The advantages of **pervasive sensing**

There was a time when sensors were used only sparingly. They were expensive to buy, install and maintain, and companies used them only where they were absolutely necessary. But the old saying that knowledge is power is still true, and the more you know about your plant the better you can maintain it. The fewer "unfortunate events" there will be, and the lower your costs will be. This article by Deanna Johnson of Emerson Process Management will discuss the idea of pervasive sensing, explain what it is and how it helps, and give examples of how it is being used now.

Pervasive sensing is simply the use of sensors to capture data on anything in a plant that could affect its operation. It is driven to a large extent by the increasing availability of inexpensive sensors – many of them wireless. While it is now gaining acceptance in industry, pervasive sensing is found in other areas as well, some of them in our daily lives.

Pervasive sensing in daily life

Today's cars have 15 times as many sensors as those of 15 years ago, and more are coming. Throttle and crankshaft position sensors, along with oxygen sensors, ethanol fuel sensors, injection pressure sensors, engine knock sensors and mass airflow sensors are essential inputs to the engine control computer; they are supplemented by other on-board sensors that aid in maintaining reliability, such as monitoring the levels of engine oil and coolant. They even watch the pressure in each tire, and trigger an alert if pressure drops too low.

On the safety side there are level sensors that monitor brake fluid and washer fluid, accelerometers that trigger air bags and wheel-mounted speed sensors that activate antilock brakes. Other sensors verify that seat belts are fastened, detect objects behind the vehicle or in the blind spots and alert the driver when a door is ajar. On some cars, sensors trigger alerts when the driver becomes drowsy or begins to drift out of the traffic lane.

Benefits of pervasive sensing in industry

In manufacturing, pervasive sensing provides measurable and significant improvements in process and worker safety, regulatory compliance, equipment reliability and energy efficiency. It makes it possible to detect and respond to hazards early, protect people and equipment, predict failures and reduce slowdowns and shutdowns. It helps to avoid environmental issues and fines, and to spot potential security threats early.

Pervasive sensing makes it possible to achieve business-critical results with incremental investments that acquire new insights without adding complexity. It provides better insight into operations and makes it possible to optimise processes and thus increase productivity and profitability.

Where it all began

One could make a good case that what made pervasive sensing possible was wireless mesh technology. A network of small (generally battery-operated) devices

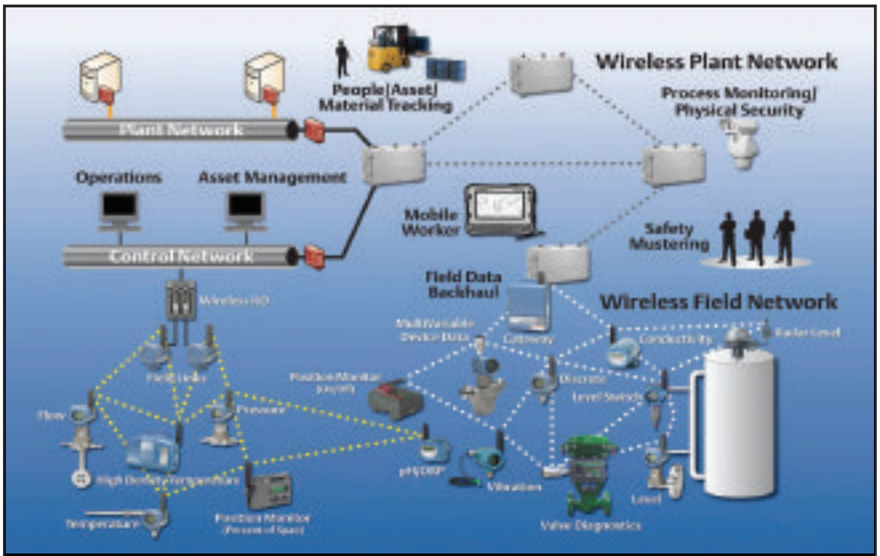

Figure 1 - In a wireless mesh network small (generally battery-operated) devices communicate with each other and with a central station. They organise themselves into a self-healing network that can pass messages over considerable distances, route signals around obstacles, and continue to communicate even if several devices go off line

communicate with each other and with a central station (Fig. 1); while each device in the network might have a radio range of only a few meters, the devices organise themselves into a self-healing network that can pass messages over considerable distances, route signals around obstacles, and continue to communicate even if several devices go off line. With wireless there is no need to design much of anything, and no need to pull cables, as the devices are battery-powered, and can be added, subtracted and moved from place to place with essentially zero impact on the system.

The first widespread sensing application of these mesh networks was in vibration monitoring: radio-equipped sensors were mounted to pumps and other rotating equipment to report (generally at intervals ranging from a few minutes to a few hours) on the health of the equipment. Asset-management software kept track of the readings and predicted when something was getting ready to fail. The result was a considerable reduction in unplanned downtime.

Since that time wireless sensors have proliferated immensely. There are predictions that over the next ten years sales of equipment in this area will more than double the $16 billion traditional measurement market. One Eastern European oil processing plant is deploying a full wireless infrastructure to allow the addition of 12 000 pervasive sensing instruments – or 60% beyond the base of traditional process measurements – in order to better detect energy losses, equipment corrosion and safety releases.

Figure 2 - Today's wireless corrosion monitoring transmitters allow for continuous, on-line monitoring at previously inaccessible locations and at an affordable cost

So pervasive sensing comes down to the use of multiple sensors everywhere, often (but not always) wireless. There are sensors being installed to monitor temperature, pressure, valve position, steam trap opening, liquid hydrocarbon spills, safety showers, pressure relief valve opening and corrosion and erosion. Wireless sensors are used in gas leak detection – both wide area and point – and for flame and smoke detection.

Pervasive sensing in process-critical applications

In manufacturing, pervasive sensing helps in both process-critical and business-critical applications. Process-critical means process control and process safety. Process-critical data requires immediate response to prevent off-spec product or even a plant shutdown. It requires maximum focus; fortunately, much of the equipment and operations involved are already automated, as the new sensors generally connect to an existing process control system. One possible drawback, however, is the possibility of information overload; most of the information gathered by pervasive sensors does not act to close process loops, but to keep plant operators informed, and if designers do not apply human-centred design principles there can be so many alerts and alarms that operators cannot keep up with them.

Pervasive sensing in business-critical applications

Business critical means site safety, reliability and energy efficiency. Business-critical data requires a timely response, rather than the immediate response needed by process-critical data. Failure to act on it can lead to things like a plant slowdown or increased energy usage. Because it is generally of lower priority, business-critical data may receive limited attention. The data gathered was previously obtained by making manual rounds, and in some cases was never gathered: hard information simply did not exist, and was replaced by assumptions, estimates or simple guesswork. Pervasive sensing corrects this.

An example: According to the *Saudi Aramco Journal of Technology*[1], 36% of a typical refinery's maintenance budget is spent on corrosion remediation and repairs. And until recently just keeping track of corrosion was a labour-intensive undertaking, with technicians making manual inspections using handheld analysers and detection coupons. But today's wireless corrosion monitoring transmitters (Fig. 2) allow for continuous, on-line monitoring at previously inaccessible locations and at an affordable cost.

Figure 3 - Gas escaping under pressure produces an ultrasonic whistle in the range from 20 to 100 kHz that can be detected instantly at distances in excess of 10 metres, regardless of wind or weather

Examples of advanced sensing

There are many examples of companies that are putting advanced pervasive sensing in place. One next-generation process plant is currently deploying wireless infrastructure to grow measurements by 60% for critical applications. It uses 20 000 wired I/O points, including 12 000 business-critical applications: 2 000 for site safety, 8 000 for reliability and 2 000 for energy efficiency.

An example of advanced sensing for process-critical applications

A gas storage facility in the southern United States injects natural gas into a salt cavern to take advantage of changing gas prices. In order to do that, they need to monitor the status of the injection wells, but there are dozens of these, spread out over several square miles. In the past monitoring meant sending someone to look at each well, but because the wells are spread out over such a wide area, it was impossible to check each one every day. If there were a leak, they might not know about it for two or three days. The company installed close to 500 wireless monitoring devices that gave them the ability to monitor each well in real time. This increased the ability to efficiently utilise the storage capacity and reduced monitoring costs. It took just 100 man hours to commission all the sensors, which is less time than it used to take to go around and monitor them. This saved the company close to a million dollars on installation costs alone, and helps them operate their field more effectively.

Advanced sensing for business-critical applications

Site safety can be considered a business-critical application because while process safety is really about containment, site safety is typically about worker safety or gas detection. One example is monitoring of safety showers; many of the safety showers in today's plants are not monitored. Another example would be safety and environmental compliance, like leak detection. It is dangerous to have people around the sites/areas where there are gas leaks, and leaks are often associated with compliance issues associated in North America with the agencies like the EPA.

Business-critical application example: site safety and compliance

A Canadian facility for underground storage of hydrocarbon gases had used shelters (essentially simple shacks) to cover wellheads, but these had created difficulties with maintenance activities, and most were scheduled for removal. This created a problem: the legacy single-point catalytic bead detectors that monitored each wellhead for dangerous gas leaks worked well enough when enclosed, but in the open air the wind dilutes any escaping gas and tends to blow it away from the sensors. The sensors must also be protected from the weather (they don't work when buried in snow), some types can become saturated and require replacement when exposed to high concentrations of gas, and they must be recalibrated at regular intervals.

Figure 4 - Acoustic monitors mounted next to steam traps took less than ten minutes per trap, and the system paid for itself in energy savings within a year

The company decided to try ultrasonic leak detection, as shown in Fig. 3. Gas escaping under pressure produces an ultrasonic whistle in the range from 20 to 100 kHz that can be detected instantly at distances in excess of 10 metres, regardless of wind or weather. The detectors work even when everything is covered with snow, and once set up do not require periodic recalibration.

The company measured the background noise at 55 dB, and set the detectors to trigger at 70 dB. Several test scenarios were run and the units responded to even the slightest leak, with no false alarms. Periodic testing consists of venting some high-pressure air or nitrogen in the area, and the detectors have functioned flawlessly.

It is worth noting that ultrasonic leak detectors are not low-power devices, and must be supplied with power from outside.

Business-critical application example: pump health monitoring with wireless vibration sensing

The operators of a refinery in the upper American Midwest wanted to prevent the formation of clouds of flammable vapour escaping from failing seals on essential pumps in LPG service (which had caused fires in the past). In addition, spotting a failing pump early reduces damage and repair costs. A process hazard analysis identified close to one hundred high-risk pumps, and further assessment and analysis increased that total. The company installed wireless vibration monitoring transmitters on the pumps, set to report every 30 minutes to an asset management system. Excessive vibration triggers an alert to the operators to switch to a spare pump and sends email notices to technicians to further evaluate with portable analysers.

This eliminated the manual rounds previously used at one tenth the cost, and completely eliminated the fires and resultant shutdowns.

Business-critical application example: Energy efficiency

A steam trap has three possible states:

1. Operating correctly, opening and closing as it should;
2. Failed closed, which keeps water in the steam system and can create a water hammer and damage equipment;
3. Failed open, blowing steam into the atmosphere or a condensate recovery line, which is a waste of energy.

Operators of a plant in the food and beverage industry had concerns about steam traps. A survey found that 25 per cent of the steam traps in the plant had failed. The company installed nearly 200 wireless acoustic transmitters at steam traps (Fig. 4) – which took less than ten minutes per trap – all providing instant alerts of failed traps, plus several dozen more at pressure safety valves. The system paid for itself in energy savings within a year.

Summary

In the past, pervasive sensing for business-critical applications was impeded by the cost and difficulty of deployment, the complexity of the technology, and the difficulty of accessing and using the resulting data. The cost was high and the information benefit was low. Improvements in instrumentation and analytic software have changed that equation. Pervasive sensing can have profound effects on reliability, safety, efficiency and environmental compliance, and it makes possible analytics-driven predictive maintenance. There is every reason to believe that pervasive sensing will continue to spread through industries of all kinds, where it will have positive impacts on productivity, environmental compliance and profitability.

(1): Robin Tems and Ahmed M. Al Zharani, "Cost of Corrosion in Production and Refining," *Saudi Aramco Journal of Technology,* Summer, 2006, p 2. ■

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