Wireless sensing improves refinery operations

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Emerson's experiences working with refiners and calculations show that the difference in operating costs associated with equipment reliability and energy efficiency between a well-run refinery and an average one is about $12.3 MMpy (million per year) for a typical 250-Mbpd facility. Assuming that about 60% of refineries are not operating as well as they could, the overall worldwide financial impact runs into hundreds of billions of dollars annually.

In terms of attaining peak performance, applying an Emerson Wireless Pervasive Sensing and predictive analytics strategy using wireless sensors enables additional process and asset health measurements to automatically collect data for further automated analysis. With predictive analytics, these additional data points are turned into alerts when abnormal operation or imminent failures occur, resulting in timely and corrective action to prevent failure.

Impacting the bottom line with informed decisions. When control and monitoring strategies are expanded with more sensors and their accompanying predictive analytics information, owner-operators are able to address multiple critical challenges simultaneously. This allows for more informed, timely decisions and safer and more consistent operation.

FIG. 1. A refinery pumping system with wireless transmitters.

Pervasive Sensing solutions add low-cost wireless points of measurements throughout the plant, monitor these points and alert plant personnel. This helps optimize production processes by monitoring the asset health of pumps, motors, steam straps, heat exchangers, valves, piping systems and other equipment.

This type of control system and instrumentation are independent of those already installed, because the Pervasive Sensing solutions are based on WirelessHART technology, an international industry standard IEC 62591.

WirelessHART, based on the HART standard, is compatible with virtually all new and legacy refinery control systems and is more widely used than any other process instrumentation communications standard. So, a Pervasive Sensing solution can be installed, running and improving operations in any refinery in short order.

Refinery issues. In complex refinery operations, it is sometimes difficult to make timely and informed decisions about operations and maintenance strategies. Often, the necessary information to pinpoint performance issues is unavailable. The first step toward improvement is to define the new sensing point locations, determine how the new information will be used and associate the economic values with each Pervasive Sensing application. Unscheduled outages and production slowdowns classified as mechanical unavailability occur from common problems, such as rotating equipment failure, heat exchanger fouling, piping corrosion and fired equipment constraints.

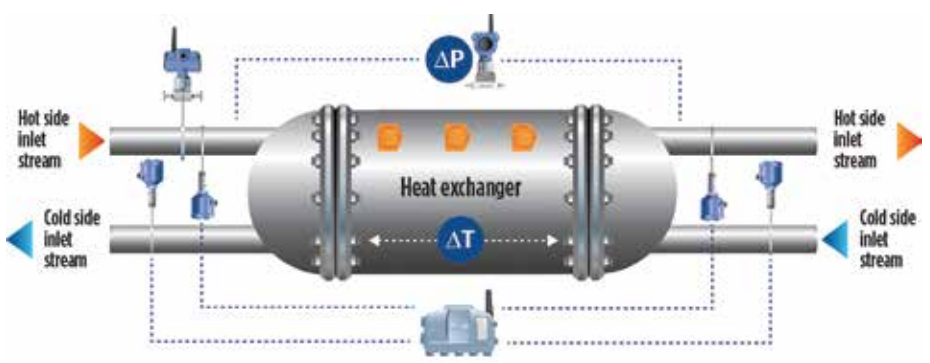

FIG. 2. Wireless transmitters on a heat exchanger.

Energy losses occur from heat exchanger fouling, failed steam traps and process unit inefficiencies, all of which may go undiscovered from a lack of complete energy measurements. Refineries understand their macro energy performance through their energy intensity index, but determining exactly where energy is lost is a common challenge when driving an energy improvement program.

Monitoring of pumps. There are 10–15 LPG pumps in a refinery that are typically checked manually once a month for vibration, and bad actors are checked once a week. With ever-changing process conditions, infrequent spot inspections are insufficient to detect pump problems and seal failures. Hydrocarbon leaks are possible due to seal failures, which can lead to production losses, fires and even safety incidents.

Online monitoring of pumps through the addition of wireless measurement of vibration, pressure and seal fluid levels allows early detection of excessive vibration, cavitation and seal failure problems, respectively. Maintenance can be notified of pending problems, leading to improved production through fewer unscheduled outages.

If a pump fails in an LPG area and seals break, this presents a high risk of explosion. A refinery can see a $100k insurance premium risk reduction by adding automated monitoring to process pumps (FIG. 1).

Combating fouling conditions. Many refiners maximize their use of discounted opportunity crude oils, but using this type of feedstock often presents significant processing challenges. Crude unit preheat exchangers can foul unpredictably with incompatible crude blends and varying crude oil properties.

As a result, energy efficiency is lost and production limited. By adding additional wireless temperature measurements to heat exchanger banks, increased data can be provided to process analytics software that can then alert operations to excessive fouling conditions and rates (FIG. 2). The information can be used to determine incompatible crude blends and when an exchanger bundle requires cleaning.

Addressing issues with wireless. Companies building new refineries are exploring the benefits of Pervasive Sensing and predictive analytics strategies. A typical modern facility will have thousands of inputs and outputs to and from control and monitoring systems. These connections are both wired and wireless, depending on the specific nature and location of each input and output.

However, older refineries were built using wiring and only the instruments required to safely operate the plant, not necessarily to optimize or operate the plant reliably. The lack of inputs to control and monitor systems can cause refineries to run blind in many critical areas, or to perform expensive, time-consuming and resource-using manual checks via field rounds.

So, given the proven financial benefits, why haven't all refineries added thousands more points of measurement? In the past, these inputs would have been wired from the sensing point, such as a pump, to a control and monitoring system. Adding this wiring to an existing facility is usually a very expensive undertaking, and it often requires significant downtime, which is not an option as many refineries operate at or near full capacity.

Pervasive Sensing technologies allow these measurements to be quickly and inexpensively compiled. Wireless sensors are connected through a plant-wide wireless mesh network to control and monitoring systems, at a fraction of the cost and time of their wired equivalents.

TABLE 1 shows representative improvements and savings that are possible for a 250-Mbpd refinery.

A typical 250-Mbpd refinery has hundreds, if not thousands, of unmonitored processes, devices and systems open to unplanned failures or degraded operations. This insufficiency can waste energy, increase the probability of safety issues and escalate repair costs, potentially shutting down processes or even an entire refinery.

Pervasive Sensing solutions enable the automatic collection of process and asset health measurements, which can be analyzed and alerted of abnormal operation or imminent failure. This can improve safety, prevent releases that could result in fines and penalties, and extend the life of expensive process equipment.

The return on investment (ROI) for these Pervasive Sensing and predictive analytics solutions is typically only a matter of months, and implementation is relatively quick and simple compared to installing traditional wired sensor solutions. ●

TABLE 1. Savings, implementation costs and ROI for a 250-Mbpd refinery

Application	Monitoring and analytics	Savings, $MM	Implementation cost, $MM	ROI, months
Heat exchanger monitoring	Fouling rate and limits	$2.7–$3.6	$0.62	3 months
Cooling tower monitoring	Efficiency and health	$0.3–$0.5	$0.16	4 months
Steam trap monitoring	Failure	$2.5–$3.3	$1.48	5 months
Relief valve monitoring	Releases and leaks	$2.4–$3.2	$1.59	6 months
Pump monitoring	Cavitation, pump health	$0.5–$0.6	$0.55	11 months
Air-cooled heat exchanger monitoring	Fan health and fouling	$0.9–$1.1	$1.20	13 months
Mobile workforce	Turnaround diagnostics	$1.6–$2.1	$0.40	3 months
Safety shower and eye wash monitoring	Trigger indication	Per incident	$0.39	Safety
TOTAL		**$10.9–$14.4**	**$6.40**	**5 months**