How to leverage heat recovery in your industrial refrigeration system

Many organizations seek ways to reduce costs and implement more sustainable practices within their operations.

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Incorporating heat recovery into facility systems can help to conserve resources such as water and power. And one place that heat recovery can be incorporated is in an industrial refrigeration system.

Typically, a facility's refrigeration system is a stand-alone system, operating separately from the water system. And each of those two systems has its own design. But with a little planning, these normally separate systems can be integrated in a way that can help to save energy costs.

Using both the refrigeration and utility systems to recover heat can lower energy consumption and its associated costs. For example, any heat recovered from the systems can be used to heat water. Although every system and installation are different, for those systems that this can be accomplished with, not only does it help to reduce the energy that is typically used to heat the water, but it also can help to reduce water usage when a system doesn't have to heat as much water. This is especially relevant in areas of the country where water costs are higher.

Understanding the system design

Before making a plan to recover heat from your industrial refrigeration system, it's important to first generally understand the various components of such a system, which includes the compressor, condenser and evaporator.

A compressor takes refrigerant from a lower pressure and compresses it to a higher pressure. That compression process requires energy. Compressing the refrigerant will significantly increase its temperature as well.

From there, the vapor is changed from a super-heated gas to a liquid. To achieve this, the heat that was added in during the compression process must be removed. Heat removal from the compression is accomplished via the condenser.

Then, the condenser liquid goes to some type of evaporator and is changed from a saturated liquid back into a saturated vapor. The vapor then returns to the compressor, where the whole cycle is repeated. (See Figure 1 for a representation of the basic system.)

Typical refrigeration system diagram

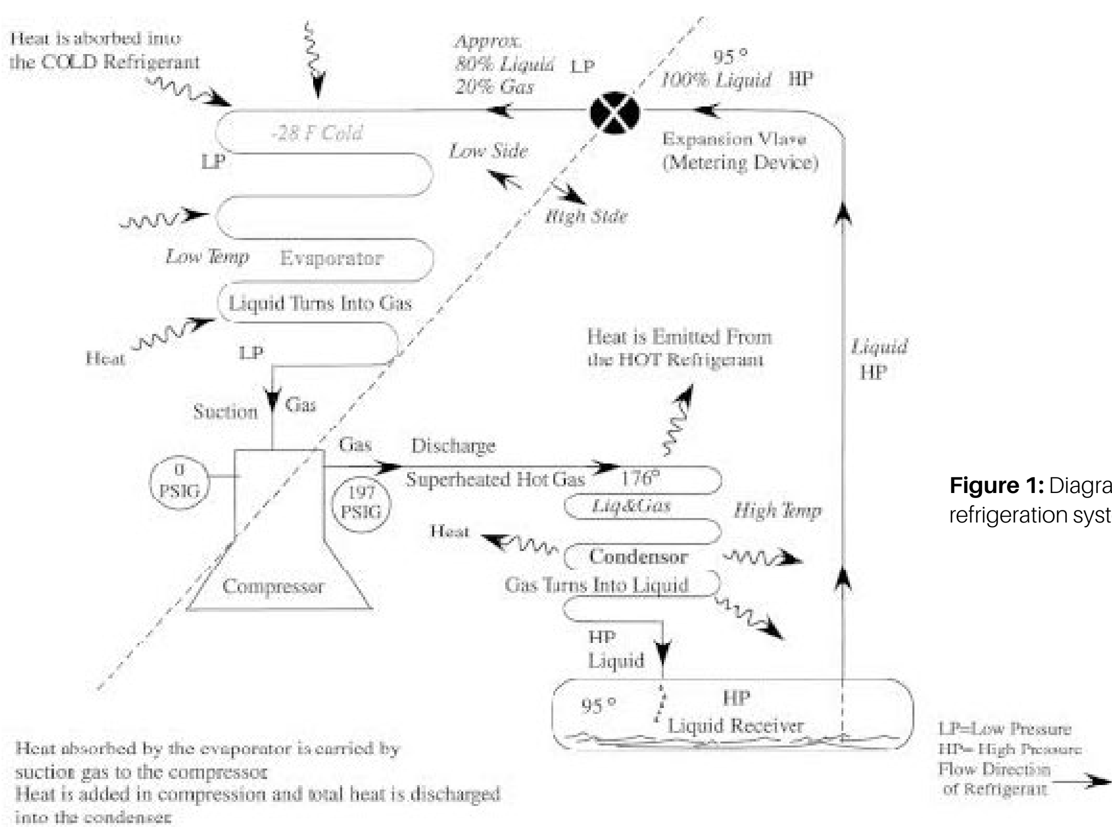

Figure 1: Diagram of a typical refrigeration system

Why the type of compressor matters

There are many types of compressors on the market, including scrolls, discus, reciprocating and screw. For the purpose of this article, we will discuss screw compressors. There are two types of screw compressors: twin screw and single screw. Copeland manufactures single-screw compressors.

Most screw compressors require oil injection. They use a sizeable oil cooling system, i.e., the oil that is injected is used and then recovered in an oil separator. The oil goes through an oil cooler to cool it back down to a lower injection temperature, and then the oil gets injected back into the compressor. By using a single-screw compressor, additional heat can be acquired for use elsewhere. (Figure 2 is an example of a single-screw compressor with a water-cooled oil cooler.)

Figure 2: A single-screw compressor with a water-cooled oil cooler

Recovering heat from a typical refrigeration system

Refrigeration systems produce condenser heat, super-heated vapor heat and oil heat; all of these heat types need to be removed from a system. In the most common system types, the super-heat and the change of state in the condenser are usually cooled by several methods.

The first cooling method is when an evaporative condenser blows air over a water-saturated coil. As the refrigerant flows through the coil, air and water remove the heat from the refrigerant and the state changes from a vapor to a liquid. Some of the water gets vaporized off, the air picks up heat, and it's discharged.

Another type of condenser cooling is through water cooling, where the water is brought in from a cooling tower or other source and then used to cool the gas and condense it. Water goes back up to a cooling tower or an air cooler to cool it back down (using more energy to cool down); then it returns to the condenser and continues that cycle.

A third cooling method is when refrigerant-cooled systems use some refrigerant and physically inject it (i.e., liquid injection) into the compressor to cool the oil and the discharge down but still need a condenser. The liquid cools down the oil but does nothing for the condenser.

When considering how the compressor works amid the process of cooling, a lot of heat within a basic screw compressor refrigeration system can be used elsewhere. How it's used can depend on the industry. Essentially, the easiest way to use the heat is to recover it to heat water, as most facilities have some need for hot water. For instance, many cold storage processing facilities have a need for hot water for wash-down and cleanup.

Heat recovery also can be utilized in ice rinks in the ice melting pits. There, the ice that is scraped off the ice rink by a Zamboni goes into the pits, then hot water coils are used to melt the ice.

Some processing plants and cold storage facilities need warm glycol/water to heat a coil under the freezer floor. This is typically done to prevent subgrade soils from freezing and the resulting concrete damage (i.e., heaving and cracking) and ice patches; the practice can also enhance worker safety. Doing this keeps the temperature of the subgrade soil and floor space just above freezing.

Design the system to use the heat

For facilities that want to use the heat from a basic screw compressor refrigeration system for the previously mentioned applications, there are multiple ways to design an industrial refrigeration system to employ heat recovery, but some extra equipment may be needed.

For a new system, first determine its hot water requirements and see if refrigeration waste heat can be utilized in the hot water system. In both new and existing systems, the system would have to be designed for this expansion. For instance, some type of water system would be needed, as would a storage tank and a pump to bring in water. Then, the water would need to be pumped out to the heat source and returned to the hot water storage tank.

An existing system may need a retrofit to recover this heat. It can be done but may require repiping, new equipment, or a change in condenser type and heat exchangers. This can be a bigger undertaking than when applied to a new system, but it may be worth the effort if a facility has extremely high energy costs.

There are several other factors that should be evaluated in order to recover heat. These include the type of refrigerant, refrigerant parameters and the net result of heat recovery versus how much heat is being created. This type of evaluation should be conducted by a qualified consultant who can evaluate the refrigeration and water systems to determine the viability of the project.

For example, that consultant might first evaluate the type of refrigerant. If ammonia is used in the system, it may be suggested that an intermediary system is needed, and precautions should be taken to prepare for a potential exchanger leak. The ammonia should not get into the water, so it's advisable to install a water heat exchanger. This may provide a drop in efficiency but is nonetheless a good precaution. If there are worries about ammonia potentially getting into the hot water system, an additional heat exchanger should be installed. It's possible to incur more capital costs with an ammonia system, but it's important to take preventive measures so the ammonia and water cannot mix.

Second, more heat can be generated by elevating the refrigeration system parameters upfront. When weighing this option, a consultant may suggest you consider how important energy recovery is. When raising the condensing temperature, higher discharge and water temperatures are achieved. But to do that, more energy will go into the compressor, so it's important to make sure that the energy recovered is worthwhile. In some U.S. areas, if the electricity cost is more than the cost of natural gas, then that may not be a good option. But in other areas of the country, if electricity costs are relatively low and using propane or natural gas is the same cost or higher, it may make sense to generate more heat with the compressor than what is normally done.

Depending on the type of condenser—for instance, in an evaporative system—water is already being wasted. More water is utilized for cooling than is used in a hot water system. So by employing heat recovery in this situation, the plant's water consumption can be significantly reduced by heat recovery.

Additionally, all these items—including the condenser and oil coolers on the compressors—use some type of energy and more water that has to be pumped through. Pump- and electric-driven fans are also parts of evaporative systems; air-cooled systems have electric-driven fans. So by utilizing the water from the system for heat recovery, energy costs can be reduced because not as much energy is required to heat the water. Not only is energy reduced in the refrigeration system, but the energy needed to heat the water is also reduced.

When evaluating energy use and the potential equipment costs to reroute water, heat recovery from industrial refrigeration can prove to be an effective way for a facility to reduce its energy costs.

About Vilter

Vilter compressors and packaged systems offer energy-efficient, environmentally conscious solutions for the industrial refrigeration and gas compression industries. Copeland's Vilter line includes technologically advanced single-screw compressors as well as reciprocating compressors sold globally through a vast network of aligned contractors and integrators. For more information, visit **Copeland.com/en-us/brands/vilter**

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