SYSTEMS FOR HEATING AND COOLING FOOD PRODUCTS

In a food processing plant, heating and cooling of foods is conducted in equipment called heat exchangers. Heat exchangers can be broadly classified into noncontact and contact types. As the name implies, in noncontact-type heat exchangers, the product and heating or cooling medium are kept physically separated, usually by a thin wall. On the other hand, in contact-type heat exchangers, there is direct physical contact between the product and the heating or cooling streams.

For example, in a steam-injection system, steam is directly injected into the product to be heated. In a plate heat exchanger, a thin metal plate separates the product stream from the heating or cooling stream while allowing heat transfer to take place without mixing

Plate Heat Exchanger

The plate heat exchanger invented more than 70 years ago has found wide application in the dairy and food beverage industry. A schematic of a plate heat exchanger is shown in Fig. This heat exchanger consists of a series of parallel, closely spaced stainless-steel plates pressed in a frame. Gaskets, made of natural or synthetic rubber, seal the plate edges and ports to prevent intermixing of liquids. These gaskets help to direct the heating or cooling and the product streams into the respective alternate gaps. The direction of the product stream versus the heating/cooling stream can be either parallel flow (same direction) or counter flow (opposite direction) to each other. The plates used in the plate heat exchanger are constructed from stainless steel: Special patterns are pressed on the plates to cause increased turbulence in the product stream, thus achieving better heat transfer.

Plate heat exchangers are suitable for low-viscosity liquid foods. If suspended solids are present, the equivalent diameter of the particulates should be less than 0.3 cm larger particulates can bridge across the plate contact points and “burn on” in the heating section.

In industrial-size plate heat exchangers, product flow rates from 5000 to 20,000 kg/h often are obtained. When using plate heat exchangers, care should be taken to minimize the deposition of solid food material such as milk proteins on the surface of the plates. This deposition, also called

fouling, will decrease the heat transfer rate from the heating medium to the product; in addition, the pressure drop will increase over a period of time. Eventually, the process is stopped and the plates are cleaned. For dairy products, which require ultra-high temperature applications, the process time is often limited to 3 to 4 h.

Plate heat exchangers offer the following advantages:

■ The maintenance of these heat exchangers is simple, and they can be easily and quickly dismantled for product surface inspection.

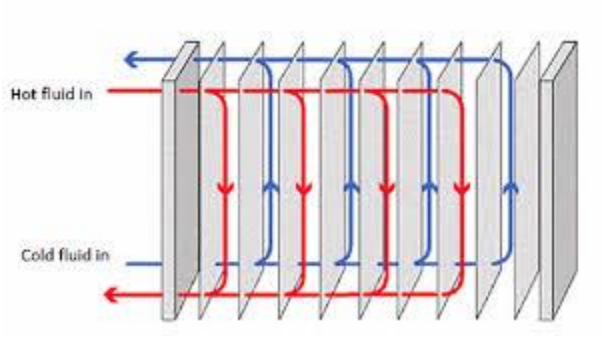
■ The plate heat exchangers have a sanitary design for food applications.

■ Their capacity can easily be increased by adding more plates to the frame.

■ With plate heat exchangers, we can heat or cool product to within 1°C of the adjacent media temperature, with less capital investment than other noncontact-type heat exchangers.

■ Plate heat exchangers offer opportunities for energy conservation by regeneration.

A liquid food is heated to pasteurization or other desired temperature in the heating section; the heated fluid then surrenders part of its heat to the incoming raw fluid in the regeneration section. The cold stream is heated to a temperature where it requires little additional energy to bring it up to the desired temperature. For regeneration, additional plates are required; however, the additional capital cost may be recovered quickly by lowered operating costs.



Tubular Heat Exchanger

The simplest noncontact-type heat exchanger is a double-pipe heat exchanger, consisting of a pipe located concentrically inside another pipe. The two fluid streams flow in the annular space and in the inner pipe, respectively. The streams may flow in the same direction (parallel flow) or in the opposite direction (counterflow). A slight variation of a double-pipe heat exchanger is a triple-tube heat exchanger. In this type of heat exchanger, product flows in the inner annular space, whereas the heating/ cooling medium flows in the inner tube and outer annular space. The innermost tube may contain specially designed obstructions to create turbulence and better heat transfer. Some specific industrial applications of triple-tube heat exchangers include heating single-strength orange juice from 4 to 93°C and then cooling to 4°C; cooling cottage cheese wash water from 46 to 18°C with chilled water; and cooling ice cream mix from 12 to 0.5°C with ammonia. Another common type of heat exchanger used in the food industry is a shell-and-tube heat exchanger for such applications as heating liquid foods in evaporation systems. One of the fluid streams flows inside the tube while the other fluid stream is pumped over the tubes through the shell. By maintaining the fluid stream in the shell side to flow over the tubes, rather than parallel to the tubes, we can achieve higher rates of heat transfer. Baffles located in the shell side allow the cross-flow pattern. One or more tube passes can be accomplished, depending on the design.