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A Review on Optimization of Heat Transfer in Six-Start Spirally Corrugated Tubes using Taguchi Method

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Abstract - **Heat transfer devices have been used for conversion and recovery of heat in many industrial and domestic applications. Over five decades, there has been concerted effort to develop design of heat exchanger that can result in reduction in energy requirement as well as material and other cost saving. Heat transfer enhancement techniques generally reduce the thermal resistance either by increasing the effective heat transfer surface area or by generating turbulence. Sometimes these changes are accompanied by an increase in the required pumping power which results in higher cost. The effectiveness of a heat transfer enhancement technique is evaluated by the Thermal Performance Factor which is a ratio of the change in the heat transfer rate to change in friction factor.**

Keywords- **Heat transfer enhancement, Thermal Performance Factor, Twisted tape.**

I. INTRODUCTION

Heat transfer devices have been used for the conversion and recovery of heat in many industrial and domestic applications. Some examples are boiling of liquid and condensation of steam in power plants, thermal processes involved in pharmaceutical and chemical industries, sensible heating and cooling of milk in dairy industries, heating of fluid in concentrated solar collector and cooling of electrical machines and electronic devices among others. Enhancing the performance of a heat transfer device is therefore of great interest since it can result in energy, material and cost saving.

Heat transfer enhancement techniques generally reduce the thermal resistance either by increasing the effective heat transfer surface area or by generating turbulence in the fluid flowing inside the device. Rough surfaces or extended surfaces are used for the purpose of increasing the effective surface area whereas inserts, winglets, turbulatorsetc. are used for generating the turbulence. These changes are usually accompanied by an increase in pumping power which can results in higher cost (Manglik, 2003). The effectiveness of a heat transfer enhancement technique can be evaluated by the Thermal Performance Factor (TPF) which represents the ratio of the relative effect of change in heat transfer rate to change in friction factor.

II. LITERATURE REVIEW

Various heat transfer enhancement techniques have different advantages and limitations. They vary in geometrical configuration and construction complexity while operating under different flow and thermal conditions. On the basis of these parameters this review is classified as follows.

1.Effect of swirl producing devices on heat transfer
The twisted tape inserts have been used as a heat transfer enhancement device in last few decades and particular most widely used in heat exchangers to reduce their size and cost. Depending upon the application, twisted tapes are used with different twist ratio, with varying twist direction, fit and loose tape insert, full and short tape insert, perforated insert, insert with peripheral cuts, etc.

2. Effect of twisted tape dimensions
Instead of full length twisted tape,

Saha et al. (2001) used regularly spaced twisted tape. They investigated experimentally the effect of twist ratio, space ratio, tape width, phase angle on heat transfer and concluded that reduction in tape width gives poor heat transfer and higher than zero phase angle creates complexity in tape manufacturing rather than improving the heat transfer.

Eiamsa-ard et al. (2006) conducted experiments with a twisted tape with twist ratio of 6–8 for a full length tape and free space ratio of 1, 2 and 3 for a regularly spaced twisted tape insert. They concluded that the heat transfer coefficient increases with decrease in twist ratio and space ratio.

Eiamsa-ard et al. (2009) also investigated the effect of short length twisted tape insert. They used twisted tape with fix twist ratio and different length ratio. Short length inserts generated strong swirl at the tube entrance while the full length tape produced strong swirl flow over the entire length. Outcome of their research revealed that the maximum Thermal Performance Factor obtained for full length tape is 1.04 at Re = 4000 and decreases as the length ratio decreases.

Sarada et al. (2011) observed that the width of the twisted tape significantly affects the heat transfer rate. It was found that the heat transfer enhances as the width of insert increases.

Piriyarungrod et al. (2015) presented the effect of taper in the twisted tape to enhance the heat transfer performance. Their experiments for different taper angles revealed that the taper twisted tape does not achieve the thermal performance factor more than 1.05 but increases the heat transfer rate. Thus, taper tape is not a feasible method for heat transfer enhancement.

Esmaeilzadeh et al. (2014) also analyzed the effect of thickness of twisted tape with nanofluid and showed that the increase in thickness of the tape increases the heat transfer rate, friction factor and TPF.

Eiamsa and Promvonge (2010) assessed the performance of alternate clockwise and counter clockwise twisted tape inserts. They used tapes in experiments having twist ratios of 3,4 and 5 each with three twist angles of 30°, 60° and 90° and conclude that the heat transfer rate and TPF of alternate twisted tapes are higher than typical twisted tapes at similar operating conditions. Heat transfer rate and TPF (1.3–1.4) increase with decrease in twist ratio and increase in phase angle.

III. IMPORTANT DEFINITIONS OF CORRUGATION

1.Thermal performance

The effective assessment of modified surfaces is the economic criteria, it represents the primary standard for this aid. But, the Thermal and hydraulic standards have to consider. Web et al. [10] Suggested that the main influential variables are pressure drop, heat transfer rate and flow rate for the obtaining the optimum surface geometry of the flow in the tube. The performance evaluation criteria PEC for the tube side heat exchanger which been used by many authors, it is defined as the ration of enhanced tube heat transfer coefficient to the plain tub at constant pumping power.

$$i_E = (Nu_c/Nu_s)/(f_c/f_s)^{0.293} = f(Re_s)$$

Another reliable and applicable criteria which have been in many researches is the thermal efficiency or performance, it also represents the heat transfer coefficient ratio of the modified tube with a promoter to that of plain tubes at constant pumping power but with different superscript power value.

2. Corrugation pitch

The distance between two successive corrugations is called a pitch p; the distance must be on a straight line from point to point at the same level. It has great effects on the degree of flow turbulence and accelerates the flow toward the transition region.

$$\eta = (Nu_c/Nu_s)/(f_c/f_s)^{1/3} = f(Re_s)$$

3. Corrugation height

The height or depth of the corrugation above or below the bore diameter or base diameter is called the corrugation depth or corrugation height e, because the corrugation could be inward or outward.

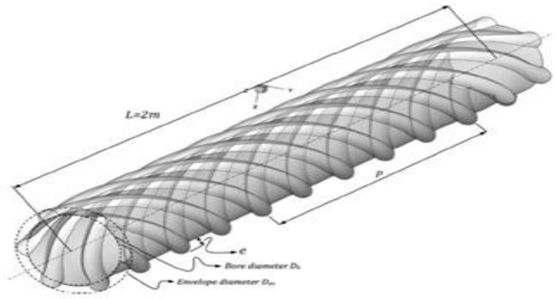

Fig.1.Six–starts spirally corrugated tube.

3.Severity index

Recently, a severity index u which represent the measure of the degree of tube roughness was proposed, where φ = (e2/pd) it combined the effects of pitch and height of corrugation.

IV. CONCLUSION

Exhaustive research has been done by many investigators on the use of twisted tape, artificial roughness or vortex generators to enhance the heat transfer characteristics in tube heat exchangers as discussed in this review; however the areas related to outer tube geometries like conical, parabolic, frustum, etc. have not yet been explored and could be the focus of new research. The TPF reduces with increase in Reynolds Number. Twisted tape does not perform well where air is used as a working fluid. It performs well where water and nanofluid are used as working fluid because of larger density of liquid. Therefore for air heating applications vortex generators, ribs or deflectors are more helpful in increasing the TPF. In case of liquids swirl producing devices are more helpful in increasing the TPF.

REFERENCES

[1]. Saha, S.K., Dutta, A., Dhal, S.K., 2001. Friction and heat transfer characteristics of laminar swirl flow through a circular tube fitted with regularly spaced

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twist edtape elements. Int. J. Heat Mass Transf. 44 (22), 4211–4223.

[2]. Eiamsa-ard, S., Thianpong, C., Promvonge, P., 2006. Experimental investigation of heat transfer and flow friction in a circular tube fitted with regularly spaced twisted tape elements. Int. Commun. Heat Mass Transfer 33 (10), 1225–1233.

[3]. Eiamsa-ard, S. et al., 2009. Convective heat transfer in a circular tube with shortlength twisted tape insert. Int. Commun. Heat Mass Transfer 36 (4), 365–371.

[4]. Sarada, S.N. et al., 2011. Enhancement of heat transfer using varying width twisted tape inserts. Int. J. Eng., Sci. Technol. 2 (6), 107–118.

[5]. Piriyarungrod, N. et al., 2015. Heat transfer enhancement by tapered twisted tape inserts. Chem. Eng. Process. 96, 62–71.

[6]. Esmaeilzadeh, E. et al., 2014. Study on heat transfer and friction factor characteristics of c-Al2O3/water through circular tube with twisted tape inserts with different thicknesses. Int. J. Therm. Sci. 82, 72–83.

[7]. Eiamsa-ard, S., Promvonge, P., 2010. Performance assessment in a heat exchanger tube with alternate clockwise and counter-clockwise twisted-tape inserts. Int. J. Heat Mass Transf. 53 (7–8), 1364–1372.

[8]. Patil, S.V., Babu, P.V.V., 2014. Heat transfer and pressure drop studies through a square duct fitted with increasing and decreasing order of twisted tape. Heat Transfer Eng. 35 (14–15), 1380–1387.

[9]. Patil, S.V., Vijaybabu, P.V., 2012. Heat transfer enhancement through a square duct fitted with twisted tape inserts. Heat and Mass Transfer/Waerme- und Stoffuebertragung 48 (10), 1803–1811.

[10]. Eiamsa-ard, S., Wongcharee, K., Promvonge, P., 2012b. Influence of nonuniform twisted tape on heat transfer enhancement characteristics. Chem. Eng. Commun. 199 (10), 1279–1297.

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