Flow management starts with pumps

Controlling flow in liquid hydrocarbon pipelines depends on reliable and optimal operation of pumping systems, explains **Wally Baker, Emerson Process Management, Rosemount, USA.**

The pipelines used to transport oil and other liquid hydrocarbons are powered by pump stations, with these facilities providing the impetus to move product from one point to another (Figure 1). For a variety of reasons, the key components in these stations are the pumps.

Pumps in general consume large amounts of electricity, so it is important that they run at the required speed and no faster. They are prone to failure if not monitored and maintained correctly, with issues ranging from leaks to downtime. Numerous regulations govern their operation, chief among them API Standard 682, which has recently been revised to require more stringent monitoring of pump seal systems in hydrocarbon applications.

Figure 1. Pump stations provide the impetus required to transport liquid hydrocarbons through miles of pipelines.

This article will first examine the role of pump monitoring sensors and systems in liquid hydrocarbon pipelines, and then will touch upon measurement technologies, which work hand in hand with control systems to manage liquid hydrocarbon flows in pipelines.

Pump monitoring measurements

Pumps in pipeline systems are monitored with a wide variety of sensor types, some of which are depicted in Figure 2 as wireless sensors. Main monitoring points include:

- Pressure at pump intake, PT-101 – ensures the pump has appropriate pressure. If there is not enough intake pressure, the pump can run dry, a particular hazard for centrifugal pumps.
- Level at pump intake – detects when the liquid level drops, can be used to protect against dry running.
- Pressure at pump discharge, PT-102 – used to infer the pump's level of output, and to ensure the pump is operating.
- Flow at pump discharge – indicates proper pump operation, and can be used to close the loop for pump control, as explained more fully later in this article.
- Differential pressure between pump intake and discharge, PT-103 – detects cavitation.
- Pump motor temperature – indicates when a pump motor is running hot.
- Pump bearing temperature – indicates when a bearing is exceeding safe temperature.
- Pump vibration, VT-101 – this measurement is a good indication of pump health, particularly when tracked over time and compared to a baseline. Increases in vibration indicate conditions such as bearing wear or pump imbalance, which can lead to failures.

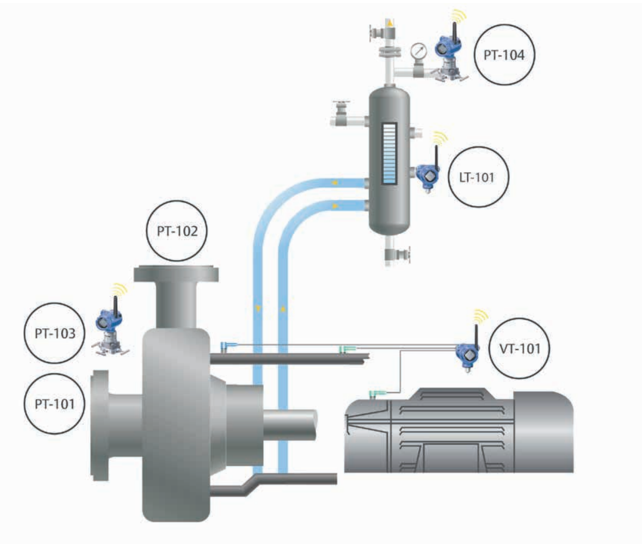

Figure 2. Pump monitoring diagram. A wide variety of parameters are typically measured on pumps used in pipelines, some of which are depicted in this diagram.

- Pump seal system reservoir level (LT-101) – indicates buffer fluid level, recommended by API-682 instead of level switch.
- Pump seal system vapour vent pressure (PT-104) – indicates high pressure, normally a result of process liquids leaking into the buffer system and flashing to the vapour phase in the seal reservoir. Recommended by API-682 instead of pressure switch.

As noted above, pump seal systems often require level and pressure measurements. API Standard 682 Fourth Edition describes changes in instrumentation used to monitor pump seal systems. This new edition now indicates a preference for continuous measurements using level and pressure transmitters versus the prior practice of using simple on-off switches.

In some applications, a pump may have a filter or a strainer. Installing a differential pressure sensor across the filter/strainer will indicate when maintenance is required. Instead of just manually checking pressure periodically, this signal can be monitored to show when the filter/strainer should be flushed or cleaned out, which will reduce excess strain on the pump by removing the flow restriction.

On larger pumps, there may be a lube system. If this is a pressurised lube system, a transmitter can be installed to ensure proper lube pressure is maintained. This is important so that process fluids in the pipeline do not contaminate the lube system. Lube level is another important measurement, and can be made with a level switch or transmitter.

Wireless sensors save

Wireless sensors are increasingly used in pump monitoring systems because they are easier to install, simpler to maintain, and much less costly to connect to control systems.

With traditional wired instruments, it's necessary to run either signal wiring for a loop-powered 2-wire instrument, or power and signal wiring for a 4-wire instrument. This new wiring is very costly to install, and many existing wiring drawings need to be updated. The signal wiring needs to be connected back to the control system, which can be very expensive, particularly if no spare I/O points are available.

By utilising wireless technologies, measurement points can be quickly deployed. No signal wiring is needed because measurement information is transmitted via a wireless mesh network, and no power wiring is needed because each wireless sensor includes its own power module.

Wireless sensors have advantages, but wired sensors are often used instead, particularly in real time control applications, and in pump installations with easy access to wiring infrastructure such as cable trays and wiring cabinets.

Benefits of pump monitoring

Outputs from these wired or wireless sensors are connected to control systems, either at the pump station or in a central control room. The sensors and control systems combine to provide a number of benefits:

- Reduces maintenance costs.
- Enables proactive maintenance.

- Facilitates regulatory compliance.
- Decreases environmental incidents.
- Improves safety.
- Reduces need for visits to the pump station.
- Provides troubleshooting information.
- Increases uptime.
- Optimises operation.

Maintenance costs are cut because it is no longer necessary to overhaul or perform maintenance on pumps on a periodic basis, or in response to a problem. Instead, pumps can be maintained only as needed, and with proactive rather than reactive scheduling.

API Standard 682 requires monitoring of pump seal systems, and other regulations also require varying types and levels of monitoring, all of which can be done more efficiently with instrumentation and control systems as opposed to manual methods.

Environmental incidents can be decreased because pumps and related systems can be continuously monitored for leaks, over pressure conditions and high temperatures. Some of these conditions, such as leaks, represent an immediate environmental issue – while others can indicate conditions leading to possible incidents.

Reducing incidents improves safety, and safety is also improved because fewer site visits are required to check conditions, which also cuts costs. Remote monitoring also provides information to aid troubleshooting, so that when site visits are required, technicians can arrive with the tools and parts in hand to perform required repairs.

All of the information gathered by sensors can be sent to a control system, where operators and engineers can use this data to increase uptime and optimise operation, particularly with respect to pump operation and flow measurement.

Flow measurement

Flow sensors close the loop on pump systems, as information from these devices is used to regulate the speed at which pumps run, and/or to modulate flow control valves. These sensors are installed at various points in the pipeline system starting at pump output, and continuing downstream to ensure proper flow is maintained throughout the pipeline. The most common type of flow sensors in pipeline systems are ultrasonic and coriolis.

Ultrasonic flowmeters use the transit times of high frequency sound pulses between a pair of transducers to determine fluid velocity. A transducer pair is positioned within a meter tube body to enable the pulses to be transmitted diagonal to the direction of the fluid flow (Figure 3). Each transducer alternates as a transmitter and a receiver, resulting in pulses being transmitted against and with the flowing fluid.

A pulse travelling with the flow traverses the pipe faster than the alternate pulse travelling against the flow, with the resulting time difference proportional to the velocity of the fluid. Relating this velocity to the known diameter of the meter tube results in a continuous inferred volume measurement.

Multi-path meters for pipeline custody transfer and pump efficiency tend to be more accurate since they collect velocity information in several points of the flow profile. Ultrasonic meters are typically considered because they are non-obstructive, have no moving parts, accommodate high volume applications, and are self-diagnosing.

Coriolis flowmeters are unique because they can measure either mass or volume flow, or both simultaneously (Figure 4).

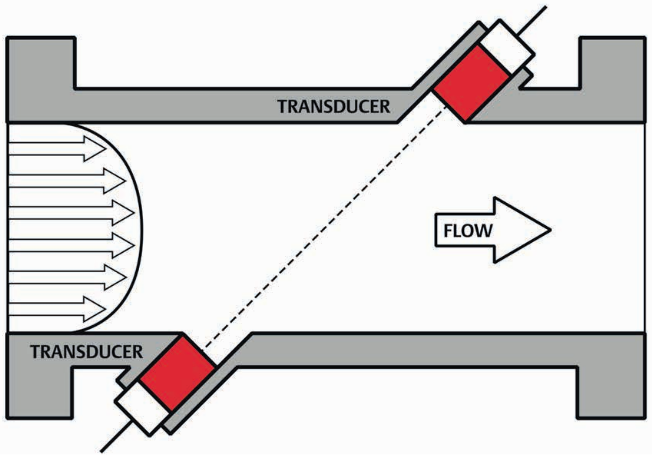

Figure 3. Ultrasonic instruments transmit and receive pulses diagonally across pipes to measure fluid flow.

Figure 4. The gray U-tube design of each of these two micro motion coriolis meters are clearly visible at this pipeline receiving station for a major storage terminal in Cushing, Oklahoma.

Coriolis meters are well known for accurate and long-term measurement stability under varying process conditions. They are able to measure different fluids including both liquids and gases without the need for recalibration. Coriolis meters are not affected by flow profile, so no flow conditioning or straight runs are required. They have advanced diagnostic capabilities to verify meter accuracy in situ without interrupting normal operations.

For these and other reasons, coriolis meters are commonly chosen as custody transfer meters, and they are also often used in leak detection systems to avoid the risk of false alarms. Coriolis meters also measure density, a parameter often used for pipeline batch interface detection to optimise the control of divert valves and minimise the loss of good product to the slop tanks.

Flow management

The output from flow sensors is sent to control systems, with modern smart sensors employing high-speed two-way digital data links such as FOUNDATION™ Fieldbus or WirelessHART®. These links allow the control system to remotely calibrate the sensors, detect problems before they occur, and provide diagnostic information to aid in troubleshooting.

Smart sensors are particularly critical given the remote location of many pump stations and correspondingly infrequent maintenance visits. If a technician does need to visit the site, the diagnostic information provided by smart sensors to the control system will allow him or her to bring the needed tools and parts to complete a repair in one trip.

The control system uses the process variable information received from flow sensors to optimise pump operation. For example, a flow sensor installed near the output of a pump is typically used as the process variable input to a PID controller. The PID controller compares this input value to the desired setpoint, and adjusts pump speed or control valve position accordingly to maintain the flowrate at or near the setpoint.

Flow sensors installed downstream of pumping stations provide critical data to the control system, which is processed internally to yield actionable information to operators and engineers. For example, comparing flows at various points in the pipeline can show if a major leak has occurred. Flow data from downstream sensors can also be used to optimise pump operation, as it is often found that pump speed setpoints can be lowered while still maintaining sufficient flow – saving energy, reducing maintenance and increasing pump life.

Conclusion

Flow management of pipelines transporting liquid hydrocarbon products starts at the pumps, and continues throughout the pipeline system. Accurate and reliable measurement of various process parameters is required throughout the pumping and pipeline system. These measurements have traditionally been made using wired instruments, but wireless sensors are finding favour for monitoring key parameters, while wired solutions are still preferred for real time control applications.