How to Size Your Chiller

Full range heating and cooling systems can effectively control process temperatures to achieve higher quality end products.

Selecting a heating and cooling system that will operate at peak performance and meet processing goals can be simple — if you pay attention to details.

By Robert Kennery, Mokon

Today's fast-paced manufacturer is continuously minimizing and eliminating underperforming equipment and rethinking "on the floor" process engineering decisions made in the past. Effective selection and sizing of the heating and cooling system for molds, dies, pipes, tanks, mixers and reactors can make a significant difference in reducing startup waste, achieving higher quality and increasing output and profitability.

Collecting the application details to calculate chiller size is a crucial element to achieve accurate process temperature control. Never assume that a comparable existing installation has been effectively sized and that the proper heating and cooling system has been designed to deliver the product quality and throughput management you're looking for.

While your end product may differ, consider an example that can illustrate the principles to apply. In this case — a chemical mixing company with a jacketed vessel, or double-walled tank — the process and calculations used are typical of many process applications.

The company previously had used an aging central hot water boiler and chiller to meet their manufacturing needs. The company had tapped into the two systems to try to regulate the temperate of the chemicals. Unfortunately, new market demands and stricter statistical recordkeeping requirements dictated a more precise level of temperature control that the old central systems had difficulty delivering.

Older individual heating and chilling units can fall short in efforts to accurately control process temperatures, and they rarely have programmable electronic controls and other features. This jacketed vessel application was well suited for a heating and cooling system that could effectively control the process temperatures to the specific sequenced intervals necessary to develop the end product.

This chemical company elected to use water and a small percentage of ethylene glycol as the heat transfer medium to be circulated through the jacketed wall. The inhibited glycol both acted as a biocide and provided a level of freeze protection in the event of an unexpected drop in temperature, thereby eliminating a potential freezeup scenario.

Remember that when using glycols, allowances must be made in heating and cooling load calculations because glycol inhibits the ability of water to transfer heat as efficiently. The amount of glycol in the system will derate the system's heating and cooling capabilities depending on the percentage of glycol mixed into the water.

The company wanted the new system to tightly control the process temperatures, so a stainless steel fluid thermocouple was used and remote control capabilities were selected. This allowed the operation of the new system to be integrated into the chemical company's computer-controlled auto-

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- Chiller Features to Consider
  Modern temperature control system offer features that can provide the level of control you need in your process.

Figure 1. Process Specifications

Weight of Vessel	200 lb
Vessel Material	Steel with a specific heat value of 0.122 BTU/lb-°F
Starting Temperature	70°F (21°C)
High Process Temperature	190°F (88°C)
Ending Temperature	70°F (21°C)
Heatup Time	15 min
Cooldown Time	10 min
Specific Heat of Product	0.78 BTU/lb-°F
Weight of Product Being Manufactured	25 lb
Temperature Difference (ΔT)	120°F (49°C)
Volume of Water/Glycol in Jacket	10 gal

The calculations for heating/cooling based on the data provided, where:

Heat Required = Weight x Specific Heat x Temperature Differential

$Q = W \times C_P \times \Delta T$

$Q_{VESSEL} = 200 \text{ lb} \times 0.122\ C_P \times 120°F = 2{,}928 \text{ BTU}$

$Q_{JACKET} = [10 \text{ g} \times 8.34 \text{ lb/g}] \times 1\ C_P \times 120°F = 10{,}008 \text{ BTU}$

$Q_{MATERIAL} = 25 \text{ lb} \times 0.78\ C_P \times 120°F = 2{,}340 \text{ BTU}$

$Q_{TOTAL} = Q_{VESSEL} + Q_{JACKET} + Q_{MATERIAL}$

$Q_{TOTAL} = 15{,}276 \text{ BTU}$

The customer required a 15 minute heatup. To calculate that, take Q_{TOTAL} and divide that by 15/60, or 0.25 of an hour:

$$Q_{HEATING} = \frac{15{,}276}{0.25 \text{ hr}} = 61{,}104 \text{ BTU/hr}$$

To convert from BTUs to kilowatts, where 1 kW equals 3,412 BTUs, divide the BTUs by 3,412.

$$\frac{61{,}104}{3{,}412} = 17.9 \text{ kW}$$

mated manufacturing system. To aid them in this, the system was supplied with:

- Controller communications using a 4 to 20 mA remote setpoint and retransmission.
- Remote start/stop capabilities via a customer-supplied momentary signal.
- Run status indication to inform the customer remotely that the system was operating correctly.
- Alarm status function in case of a safety shutdown.

Because the insulated jacketed vessel was relatively small, the exothermic or endothermic reactions were minimal and not included in the heating and chiller loads calculation in figure 1.

Once the kilowatt requirements were established, surface losses from the temperature control unit must be considered for operating temperatures above 200°F (93°C). (Below 200°F, losses generally are negligible.) This is a function of the surface temperature of uninsulated components and piping, the materials of construction of the components and piping, the ambient temperature, and the circulating fluid temperature.

When required, multiply the heat loss per square foot by the surface area to get total watts at the desired operating temperature. Convert it to kilowatts and add it to process requirement.

Additionally, a safety factor should be added to the final calculation for assurances of coverage for unexplainable items not previously considered.

A combination heater/chiller with all stainless steel cabinetry can be used in a cleanroom environment.

Once the requirements were calculated, the temperature control system manufacturer recommended a 21 kW heater. This size unit accounted for system surface losses and derating due to 15 percent glycol/water mix. It also took into account any line losses due to uninsulated, exposed surfaces outside of the temperature control system.

The customer also required cooling the product in 10 minutes.

$Q_{COOLING} = 15{,}276 / 0.166 \text{ hr}$

$Q_{COOLING} = 92{,}024 \text{ BTU/hr}$

Because 1 ton of cooling equals 12,000 BTUs, and to account for derating due to the glycol, the manufacturer determined that the most appropriate selection was a 10-ton chiller design.

While the chemical company's specifications may not match yours, the process of calculating heating and cooling requirements is universal. So, if you need both heating and cooling for effective process control, consider a temperature control system. **PC**

Robert Kennery is vice president of sales and marketing at Mokon, Buffalo, N.Y., a manufacturer of process heating and cooling equipment. For more information, call (716) 876-9951 or visit www.mokon.com.