Wireless for Asset Uptime

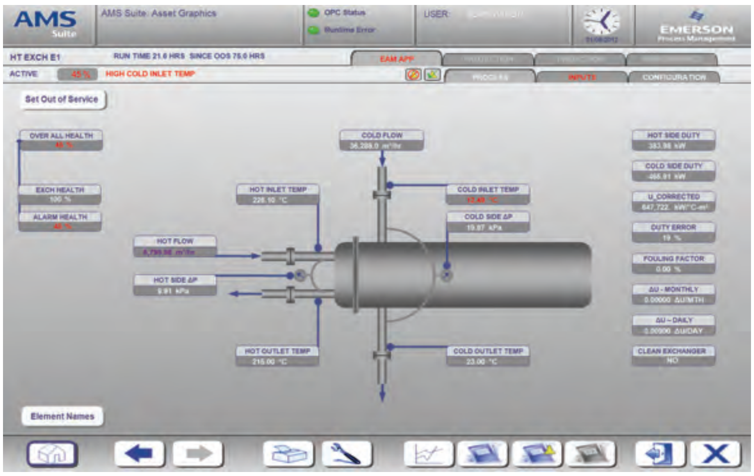
***Jonas Berge* explains how WirelessHart technology can be used to increase plant asset performance by enabling key additional measurements without extensive disruption.**

Most plants in existence today were built years ago with the minimum amount of instrumentation necessary for control. Improving process unit utilization, energy efficiency, reducing maintenance costs, and mitigating safety and environmental incidents requires additional measurements. The good news is that older plants can now easily be modernized by installing wireless instrumentation to supply the missing measurements and intelligence.

Critical assets in the plant such as expensive compressors and large pumps are already being monitored by protection systems. Due to the high cost of traditional machinery protection and equipment monitoring systems, the balance of assets may not have been previously fitted with monitoring systems. Many of these unmonitored assets are still essential to operation. These "second tier" assets are typically spot-checked manually in the field on a periodic basis.

Originally these assets may have had standby backups, but subsequent debottlenecking and expansion projects may have put former standby assets into continuous service without corresponding backup. Monthly manual readings are not frequent enough to catch developing issues, as process conditions often create equipment failures. Unexpected equipment failures in turn cause process upsets and potentially unsafe conditions. Running to failure can result in even worse damage to the equipment.

Asset monitoring requires additional measurements for which instrumentation is rarely included in the original plant design. The risk of disrupting the running plant while laying cable, opening cable trays, and rewiring junction boxes is high, and therefore improvements don't get done. WirelessHart instrumentation drastically reduces risk since full multi-hop, multi-path, mesh topology eliminates all cables.



Wireless temperature monitoring enables valuable information on heat exchanger condition and performance.

Heat exchanger monitoring

In petroleum refining, the primary challenge for operating the crude unit pre-heat exchangers is fouling due to asphaltene precipitation or poor desalter performance, which reduces heat transfer between the fluids on the tube and shell sides.

As a heat exchanger fouls, a downstream fired heater has to make up the process heat requirements, increasing fuel cost. At the point the heater reaches its maximum capacity, it is necessary to slow throughput to meet process temperature requirements resulting in underutilization of the unit.

Cleaning the heat exchanger too often is not practical since it typically requires a process shutdown. If the exchanger is severely fouled, it may even be necessary to pull it by crane and send it offsite for de-coking. Therefore, a heat exchanger should be cleaned at the optimum time taking these factors into consideration.

Today, plants typically do not know the rate of fouling for each heat exchanger. Manual measurements of hot fluids are difficult and time consuming to make on stacked heat exchangers. Thus plants are not aware of accelerated fouling. Lack of information prevents decision making and planning; that is, to choose cost of cleaning or cost of additional heater fuel.

A secondary problem is that the heating fluid leaves the fouled heat exchanger flowing into the next, hotter than the heat exchanger was designed for. This could cause damage. If the exchanger gets severely fouled, plugging may prevent fluids from flowing through.

Maintenance personnel need heat exchanger performance data at least daily to allow timely fouling analysis and maintenance planning. The only practical approach is to automatically monitor the rate of fouling on each heat exchanger. This can be achieved with a new solution that measures hot and cold fluid inlet and outlet temperature using single or multi-input wireless temperature transmitters on each heat exchanger.

The raw measurement data is communicated to the asset monitoring software and plant historian through a wireless gateway, and used together with flow to compute hot and cold side heat duty, average heat duty, heat duty error, observed heat exchanger coefficient, corrected heat exchanger coefficient and fouling factor, etc. The software trends the rate of heat transfer degradation (fouling) in all exchangers. It also takes this information further, notifying if the heat exchanger requires cleaning, and providing operators the knowledge on which to base decisions: weigh cost of make-up heat fuel against cost of taking out of service and cleaning.

High alarms on these new temperature measurements warn when each heat exchanger nears its design limits. By also measuring hot and cold side pressure drops across the exchanger, developing plugging can be detected early.

As a result, wireless heat exchanger monitoring can be used to initiate actions which reduce energy loss and prevent throughput drop. The maintenance shutdown period is shortened by optimizing heat exchanger cleaning, and maintenance costs are reduced by avoiding unnecessary cleaning and disposal costs of chemicals. In addition, overheating damage to heat exchangers can be avoided and severe plugging of heat exchangers can be prevented, eliminating the cost of decoking.

In steam trap monitoring, a wireless acoustic transmitter 'listens' for ultrasonic noise created by steam or condensate, and also measures the temperature at the steam trap inlet via a built-in sensor.

Pump health monitoring

A plant may have more than a hundred pumps, and a pump can be affected by many different problems. One type of pump problem often leads to another and may eventually turn into a unit or plant shutdown.

A plugged suction strainer before the pump creates pressure drop, leading to suction pressure drop which may cause cavitation. Cavitation may also occur due to high discharge pressure because of a restricting downstream valve controlling at low flow. This causes internal recirculation across the impeller, heating up the fluid, which could then begin to vaporize and cause cavitation. An operator may inadvertently have set the setpoint for low flow, unaware it is causing cavitation. Cavitation causes impeller damage which in turn causes rotor imbalance and vibration.

Vibration causes yet other problems. Vibration may be caused by misalignment of the motor-pump shaft, worn bearings due to insufficient lubrication, broken or loose mounting bolts. etc. Vibration will cause excessive bearing wear and eventually lead to pump failure, days of maintenance, expensive repairs, and downtime. Vibration will also increase the stress on the pump's seals eventually leading to seal failure and spill. Leaking seals may lead to production interruption, emissions, cleanup, and even fires.

Poor lubrication may result in bearings overheating and eventual failure. Similarly, locked rotor, overload, ambient temperature, voltage imbalance, high/low voltage, and blocked ventilation, etc will result in excessive motor winding temperature which can permanently damage the windings, shortening lifespan and may cause complete insulation breakdown and motor failure.

For the less critical pumps, vibration is usually checked manually using a vibration tester in the field, one pump at a time. However, manual checks may not be frequent enough to capture impending pump failures. Pumps with intermittent duty may not get tested if not running during the operator round.

The only practical approach then is to automatically monitor the pump and motor assembly. The new solution measures a number of points on the pump:

- A wireless vibration transmitter with two sensors and PeakVue vibration (peak acceleration) measurement detects vibration which may be caused by a number of abnormal situations. Note that overall vibration (velocity) measurement would detect these problems much later, possibly too late.
- A wireless differential pressure transmitter measures pressure drop across suction strainers, where provided.
- For pressurized seals, a wireless pressure transmitter measures sealing fluid pressure to detect insufficient pressurization. For unpressurized seals, it detects pressure increases caused by the inboard seal leaking process fluid into the auxiliary seal flush reservoir when the pumped fluid vaporizers at atmospheric pressure.
- Two wireless level switches monitor high sealing fluid level in the sealing fluid pot detecting inner seal leakage, and low level detecting outer seal fluid leakage.
- A hydrocarbon detection sensor placed in the sump or around the pump, with a wireless discrete input transmitter detects hydrocarbon leaks.
- A four input wireless temperature transmitter measures temperature of bearings and motor windings.

Not all pumps need all of these monitoring points. Pump health packages can be customized for each pump in the plant. The raw measurement data from all essential pumps is communicated through the wireless gateway to the software for trending. The software takes this information further, providing notification that the pump requires attention, providing operators the knowledge on which to base decisions.

As a result, wireless pump health monitoring detects strainer plugging early so it can be fixed before suction cavitation sets in. Note that the alarm must be displayed to the operators, not just the maintenance technicians. Seal leak from process or flush fluid is detected early and can be fixed. Early detection of hydrocarbon leaks can limit the extent of the spill. Motor winding overheating is detected before windings are damaged. Bearing temperature rise is detected before bearings seize.

Steam trap monitoring

A steam trap has a life expectancy of four years. Therefore, with yearly inspection, as many as 25 percent of steam traps in a plant may have failed and should be replaced or possibly repaired (American Institute of Chemical Engineers (AIChE), February 2011) – but which ones? A typical plant could have thousands of steam traps. Depending on the steam trap size and steam pressure, failed steam traps may cost the plant millions of dollars annually.

Over time, steam trap parts will erode, causing the steam trap to fail "blow-through" – passing live steam into the condensate return line thus wasting energy, and driving up energy costs. The energy loss is particularly significant for high pressure steam lines.

Conversely, condensate may be blocked from draining to the return line, leaving the steam trap "cold", caused by debris caught in the steam trap. This condensate may back up in the turbines, heat exchangers, and heating coils causing turbine damage and heating inefficiencies.

Manually checking steam traps is difficult due to the large quantity and because many are difficult to access, and it requires an experienced technician to make a correct diagnosis. Thus the only practical approach is to automatically monitor the steam traps.

The new solution for this is a wireless acoustic transmitter, a non-intrusive multi-variable instrument strapped onto the outside of the pipe at the trap inlet. The acoustic transmitter "listens" for the ultrasonic noise created by steam or condensate. A temperature sensor built into the wireless acoustic transmitter measures the temperature at the steam trap inlet.

The raw acoustic and temperature measurement data is communicated to the steam trap software through the wireless gateway. The software exploits the different noise profiles of condensate and steam to detect if the steam trap is correctly discharging condensate or if it has failed "blow-through" passing steam.

Steam trap monitoring overview screen.

The temperature tells the software if there is cool condensate or hot steam at the steam trap inlet and can thus detect if the steam trap has failed "cold" blocking condensate discharge. The status of all steam traps is displayed in software for easy review by technicians, allowing them to make decisions as to which steam traps to replace.

As a result, energy costs can be significantly reduced as less steam lost means reduced fuel consumption. Moreover, turbine blade damage and production loss can be avoided.

Lean wireless infrastructure

Although the new measurement points for the above examples could be integrated to the control system, often they are not because the DCS would require an increased tag count. Instead the data goes to asset monitoring software. The software combines multiple measurements for more sophisticated analysis.

WirelessHart transmitters make it economical and low risk to deploy these essential asset monitoring packages in a running plant as there is no need to lay cable, or open cable trays and junction boxes. Once an initial WirelessHart gateway has been deployed, more transmitters can be added at will to also manage blowers, compressors, cooling towers, fired heaters, and take the place of dial gauges, etc in the future.

With the great mix of assets in a plant it is clear that several different monitoring packages utilizing a variety of wireless transmitters are required. Since a plant can only afford to have a single wireless sensor network infrastructure in place, an open standard covering these diverse needs is required.

IEC 62591 (WirelessHart) is supported by multiple manufacturers, which together provide WirelessHart gateways as well as transmitters for pressure, flow, level, valve position, pH, conductivity, vibration, temperature, multi-input temperature, and acoustic monitoring. Level switches and contact inputs are also available. A "wireless adapter" can be used for conventional transmitters not available in a wireless version.

The WirelessHart standard meets diverse user needs such as multi-vendor interoperability, transparent integration, simple commissioning, reliability, statistics and diagnostics, security, real-time determinism, long battery life, interchangeability, coexistence, lifecycle version management, familiar tools, and independent third-party certification.

WirelessHart transmitters make it economical and low risk to deploy essential asset monitoring packages in a running plant.

Beyond the P&ID

Plants which were built years ago can be modernized to improve process unit utilization (reduce shutdowns and slowdowns) and energy efficiency, reduce maintenance costs, and mitigate safety and environmental incidents using additional wireless measurements and intelligence.

But what if you are about to build a new plant, but did not make provisions for essential asset monitoring? The process licensor's design includes instrumentation for efficient operation but not for efficient maintenance. These missing measurements must be included. Perhaps the project has already passed the FEED stage?

This is not a problem with WirelessHart because the additional measurement points do not affect DCS I/O count, cable layout, or junction boxes, etc. You can start with an audit of the site to uncover the essential assets. Then build a wireless mesh topology network, and deploy essential asset monitoring packages as necessary. **CEA**

Jonas Berge is Director Applied Technology, Emerson Process Management.