

Description

SEQUENTIAL SPIRALING-CUT ARRANGEMENT OF BAFFLE PLATES FOR SHELL-AND-TUBE HEAT EXCHANGERS

Field of the Invention

The present invention relates to a heat exchanger, specifically a shell-and-tube heat exchanger, with improvements to the fluid flow and shell outlet orientation. The invention comprises of the sequential spiraling-cut baffle plates' arrangement which engineers a spiral fluid flow and the flexibility of the shell outlet which can be placed according to the implementation requirements.

Background of the Invention

Traditional shell-and-tube heat exchanger with normal baffle plate's arrangement has proved to be ineffective. The effective shell-side heat transfer coefficient for the heat exchanger is of the order of 60% (*McAdams, W. H., Heat Transmission, third edition, McGraw-Hill, New York, 1954, p.229*). The traditional shell-and-tube heat exchanger's baffle plates are arranged at 180° to each other and the fluid vertically flows up and down along the shell. There are some designs of the traditional shell and tube heat exchanger that uses vertical baffle cuts and rotated baffle cuts, but all of them are arranged at 180° to each other.

These traditional baffle plate's arrangements will cause the shell-side fluid to flow from side to side and hit the inner shell surface of the heat exchanger. This fluid movement produces excessive amount of turbulence and vibration. Therefore, there will be a high pressure drop for the shell-side fluid. With a higher pressure drop, the more the power required to maintain the fluid flow. In addition, the impact on the inner shell surface shortens the shell-and-tube heat exchanger service life.

In the prior arts, there are several inventions that use the 180° baffle plate arrangement. In *U. S. patent letter no. 1904875, 2581121, 3739443, 4412582, 2581121 and 5063663*, the baffle plates are arranged at 180° to each other. This design causes a high force on the inner shell surface which lead to excessive turbulence and vibration. Thus, assumptions of the abovementioned prior arts are not as effective as mentioned.

The traditional shell and tube heat exchanger are designed with the shell having one shell pass, the shell-side fluid entry and exit nozzles are attached at the two opposite ends of the shell. This design has a major disadvantage which the installations of the shell-and-tube heat exchanger will be limited by the space constraints. This makes it impossible to place the shell outlet on the opposite end of the shell.

In *U. S. patent letter no. 2496301 and 3739443*, the shell outlet is positioned exactly on the other opposite end part of the shell.

In summary, the baffle plate's arrangement of the traditional shell-and-tube heat exchanger has more disadvantages compared to the present invention: the sequential spiraling-cut arrangement of baffle plates. The traditional arrangement is ineffective, produces excessive turbulence and vibration which leads to a high pressure drop and also has a short service life.

Summary of the Invention

The shell-and-tube heat exchanger comprises of a shell with a flow inlet and a flow outlet, and a large number of tubes inside the shell. The main idea of this invention is the baffle plates' new sequential spiraling-cut arrangement. Baffle plates are arranged where the cut section spirals sequentially in the shell to produce a helical flow along the shell in order to reduce excessive turbulence and vibration. Unlike the traditional shell and tube heat exchanger that uses an arrangement of baffle plates arranged with baffle cuts at fixed 180° to each other, the present invention has baffle plates arranged at certain degree (α) to each other. If the first baffle plate has an angle of θ , the second baffle plate will be at $(\theta+\alpha)$, the third will be at $(\theta+2\alpha)$, the forth will has an angle of $(\theta+3\alpha)$ and so on. The shell-side fluid that passes through these baffle plates will form a helical flow. The helical fluid movement will reduce the impact of the shell-side fluid on the inner shell surface. Therefore, it reduces the excessive amount of turbulence and vibration so as to minimize the pressure drop. The lower the pressure drop, the lesser the amount of energy is required to pump the shell-side fluid into the shell. This present invention saves energy and has lower operation costs in the long run.

The orientation of shell outlet can be placed on any side around the pipe; there is no need to place the shell outlet on the opposite side of the shell. The shell outlet placement is flexible and the position can be determined according to implementation situations and space requirements.

Brief description of the drawings

Fig.1 gives a perspective view of the shell-and-tube heat exchanger, showing the tubes and baffle plates.

Fig.2 gives a perspective view of the shell-and-tube heat exchanger, showing the sequential spiraling-cut arrangement of the baffle plates.

Fig.3 gives a front view of the baffle plates which are arranged in a sequential spiral

Detailed description on the preferred embodiment

As shown in fig.1, the present invention is a multi-pass shell-and-tube heat exchanger (8) which comprises of: a shell (2), shell inlet (1), shell outlet (3), tube inlet (9), tube outlet (10), tube sheet (11), tube bundle (4), and baffle plates (5). The tube-side fluid flows in through tube inlet (9) and then passes through the tube sheet (11) and into tube bundle (4), then flows all the way to the tube outlet (10). In the process, the fluid is cooled down by the shell-side fluid. The shell-side fluid flow in through the shell inlet (1) and passes through the cut-off (7) on the baffle plates (5). The shell-side fluid then flow out through the shell outlet (3). The baffle plates (5) are arranged such that the flow will form a helix. The tube bundles (4) penetrate through the baffle plates (5) on the holes (6). The orientation of the shell outlet (3) is flexibly placed on any side around the shell (2) according to the implementation requirements.

In fig. 2, the tube bundles (4) are removed from the figure as shown so as to provide a view of the baffle plates' (5) position clearly. The baffle plates (5) have a cut-off

(7) and holes (6) on it. This cut-off (7) on the baffle plates (5) allows the fluid to pass through it. The holes (6) allow the tubes (4) to penetrate the baffle plates. These baffle plates (5) also increase the contact surface area which improves the heat exchange efficiency.

As shown in fig. 3, the baffle plates (5) are arranged in such way that the first baffle plate has an angle of θ , and the second baffle plate has an angle of $\theta_1=(\theta+\alpha)$, the third baffle plate has an angle of $\theta_2=(\theta+2\alpha)$, the forth plate has an angle of $\theta_3=(\theta+3\alpha)$ and so on. With the mentioned positions, the flow in the shell will be helical due to the arrangement of the baffle plates. The helical movement of the fluid reduces the impact on the inner surface of the shell and tube heat exchanger. Moreover, this also reduces the amount of excessive turbulence, vibration and pressure drop. The lower the pressure drop, the lower the energy required to operate the shell and tube heat exchanger which saves energy and operation costs in the long run.

References

U. S. Patent Documents

1904875		Chester W. Metzgar	April 1933
2496301		Carl Meixl	February 1950
2581121		McCurdy, Jr. et al.	January 1952
3739443		Irwin R. Friedman	June 1973
4221261		John E. Wunder et al.	September 1980
4412582		Walter P. Mecozzi et al.	November 1983
4699211		David F. Geary et al.	October 1987
5063663		Richard Casterline	November 1991

Claims

1. Shell-and-tube heat exchanger with sequential spiraling-cut baffle plates, comprising of: a shell body, a large number of tubes, a series of sequential spiraling-cut baffle plates, tube sheets, tube-side inlet, tube-side outlet, shell inlet and shell outlet; wherein the baffle plate's arrangement produces a helical shaped fluid flow, the shell outlet orientation is flexible.
2. A shell-and-tube heat exchanger with sequential spiraling-cut baffle plates described according to claim 1, wherein the baffle plates are arranged in a way that the first baffle plate has an angle of θ , and the second baffle plate has an angle of $(\theta+\alpha)$, the third baffle plate has an angle of $(\theta+2\alpha)$, the forth plate has an angle of $(\theta+3\alpha)$ and so on.
3. A shell-and-tube heat exchanger's sequential spiraling-cut baffle plates according to claim 2, wherein the baffle plate's arrangement produces a helical shell-side fluid flow.
4. A shell-and-tube heat exchanger's sequential spiraling-cut baffle plates according to claim 2, wherein the number of baffle plate may vary. It's not fixed to four or five baffles.
5. A spiral shell-side fluid flow according to claim 3, wherein the helical shell-side fluid flow reduces the excessive turbulence and vibration in the shell.
6. A helical shell-side fluid flow according to claim 3, wherein the helical shell-side fluid flow reduces the pressure drop of fluid which saves energy and lengthens the service life of the shell and tube heat exchanger.
7. A shell-and-tube heat exchanger with sequential spiraling-cut baffles according to claim 1, wherein the shell outlet is flexibly designed according to the implementation situation and space requirements so that it will not be impeded by the constraint around the shell.