Flow monitoring in process cooling applications

Process cooling and refrigeration systems can consume too much energy from leaks and poor operation. Monitoring key parameters can identify problem areas and improve efficiency.

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Figure 1: Process cooling and refrigeration systems consume large amounts of energy. Installing flowmeters and other instrumentation helps analyze problems and find leaks

Cooling and refrigeration are required in all types of process industries. In this article, we'll look at ways to monitor flow (Figure 1) to improve efficiency and detect operating problems.

Process cooling systems

In direct cooling systems, the medium which requires cooling (air) is in direct contact with the evaporator. Examples include air conditioning, cooling chambers and cooling tunnels.

Indirect cooling systems use a secondary medium—a refrigerant—to transport cooling energy to the point of use. Examples include cooling down milk, beer, soup or chocolate using contact cooling with plates, dipping cooling methods or a heat exchanger.

In breweries, air coolers keep hops at a certain temperature. Direct cooling is done within production processes, such as preparing hops for fermentation or beer aging. Dairies also use direct cooling within processes such as pasteurization, yoghurt preparation, cream and butter processing.

The chemical industry use direct and indirect cooling for many different processes, such as separation of gases, condensation of gases, dehumidification of air, solidification of solute, storage as liquid at low pressure, removal of heat of reaction, and cooling for preservation.

The life science industry needs cooling systems for product cooling, preservation, cooling production tanks, cleaning stations and room cooling. Blood plasma and antibiotics are manufactured by freeze-drying process where water is made to sublime at low pressure and low temperature.

Refrigeration and cooling energy accounts for a huge proportion of overall energy costs in many industries. A small reduction in energy consumption can lead to significant cost savings. The first step in setting up an effective measurement program is knowledge about system characteristics at different operating conditions.

Need to know

Assuming that a plant engineer is familiar with cooling systems and knows what needs to be measured to obtain the necessary information, instruments and data acquisition systems can be employed. Such a measurement system will help determine:

- How efficient is the cooling system
- How efficient are each of the cooling compressors and pumps
- Are there any leakages within the cooling system
- What loads significantly affect cooling costs
- How to keep the cooling system at the ideal point of operation
- How to reduce start/stop cycles

Analyzing the performance of a cooling system also helps to:

- Benchmark efficiency of cooling systems compared to similar systems or industry values
- Determine the cost of refrigeration
- Assess a system's ability to meet added loads
- Quantify benefits of system modifications and improvements
- Verify predicted performance

Measurement requirements

Efficient refrigeration requires more than efficient components—it depends mainly on system configuration and operation. As refrigeration systems are typically custom engineered for each application, individual analysis of the supply and demand side is necessary to find the ideal point of operation.

It's important to define the right measurements to help evaluate cooling system efficiency, system leakages and energy consumption.

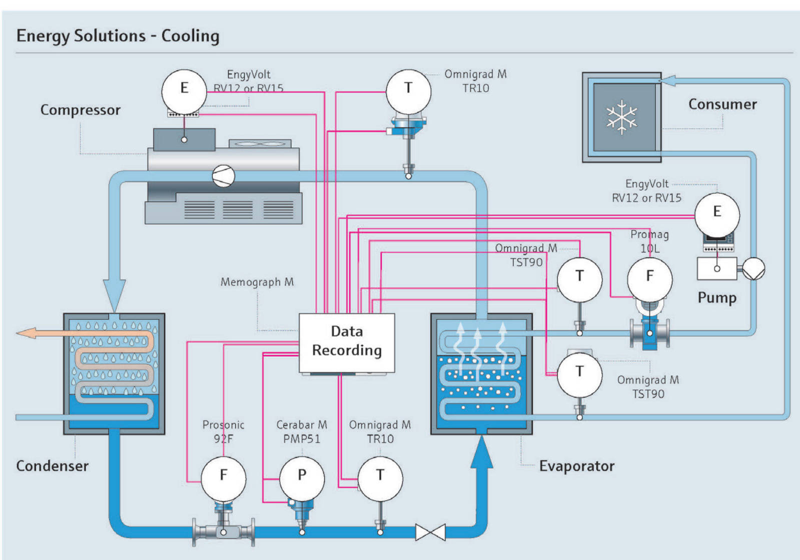

Figure 2: Typical cooling system and instrumentation. F = flow, P = pressure, T = temperature and E = electrical energy instruments

Typical measurements (Figure 2) needed on a cooling system include:

- Volume or mass flow (typically after condenser; i.e., in liquid phase)
- Temperature in liquid line (after condenser and before expansion valve)
- Temperature in gas line (after evaporator)
- Electrical power consumption of compressor, fans, pumps
- Pressure at condenser outlet, before expansion valve
- Pressure at evaporator outlet

Making Measurements

Flow measurements in a cooling system typically are made:

- Flow in liquid line, temperature of liquid, temperature of gas, and pressure of gas and liquid to calculate cooling energy flow in primary circuit
- Flow and temperature in feed line, and temperature in return line to calculate cooling energy flow in secondary circuit (e.g., cold water)
- Flow and temperature in feed line, and temperature of return line at consumers

For flow metering in a primary refrigerant circuit, an ultrasonic flowmeter is recommended as there is virtually no pressure drop. Other types of flowmeters can cause a pressure drop which can lead to problems in the system. A clamp-on ultrasonic flowmeter works very well.

In some cases a vortex flowmeter can be used. It's important to ensure the wetted materials are selected properly for use with refrigerants such as NH_3.

For flow metering a heat transfer medium such as water, almost any flowmeter will work, including electromagnetic, Coriolis mass flow and differential pressure devices.

In indirect cooling, measurement of the flow rate of a coolant such as glycol in a secondary cooling circuit in the return line after a consumer may be needed. This measurement along with the temperature differential can be used to calculate the cooling efficiency.

Other measurements needed include:

- Electrical energy consumption of the compressor (including fans)
- Heat input of absorption chiller
- Electrical energy consumption of pumps in the distribution system
- Pressure of cooling fluid and process fluid at various points throughout the system to ensure there are no leaks and thus ensure system integrity

Processing the Data

Acquiring the data requires installing instrumentation on the various components in a cooling system. Processing the data requires specialty software that can either be developed by the plant or an outside expert, or is available in a data acquisition system such as the Endress+Hauser Memograph M RSG45 Data Manager, a data-acquisition system for small process-control applications.

Figure 3: A small data acquisition system, such as the Endress+Hauser Memograph M with built-in cooling system software, can calculate and display vital trends and results

The Memograph M adapts quickly and easily to every cooling system application. Measured process values are clearly presented on the display and logged safely, while limits are monitored and analyzed. Via common communication protocols, the measured and calculated values can be easily communicated to higher-level systems and individual plant modules can be interconnected.

The Memograph M comes with an energy package for glycol-based refrigerant media. By comparing input variables such as flow, electrical energy and pressure, users can calculate overall balances, efficiency levels etc. These values are important indicators for the quality of the process and form the basis for process optimization and maintenance.

Summary

Installing instrumentation on process cooling and refrigeration systems and then processing the data with specialized software will help plant operators and maintenance people find problems, such as leaks. Analysis of the data can also calculate load factors, detect peaks in demand, reduce start/stop cycles or run the system at the most efficient time.

About the Author

Ravi Jethra has more than 20 years of experience with instrumentation. He holds an MBA from Arizona State University and a BS in instrument engineering from the University of Bombay. In 2010, following five years of service as Product Manager for Temperature & Data Acquisition, Ravi became the Industry Manager for Power & Energy for Endress+Hauser. In this capacity, he leads marketing, project pursuit and business development for the U.S. power generation and renewables market including biofuels and energy efficiency products.

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