Chillers – the main characteristics and types

Science, Chemistry

A chiller is a machine that removes heat from a liquid via a vapor-compression or absorption refrigeration cycle. A vapor-compression water chiller comprises the 4 major components of the vapor-compression refrigeration cycle (compressor, evaporator, condenser, and some form of metering device). These machines can implement a variety of refrigerants. Adsorption chillers use municipal water as the refrigerant and benign silica gel as the desiccant.

Absorption chillers utilize water as the refrigerant and rely on the strong affinity between the water and a lithium bromide solution to achieve a refrigeration effect. Most often, pure water is chilled, but this water may also contain a percentage of glycol and/or corrosion inhibitors; other fluids such as thin oils can be chilled as well. Contents [hide] 1 Use in air conditioning 2 Use in industry 3 Vapor-Compression ChillerTechnology4 How Adsorption Technology Works 5 How Absorption Technology Works 5. 1 Industrial chiller technology Industrial chiller selection 7 Refrigerants 8 See also 9 References 10 External links [edit] Use in air conditioning In air conditioning systems, chilled water is typically distributed to heat exchangers, or coils, in air handling units, or other type of terminal devices which cool the air in its respective space(s), and then the chilled water is re-circulated back to the chiller to be cooled again. These cooling coils transfer sensible heat and latent heat from the air to the chilled water, thus cooling and usually dehumidifying the air stream.

A typical chiller for air conditioning applications is rated between 15 to 1500 tons (180, 000 to 18, 000, 000 BTU/h or 53 to 5, 300 kW) in cooling capacity. Chilled water temperatures can range from 35 to 45 degrees Fahrenheit or 1.

5 to 7 degrees Celsius, depending upon application requirements. [1] [2] [edit] Use in industry In industrial application, chilled water or other liquid from the chiller is pumped through process or laboratory equipment. Industrial chillers are used for controlled cooling of products, mechanisms and factory machinery in a wide range of industries.

They are often used in the plastic industry in injection and blow molding, metal working cutting oils, welding equipment, die-casting and machine tooling, chemical processing, pharmaceutical formulation, foodand beverage processing, paper and cement processing, vacuum systems, X-ray diffraction, power supplies and power generation stations, analytical equipment, semiconductors, compressed air and gas cooling. They are also used to cool high-heat specialized items such as MRI machines and lasers, and in hospitals, hotels and campuses.

The chillers for industrial applications can be centralized, where each chiller serves multiple cooling needs, or decentralized where each application or machine has its own chiller. Each approach has its advantages. It is also possible to have a combination of both central and decentral chillers, especially if the cooling requirements are the same for some applications or points of use, but not all. Decentral chillers are usually small in size (cooling capacity), usually from 0. 2 tons to 10 tons. Central chillers generally have capacities ranging from ten tons to hundreds or thousands of tons.

Chilled water is used to cool and dehumidify air in mid- to large-size commercial, industrial, and institutional (CII) facilities. Water chillers can be either water cooled, air-cooled, or evaporatively cooled. Water-cooled chillers incorporate the use of cooling towers which improve the chillers' thermodynamic effectiveness as compared to air-cooled chillers. This is due to heat rejection at or near the air's wet-bulb temperature rather than the higher, sometimes much higher, dry-bulb temperature.

Evaporatively cooled chillers offer efficiencies better than air cooled, but lower than water cooled. Water cooled chillers are typically intended for indoor installation and operation, and are cooled by a separate condenser water loop and connected to outdoor cooling towers to expel heat to the atmosphere. Air Cooled and Evaporatively Cooled chillers are intended for outdoor installation and operation. Air cooled machines are directly cooled by ambient air being mechanically circulated directly through the machine's condenser coil to expel heat to the atmosphere.

Evaporatively cooled machines are similar, except they implement a mist of water over the condenser coil to aid in condenser cooling, making the machine more efficient than a traditional air cooled machine. No remote cooling tower is typically required with either of these types of packaged air cooled or evaporatively cooled chillers. Where available, cold water readily available in nearby water bodies might be used directly for cooling, or to replace or supplement cooling towers. The Deep Lake Water Cooling System in Toronto, Canada, is an example.

It dispensed with the need for cooling towers, with a significant cut in carbon emissions and energy consumption. It uses cold lake water to cool the chillers, which in turn are used to cool city buildings via a district cooling system. The return water is used to warm the city's drinking water supply which is desirable in this cold climate. Whenever a chiller's heat rejection can be used for a productive purpose, in addition to the cooling function, very high thermal effectivenesses are possible. [edit] Vapor-Compression Chiller Technology

There are basically four different types of compressors used in vapor compression chillers: Reciprocating compression, scroll compression, screw-driven compression, and centrifugal compression are all mechanical machines that can be powered by electric motors, steam, or gas turbines. They produce their cooling effect via the " reverse-Rankine" cycle, also known as 'vapor-compression'. With evaporative cooling heat rejection, their coefficients-of-performance (COPs) are very high and typically 4. 0 or more. In recent years, application of Variable Speed Drive (VSD) technology has increased efficiencies of vapor compression chillers.

The first VSD was applied to centrifugal compressor chillers in the late 1970s and has become the norm as the cost of energy has increased. Now, VSDs are being applied to rotary screw and scroll technology compressors. [edit] How Adsorption Technology Works Adsorption chillers are driven by hot water. This hot water may come from any number of industrial sources including waste heat from industrial processes, prime heat from solar thermal installations or from the exhaust or water jacket heat of a piston engine or turbine. The principle of adsorption is based on the interaction of gases and solids.

With adsorption chilling, the molecular interaction between the solid and the gas allow the gas to be adsorbed into the solid. The adsorption chamber of the chiller is filled with solid material, silica gel, eliminating the need for moving parts and eliminating the noise associated with those moving parts. The silica gel creates an extremely low humidity condition that causes the water refrigerant to evaporate at a low temperature. As the water evaporates in the evaporator, it cools the chilled water. The use of a benign silica gel desiccant keeps the maintenance costs and operating costs of adsorption chillers low. edit] How Absorption Technology Works Absorption chillers' thermodynamic cycle are driven by heat source; this heat is usually delivered to the chiller via steam, hot water, or combustion. Compared to electrically powered chillers, they have very low electrical power requirements - very rarely above 15 kW combined consumption for both the solution pump and the refrigerant pump. However, their heat input requirements are large, and their COPs are often 0. 5 (single-effect) to 1. 0 (double-effect). For the same tonnage capacity, they require much larger cooling towers than vapor-compression chillers.

However, absorption chillers, from an energy-efficiency point-of-view, excel where cheap, high grade heat or waste heat is readily available. In extremely sunny climates, solar energy has been used to operate absorption chillers. The single effect absorption cycle uses water as the refrigerant and lithium bromide as the absorbent. It is the strong affinity that these two substances have for one another that makes the cycle work. The entire process occurs in almost a complete vacuum. 1. Solution Pump – A dilute lithium bromide solution is collected in the bottom of the absorber shell.

From here, a hermetic solution pump moves the solution through a shell and tube heat exchanger for preheating. 2. Generator – After exiting the heat exchanger, the dilute solution moves into the upper shell. The solution surrounds a bundle of tubes which carries either steam or hot water. The steam or hot water transfers heat into the pool of dilute lithium bromide solution. The solution boils, sending refrigerant vapor upward into the condenser and leaving behind concentrated lithium bromide. The concentrated lithium bromide solution moves down to the heat exchanger, where it is cooled by the weak solution being pumped up to the generator. . Condenser – The refrigerant vapor migrates through mist eliminators to the condenser tube bundle. The refrigerant vapor condenses on the tubes. The heat is removed by the cooling water which moves through the inside of the tubes. As the refrigerant condenses, it collects in a trough at the bottom of the condenser. 4. Evaporator – The refrigerant liquid moves from the condenser in the upper shell down to the evaporator in the lower shell and is sprayed over the evaporator tube bundle. Due to the extreme vacuum of the lower shell [6 mm Hg (0. kPa) absolute pressure], the refrigerant liquid boils at approximately 39°F (3. 9°C), creating the refrigerant effect. (This vacuum is created by hygroscopic action - the strong affinity lithium bromide has for water - in the Absorber directly below.) 5. Absorber – As the refrigerant vapor migrates to the absorber from the evaporator, the strong lithium bromide solution from the generator is sprayed over the top of the absorber tube bundle. The strong lithium bromide solution actually pulls the refrigerant vapor into solution, creating the extreme vacuum in the evaporator.

The absorption of the refrigerant vapor into the lithium bromide solution also generates heat which is removed by the cooling water. The now dilute lithium bromide solution collects in the bottom of the lower shell, where it flows down to the solution pump. The chilling cycle is now completed and the process begins once again. [edit] Industrial chiller technology Industrial chillers typically come as complete packaged closed-loop systems, including the chiller unit, condenser, and pump station with recirculating pump, expansion valve, no-flow shutdown, internal cold water tank, and temperature control.

The internal tank helps maintain cold water temperature and prevents temperature spikes from occurring. Closed loop industrial chillers recirculate a clean coolant or clean water with condition addititives at a constant temperature and pressure to increase the stability and reproducibility of water-cooled machines and instruments. The water flows from the chiller to the application's point of use and back. If the water temperature differentials between inlet and outlet are high, then a large external water tank would be used to store the cold water.

In this case the chilled water is not going directly from the chiller to the application, but goes to the external water tank which acts as a sort of " temperature buffer. " The cold water tank is much larger than the internal water tank. The cold water goes from the external tank to the application and the return hot water from the application goes back to the external tank, not to the chiller. The less common open loop industrial chillers control the temperature of a liquid in an open tank or sump by constantly recirculating it. The liquid is drawn from the tank, pumped through the chiller and back to the tank.

An adjustable thermostat senses the makeup liquid temperature, cycling the chiller to maintain a constant temperature in the tank. One of the newer developments in industrial water chillers is the use of water cooling instead of air cooling. In this case the condenser does not cool the hot refrigerant with ambient air, but uses water cooled by a cooling tower. This development allows a reduction in energy requirements by more than 15% and also allows a significant reduction in the size of the chiller due to the small surface area of the water based condenser and the absence of fans.

Additionally, the absence of fans allows for significantly reduced noise levels. Most industrial chillers use refrigeration as the media for cooling, but some rely on simpler techniques such as air or water flowing over coils containing the coolant to regulate temperature. Water is the most commonly used coolant within process chillers, although coolant mixtures (mostly water with a coolant additive to enhance heat dissipation) are frequently employed.
[edit] Industrial chiller selection

Important specifications to consider when searching for industrial chillers include the total life cycle cost, the power source, chiller IP rating, chiller cooling capacity, evaporator capacity, evaporator material, evaporator type, condenser material, condenser capacity, ambient temperature, motor fan type, noise level, internal piping materials, number of compressors, type of compressor, number of fridge circuits, coolant requirements, fluid discharge temperature, and COP (the ratio between the cooling capacity in RT to the energy consumed by the whole chiller in KW).

For medium to large chillers this should range from 3. 5-7. 0 with higher values meaning higher efficiency. Chiller efficiency is often specified in kilowatts per refrigeration ton (kW/RT). Process pump specifications that are important to consider include the process flow, process pressure, pump material, elastomer and mechanical shaft seal material, motor voltage, motor electrical class, motor IP rating and pump rating. If the cold water temperature is lower than -5°C, then a special pump needs to be used to be able to pump the high concentrations of ethylene glycol.

Other important specifications include the internal water tank size and materials and full load amperage. Control panel features that should be considered when selecting between industrial chillers include the local control panel, remote control panel, fault indicators, temperature indicators, and pressure indicators. Additional features include emergency alarms, hot gas bypass, city water switchover, and casters. [edit] Refrigerants A vapor-compression chiller uses a refrigerant internally as its working fluid.

Many refrigerants options are available; when selecting a chiller, the application cooling temperature requirements and refrigerant's cooling characteristics need to be matched. Important parameters to consider are the operating temperatures and pressures. There are several environmental factors that concern refrigerants, and also affect the future availability for chiller applications. This is a key consideration in intermittent applications where a large chiller may last for 25 years or more. Ozone depletion potential (ODP) andglobal warmingpotential (GWP) of the refrigerant need to be considered.

ODP and GWP data for some of the more common vapor-compression refrigerants: Refrigerant ODP GWP R-134a 0 1300 R-123 0. 012 120 R-22 0. 05 1700 R401a 0. 027 970 R404a 0 3260 R407a 0 ??? R407c 0 1525 R408a 0. 016 3020 R409a 0. 039 1290 R410a 0 1725 R500 0. 7 ??? R502 0. 18 5600 [edit] See also HVAC Cooling tower Evaporative cooling Chemical engineering Mechanical engineering Architectural engineering Building services engineering [edit] References ^ American Society of Heating and Refrigeration Enginneers http://www. ashrae. org/publications/page/158 ^ Hydronika supplies 5 ton chiller units http://hydronika. com