Tech Sheet #133
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# Basics of Shell & Tube Heat Exchangers

## 1.0 Introduction to shell and tube heat exchanger

Shell and tube heat exchangers transfer heat indirectly from one fluid to another by means of a number of tubes arranged in an optimized pattern enclosed by a cylindrical shell. One fluid flows through the tubes and the other flows over and along the length of the exchanger.

Almost every exchanger is customer designed and constructed. Requirements can vary over a wide range of pressures and temperatures. For each basic construction, there are many possible variations in configurations to suit special operating needs such as designing for desired heat transfer, lower pressure drop, corrosion, fouling, erosion etc. They are the most versatile of any other heat transfer equipments in terms of materials used for the construction and size. Maintenance such as cleaning, replacement of failure prone components etc. can be made relatively easy.

## 2.0 Applications

Depending on the state of the working fluids, exchangers can be classified into liquid-liquid exchangers, gas-liquid exchangers, and gas-gas exchangers. Some common applications of these exchangers in power plants are given below.

- Auxiliary steam generators (gas-liquid or gas-gas exchangers)
- Bearing water coolers (liquid-liquid exchangers)
- Blowdown exchangers (liquid-liquid exchangers)
- Bypass condensers (gas-liquid exchangers)
- Component cooling water exchangers (liquid-liquid exchangers)
- Condensate coolers (liquid-liquid exchangers)
- Reboilers and Evaporators (gas-liquid or gas-gas exchangers)
- Lube oil coolers (liquid-liquid exchangers)

## 3.0 Basic components of a shell and tube heat exchanger

### *3.1 Shell and shell side nozzles*

The shell is usually a closed cylinder and contains the fluid flowing over the tubes. Shells can be arranged in several basic configurations. The "E" type shell is the most basic commonly used type. The fluid enters at one end and exit out of the other end. "T" type shells are used to obtain pure counter-flow arrangement. A longitudinal steel plate (or baffle) divides the shell into two halves. The inlet and the outlet nozzles of this shell type are located at the same end. Split-flow shell configuration such as "S" type has a longitudinal baffle but is used for lower allowable shell side pressure drop applications.

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Another configuration is the divided flow "D" type shell. These shells are similar to "E" type shells with either two inlet nozzles and one outlet nozzle or two outlet nozzles and one inlet nozzles. "K" and "X" type shells are mainly used in boiling and/or condensing applications and have negligible pressure drop on the shell side. Shell side fluid enters and exits out of inlet and outlet nozzles respectively. Usually for diameters over 24 inches, shells are rolled and welded longitudinally out of a metal plate. Shells of smaller diameters are available as pipes of nominal sizes and appropriate thicknesses. The differential configurations are shown in Appendix M in the Standards for Shell and Tube Heat Exchangers.

### *3.2 Tubes*

Tubes are mostly bare cylinders with circular cross-section and are commonly available in welded or seamless forms. They are normally laid with their axis parallel to that of the axis of the shell. Tubes can be either straight or bent to U-shape. The number of tubes that can be fit within a given shell diameter depends mainly on the pattern of arrangement, diameter of tubes and distance between adjacent tubes. Design considerations, including velocities and pressure drop, also affect the number of tubes that are used.

Other tube types such as extended fin or low fin tubes are also available for specific applications. U-tubes usually offer the most economical solution to minimize stress due to differential thermal expansion between the shell and the tubes.

### *3.3 Tubesheet*

Tubes are secured at the end by tubesheet(s). They are most commonly plate material, with holes drilled to a specific pattern. The tubes are typically attached to the tubesheet by expanding the tubes or by welding and expanding. If tubes are straight, then the tubes are held in place by tubesheets at both ends. In straight tube exchangers, the tubesheet at one end of the shell is stationary and this end is commonly called the front-end. The other end, also known as the rear-end, may be fixed (stationary) or sometimes floating (moving). Floating tubesheets are provided to reduce stresses between the shell and the tubes due to differential thermal expansion. If the tubesheets are stationary at both ends, then the tubesheet is attached to both the shell and channel cylinders by either bolting or welding or combinations of both. Usually, exchangers with a floating tubesheet have two tube passes and are enclosed by the shell cylinder and shell closure at the rear-end.

### *3.4 Baffles, Impingement plates, and tie-rods and spacers*

Baffles are plates with holes in them to the same pattern as that of the tubesheet(s). Baffles serve two purposes. One is to provide support to tubes to prevent vibration, and the other is to guide the flow of the shell side fluid through the shell. Heat transfer coefficient and pressure drop both vary with the baffle configuration and spacing. Commonly used baffle configurations are single segmental, double segmental, and no-tubes-in the window. Tie-rods and spacers are used to secure baffles in places at the desired location.

Impingement plates or rods are used under shell side inlet nozzles with high velocities to prevent direct impingement of shell side fluid on the tubes. Under high velocity condition, direct impingement of fluid on tubes may cause erosion and failure of tubes, but is acceptable under typical low velocity conditions.

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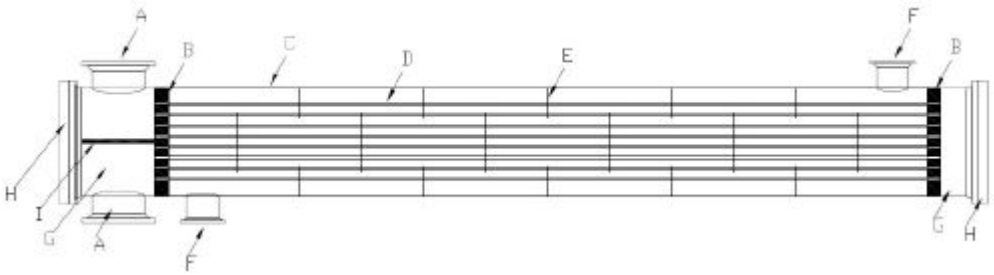
### *3.5 Channel, channel cover, pass partition plates, and tube side nozzles*

Channels are components which contain the tube side fluid and allow for proper distribution of fluid into the tubes. Tube side nozzles are components through which the tube side fluid enters and exits the channel.

The channel cover is used as a closure to the channel cylinder and can be of various forms such as flat plates and/or elliptical/spherical heads. The channel cover configuration determines the access to the tube ends in tubesheet. Several possible combinations are described in HEI Standards for Shell and Tube Heat Exchangers. Within the channel of multipass heat exchangers, pass plate(s) separate the tube passes one from another directing the flow through tubes. They are usually attached at one end to the tube sheet and to the channel cover at the other end. Several combinations of pass plate arrangements are possible.




A typical one shell pass, two tube pass, fixed tubesheet heat exchanger.

A) Tubeside nozzles
B) Tubesheet
C) Shell
D) Tubes
E) Baffles
F) Shellside nozzles
G) Channel
H) Channel cover
I) Pass plate

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