Technical Publication

Protecting Cooling Towers From Fluid Delivery Pump Failures

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Oil refineries separate crude oil into a variety of feedstocks and final products through high pressure distillation processes, which require extremely high temperatures that can approach 750°F (400°C). As with any high temperature process, cooling is essential at oil refineries to protect their equipment from overheating conditions that can result in equipment failures or lead to potentially serious plant accidents..

The extremely high temperature, high pressure distillation process environments encountered in crude oil refining process plants require continuous cooling of the separation equipment with large cooling towers. These devices use water-based coolants for air evaporative cooling or employ various fluid coolants that are designed to dissipate heat.

Large cooling towers at oil refineries draw hot air into the cooling tower or move air with large fans across and around equipment. Their water-based coolant typically is recycled multiple times and is treated with corrosion-inhibiting chemicals that protect both the cooling system and the equipment being cooled. In addition to their use in petrochemical plants, such cooling towers are used in electric power generation plants and other industrial processes including chemicals, food and beverage.

Cooling System Fluid Pumps

Whatever type of active cooling system is in use at a refinery, they all have several things in common. One of them, however, is essential for safety and throughput. Pumps are required to move the water or coolant fluid into the cooling tower. If a pump fails to move or replace the fluid into the cooling system — or fails to recycle the fluid into the system — then equipment cooling is affected. Similar to the way a leaky car radiator stops functioning, if the driver (or, in this case, the plant control system or operator) sees the temperature gauge climbing fast, it is time to pull over and turn off the engine to avoid damage.

Dry running a pump means operating the pump with no liquid. Some pumps such as screw-style or rotary-lobe pumps can tolerate dry running; centrifugal pumps cannot be run dry. These pumps depend on the pumped liquid to cool the components. When run with insufficient or no liquid, excessive heat can result in damage to the pump seals, bearings, impeller and shaft. The cost of replacement parts can quickly add up to thousands of dollars — and double that amount when adding in maintenance work on the pump.

Figure 1: A thermal flow switch can measure both a low flow condition and a lack of flow with dual-alarm capacity.

One of the typical causes of dry-running pump failures in any application, including refinery cooling systems, is a failure of the fluid-delivery system. A broken valve or clogged pipe are two common causes of this issue.

If there is any good news when it comes to pump dry-running conditions, it is that in many cases, there can be an early warning signal: Flow is reduced due to broken valves, clogging pipes or other causes. The challenge is to detect the reduced flow at the pump before the flow stops altogether.

When the cooling system fails in an oil refinery because of a coolant pump operational issue, immediate action is required by the process control system to begin a safe, gradual shutdown for emergency maintenance. These types of unplanned maintenance shutdowns can be dangerous and time-consuming, requiring a plant or operational unit restart. After safety issues, unplanned downtime is perhaps the number two enemy of all industrial processes.

How To Prevent Dry Pumping

Pump manufacturers and engineers have recommended various ways to monitor for loss of flow. Power monitors, for example, measure the current draw of the pump's motor to indicate that the pump is running dry and signal for it to turn off. Similarly, the drive-shaft torque can be measured and used to shut off the pump if there is no resistance.

While these methods reliably measure over- or underloaded conditions, they rely on measuring how the pump is functioning and not what is actually in the pump. The alarm and shutoff could occur only after the pump has started to run dry, and the pump could still be damaged.

One potential solution — a pressure switch — measures a reduction in head, which indicates the pipe is emptying. They are effective at shutting off the pump before dry conditions. Because the process flow could have changes in pressure regardless of flow, however, pressure switches may not fully protect the pump from dry running.

Another potential solution is a flow switch. Flow switches can be installed in piping upstream of the pump to allow time for shutdown before a dry-pump condition is reached. They can determine whether there is any flow or whether the flow is above or below a predetermined setpoint.

Several types of flow switches are available. Mechanical flow switches such as paddle switches can be effective but they are sensitive to wear and corrosion damage. Ultrasonic flow switches do not have any moving parts and are easy to install. Their accuracy may drop at low flow rates, however, and pitting or fouling of the pipe can affect flow readings.

Thermal dispersion flow switches are another solution. One model, for example, can measure both a low flow condition and a lack of flow with dual-alarm capacity (figure 1). When flow reduces to a setpoint, it triggers an alarm. The operator can check the system and reset the flow switch after determining the cause of the problem. If the line runs dry, a second alarm rings, and the pump is immediately shut down.

Thermal Flow Sensing Technology

Thermal flow switches frequently are installed in refinery cooling systems and chemical plant applications to protect pumps. Thermal flow switches do not have moving parts and offer a mean time between failure (MTBF) rating of 190 years.

A typical sensing element in a thermal flow switch contains two thermowell-protected platinum resistance temperature detectors (figure 2). One RTD is heated and the other RTD senses the process temperature. The temperature difference between the two RTDs is related to the process flow, level or interface medium. Higher flow rates or denser media cause increased cooling of the heated RTD and a reduction in the RTD temperature difference. In addition to measuring flow rate, thermal-type switches also can measure temperature and level.

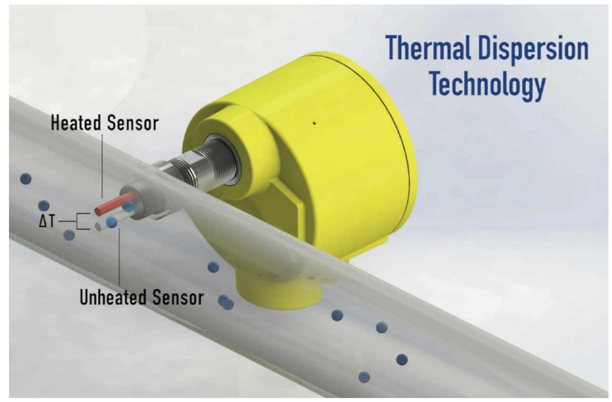

Figure 2: The thermal flow switch sensing element contains two thermowell-protected platinum resistance temperature detectors.

Thermal dispersion technology provides a flow switching approach that is accurate, responsive to changing flow conditions and relatively low maintenance. Because thermal flow switches do not have moving parts, parts cannot break nor can orifices plug or foul.

Accuracy and Repeatability. Users need to know the accuracy, repeatability and flow range of the flow switch they plan to use for pump protection in cooling systems or other applications. For example, one thermal flow switch operates over a liquid flow range from 0.01 to 3 ft/sec (0.003 to 0.9 m/sec), with an accuracy of 2 percent of the setpoint velocity over a 50°F (28°C) temperature range and repeatability of 0.5 percent of reading. Some high velocity liquid flow switches can serve in applications to 10 ft/sec (3 m/sec).

One thermal flow switch design is a dual-function instrument; it indicates flow, temperature and level sensing in a single device. Such a design allows the user to monitor key variables necessary to protect pumps with a single switch. Pipe or tube insertion or inline styles accommodate different installation conditions.

Temperature Compensation. Thermal flow switches are temperature compensated to ensure the accuracy of factory-preset and field-set alarms when installed in dynamic process applications such as those found in oil-and-gas refineries. The addition of temperature compensation circuitry helps prevent false alarms or alarm failure, maximizes operator and process safety, and provides an option to set alarms within a narrow setpoint range.

A typical flow curve diagram illustrates how temperature-compensated flow switches will not experience signal drift during temperature changes caused by changing process conditions or seasonal environmental swings in temperature (figure 3). This helps prevent false alarms due to signal drift.

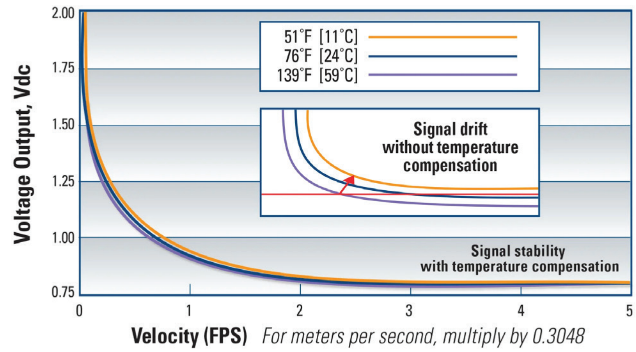

Figure 3: The flow curves provided illustrate how temperature-compensated flow switches will not experience signal drift caused by changing process conditions or seasonal temperature swings.

Plant and Process Environment. By considering a plant's environmental factors such as climate, process temperatures, humidity levels and process pressure, plant engineers find that some flow monitoring technologies are better in extreme environments. Look for a flow switch with a metal enclosure that is NEMA/IP rated for rugged outdoor applications. Some thermal flow switches, for example, are rated NEMA4X and EExd.

Installation and Maintenance. Some flow switches are easier to install. Ask if the flow switch can be inserted directly into the process pipe or if it requires an inline configuration. Of course, the size of the piping matters; remember that smaller diameter pipes — those below 1" diameter —may require the user to cut and splice the pipes in multiple places. Those measuring 1.5" diameter or larger typically can accept a direct-insertion switch. The thermal flow switch is inserted (or with a spool piece for smaller line sizes) into the line using a threaded or flanged process connection. Check the maintenance schedules as well. They will differ depending on the flow technology.

In Conclusion

when upgrading or expanding systems that require cooling in a refinery or other type of industrial application, think ahead about the type of flow switches that are needed to protect pumps and detect leaks. Consider the switch's reliability, accuracy, installation, maintenance requirements and service life when analyzing switch total lifecycle costs to determine the lowest cost of ownership.

By monitoring flow to prevent dry-run conditions, plant engineers can extend the life of their pumps. In addition to the cost savings, they can avoid non-compliance with regulatory limits. Operators will be happy to not come to work in the middle of the night. And most importantly, they can operate their processes safely without process cooling worries. ■