HEAT EXCHANGERS
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Heat Exchangers

Heat Exchangers are mechanical heat transfer devices that are used to cool and heat liquids and gases by passing them through a liquid or gas of another temperature. This occurs by way of a metal, conductive interface that keeps the two media apart. Liquids cooled with air often use finned plates that radiate heat from the fluid into the ambient air. Liquids cooled or heated with other liquids generally rely on a circuit of tubes that are immersed in the secondary medium, or a series of plates that stack together to form a group of contacting passages through which the two fluids pass. Heat exchangers come in many sizes and shapes and are specified by the incoming and outgoing temperatures of the primary medium, the ambient temperature of the secondary medium, and the flow rate of the system. Special features such as easy disassembly for food-service sanitization are available in some designs.

Types of Heat Exchangers

Air Cross Flow Heat Exchangers
Air Cross Flow Heat Exchangers are mechanical heat transfer devices used to remove heat from liquid by passing the liquid through tubes attached to fins which radiate the heat into a stream of air. These are common in automotive radiators and air conditioner circuits, but have uses throughout industry.

Key specifications include medium exchange type, exchange mechanics, as well as the operating parameters of input and output temperatures, pressure drop, and flow rate. Dimensional information can be an important as well.

Air cross flow heat exchangers are used throughout industry, from refrigerators to cooling towers, wherever a process fluid needs cooling and the heat can be transferred to the ambient air.

Plate Heat Exchangers
Plate Heat Exchangers are mechanical heat transfer devices used to remove heat from or add heat to a liquid by way of a second liquid at a different temperature. Individual plates are brazed or clamped together to form a series of pockets through which the two liquids pass without touching. A common application is milk pasteurizing.
Key specifications include exchange mechanics and the operating parameters of input and output temperatures, pressure drop, and flow rate. Dimensional information can be an important as well.

Plate heat exchangers are used where liquid to liquid heat transfer takes place. Brazed designs are used in heating applications where access to the exchanger internals is not required. Clamped or gasketed designs are used in food processing because the exchangers plates can be washed individually.

**Tube and Shell Heat Exchangers**

Shell and Tube Heat Exchangers are mechanical heat transfer devices used to remove heat from or add heat to a liquid by way of a second liquid at a different temperature. They consist of a tube bundle through which one fluid passes surrounded by a shell where a second fluid flows. These are common in the processing industries.

Key specifications include exchange mechanics, tube geometry, shell type, and the operating parameters of input and output temperatures, pressure drop, and flow rate. Dimensional information can be an important consideration as well.

Shell and tube heat exchangers are used throughout the petro-chemical industry and have specific applications such as condensate cooling, feedwater preheating, and engine jacket water cooling.

**Applications and Industries**

Air cross flow heat exchangers are heavily used in the refrigeration and cooling industry on both sides of the refrigeration circuit and are sometimes called simply coils. The typical air conditioning circuit uses a heat exchanger mounted outside the building where hot, condensed refrigerant is cooled as it circulates through a loop of finned tubes over which ambient air is blown by a fan. The cooled liquid is then returned to the building interior where the liquid passes through a second heat exchanger where it is warmed by the inside air and changes from liquid to gas, absorbing heat in the process. The two heat exchangers are called the condenser and evaporator, respectively. In both instances the primary medium is the refrigerant and the secondary medium is air.

An automobile radiator is another common application of air cross flow heat exchangers, where ambient air is used to cool engine coolant. Unlike air conditioners, automotive coolant doesn’t go through a phase change but remains liquid throughout the cycle. A pump is used to circulate the fluid through the heat exchanger, while a combination of fan cooling and forced air cooling transfers heat from the fins to the air. A second heat exchanger is employed inside the passenger compartment for
cooling and heating the occupants. Another spot for air cross flow heat exchangers is for transmission fluid cooling, and is often used by passenger vehicles intended for towing.

Plate heat exchangers and tube and shell heat exchangers are mostly used for liquid-to-liquid and steam-to-liquid heat transfer. Plate heat exchangers can be designed as gasketed, take-apart systems to aid sanitizing and so are often used in hygienic applications such as found in the food industry. They can also be designed as permanent, brazed or welded assemblies when sanitization isn’t a concern.

Tube and shell exchangers are generally brazed or welded assemblies and are often used in higher pressure applications such as in steam heating of water. Vendors offer off-the-shelf sizes in the smaller ranges while full scale process exchangers are generally manufactured to order. The U-tube design is a common architecture.

Industries and applications in which heat exchangers are common include:

- Aerospace
- Chemical
- Electronics
- HVAC
- Medical
- Petroleum
- Biotech
- Cryogenic
- Food Processing
- Marine
- Paper and Pulp
- Pharmaceutical
- Acid Cooling
- Brewing
- Heating Systems
- Refrigeration
- Semiconductor Fabrication
- Motors
- Cogeneration Systems
- Power Plants
- Shipboard
- Boilers
- Environmental Clean Up
- Sanitary Pumps
- Soil Remediation

Considerations

Temperature, Flow Rate, and Maintenance

In specifying heat exchangers the temperature of the primary and secondary media are of utmost importance. Flow rates of the two media are important also. Size of the exchanger can also be a consideration where space is minimal and may lead to selecting one design over another. Sanitary design can be a determining factor for heat exchangers used in pharmaceutical processes. Maintenance ease is important too, especially when primary fluids carry solids such as orange juice pulp that can clog passages. Water chemistry can also affect heat exchanger performance and can lead to cooling/heating inefficiencies as passageways clog.

Compatibility and Materials

Fluid compatibility can be another consideration when selecting or specifying a heat exchanger. Many standard heat exchangers use copper for the tubes and copper or aluminum for the fins, achieving a
good combination of conductivity and light weight. For corrosive fluids or deionized water, stainless steel makes a good choice for tube material. Aluminum is used for tubes as well.

**Sizing**

Sizing heat exchangers is a matter of balancing the various given and required temperatures of the system with flow rate and then selecting a model based around a vendor’s sizing charts. Pumps can then be selected to overcome the pressure drop of the fluid moving through the selected heat exchanger. Where charts don’t cover the parameters of a particular design, engineers refer to the equations of heat transfer.

**Important Attributes**

**Industry Standards/Certifications** ASME publishes several codes that relate to the design and construction of heat exchangers, specifically pertaining to pressure vessels, weldments, materials, etc.

**Medium Exchange Type** Air-to-Air and Air-to-Water are common choices for crossflow designs while Liquid-to-Liquid types are common for plate type and tube and shell exchangers.

**Secondary Medium Type** refers to the cooling or heating fluid used to heat or cool the primary, or process fluid, and is sometimes called the cold side.

**Fluid Temperature In / Out** refers to the two parameters of the primary fluid, the incoming temperature and the desired outgoing temperature.
**Secondary Fluid Temperature In / Out** refers to the two parameters of the secondary, or cooling, fluid, the incoming temperature and the desired outgoing temperature.

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**Primary Medium /Secondary Medium Flow Rate** refers to volume of fluid per unit time that the exchanger needs to process in the case of the primary loop or has available in the case of the secondary.

**Allowable Pressure Drop** specifies the permissible pressure loss through the exchanger.

**Maximum Allowable Working Pressure** refers to maximum pressure the heat exchanger will see during its life, including variations over and above the normal operating pressure of the process, and is usually greater than a heat exchanger’s design pressure.

**Connection Type** refers to the attachment of piping to the heat exchanger, usually by way of pipe threads or flanges.

**Exchanger Material** refers to materials used to fabricate the exchanger elements and often differ by function; that is, the tubes are often copper in air cross flow exchangers and the fins are aluminum, achieving a good balance of corrosion resistance, thermal conductivity, lightness, and economy. Stainless steel is often used for food industry exchangers for sanitary considerations. Other materials are selected for their compatibility with various primary mediums.

**Exchanger Mechanics/Design** refers to architecture of the exchanger, commonly finned plate or plate and shell for plate exchangers; finned tube for air cross flow exchangers; and, tube-in-tube or double pipe/hairpin for tube and shell exchangers.

**Shell Type/Tube Geometry** In the case of tube and shell exchangers, Shell Type and Tube Geometry describe further the architecture of these exchangers, referring to the arrangement of the shells and tubes. The u-tube shape, for example, circumvents some of the problem associated with differential expansion of shells and tubes, though at the expense of repair and cleaning. Shell type dictates the direction of flow and the number of passes the primary fluid makes through the exchanger.

**Related Product Categories**

- **Radiators** is a term often ascribed to automotive heat exchangers used for engine cooling, although, technically, their heat transfer mechanisms are convection and conduction and not radiation.
- **Economizers** are special heat exchangers designed to capture waste heat from boiler processes.
- **Intercoolers** are heat exchangers inserted between portions of processes to cool gases before the next stages, as between an automotive engine turbocharger and an engine intake.

## Resources

### General

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<td>Trade Associations: Tubular Exchanger Manufacturers Association (TEMA)</td>
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### Industry

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