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# Performance On Shell And Tube Heat Exchanger Using Helical Baffles

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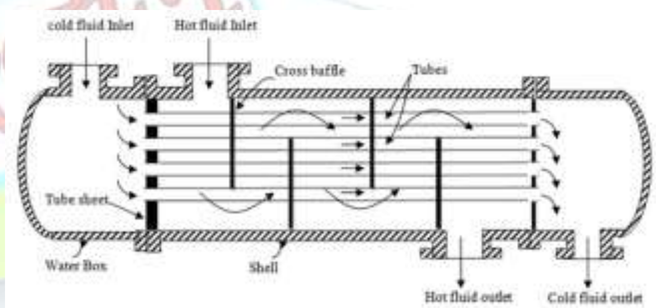
***Abstract*— Heat exchangers are important heat & mass exchange apparatus in oil refining, chemical engineering, environmental protection, electric power generation, etc. Among different types of heat exchangers, shell-&-tube heat exchangers (STHXs) have been commonly used in industries. About 35–40% of heat exchangers are of the STHXs, & this is primarily due to the robust construction geometry as well as easy maintenance & possible upgrades of STHXs. Segmental baffles are most commonly used in conventional STHXs to support tubes & change fluid flow direction. But, conventional heat exchangers with segmental baffles in shell-side have some shortcomings resulting in the relatively low conversion of pressure drop into a useful heat transfer.**

Keyword : STHXs, oil refining, chemical engineering, environmental protection, electric power generation

## INTRODUCTION

It consists of a bundle of circular tubes mounted in a cylindrical shell. One of the fluids flow through the bundle of tubes. The other fluid is forced through the shell and flows over the outside surface of tubes. The flow condition become more complicated in this exchanger. Fig. 2.1 shows a shell and tube exchanger with one shell pass and tube pass. Baffle are generally installed in the exchanger in order to generate turbulence in the shell side fluid and to promote a cross flow component in the velocity of this fluid relative to tubes. As a result of this effects, a higher heat transfer coefficient for the outer tube surface is obtained. The tubes may be arranged in a regular and staggered fashion. This type of exchanger is commonly used for liquid to liquid heat transfer.




Sectional view of Shell and Tube Exchanger

In order to increase the overall heat transfer. Multiple shell and tube passes are used. The two fluids traverse the exchanger more than once ( i.e. multi pass ). By suitable heater design, the fluid within the tubes can be made to traverse back and forth from one ends of the shell to other. Similarly, by suitable shell and heater design, the flow inside the shell may be traversed more than once. Fig 2.2 shows the heat exchanger with multiple

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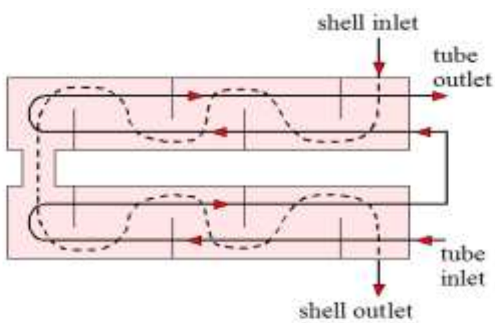
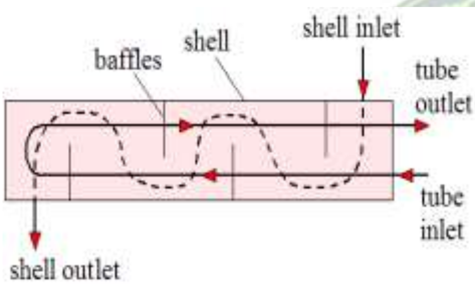
shell and tube passes. This type of exchanger is preferred due to its cost of manufacture, easy to repair and maintain and reduce thermal stresses due to expansion facility.




Heat transfer is considered as transfer of thermal energy form physical body to another. heat transfer Co – efficient and Pressure drop are the most important parameters to be measured as the performance and efficiency of the shell and tube heat exchanger. The developments of shell and tube exchangers on better conversion of pressure drop into heat transfer by improving the conventional baffle design or using the Helical Baffle.

**Introduction of Baffle**

Shell & tube heat exchangers (STHXs) are widely used in many industrial areas, such as power plant, chemical engineering, petroleum refining, food processing, etc. More than 35-40 % of heat exchangers are of the shell & tube type due to their robust geometry construction, easy maintenance & possible upgrades. Rugged safe construction, availability in a wide range of materials, mechanical reliability in service, availability of st&ards for specifications & designs, long collective operating experience & familiarity with the designs are some of the reasons for its wide usage in industry.

Baffle is an important shell side component of STHXs. Besides supporting the tube bundles, the baffles form flow passages for the shell side fluid in conjunction with the shell. The most commonly used baffles is the segmental baffle, which forces the fluid in a zigzag manner, thus improving the heat transfer but with a large pressure drop penalty. This type of heat exchanger has been well developed & probably is still the most commonly used type of the shell & tube heat exchanger. The major draw backs of the conventional shell & tube heat exchangers with segmental baffles are threefold: firstly it causes a large side pressure drop; secondly it results in a dead zone in each component between 2 adjacent segmental baffles, leading to an increase of fouling resistance; thirdly the dramatic zigzag flow pattern also causes high risk of vibration failure on tube bundle. To overcome the above mentioned drawbacks of the conventional segmental baffle, a number of improved structures were proposed for the purposes of higher heat transfer coefficient, low possibility of tube vibration & reduced fouling factor with a mild increase in pumping power.However, the principal shortcomings of the conventional segmental baffle still remain in the above-mentioned studies, even though the pressure drop across the heat exchanger has been reduced to some extent. A new type of baffle, called helical baffle, provides further improvement.

. **Problems affecting Performance on shell and tube heat exchanger**

The main problems affecting the performance are usually due to one of the following:

(i) Fouling
(ii) Tube vibrations
(iii) Leakage
(iv) Dead Zones

**Fouling**

This can be generally defined as the precipitation of unwanted material within the heat exchanger over time which hamper the performance.
The principal types of fouling encountered in process heat exchangers include:

- Particulate fouling
- Corrosion fouling
- Biological fouling
- Crystallization fouling
- Chemical reaction fouling
- Freezing fouling

In the case of corrosion, the surfaces of the heat exchanger can become corroded as a result of the interaction between the process fluids and the materials used in the

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construction of the heat exchanger. The situation is made even worse due to the fact that various fouling types can interact with each other to cause even more fouling. Fouling can and does result in additional resistance with respect to the heat transfer and thus decreased performance with respect to heat transfer. Fouling also causes an increased pressure drop in connection with the fluid flowing on the inside of the exchanger

To improve the performance of fouled heat exchangers requires that the tubes be cleaned periodically. Tube cleaning procedures for shell and tube heat exchangers are performed off-line, the most frequently chosen and fastest method being mechanical cleaning. Among other off-line methods is the use of very high pressure water but, since the jet can only be moved along the tube slowly, the time taken to clean a heat exchanger can become extended. Chemicals are also used for the off-line cleaning of heat exchanger tubes. Several mildly acidic products are available and will remove more deposit than most other methods; but it is expensive, takes longer for the operation to be completed, and the subsequent disposal of the chemicals, an environmental hazard, creates its own set of problems.

**Tube vibrations**

Another problem that often arises in connection with the use of heat exchangers is tube vibration damage. Tube vibration is most intense and damage is most likely to occur in cross flow implementations where fluids flow is perpendicular to the tubes, although tube vibration damage can also occur in non cross flow (i.e. axial) implementations in the case of very high fluid velocities. Vibration may be eliminated by reducing velocities, decreasing the unsupported span or, in some cases, by altering the method of fixing or pinning the ends of the unsupported span.

This problem can cause significant damage to the exchanger if within high limits.

**Leakage**

Sometimes the fluid of the tube side can leak to shell side or vice versa, This problem can cause huge production loss. Leaks may develop at the tube to tube sheet joints of fixed tube sheet exchangers because differential thermal expansion between the tubes and the shell causes overstressing of the rolled joints. Or, thermal cycling caused by frequent shutdowns or batch operation of the process may cause the tubes to loosen in the tube holes. Floating heads or U-bend exchangers would be considered first for this type of service. If a fixed tube sheet unit is required, an expansion joint will be specified. An exchanger that will be thermally cycled two or three times a day will require superior mechanical construction such as the strength welding of tubes to the tube sheet, complete inspection of the shell and channel welds during fabrication. Welding the tubes to the tube sheets does not guarantee that a leak will not occur as sometimes weld failure due to porosity in the welds or just one poorly welded tube out of the hundreds of welds can cause a leakage. The use of double tube sheets to minimize the chances of leakage between the tube side and shell side can be a good solution to the problem. Nevertheless, double tube sheet can cause considerable maintenance problems because the outboard and inboard tube sheets may be subjected to considerably different process temperatures and this can have differential expansion between the tube sheets resulting in bending the tubes

**Dead Zone**

Areas that have the flow to minimal or even non existent and usually produce poor heat transfer and can lead ultimately to excessive fouling.
Existing shell and tube heat exchangers suffer from the fact that they must typically use baffles to maintain the required heat transfer. This, however, results in “dead zones” within the heat exchanger where flow is minimal or even non existent. These dead zones generally lead to excessive fouling. Other types of heat exchangers may or may not employ baffles. If they do, the same increased fouling problem exists. Further, in heat exchangers fitted with baffles, for example, the cross flow implementation results in the additional problem of potential damage to tubes as a result of flow induced vibration. In the case of such damage, processes must often be interrupted or shut down in order to perform costly and time consuming repairs to the device.

**Expected Outcomes**

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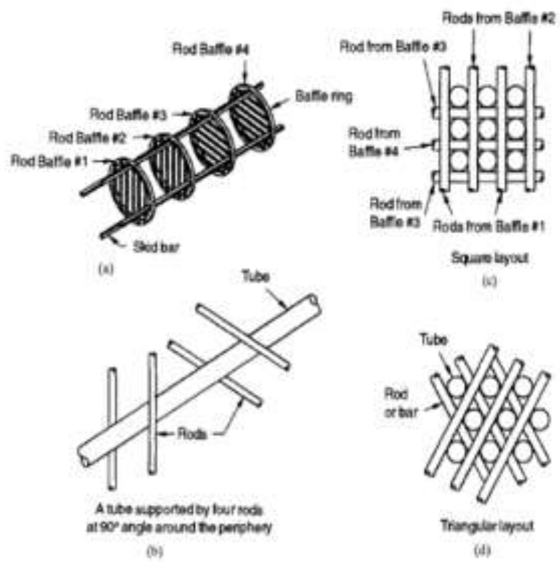
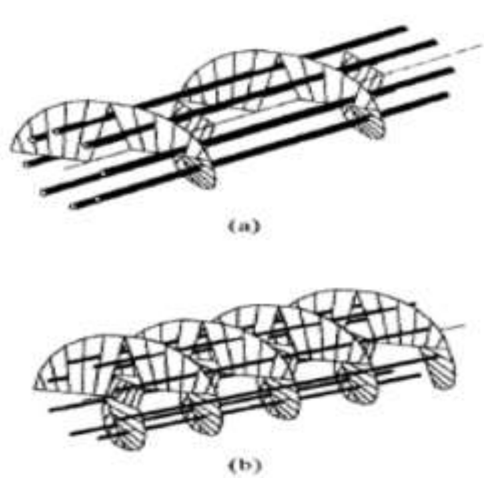



(a) four rod baffles supported by skid bars (no tubes shown)
(b) A tube supported by four rods at $90^0$ angles around the periphery
(c) A square layout of tubes with rods
(d) A triangular layout of tubes with rod

Fig 3.1 Rod Baffle Supports



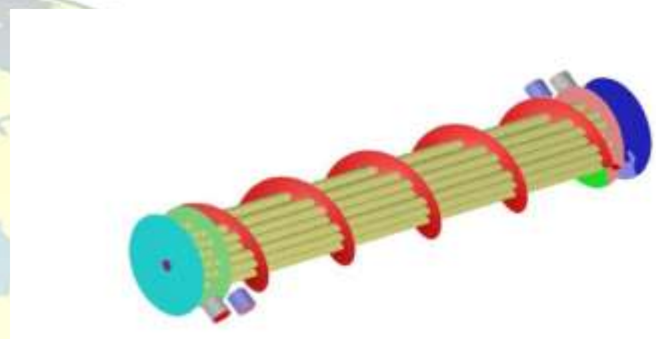

I.

(a) Single Helix.
(b) Double Helix.

Fig 3.3 A Helical baffle Shell and Tube Heat Exchanger

An alternative to conventional and axial flow shell-and tube exchangers is an exchange with helical shell side flow. It can be either a single-helix baffle, as shown in Fig. 3.3(a), or a double-helix baffle as shown in Fig. 3.3(b). There are several variations of angled baffle exchangers available commercially. The helical flow reduces the shell side flow turning losses and fouling tendency compared to a conventional shell-and-tube exchanger, but introduces radial variations in shell side mass flow rate and temperature variations that can be overcome by a radial variation in the tube pitch design.

### HELICAL BAFFLE HEAT EXCHANGER



Helical Baffle Heat Exchanger

The concept of helical baffle heat exchangers was developed for the first time in Czechoslovakia. The Helical baffle heat exchanger, also known as Helix changer, is a superior shell-and-tube exchanger solution that removes many of the inherent deficiencies of conventional segmental-baffle exchangers. Helical baffle heat exchangers have shown very effective performance especially for the cases in which the heat transfer coefficient in shell side is controlled or less pressure drop and less fouling are expected. It can also be very effective, where heat exchangers are predicted to be faced with vibration condition. Quadrant shaped baffle segments are arranged at an angle to the tube axis in a sequential pattern that guide the shell side fluid to flow in a helical path over the tube bundle. Helical flow path of the shell-side fluid can also be achieved by a continuous helix shaped baffle running throughout the length of the shell and tube heat exchanger.

The helical flow provides the necessary characteristics to reduce flow dispersion and generate near plug flow conditions. It also ensures a certain amount of cross flow to the tubes to provide high heat transfer coefficient. The shell-side flow configuration offers a very high conversion of pressure drop to heat transfer.

**Conclusion**

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(1) Use of helical baffles in heat exchanger reduces shell side pressure drop, pumping cost, size, weight, fouling etc. as compare to segmental baffle for new installations. The helix changer type heat exchangers can save capital cost as well as operating and maintenance cost and thus improves the reliability and availability of process plant in a cost effective way.

(2) For the helical baffle heat exchangers, the ratios of heat transfer coefficient to pressure drop are higher than those of a conventional segmental heat exchanger. This means that the heat exchangers with helical baffles will have a higher heat transfer coefficient when consuming the same pumping power.

(3) It can be concluded that proper baffle inclination angle will provide an optimal performance of heat exchangers

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