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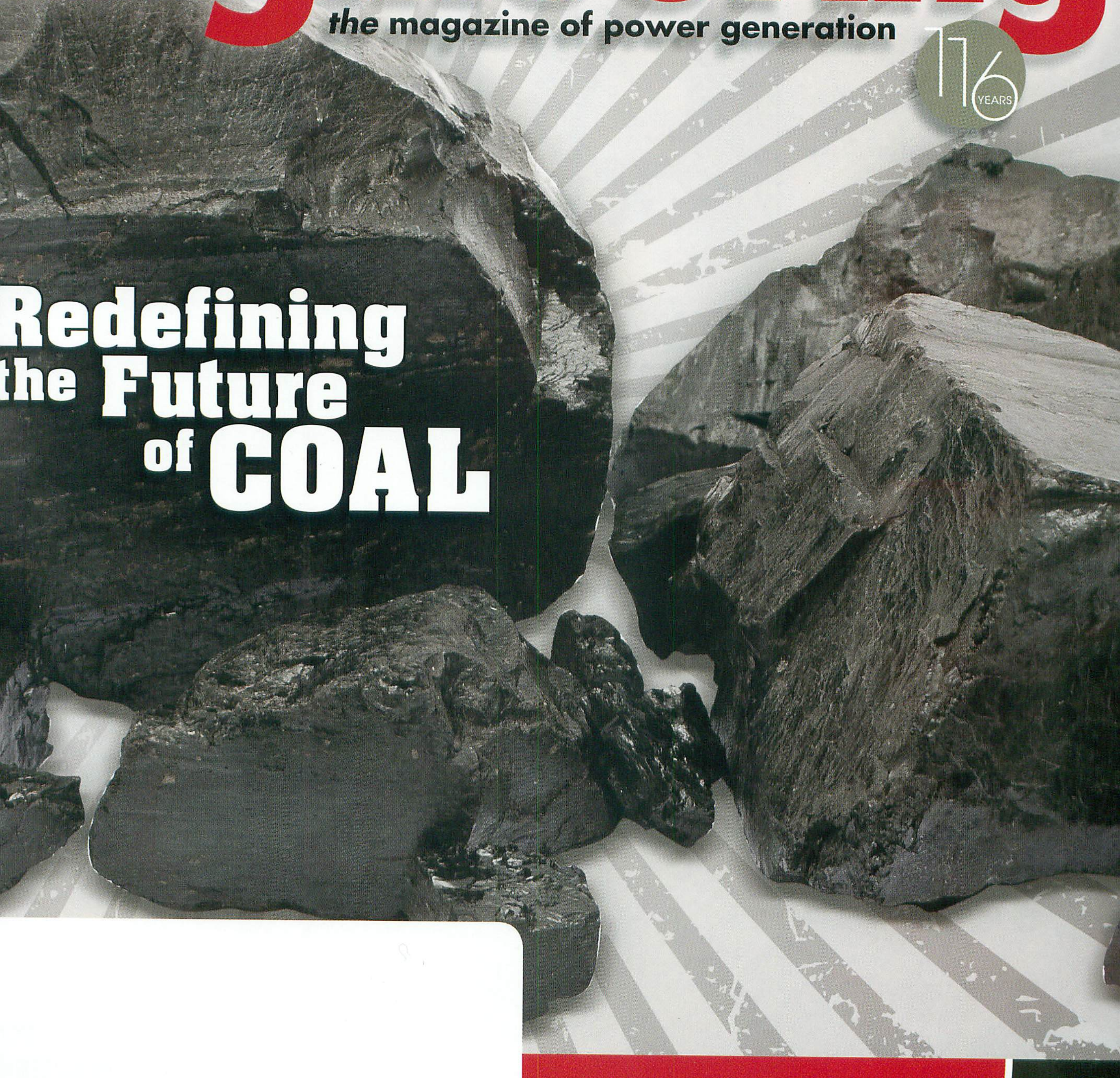

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Improving Productivity & Accuracies While Reducing Downtime

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Global process industry losses amount to $20 billion, or 5 percent of annual production, caused by unscheduled downtime and poor quality. ARC estimates that almost 80 percent of these losses are preventable and 40 percent are primarily the result of operator error. Smart instrumentation combined with asset management offers the opportunity to minimize these losses.

Smart instrumentation first appeared in process and power plants in 1983. Advances since then have provided technology that takes full advantage of improvements in sensors and microprocessors. Intelligent devices in the field offer more information than users could have dreamed in the past.

Smart instruments in the field measure or directly affect single or multiple plant variables, contain a microprocessor for processing data, and are commercially available "off the shelf." These instruments include not only sensors for measurements and communications, but also actuators, valves, motor variable speed drives and other control equipment. They allow operators and engineers to gain more useful information about the process and the device itself.

The result is that plant engineers and operators have access to such functions as power management, maintenance systems, process automation, asset optimization and safety systems. Standards such as NAMUR NE107 are steadily improving the Human Machine Interface (HMI), making it easier to commission, configure and manipulate instrument parameters.

BENEFITS OF SMART INSTRUMENTS

Smart instruments are characterized by:

- Fast, bidirectional digital-communication capability
- Enhanced diagnostics of the sensor, electronics and process
- Increased measurement accuracy under varying operating conditions
- Better recordkeeping
- Capability for wireless communications.

No longer are power engineers limited to a process variable measurement from a unidirectional 4-20 mA analog signal. Intelligent instruments in fieldbus networks offer remote configuration and calibration, data beyond process variables, diagnostics, and much more. These systems are decreasing the cost of process instrumentation while providing much more informational value.

The key benefits of smart instrumentation include:

- Scaled process variable: No further scaling needed outside of instrument, reducing complexity and the possibility of introducing error
- Self-validation/status: Indication of instrument's state and health, alerting operators to a change in quality of measurement and potential problems
- Tag-number: Clear P&ID identification of the device within network, reducing potential errors
- Description: Written definition of instrumentation and its application more clearly identifies its role
- Time stamp: Provides real-time record of process variable information
- Serial number: Can be synchronized with remote instrument life-cycle management systems and maintenance information
- Traceable validation: Indication that device calibration is valid, often addressing ISO 2001 Chapter 7.6

Bus communications drastically increase the amount of transmissible information. Also, bidirectional communication of digital information can take place between a field device and a system, and between field devices. To make the most of communication improvements and to satisfy more advanced needs, big changes are taking place within field devices.

WIRELESS POSSIBILITIES

In today's economic climate, maximizing plant assets and reducing unplanned plant shutdowns have become a focus for reducing costs and maximizing productivity. Currently, potentially valuable information acquired by process instruments is often left stranded in the field. This information could be monitored if a communications pathway back to the host control system were created.

Typically existing instruments have a built-in HART communication protocol, used normally during instrument commissioning. The arrival of wireless standards, such as WirelessHART, has allowed instrument manufacturers to develop wireless adapters. The adapters can be fitted to existing HART instruments, providing a cost-effective and secure communication pathway back to remote condition monitoring applications, such

Accurate pressure measurement for up to 8,706 PSI. Photo courtesy ABB

Multivariable DP flow installation	
Multivariable solution	Error
Smart transmitter	0.34%
Pressure & Temperature compensation	0.10%
Dynamic compensation	0.60%
Total error	**0.68%**

Traditional DP flow installation	
Source of Error	Error
Transmitter	2.60%
Pressure & Temperature Variation	1.10%
Primary Element	1.70%
Total Error	**3.30%**

as ABB's AssetVision Professional.

Estimates indicate that only 10 percent of the 30 million HART instruments installed since 1989 have a digital pathway back to the host. Remote digital access would allow operations and maintenance to take full advantage of this stranded instrument information. WirelessHART adapters for field instruments eliminate significant rewiring costs. Recovered information could include, for example:

- Multivariable process data
- Instrument condition monitoring
- Degrading valve performance
- Sticking valve
- Analyzer calibration required
- Low level of pH calibration buffer stock
- Instrument over-pressure counter
- Mass flow and totalizer
- Mass flow and density/temperature

Wireless communications would improve plant uptime in three steps. Initially, the instrument identifies a fault and sets an internal alert. Then an application that monitors conditions, such as.ABB's AssetVision Professional, reads the instrument alert via WirelessHART network. Asset Management system generates and routs a fault report based upon severity. Finally, the maintenance or remote support team connects to the field instrument and drills down via HART tools such as DTM (Device Type Manager) to diagnose the fault and arrange repair.

The use of smart and wireless technologies considerably increases the range of information from field instruments. In addition to the measured value, status and alarm messages provide valuable information about plant conditions as well as the reliability of the measured values.

MULTIVARIABLE TRANSMISSION

In this case one field device detects multiple measured variables. A traditional analog transmission system requires one cable for each measured variable. Bus communication supports multivariable transmission. So the field device can transmit all measured variables detected via a single cable. The same goes for control signal transmission to a positioner for an actuator or control valve. Bus communication system can transmit multiple pieces of information such as control signals, limit signals, and valve opening signals.

Examples of uses for multivariable detection and transmission include:

- Monitoring the condition of the steam heat tracing of differential pressure transmitters by ambient temperature information.
- Detecting clogging in impulse lines by static pressure information.

Many other pieces of information can also be used to expand measurement and control capabilities.

The valuable combination of multiple sensor systems in a single pressure transmitter permits simultaneous measurement of differential pressure, absolute pressure and, via an external sensor, process temperature. Additionally, the sensor's internal temperature is measured and recorded for service and diagnostic purposes. The sensor temperature and the absolute pressure can be used to eliminate environmental effects on the sensor.

IMPROVING DP FLOWMETER ACCURACY

A single multivariable DP instrument can measure gage or absolute pressure, differential pressure, and temperature. This unit takes the place of three single-variable instruments and, more importantly, reduces pipe intrusions and the opportunities for leaks while facilitating regulatory compliance.

Three sources of error exist in a DP flow measurement. Minimizing all three sources provides the best accuracy and repeatability.

- Minimizing transmitter errors
- Minimizing errors in gas and steam caused by pressure and temperature variations
- Minimizing primary element errors

Based on their experience with traditional analog systems, most users believe that the transmitter is no longer important when it comes to improving DP flow measurement performance. They believe the transmitter is a 3 to 5 percent device

Gas analyzers installed in an analyzer house. Photo courtesy of ABB.

over a 3:1 flow turndown, and that the orifice plate is the main source of error. But new smart transmitters can dramatically improve DP flow measurement performance.

Suppose the following application conditions prevail:

- Gas: Nitrogen
- Line size = 4 inch
- Pressure = 50 psig
- Process temperature ~70 F
- Ambient temperature 60F +/- 50F
- Minimum flow = 250 SCFM
- Normal flow = 1500 SCFM
- Maximum flow = 2500 SCFM
- Calibration cycle = 24 months

Most users assume they know the pressure at the flow point because they are measuring it at a header or controlling it off a regulator some distance upstream of the flow measurement. But even a short distance of piping can cause significant pressure variability.

Suppose 20 feet of clean pipe and two 90-degree elbows between the regulator and the flow point. (In many applications, the distance and disturbances in the line will be much greater.) Three sources make up the maximum total pressure variability.

1. Friction, a well established, but often unaddressed source of pressure variability. In this case, the gas is normally flowing at 1,500 SCFM. At the given conditions the flow velocity is about 180 ft/sec. The amount of friction loss depends on the distance and disturbances, the flow velocity, and the density. A calculation via the well-known Crane handbook indicates a frictional pressure loss of 0.28 psi. This loss amounts to 0.4 percent of the absolute pressure in the pipe.
2. Regulator accuracy and droop. Often users regulate higher pressures in a header down to lower pressures. A brand new regulator is 1percent accurate at full scale. If it is regulating the pressure at 50 psig (64.7 psia), 1 percent uncertainty is 0.64 psi or about 1 percent of the absolute pipe pressure.
3. Barometric pressure. While atmospheric pressure is generally about 14.7 psia, high and low weather systems moving in and out can result in variability of 0.5 psi. This amounts to 0.8 percent of the absolute pressure in the pipe.

The three sources of pressure variability add to 2.2 percent. This variability is not constant over the flow range, so it can't be "calculated out." To address it, the pressure must be measured at the flow point.

So if a DP gas flow measurement does not include pressure compensation, the measured flow variability is 1.1 percent (half of 2.2 percent). This affects repeatability as well as accuracy. At a given flow, the measurement could be off by 1.1 percent, depending on the regulator, the friction, and the barometric pressure. Velocity flowmeters, since they're not subject to the square root function associated with DP measurements, would be off the entire 2.2 percent. For a compensated or multivariable meter, this error is virtually eliminated.

Further improvements to flow accuracy require and understanding of the DP flow equation. Recall that flow Q through an orifice plate is proportional to the square root of differential pressure DP. Traditionally, the proportional factor 'K' term is calculated at the sizing conditions of normal flow, and then assumed constant. Changing flow conditions, however, can produce inaccuracies. The K factor itself changes with flow rate and temperature. The components of the K factor subject to these changes are:

- Discharge coefficient, C_D
- Gas expansion factor (gases only), Y_1
- Velocity of approach, E and
- Square of orifice bore diameter, d^2

Recalculating these components based on the flow rate and temperature significantly improves performance, and can greatly extend the flow range that can be measured accurately with DP Flow.

Recognizing these issues explains how DP orifice flow measurement can improve from a 3 to 5 percent device to a better than 1.0 percent device (see Table on pg. 70).

ASSET MANAGEMENT

Equipment uptime for continuous production represents an important factor in improving process plant productivity and overall profitability. Smart instruments can play a key role in optimizing the maintenance function toward this end.

- An automotive customer increased uptime by 10 percent by improving their repair process
- Customers average productivity improvements of 1 percent through control system preventive maintenance contracts
- A regional brewery reduced waste by $2 million in retail product through remote monitoring
- A chemical company reduced their overall maintenance costs by $10M the first 5 years after implementing a predictive maintenance strategy
- A tire manufacturer reduced repair costs by 30 percent and increased warranty utilization by 100 percent through asset management services
- A major beverage company is saving over $250K per year through a parts management program

Coal pulverizing and rotating machinery provide good examples of the benefits of asset management principles.

In coal pulverizing operations typical of power plants, plant maintenance sometimes has to deal with problems associated with the long impulse lines that transfer pressure to remotely mounted pressure transmitters. The lines may plug as often as once a week and even once a shift in some cases. A small air purging system in the sensing line may be present to provide positive pressure, attempting to keep the coal out of the sensing line. But wet coal following a rainstorm, for example, invariably leads to plugged lines. In the worst cases, maintenance technicians have to drill out impulse lines plugged with dried "mud."

Ideally, the pressure would be sensed directly, with the transmitter mounted on the pulverizing mill, exhauster, or ductwork. This arrangement would eliminate the need for long, narrow impulse lines. But the pressure sensing diaphragm would have to withstand the severe abrasive effects from high-velocity pulverized coal.

Once impulse lines are plugged, reliability of measurement becomes questionable. Smart pressure transmitters equipped with Plugged Impulse Line Detection (PILD) can quickly alert maintenance departments to measurement problems. On sensing a plugged impulse line, the transmitter displays a diagnostic message while sending a digital and/or analog alarm. This capability protects the transmitter while offering predictive diagnostics of the pressure measurement loop.

The operating condition of critically important rotating machinery can be monitored continuously. Permanently installed sensors make it possible to communicate vibration information continuously. Vibration levels of support machinery can also be measured periodically in the field by plant personnel using portable equipment.

The operating condition of critically important rotating machinery can be monitored continuously.

In both cases, health management software processes the data, providing a complete picture of the operating condition. The ability to overlay frequencies, and match fault frequencies to peaks, allows trained personnel to efficiently analyze the data.

Alarm reports enable decision makers to quickly evaluate a situation and take appropriate action to prevent a breakdown.

NAMUR STANDARDS

The aim of the Namur NE107 recommendation is to summarize how to make use of diagnostic data from field devices to support operators to take appropriate actions as required. ABB smart instruments follow the NAMUR "Traffic Light" standard for identifying fault levels, which can be adapted by the customer, depending on the application:

- White — No Maintenance required:
- Green — 500--Low priority maintenance, no influence to process
- Yellow — 750--High priority maintenance, influence on process possible
- Red — 1000--Critical maintenance immediately, definite influence on process

The user must be able to interpret appropriate response to a diagnostic event. Reactions to a fault in the device may vary, depending on the user's requirements. For example, the control loop may or may not be critical. The plant operator will see only the four status signals. Detailed information can be viewed and analyzed by a specialist engineer.

Focused asset management supports maximum productivity while incurring minimum costs. Productivity is maximized by fast, reliable startups, by adopting predictive maintenance strategies to assure reliability of essential production assets, and by using field-based information and diagnostics to identify and avoid potential trouble. Careful planning and execution of plant turnarounds minimizes their duration and extend intervals between them. A predictive maintenance program can be expected to bring a 1 percent to 3 percent improvement in product throughput. pe