Smart Instruments Enable Improved Pumping

Smart pumping techniques are easier to implement with smart flow, pressure and temperature instruments.

By Nathan Hedrick, Endress+Hauser

FIGURE 1. With smart pumping, cascading pumps from large reservoirs ensure required flow rates are achieved reliably and efficiently based on system demand.

Smart pumping applications are designed to adjust the speed of a pump to compensate for changing process conditions or plant requirements. To accomplish this, they typically use adjustable speed drives to control pump speed; smart valves to control flow; pump controllers ranging from on-board microprocessors to PLCs, PACs and DCSes and—of course—smart instruments.

For instrumentation, a smart pumping system (Figure 1) needs flow, pressure and temperature devices that are reliable, accurate, able to detect process conditions that can cause problems, and able to predict when maintenance is needed.

Several instrument manufacturers offer various types of "smart instruments," and their approaches vary. In this article, we'll cover how Endress+Hauser flow sensors with Heartbeat Technology provide the kind of information needed to implement smart pumping.

What's a Smart Instrument?

Smart instruments provide a great deal of information to an automation system, in contrast to standard instruments which only provide a 4-20mA output proportional to the process variable. This article will focus on smart instruments, and we'll drop the "smart" prefix going forward.

A flow transmitter, for example, typically provides a flow signal and a variety of status and diagnostic information. A Coriolis flowmeter not only sends a flow signal, it can also send data on temperature, mass, density or even viscosity. This data is typically sent via fieldbus or a 4-20mA signal with HART.

Some instruments take the smart concept even further. Not only do they send a signal for flow or pressure with diagnostic information, their built-in electronics continuously monitor device and process health to provide timely information with suggested remedies when problems occur. In pumping applications, such an instrument doesn't tell operators there's a problem with a pump, but it does say when it detects conditions that can lead to pump problems.

Error code	Error	Actions	Alarm type
843	Process limit	Check process conditions	Alarm
962	Partially filled pipe	Check for gas in process Adjust detection limits	Warning
910	Tubes not oscillating	Check input configuration Check external device or process conditions	Alarm
912	Medium inhomogeneous	Check process condition Increase system pressure	Warning
913	Medium unsuitable	Check process conditions Check sensor	Alarm
948	Oscillation damping too high	Check process conditions	Warning

FIGURE 2. Typical errors that can be generated by a Proline flowmeter, which can detect up to 125 different problems.

For example, the Endress+Hauser Proline flowmeter can detect entrained air, vibration (which could be caused by pump cavitation), coating, corrosion, and inhomogeneous or unsuitable media. All of these could negatively affect the pump and its performance. The flowmeter can also diagnose itself for problems with its electronics or subcomponents. When process conditions warrant it (Figure 2), the flowmeter will generate an event message.

The diagnostics and error reporting are accomplished with Endress+Hauser's Heartbeat Technology, which is built into the flowmeter. No external software is required.

While every instrument manufacturer's diagnostics differ, each typically monitors internal parameters, observes changes, and diagnoses problems. For example, Proline Coriolis flowmeters can monitor oscillation damping and frequency, temperature, signal asymmetry, exciter current, carrier pipe temperature, frequency fluctuation and other parameters. Changes in these parameters indicate potential problems.

For example, a deviation in the frequency fluctuation is an indicator of rapidly changing process conditions such as gas present in a liquid fluid, while drift in oscillation damping can be caused by the formation of coating or buildup—or by fouling, corrosion or abrasion.

Heartbeat Technology can also generate a Heartbeat Sensor Integrity (HBSI) parameter using Heartbeat Verification. This parameter represents the relative change of the entire sensor, with all its electrical, mechanical and electromechanical components. The reference HBSI is set at the factory when the flowmeter is calibrated. Any deviation between the calculated HBSI and the reference HBSI indicates a change in the sensor which can be caused by excessive mechanical or thermal strain on the sensor, increased wear from corrosion or abrasion, multi-phase fluids, wet gases, the formation of buildup in the measuring tube, or other conditions.

Whenever a deviation occurs in the HBSI, built-in intelligence examines changes in all the parameters, determines the probable cause, and sends an alarm or warning message to the operator.

A Proline flowmeter has a choice of outputs—including 4-20mA with HART, EtherNet/IP and PROFINET—and Proline 300 and 500 devices can also have a WLAN enabled display. The pump control system can get the Heartbeat diagnostics, monitoring information and alarm messages via any preferred communication protocol. In addition, operators or maintenance technicians can see the diagnostics on the display of the meter, or on their laptop, smartphone or tablet via the WLAN connection.

Minimizing Maintenance

Smart pumping systems depend on accurate data from flow transmitters, so each instrument must be able to detect when it is in need of verification or recalibration. In some industries, such as water recovery, flowmeters have to be verified at regular intervals. Verification has to be performed by a qualified third party with an accepted inspection method based on quality regulations such as ISO 9001, and a test report needs to be provided for documented proof of evidence.

Verification can be done in the field as a manual process with a verification tool and a simulation box. During field verification, the transmitter is opened to the atmosphere, and the meter cannot be used for measurement and control of the process for the duration of the test. External verification must be performed by a trained technician, and the verification tool itself is defined by ISO 9001 as test equipment, which means that it must periodically undergo traceable calibration.

FIGURE 3. This smart pumping application in UV disinfection uses smart instruments to monitor flow control and pump speed to ensure water is passing through the system at precise rates to guarantee quality.

Some plants do not have the capability to manually verify a flowmeter, or do not want to shut the pumping system (Figure 3) down to accomplish it. If a plant doesn't have internal capability, a third-party firm must be hired to verify the meter, or the meter must be removed from service and sent to an offsite calibration facility.

Modern flowmeters have integrated verification into the device itself, so that verification does not require a skilled technician, removal of the instrument or a process shutdown. For example, Proline flowmeters from Endress+Hauser have integrated self-verification that can be initiated from the pump control system at any time.

During flowmeter verification, the current conditions of various parameters are compared with their reference values, thereby determining the device status. Heartbeat Technology produces a "pass" or a "fail" statement based on the tests, which is performed by traceable and redundant internal references. The individual tests and test results are automatically recorded in the flowmeter and used to print a verification report.

A traceable and redundant reference, contained in the verification system of the device, is used to ensure reliability of results. In the case of an electromagnetic flowmeter, this is a voltage reference, which provides a second, independent reference value.

Integrated self-monitoring replaces the need for external test equipment only if it is based on factory traceable and redundant references, as with the Proline flowmeters. The reliability and independence of the testing method is ensured by traceable calibration of the references at the factory, and by the constant monitoring of the flowmeter's long-term stability during the lifecycle of the product.

The verification procedure for Endress+Hauser flowmeters typically takes less than five minutes. If the flowmeter has a permanent Ethernet or other digital bus connection to the pump control system, the procedure can be performed remotely from a PC located in the maintenance department or the plant's control room, or from the control system.

If the verification procedure determines that the flowmeter needs maintenance or re-calibration, Heartbeat Technology notifies the plant operators.

Summary

Smart instruments ensure that reliable, accurate data is always provided to a smart pumping system. When problems arise in the process or the instrument itself, the smart instrument notifies the pumping system controller and makes a recommendation. And, with automatic self-verification, the plant will know when an instrument needs to be removed for maintenance or re-calibration, and can remain in compliance with regulations. All this ensures reliable operation and minimum maintenance.

About the author

Nathan Hedrick has more than seven years of experience consulting on process automation. He graduated from Rose-Hulman in 2009 with a Bachelor's degree in Chemical Engineering. He began his career with Endress+Hauser in 2009 as a Technical Support Engineer. In 2014, Nathan became the Technical Support Team Manager for Flow where he was responsible for managing the technical support team covering the flow product line. He has recently taken on the position of Flow Product Marketing Manager.

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