on a specific, expected amount of consumption. If the manufacturer exceeds the expected amount, then the extra energy is charge at a different, higher price.

To manage consumption, though, the manufacturer would need data from across its production operation. Collecting the data is one thing. But, analyzing it to discern patterns of energy usage? That's no small task.

"That's also Big Data Mining." Simon says. **PTE**

"The here and now is adding sensors to existing equipment," he says. "The future is embedded."

The Right Voltage

To bring in smart technology, companies in heavy industry may have to overcome a problem: supplying the PT component's smart sensors with the right type of power, according to Rexnord's Weber.

While heavy industry uses power aplenty, it may not be at the right voltage. As an example, Weber uses a mine where machines were connected to the internet via edge devices. "You might have 480 volts down there to run the motors," he says, "but you don't have 220 or 110 down there to power the edge."

Internet Connectivity

Weber's mine indicates another problem: ability to connect to the Internet.

Internet connectivity may not seem like a problem. Smartphones and tablets work all the time. Internet connectivity is everywhere, but is it on the floor of a steel mill or underground in a mine?

If it isn't, new lines may need to be laid down so connectivity can be gotten to machines to take advantage of smart PT components.

Alternatively, the smart components can communicate with the Internet indirectly. For example, ABB's sensors use wi-fi to communicate with an app on a maintenance employee's cell phone. The employee makes his rounds, gathering data as he goes. Then, when the cell phone has a reliable Internet connection, the data is automatically uploaded, Rdzanek says.

In Weber's experience, though, the problem of connecting to the Internet is disappearing: "Over time, that's becoming less of an issue." And the reason? Advantages through connectivity are a coming thing. "There's more things like what we're doing that need connectivity," he says.

Changing Culture

In Daniel Phillips' experience, the biggest problem is culture, like he encountered with a mill.

Phillips is technical director, services and Perceptive Technologies with Regal Power Transmission Solutions, which is part of Regal Beloit America Inc., Beloit, WI. Regal makes bearings, couplings, and gears and serves the metals industry and the minerals and mining industry.

Culture can be a major challenge because a company may be reluctant to change the way it does things, especially if it has done them that way for decades.

If change comes from the top down, culture may be overcome quickly. If from the top down, the change may be comprehensive, with smart PT components installed throughout a manufacturing site. If from the bottom up, the change may be small at first, a pilot program, to show the benefits of smart technology. A small, initial installation was the case for the mill that Phillips encountered. "Then, they can understand the value of the data, how to interact with it," he says. After a pilot program, a company may be more willing to implement larger installations, with evidence slowly overcoming culture.

A Path to More Productivity

The path of smart technology may seem long: PT components equipped with sensors that can access software, that includes algorithms, which can mimic human decision-making to detect and diagnose problems.

And the path may lead to places that seem strange at first: the operator walking the steel mill's floor, looking at his smartphone, who appears to be on break but is working, reviewing real-time data about the mill's machines.

However, smart technology's path is only part of a much longer trail toward ever greater productivity in industry. As Huston says: "It's just the continued tightening of everything that allows you to be more efficient, more economical, more sustainable, and generate better results." **PTE**

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Becoming Smart: Products and Services

To take part in Industry 4.0, a manufacturer must survey the field of companies that offer smart technology in order to find the companies that offer the smart products and services best suited for the manufacturer's needs. Some companies in that field appear below.

One source of smart technology is ABB Motors and Mechanical Inc., Fort Smith, AR. Previously Baldor Electric Co., ABB Motors and Mechanical is a business unit of ABB Ltd.

ABB's smart technology, a sensor and analysis software, is for mounted bearings, like ABB's Dodge mounted bearings. Named Smart Sensor, the sensor measures temperature and vibration. The data can be displayed on a smartphone or tablet and can be analyzed for trends on ABB's digital platform, ABB Ability.

Also available for Industry 4.0 is TorqueControl4.0, developed by Bauer Gearmotor GmbH, Esslingen, Germany. TorqueControl4.0 monitors a gearmotor's torque, voltage, and active power and can transmit data to an Industry 4.0 network.

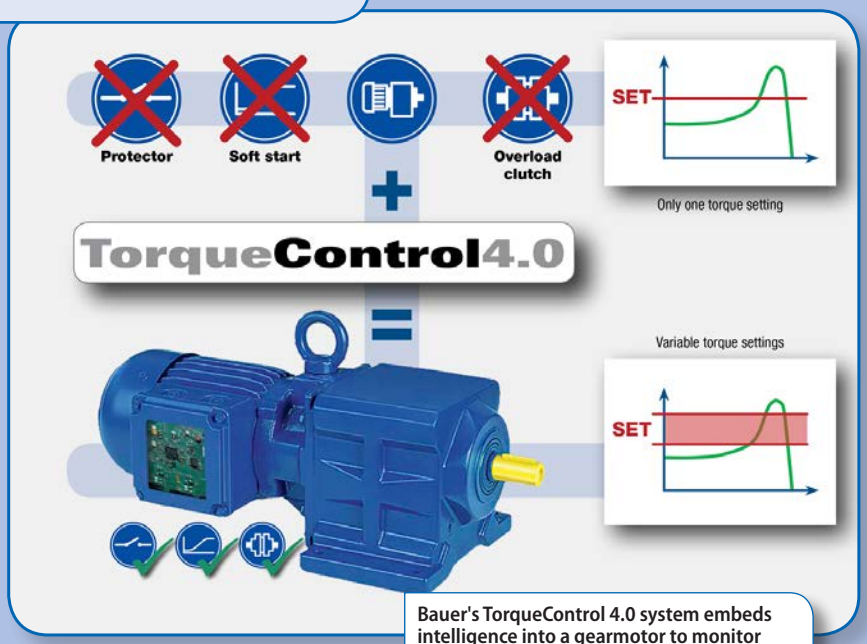
For Regal Power Transmission Solutions, its smart monitoring and diagnostic services are offered under the brand name Perceptive Technologies, through the company's lifecycle-services division.

Rexnord offers its smart technology for use on Falk brand A-, Y-, and V-class unit drives. Sensors measure aspects of a gear drive, like temperature, vibration, oil quality, output shaft speed, and then transmit the data to Rexnord's Smart Condition Monitoring System powered by DiRXN. Its software analyzes the data, and results can be viewed on a web portal, Rexnord Connect.

Meanwhile, Schaeffler's monitoring and diagnostic services are aspects of its Smart EcoSystem, which also interacts with the cloud, using data collected from products like SmartCheck for retrofit applications and embedded VarioSense sensor bearings. **PTE**

ABB's Smart Sensor for Mounted Bearings is designed to put in remote locations. The battery-powered sensor uses wi-fi to communicate and doesn't require any additional wiring. (Photo courtesy of ABB Motors and Mechanical Inc.)

Schaeffler's Smart EcoSystem provides the IT infrastructure for the integration of smart components, visualization and analysis tools, and digital services. (Photo courtesy of Schaeffler Group USA Inc.)



Bauer's TorqueControl 4.0 system embeds intelligence into a gearmotor to monitor torque, voltage and active power. (Photo courtesy of Bauer Gear Motor GmbH)