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Shell-and-Tube or Plate Heat Exchangers: How to Choose?

The high degree of performance efficiency and other benefits of plate heat exchangers (PHEs) -including improved productivity, accessibility and energy conservation - have lead to their increased use in both industrial and HVAC industries during the last 15 years.

Engineers have realized that PHEs, while excellent heat transfer devices, are not suitable for all applications. Many of the switchovers from shell-and-tube to PHEs have resulted in improved energy savings and recovery or improved process productivity. Others have been plagued with constant problem leakage.

The basic difference between shell-and-tube and plate heat exchangers is that shell-and-tube heat exchangers are designed as a pressure vessel first and a heat transfer device second. Conversely, a PHE is designed as heat transfer equipment first and as a pressure vessel second.

Several factors must be considered before deciding which heat exchanger is best for a particular application. These factors include:

$ Materials of construction
$ Performance parameters such as thermal requirements and pressure drop restrictions
$ Types of media
$ Fouling characteristics
$ Cleaning and maintenance requirements
$ Weight and dimensional restrictions

Key Components:

The primary components of shell-and-tube and plate heat exchangers are the tubes and channel plates.

Tubes come in a wide variety of materials and thicknesses such as copper, cupro-nickel, admiralty, 304SS, 316SS, carbon steel, titanium, carpenter 20, etc. Tube wall thickness is designated as BWG (Birmingham Wire Gage). The most common wall thicknesses are 18BWG and 20BWG, or .049" and .035" respectively.

Channel plates also come in a variety of pressable materials such as 304SS, 316SS, titanium, and Hastelloy C276. The most common materials, however, are 304SS and 316SS. Advances in design now allow plate thicknesses as low as 0.4 mm. Channel plates are stamped to form corrugations which add strength to the thin plate: turbulence is created in the fluid flows, resulting in very high heat transfer coefficients can be as much as three times those of shell-and-tube heat exchangers, resulting in approximately one-third the required surface area.

Another major component of the PHE is the gasket. Every channel plate of a PHE has a gasket. The most popular gaskets are nitrile (NBR) and EPDM. Other gasket materials such as hypalon and viton are also available. These gaskets are common in industrial applications. If a PHE has a weakness, it lies in the gaskets. Unlike a shell and tube heat exchanger which has basically two internal gaskets, the amount of gasket surface in a PHE is very large. The potential for leakage is, therefore, very high.

The average life of a PHE gasket is approximately 6 - 7 years. One factor that affects gasket life is temperature. Each gasket has a maximum temperature rating. Nitrile's maximum temperature is 230°F while high temp EPDM can be rated to as high as 320°F. Through experience, however, it has been found that gasket life is drastically reduced when operating temperatures are at or near the maximum temperature of the gasket. Gaskets, when subjected to high operating temperatures, have failed as quickly as 6 to 9 months while others have lasted approximately two years. This is not the kind of service life an engineer or end user would expect if he or she were used to dealing with shell-and-tube units.

Other causes for gasket leaks include "cold leakage" due to quick cooling of a heat exchanger in cyclic operation, and large differential pressures between the hot and cold media when operating temperatures are relatively high. While these periodic leaks are not catastrophic, they are nuisance leaks which can cause damage to property and customer relations.

Since gaskets in a PHE are a replaceable item, most are not of a glueless design. Clip type and stud type are the two most common forms of glueless gaskets. Both simplify regasketing by eliminating lengthy removal procedures of the old glued gaskets. And they make possible gasketing on site, thereby reducing service downtime.

Design Considerations:

Design pressure and temperatures are primary considerations when deciding which heat exchanger type is best for a given system. Shell-and-tube heat exchangers can be designed for almost any combination of temperature and pressure. The majority of shell-and-tube heat exchangers have design pressures between 125 PSIG and 400 PSIG, and design temperatures between 300°F and 400°F. Much higher design pressures and temperatures also are available.

Plate heat exchangers generally are constructed with thinner materials and, consequently, have lower pressure and temperature design ratings. The limiting factor regarding temperature is the choice of the gasket, a subject previously discussed. PHEs can be designed to 300 PSIG and 300°F, but **these maximum limits should not be considered to be operative simultaneously**. A trade-off between maximum operating temperature and pressures should be a consideration; the higher the working pressure, the lower the working temperature, and vice versa.

Many times, performance parameters dictate the type of heat exchanger that best meets the requirements of an application. Plate heat exchangers are considered to be the most efficient heat exchanger with regard to thermal requirements. They are best suited for applications where the LMTD is very small - which usually involves a temperature cross and a very close approach temperature. The practical limit for an approach temperature in a PHE is 2°F. On the other hand, shell-and-tube units are best suited for operating conditions involving a large LMTD, no temperature cross, and no close approach. Either type of heat exchanger can operate in the other's thermal regime, both cost then becomes a consideration.

Since PHEs are very efficient thermally, a correspondingly high pressure drop is usually the result. Pressure drops of approximately 10 PSIG are very common. On the plus side, however, high heat transfer coefficients and high pressure drops are associated with high fluid velocities and a high degree of turbulence. These factors lead to a PHEs low potential for fouling. Generally speaking, most PHEs are selected with no fouling factor.

Both shell-and-tube and plate heat exchangers have ideal applications, whether commercial, HVAC or industrial. Knowledge of each heat exchanger's advantages and disadvantages and how they apply to the requirements of a specific application are paramount.