Head: Get the Data, Use the Data

Deck: Smart instruments can deliver unprecedented amounts of information, but using the data to improve plant performance can be challenging

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To paraphrase an old axiom, accurate measurement is a prerequisite for control. For industrial automation applications, this means that sensors and instruments must first measure data consistently, reliable and accurately. Once these measurements are made, then actions can be taken in the form of improved real-time control and proactive maintenance.

End users are increasingly moving away from traditional solutions that rely on pneumatic, mechanical or analog technologies as they design new plants or upgrade existing facilities. These traditional technologies are being rapidly replaced with newer solutions that rely on innovative measurement techniques and digital technologies. The end result is more and better data—and if used properly these data can increase quality, reliability and safety.

The product mix demanded by end users tells the tale as purchases of more modern instrumentation have shifted dramatically over the past two decades. For example, flow meter purchases have seen a dramatic trend of increasing Coriolis meter sales and decreasing mechanical flow meter purchases as end users recognize the value of increased accuracy and reliability from meters with fewer moving parts.

Another example can be found in the pressure transmitter market space. Pressure transmitters have evolved from a simple one-measurement analog device to a digital product capable of measuring multiple variables simultaneously while providing real-time process diagnostics such as impulse line blockage monitoring.

What were once considered new technologies—products and features such as Coriolis meters, pressure transmitters with digital sensors, and smart instruments with digital signal processing, advanced diagnostics and digital communication protocols—have now gone mainstream. With hundreds of thousands of these modern smart field instruments installed and running, it’s obvious that end user applications and expectations have been permanently altered.

This article will look at some specific examples of how modern instruments can be used to make even the toughest measurements, and how the data from these instruments can be used to improve automation system performance while cutting maintenance costs.

GOOD DATA CAN BE HARD TO FIND

Sensors and instruments have been used for decades to measure various process parameters, chief among them pressure, flow, level and temperature—but there remain many difficult applications that challenge even modern technologies.

In some of these applications, end users must resort to off-line lab analysis. This type of analysis requires a sample to be drawn, taken to a lab, and processed with a lab instrument. Lab analysis is expensive, prone to variability and slow to deliver results.

In other tough applications, data is measured on-line and in situ, but compromises are made with respect to accuracy, repeatability, and frequency of required maintenance.

But in at least some of these difficult applications, modern instruments and technologies are now available that make on-line, accurate and reliable measurement a practical reality. Two specific examples are detailed in the sidebars.

In the first sidebar, Accurate Flow Measurement in Chemical Injection Applications, a dual frequency excitation magmeter is used to make accurate flow measurements just downstream of an injection point in a process line. Older magmeter and other flow measurement technologies generated spurious spikes in response to disturbances generated by the injection, but applying newer technologies allows for more accurate measurement.

In the second sidebar, Multivariable Transmitters Lift Gas and Lower Costs, a multi-variable gage and differential pressure transmitter is used to replace two pressure transmitters in an oil drilling application. This application also shows the value of digital sensing elements as compared to conventional sensing methods.

USING THE DATA

As detailed above and in the sidebars, modern instruments and measurement technologies can often be used to solve particularly vexing measurement problems. But getting accurate data is only half the issue, with the other half being how to use the data once it’s acquired.

When a multivariable smart instrument is connected to a modern automation system via a digital fieldbus-type network, the amount of data delivered can be daunting. In addition to the process variables, other key information can include instrument status, tag number, written description of function, time stamps, serial number and traceable validation number.

In all, more than 100 parameters might be available from a single multivariable transmitter. Multiply 100 plus parameters by hundreds or even thousands of instruments in a process plant, and the sheer amount of data can be overwhelming. Adding to data overload, many of these parameters aren’t static and can change frequently, either during normal operations in the case of process variables, or in abnormal situations in the case of status information.

There are many different ways to handle this potential data overload. A typical method that might be employed in a process plant is outlined below, with common uses for these data listed in Table 1.

First, each instrument is connected to the automation system via a digital fieldbus. The automation system uses the process variable to perform real-time control, and the system’s HMI displays the process variable to the operators.

Because so much potential alarm and trouble data is available, most large process plants need some type of an alarm management system, generally a PC-based software solution. These alarm management systems can be configured to automatically display key alarm information such as the top ten alarms in terms of total quantity and average per hour.

Information from a correctly configured alarm management system can be used by plant engineers and operators to eliminate nuisance alarms, and to prioritize alarms in order to facilitate quick operator response. Alarm grouping can also be performed, showing alarms from a common item of equipment on one screen to aid in troubleshooting.

Real-time control, operator interface and alarm management are the three main uses of data supplied by field instruments and sensors—but modern process plants also have other systems that make use of these data.

Before the advent of smart instruments and digital fieldbus networks, calibration management systems were heavily paper-based. Typically, calibration management consisted of taking paper and pen to the instrument along with the required calibration equipment. Instrument calibrations were made, and the results were written down and filed away.

Today, modern instrumentation and automation systems offer automated on-line calibration checks assessed against traceable calibration standards to confirm the quality of the measured variable. Many smart instruments have internal self-test diagnostics that indicate if verification of calibration needs to be performed.

PC-based computerized maintenance management systems (CMMS) often encompass calibration management systems, as well as generating and tracking repair work orders. Using digital data from instruments, a CMMS can be used to manage the entire life cycle of an instrument from purchase to disposal. Because digital data is used, manual data entry errors are minimized, and labor hours are greatly reduced.

Asset management functions are sometimes part of a CMMS, but can also be provided by separate systems, again PC-based. Asset management systems often include sophisticated algorithms that can predict problems before they occur, allowing maintenance to be performed on a proactive instead of a reactive basis.

Rationalizing maintenance can save millions, as studies have found that up to 40% of the indirect manufacturing costs are devoted to maintenance. Without asset management, about 50% of maintenance is typically reactive, which costs 10 times more than predictive maintenance.

Yet another use for instrument data is within Enterprise Resource Planning (ERP) systems, typically for internal reporting of production data. Most large process industry firms have these systems installed across their enterprises, and many ERP systems are connected to instruments either through the automation system or directly to the instrument.

These direct connections are facilitated by increased connectivity options available with modern instruments, including Ethernet ports and web server capabilities. In fact, at some process plants, up to 70% of instruments don’t have any associated control functions—so direct connections to CMMS, asset management and ERP systems can be the best option.

Smart instruments and digital fieldbus networks can automatically deliver a wealth of information to various control, monitoring and maintenance systems within a process plant. Intelligent use of these data can improve plant operations, reduce maintenance and cut required labor hours. These benefits can be realized with a minimum of on-going attention provided the entire automation and instrumentation system is correctly installed and integrated with related monitoring and maintenance systems.

Table 1, Where and How Instrument Data Is Used

1. Real-time control
2. Operator interface
3. Alarm and monitoring
4. Calibration
5. Computerized maintenance management
6. Asset management
7. Enterprise resource planning

Figure 1. Refineries and other process plants make extensive use of the data supplied by smart instruments to improve operations, cut maintenance and increase safety.

Figure 2. This multi-variable transmitter supplies hundreds of data points to various control and monitoring systems located on this offshore drilling platform, and also located remotely in an onshore monitoring facility.

Figure 3. Injecting chemicals into process streams can often cause measurement problems, but modern instruments can address these and other issues.

Figure 4. Replacing multiple instruments with one multivariable transmitter saves costs up front and throughout the product life cycle, and it also simplifies installation.

SIDEBAR: ACCURATE FLOW MEASUREMENT IN CHEMICAL INJECTION APPLICATIONS

In many process plants, one or more chemicals are injected into a process stream. Measuring flow rates downstream of these injection points can be difficult as injection can disturb the flow profile and change the chemical composition of the stream.

Figure 3 depicts a typical chemical injection process in a flow line with a magmeter installed just downstream of the injection point to measure the flow rate. In this specific lab test, salt water was injected into a tap water stream as a simulation. Injecting salt water into the tap water stream caused a sudden conductivity change and a non-uniform distribution of conductivity in the process stream.

In the lab test and in many chemical injection processes, this type of injection would cause the magmeter to generate inaccurate readings in the form of spikes as illustrated in the graphs marked Y, K, A and E. These graphs were generated from the measured variable 4-20mA output of various conventional magmeters. To eliminate these spikes, a unique excitation method called dual frequency excitation can be used to deliver accurate and stable readings.

Most magmeters excite an electromagnet with either ac or pulsed dc power, but a dual frequency magmeter uses both excitation methods simultaneously. This combines the benefits of ac and dc excitation, using both high 75Hz frequency and low 6.25Hz frequency excitation. Dual frequency magmeters exhibit the immunity to elevated noise and the fast response of high frequency excitation meters, while maintaining the high zero stability of low frequency excitation.

Initially, dual frequency magmeters required a 4-wire connection, two wires for signal and two for power. But recent advances have made this measurement technology available with 2-wire meters, conferring some specific advantages.

Replacing a 4-wire instrument with a 2-wire instrument cuts power consumption by over 96%. This results in a reduction in carbon footprint from 46kg CO_2 excretion to 1.2kg on an annual basis.

Installation costs are also greatly reduced. Assuming a 100m cable run from the instrument to a junction box, the cable installation costs would be $1,500 lower for a 2-wire device. There would also be no need for a power supply and its associated housing, reducing costs by about another $500, and bringing total installation cost savings to $2,000.

SIDEBAR: MULTIVARIABLE TRANSMITTERS LIFT GAS AND LOWER COSTS

In many pressure sensing applications, both differential and static pressure must be measured. Traditionally, this required two separate pressure transmitters, but newer instruments allow both measurements to be made with one device. This saves costs up front and throughout the product life cycle, and it also simplifies installation.

In a gas lift system, a compressed gas is injected into the downhole well production tubing to reduce the hydrostatic pressure of the drilling fluid column (Figure 4). As a result of the pressure reduction, oil or gas can be produced at higher flow rates. Proper monitoring and control requires measurement of both static and differential pressure.

As shown in the left side diagram on Figure 4, pressure measurements on gas lift systems are usually made with two instruments each on the High Pressure Gas In and the Oil & Gas Out lines. On both lines, the first transmitter—labeled PT—measures static pressure. The second transmitter, labeled FT, measures differential pressure across an orifice plate, and derives flow as a value proportional to the square root of the differential pressure.

Using multivariable pressure transmitters allowed the end user to use a single instrument on each of the two lines, instead of a PT and an FT. This configuration is shown on the right side Figure 4 diagram. Using multivariable transmitters cut purchase costs by 40%, reduced installation costs and time, and reduced required maintenance.

The particular multivariable transmitters selected for this application also feature unique silicone resonant digital sensors. These sensors exhibit superior stability and repeatability, even under overpressure and high static pressure condition.

This was very important for this application as unexpected overpressure from underground oil and gas formation is sometimes generated in production line (how high of a pressure?). The process static pressure of the injection gas line is also quite high, typically about 1.7MPa (250psi).

Unlike conventional sensing elements, the digital sensors in these multivariable transmitters are inherently fail-safe. This allows the transmitters to deliver TÜV -certified safety in compliance with IEC 61508 without the need for any external components.