An overview on different tube shape in heat exchanger

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***Abstract*—Conventional heat exchangers are large in size and heat transfer rate is also poor. Furthermore, in conventional heat exchanger dead zone is produce which lowers the heat transfer rate and to create turbulence in conventional heat exchanger some external means is required and the fluid in conventional heat exchanger is not in continuous motion with each other. Tube in tube helical coil heat exchanger provides a compact shape with its geometry offering more fluid contact and eliminating the dead zone, increasing the turbulence and hence the heat transfer rate. An effect of different tube shape and geometry with wire is wounded in the core to increase the turbulence in turn increases the heat transfer rate. This heat exchanger finds its application mostly in food industries and waste heat recovery.**

***Key words*—Helical coil heat exchanger, Heat transfer coefficient, effectiveness, turbulence.**

I. INTRODUCTION

Heat exchangers are used in different applications including power plants, nuclear reactors, refrigeration and air-conditioning systems, automotive industries, heat recovery systems, chemical processing, and food industries .Besides the performance of the heat exchanger being improved, the heat transfer enhancement enables the size of the heat exchanger to be considerably decreased. In general, the enhancement techniques can be divided into two groups: active and passive techniques. The active techniques require external forces like fluid vibration, electric field, and surface vibration. The passive techniques require special surface geometries or fluid additives like various tube inserts. Both techniques have been widely used to improve heat transfer performance of heat exchangers. Due to their compact structure and high heat transfer coefficient,

helically coiled tubes have been introduced as one of the passive heat transfer enhancement techniques and are widely applied in different industrial applications. Several studies have indicated that helically coiled tubes are superior to straight tubes when employed in heat transfer applications .The centrifugal force due to the curvature of the tube results in the secondary flow development which enhances the heat transfer rate. This phenomenon can be beneficial especially in laminar flow regime. Thermal performance and pressure drop of a helically coiled tube heat exchanger with and without helical crimped fins have been seen one of the most frequent uses of helically coiled tubes is in helically coiled tube heat exchangers. Going through the existing literature, it was revealed that there are a few investigations on the heat transfer coefficients of this kind of heat exchangers considering the geometrical effects like coil pitch. Also, this scarcity is more prominent for shell-side heat transfer coefficients. To get with different designs such as circular tube, elliptical tube, oval tube, twisted and coil type etc. to enhance heat transfer along with construction issue we too come across the difficulties in improving heat transfer rates, which means to have high effectiveness, we were in flow to compromise the design and robustness [1-3].

Therefore, utilization of the heat exchanger tubes having different shapes may be more beneficial as far as energy saving is concerned. This has motivated the present review to carry out an in-depth investigation regarding the influence of tube shapes applicable for different exchangers and its effects on heat transfer and fluid flow are thoroughly reported.

II. DIFFERENT TUBE GEOMETRICAL SHAPES

In heat transfer processes of two different working fluids for example: the heat is transferred from a high temperature air to a cold refrigerant which take place in evaporators or from a high-temperature refrigerant to a cold air which take place in condensers or similar heat-transfer processes of other working fluids the fin-and-tube heat exchangers could significantly enhance the thermal performance of the heat exchangers. The heat exchangers accommodate a lot of surface area on the air side to augment the heat transfer rate. In recent demands of the heat recovery, the heat is transferred from hot air like as a dusty air such as industrial flue gases or other high temperature exhaust gases to cold air such as a clean air, in some cases, the air even treated well before receiving the heat such as the applications in food-and-beverage manufacturing factories or chemical factories. In these applications, the heat exchangers must contain characteristics like leakage free amid hot and the cold airs, easiness to clean within both hot and cold sides, low pressure drop, and high effectiveness. The recent demands of the regenerators indicate that the fin-and-tube heat exchangers are not suitable, and the shell-and-smooth-tube heat exchangers may be more appropriate as far as a reliable operation is concerned. However, the studies of shell-and-tube heat exchangers for such applications were rather rare; and more specially, no studies on the effects of different tube shapes on heat transfer and fluid flow characteristics for such applications have not been found in detail. The existing studies [4-7] of shell and- tube heat exchangers had been applied for high-pressure applications; therefore, the tubes and shells, which have been applied in the shell-and-tube heat exchangers, are almost in a circular shape; however, in the recent demands of the energy recovering applications, the supplied fan power may be limited; therefore, utilization of the tubes or shells having different shapes may be more beneficial as far as energy saving is concerned [8-12]. This has motivated the present study to carry out an in-depth investigation regarding the influence of tube shapes applicable for various heat exchangers and its effects on heat transfer and fluid flow are thoroughly reviewed. The different tube geometry has been shown in Fig. 1.

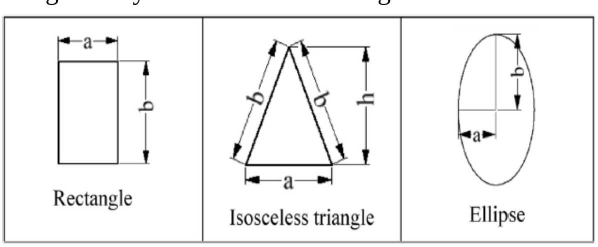

Fig. 1. Different tube geometry according to shape.

III. COMPARISON BETWEEN VARIOUS TUBE GEOMETRY

Fig. 2 depicts a comparison of the effectiveness between different tube shapes such as rectangular, triangular and elliptical tubes [13]. It is found that the effectiveness of the triangular tube is superior to those of the elliptical and rectangular tubes. At the laminar flow regime, the effectiveness of the rectangular tube shows the sharpest decline against the Reynolds number, followed by the elliptical tube and lastly the triangular tube. However, with the increase Reynolds number from 2200 to 3000, the rectangular tube shows the fastest improvement in effectiveness, followed by the elliptical tube and finally the triangular tube.

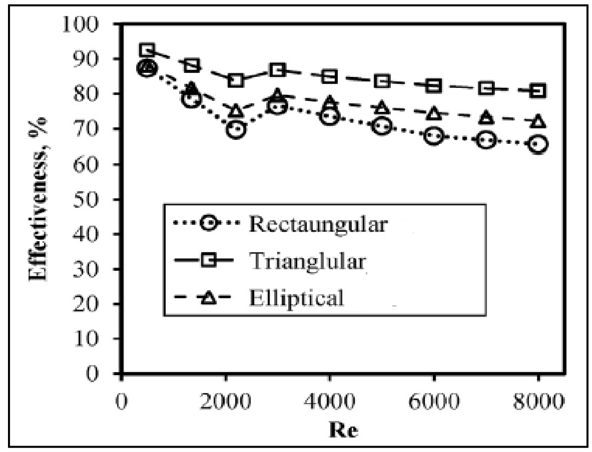

Fig. 2. Variation in effectiveness with Reynolds number

Fig. 3 illustrates a comparison of pressure drop among the above selected tube shapes and it is found that the pressure drop of elliptical tube is found higher than the triangular tube which have higher pressure drop than the rectangular tube [13]. Fig. 4 shows a comparison of the hot side convective heat transfer coefficient (HTC) among the three selected tube shapes described above [13]. The corresponding HTC for the hot-side of the triangular tube is highest among all and it also shows the largest increasing trend with the rise of the Reynolds number, followed by the elliptical tube and lastly the rectangular tube.

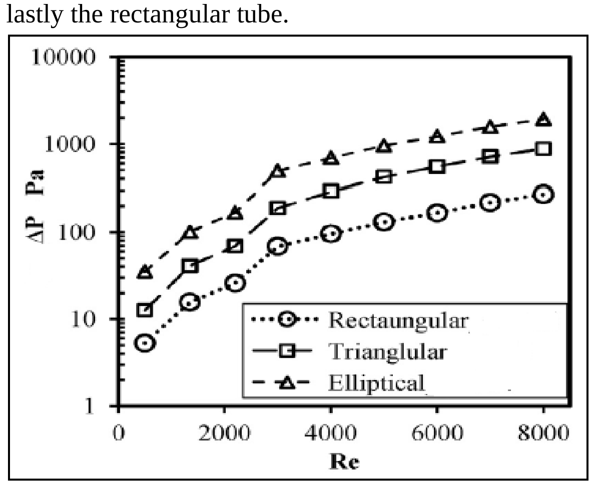

Fig. 3. Variation in pressure drops with Reynolds number

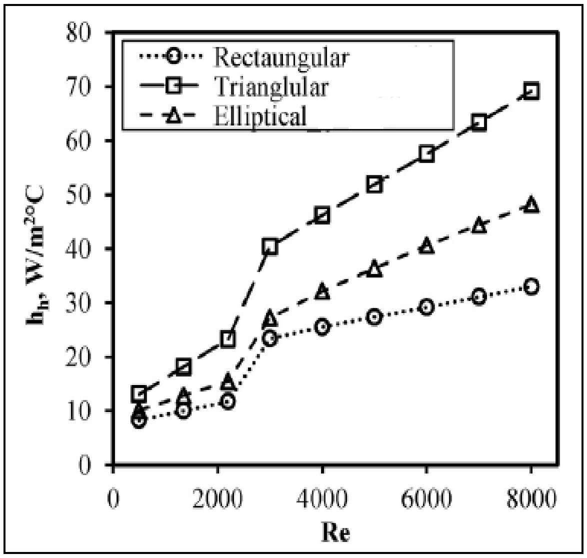

Fig. 4. Variation in HTC with Reynolds number.

For all cases as discussed above, it is found that the thermal performance of the triangular tube is seen superior to those of the elliptical or rectangular tube, and the system performance of the triangular tube is also better than that of the elliptical tube.

IV. CONCLUSIONS

An overview is conducted among the different geometrical shapes used in the heat exchangers. It shows that the helical tubes are found better than the straight tube based on effectiveness and heat transfer rate. For the same heat transfer rate of these heat exchangers, straight tube-in-tube heat exchanger is large in size and thus bulky. Thus, compact size provides a distinct benefit of helical coil heat exchanger. Conversely, it also implies that for the same surface area, the heat energy absorbed by helical tube is more than that of straight copper tube.

Pressure drop in case of helical coil heat exchanger is more straight tube heat exchanger, but heat transferred is significantly more in helical coil. The enhancement in heat transfer is obtained at the expense of pressure drop within permissible limit. Furthermore, the overall heat transfer coefficient in helical tube heat exchanger increased with flow rate and approached a maximum value at higher flow rates.

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