A chiller is a heat-transfer device that uses mechanical refrigeration to remove heat from a process load and transfers the heat to the environment. Chillers are used by plastics processors when they need a lower process fluid temperature than a simpler system, such as an evaporative cooling tower, can provide.

Chillers are designed to ensure a continuous flow of coolant to the cold side of a process water system at a desired “leaving water temperature” or LWT of about 50°F (10°C). The coolant is then pumped through the process, extracting heat out of molds and machinery as it flows back to the return side of the process water system. The coolant flow, now at an elevated “entering water temperature” or EWT (5 to 10 degrees warmer than LWT), then re-enters the chiller, which does three things:

• it captures the heat from process coolant,
• it transfers the captured heat out to the environment, and
• it lowers the temperature of the coolant to the desired LWT, making it ready for re-circulation.

HOW DOES A CHILLER WORK?
A chiller is a vapor compression mechanical refrigeration system that connects to the process water system through a device called an evaporator. See Figure 1. The evaporator is a heat exchanger in which heat captured by the process coolant flow is transferred to the flow of refrigerant fluid. As the heat-transfer takes place, the refrigerant evaporates, changing from a low-pressure liquid into vapor, while the temperature of the process coolant is reduced down to the desired LWT.

Next, the refrigerant flows to a compressor, which performs two functions. First, it removes refrigerant vapor from the evaporator and ensures that the pressure in the evaporator refrigerant line (vapor pressure) remains low enough to absorb process heat at the correct rate. Second, it raises the pressure in outgoing refrigerant vapor to ensure that its temperature is high enough to release its heat when it reaches the condenser, where the refrigerant returns to a liquid state.

The latent heat given up as the refrigerant changes from vapor to liquid is carried away to the environment by a cooling medium (air or water). Thus, there are two types of condensers: air-cooled and water-cooled.

• Air-cooled condensers resemble the “radiators” that cool automobile engines. They use a motorized blower to force air across a grid of refrigerant lines. Unless they are specially design for high-ambient conditions, air-cooled condensers require ambient temperatures of 95°F (35°C) or below to operate effectively.
• Water-cooled condensers perform the same function as air-cooled condensers, but require two steps, rather than one, to complete heat transfer. First, heat moves from refrigerant vapor into the condenser water. Then the warm condenser water is pumped to a cooling tower where the process heat is ultimately discharged to the atmosphere.

AIR-COOLED OR WATER COOLED?
If minimizing operating costs is of paramount concern and the processor can invest in systems and facilities for a long period, a water-cooled chiller system may well be the best.
choice. The condenser cooling provided by tower-water is less costly than the electrically driven fan used on an air-cooled system. In fact, tower water cooling can actually be used in place of chiller cooling during cold weather or if process-water temperatures below 85°F (29°C) are not required. However, water cooling involves a higher initial investment, since these systems require both a chiller and a circulating tower system, which in turn will require additional pumps, piping, and tanks. In addition, all water-cooling systems will consume significant amounts of water due to evaporation, purging, and bleeding. If water cost, quality and conservation are of concern, an air-cooled chiller may be the better choice.

Air-cooled chillers cost significantly less per ton than water-cooled systems primarily because they require fewer components to build and operate, and require less support equipment and plumbing. Installation of an air-cooled chiller is faster and easier than that of a water-cooled chiller. Installation of an air-cooled chiller requires three things: a chiller location, electrical service, and process water pump and piping connections. While central air-cooled chillers are typically located outside, most portable air-cooled chillers are indoors and send a stream of warm air directly from the condenser fan to the plant floor. This may be undesirable except during cool weather when the warm airflow produced by the condenser fan can supplement a plant’s space heating system. Where chiller space is limited or ambient temperatures are high, air-cooled condensers can be located outdoors, remote from the main chiller, to conserve space or improve condenser performance.

PORTABLE CHILLERS & CENTRAL CHILLERS

There are two types of chillers: portable chillers and central chillers. Portable chillers are typically smaller in capacity (30 tons or less), simpler in overall design, and lower in installed cost. Equipped with caster wheels, they are easy to move, easy to connect (using flexible hoses), and easy to power up. Their greatest benefit may be that they provide a convenient, “plug and play” capability when and where they’re needed.

Portable chillers are designed and optimized to deliver a fixed amount of heat-transfer capacity, usually for a single piece of processing equipment or work cell. They incorporate a single circuit, or zone, that handles heat transfer. They are well suited for use on processes where the loading remains consistent, day after day, and operate most efficiently when the process load is closely matched to the chiller’s rated capacity.

Central chillers are generally larger in capacity, more complex in design, and higher in installed cost. The key advantage of a central chiller system is the ability to offer flexibility in handling varying process loads at a lower electrical consumption while taking advantage of the process diversity to handle the load with less overall tonnage. Central chillers can reduce their capacity to match the changing production loads to operate at lower costs, and higher operating efficiency than a group of portable chillers with the same total capacity.

However, obtaining the substantial, long-term savings available by using a central chiller system requires a significantly greater up-front investment. A central chiller not only requires more complex controls, automation, and instrumentation in order to operate, but also a greater amount of dedicated plumbing to circulate coolant throughout the plant. Both types, however, require maintenance to keep the equipment healthy.

The key to deciding which is best is the overall processing mix in a plant. As a rule, if 80% or more of a plant’s materials are processed within a ±5°F temperature range, a central chilling system will meet the need while requiring less operating tonnage, less floor space, and likely less daily maintenance than numerous portable units. If, on the other hand, the materials processed have widely different temperature requirements, properly sized portable chillers may be more effective. Or, the central system can be designed to handle all but the lowest temperatures, with portable chillers used for the special temperature requirements.

Clearly, there are many issues and factors to understand and consider before deciding on a heat transfer solution for a plastics processing plant. A competent and trusted equipment team member can help clarify and quantify plant requirements and also sort out subjective factors and intangibles that can drive a final decision.