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Review Thermal Performance Enhancement of Double Pipe Heat Exchanger With Wavy

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***Abstract* - In present study, wavy-tape inserts are introduced to help establish swirl flow inside a straight pipe. Three-dimensional models will be created to simulate the flow and heat transfer characteristics inside the pipe with wavy-tape inserts. CFD simulation will be carried out to investigate the effects of different tape angles on the thermal-hydraulic performance of pipe. The effect of wavy strip turbulators with different angles on the NU, friction factor and thermal performance enhancement factor of double tube heat exchanger was studied.**

Keywords- **Taguchi method, DPHE, Computational Fluid, Dynamics, Reynolds Averaged Navier-Stokes.**

I. INTRODUCTION

The discipline of heat transfer is apprehensive with the generation, use, exchange, and conversion of heat and thermal energy between physical systems. Heat transfer is the discipline of thermal engineering those apprehensions the calculation of rate at which heat flows within the medium, across the interface or from one surface to another. Various modes of heat transfer which includes:

- Heat transfer through conduction
- Heat transfer through convection
- Heat transfer through radiation

II. HEAT TRANSFER ENHANCEMENT USING TWISTED TAPES

Heat transfer augmentation is always an important matter of concern since the enhancement of heat transfer rate leads to increase the performance of system which is quite important in various heat transfer applications. Twisted tapes are well known heat transfer enhancement devices and several correlations of heat transfer and pressure drop have been developed for different types of twisted tapes.

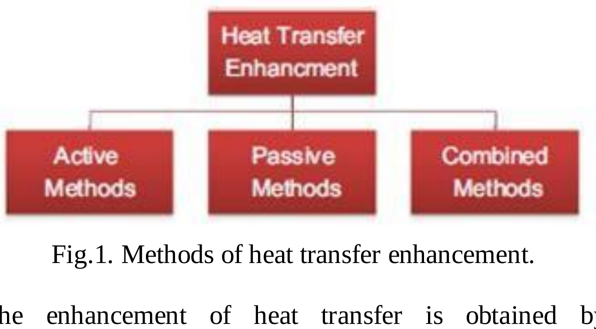

Fig.1. Methods of heat transfer enhancement.

The enhancement of heat transfer is obtained by developing swirl flow of the tube side fluid, which gives high velocities near boundary and fluid mixing and consequently high heat transfer coefficient. In heat transfer systems equipped with twisted tapes, the heat transfer and pressure drop.

III. DOUBLE PIPE HEAT EXCHANGER

A double pipe heat exchanger (also sometimes referred to as a 'pipe-in-pipe' exchanger) is a type of heat exchanger comprising a 'tube in tube' structure. As the name suggests, it consists of two pipes, one within the other. One fluid flows through the inner pipe (analogous to the tube-side in a shell and tube type exchanger) whilst the other flows through the outer pipe, which surrounds the inner pipe (analogous to the shell-side in a shell and tube exchanger). A cross-section of a double pipe exchanger would look something like this.

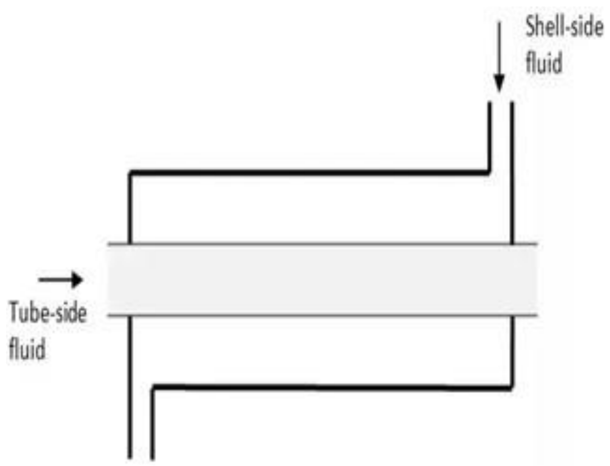

Fig.2. Double pipe heat exchanger.

They often have a U-tube structure to accommodate thermal expansion of the tubes without necessitating expansion joints, as illustrated below

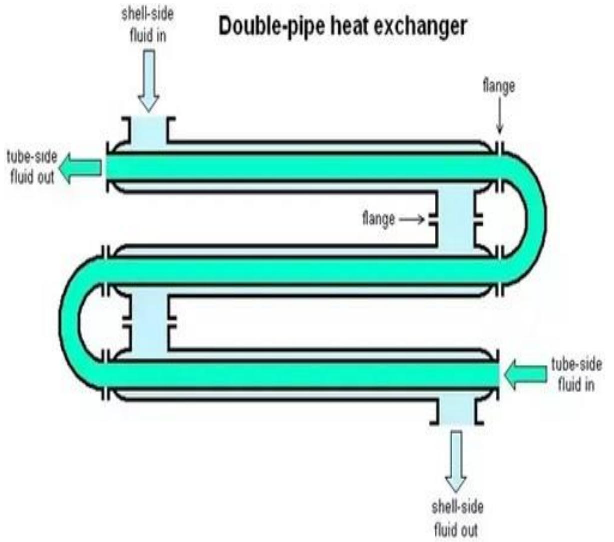

Fig.3. U-type double pipe heat exchanger.

They are one of the simplest and cheapest types of heat exchanger. They can be used for high temperature, high pressure, and highly viscous service. One of the most simple and applicable heat exchangers is double pipe heat exchanger (DPHE) (Fig. 1.2). This kind of heat exchanger is widely used in chemical, food, oil and gas industries. Upon having a relatively small diameter, many precise researches have also hold firmly the belief that this type of heat exchanger is used in high-pressure applications.

They are also of great importance where a wide range of temperature is needed. It is also well documented that this kind of heat exchanger makes a significant contribution to pasteurizing, reheating, preheating, digester heating and effluent heating processes. Many of small industries also use DPHEs due to their low cost of design and maintenance. As a result, we came to conclusion that the previous researches carried out on this type of heat exchanger should be categorized in order to overcome the perplexities of choosing the most appropriate methods of interest.

IV. LITERATURE SURVEY

Instead of using twisted tape inserts,
Deshmukh and Vedula (2014) used curved delta type vortex generator to analyze the heat transfer and friction factor characteristics of flow through a circular tube. The insert was constructed with a central rod on which curved delta wings were attached at specific locations. Local heat transfer coefficient and average pressure drop were examined for different pitch to projected length ratio, height to tube inner diameter and angle of attack. Nu/Nu0 ratio was found to be in the range of 1.3–5.0 and TPF from 1.0 to 1.8.

Behfard and Sohankar (2016) conducted a numerical study of delta winglet vortex generator used in a rectangular duct. They found a TPF of 1.49. Augmentation of heat transfer by using wire-rod bundles was investigated by Nanan et al. (2013). Analysis was done for 4, 6 and 8 wire bundles with three different pitch ratios. Heat transfer rate increased compared to the plain tube. But TPF was less than one in most of the combinations. The combined effect of the twisted tape and vortex generator was experimentally investigated by Promvonge et al. (2014). Experiments were conducted in a square duct with simple, two V winglets and four V winglets with a fixed angle of attack of 30°. Highest TPF of 1.62 was obtained which was 17% more than that of twisted tape.

Arulprakasajothi et al. (2015) investigated the effect of staggered and non-staggered conical strip inserts in a circular tube under laminar flow condition. The conical strip of forward and backward direction was used as turbulators which led to enhanced heat transfer coefficient. Numerical simulation was carried out by Zheng et al. (2017) to investigate the effect of vortex rod in heat exchanger tube. Their results revealed that the vortex rod inclination angle, diameter ratio and Re affects heat transfer and friction factor considerably. Also by using Artificial Neural Network they concluded that the vortex rod with diameter ratio 0.058 and inclination angle 57.05 at Re = 426.767 gives the best TPF.

Wongcharee and Eiamsa (2011) used a twisted tape with alternate axis and triangular, rectangular and trapezoidal wings for heat transfer enhancement. Performance was evaluated for three different wing chord ratios of 0.1, 0.2 and 0.3 with constant twist ratio of 4. Wings were fabricated at an angle 60° relative to the adjacent plane. For the same operating conditions, Nu ratio, friction factor ratio and TPF were higher in trapezoidal cut compared to the other two. Maximum TPF was 1.43 with trapezoidal wings with wing-chord ratio of 0.3.

Bali and Sarac (2014) investigated the effect of propeller type vortex generator. They used two propeller vortex generators as the swirling flow decayed after some distance. They examined the effect of joint angle and number of joint vanes for a range of

Re. Murugesan et al. (2010, 2011, 2011) analyzed the effect on heat transfer characteristics due to square (Murugesan et al., 2010), triangular (Murugesan et al., 2011) and trapezoidal (Murugesan et al., 2011) cut on the periphery of a plain twisted tape. They carried out experiments for twist ratio 2, 4.4 and 6. Their results revealed that Nu and friction factor increased simultaneously. TPF of 1.02–1.22, 1.07–1.27 and 1.02–

1.27 was achieved for trapezoidal, triangular and square cut respectively.

Smith Eiamsa-ard et al. (2010) performed experiments for peripherally cut twisted tape with constant twist ratio of 3. Experiments were performed for different tape width and depth ratios in the range of Re 1000–20,000. They concluded that the peripherally cut twisted tape had better performance compared to a plain tube. TPF achieved was 2.28–4.88 in laminar regime and 0.88–1.29 in turbulent regime.

Smith Eiamsa-ard et al. (2010) conducted experiments for center cut wings in twisted tape. The wings were constructed along the centerline with three different angles of attack (43°, 53° and 74°). Center cut twisted tape with 74° inclined wings were found most effective giving TPF up to 1.4.

Lei et al. (2012) made a hole in the center of the twisted tape and observed that it performed well compared to the plain twisted tape. Another advantage of it was the material saving due to the material removal from the hole. TPF achieved was in the range 1.0–1.4 for different combinations of parameters.

Anvari et al. (2014) used the convergent and divergent type ring inserts. They placed the ring inserts in the tube at equal distance and uniform heat flux was applied from the outer surface. They concluded that the divergent type ring insert was more efficient than the convergent type ring. This approach is different since the fluid moves from periphery to the center where as in twisted tape fluid moves from center to the periphery. Numerical study of heat transfer characteristics in laminar flow have been carried out by Lin et al. (2017) using twisted tape having parallelogram winglet vortex generator. This newly designed twisted tape has two ways to generate secondary flow which includes secondary flow generated by base tape and secondary flow generated by the parallelogram winglet. They observed improvement in TPF ranges from 1.25 to 1.85 for the studied range of Re.

V. CONCLUSION

From the present review, it can be concluded that the heat transfer enhancement occurs in all cases due to reduction in the flow cross section area, an increase in turbulence intensity and an increase in tangential flow established by various types of inserts. Geometrical parameters of inserts like width, length, twist ratio, etc. affect the heat transfer enhancement considerably. Twist direction is also an important parameter in case of multiple twisted tapes since the counter-swirl performs better than the co-swirl. The role of inserts in increasing the turbulence intensity is more significant in laminar regime than in turbulent regime. Therefore to enhance the heat transfer in turbulent flow, wire coil inserts are used. In recent years, second generation enhancement techniques that combine the twisted tape inserts and wire coil have been used to get better heat transfer performance in laminar as well as turbulent flows. Some researchers have also used regularly spaced and perforated twisted tape for the purpose of material saving; the results have shown that the perforation can lead to TPF of more than one. Since perforation results in less obstruction.

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