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A Review on Performance Evaluation Of Heat Transfer And Friction Factor Characteristics Of Double Pipe Heat Exchanger Fitted With Square Jagged Twisted Tape Inserts

#1 Satyajit D.Ghorpade, #2 Prof. K.P.Kolhe

[1] satyajitghorpade@gmail.com

[2]skishor75@gmail

#1 PG Student: Mechanical Engineering Department
JSPM's Imperial College of Engineering & Research Wagholi,Pune. (India)

ABSTRACT

In present paper, the characteristics of heat transfer parameter and achievement of pressure drop at a place of horizontal & double pipe with square jagged twisted tube inserts are investigated. As a working fluid cold and hot water are used in shell and tube side respectively. As a result of insertion of helical screw tape, square jagged twisted tape in a concentric double tube heat exchanger gives better effectiveness on a flow friction characteristics and heat transfer rate those are experimentally investigated. Mean fanning friction factor, heat transfer coefficients & factors of thermal performance in tube fitted with square jagged twisted tape inserts are augmented respectively. The consideration is done with the effect of twist ratio and other related parameters on characteristics of heat transfer and pressure drop.

The major goal of enhancement of heat transfer rate is possible with encouragement of high heat fluxes. The application of square jagged twisted tape was found to improvement in condensing heat transfer coefficients. In addition the effectiveness of square jagged twisted tape on heat transfer enhancement is also investigated. The outcomes of experimental investigations are that combination of twisted tape inserts with square jagged performs significantly better than individual enhancement technique. The study gives better agreement with the introduction of turbulence flow which can be used to predict improved performance of heat transfer rate.

Keywords— **Square tape inserts;Channel flows turbulators; Performance Criteria ; thermal performance; friction factor.**

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I. INTRODUCTION

Due to tremendous advancement from last few decades the heat exchangers are widely used in industrial processes. For cooling and heating applications such as refrigeration and air conditioning system. Heat recovery in dairy and food processes, chemical industries etc. The main challenging thing in the designing of heat exchanger is the making compact equipment and gains the maximum heat transfer rate with minimum pumping power. Heat transfer augmentation techniques are relevant to engineering applications. Now a days the high cost of energy and material has resulted in an increased effort aimed to producing heat exchanger equipment with more efficiency.
The performance of heat exchanger in view of heat transfer rate or thermal performance can be improved by implementation of heat transfer enhancement technique. There are so many investigations are carried out on size, orientation and shape etc. of different types of inserts and

rough surfaces like helical screw, twisted bar and coiled wire etc.

II. LITRATURE SURVEY

Heat exchangers are mostly used devices in many areas of the industries. Hence, the using of high performance heat exchangers is very important for saving energy. A lot of methods are applied to increase thermal performance of heat transfer devices such as treated surfaces, rough surfaces, swirling flow devices, coiled tubes, and surface tension devices [1]. Twisted tape swirl turbulator is of steady performance, simple configurations and ease of installation [2]. These type inserts generate swirling flow and cause improved fluid mixing between central region and the nearly wall region so, the heat transfer in tubes can be enhanced by fluid mixing. Sarma et al. [3] gave generalized correlations to predict friction factor and convective heat transfer coefficient in a tube fitted with twisted tapes for a wide range of Reynolds number and Prandtl number.

The contribution to thermal performance of the conventional, short-width and center-cleared twisted tapes was studied numerically [2].Among the passive techniques, insertion of twisted tape swirl generator is one of the most promising techniques. Tubes with twisted tape insert have been widely used as the continuous swirl flow devices for augmentation the heat transfer rate in heat exchanger tubes and applied in many industrial applications such as heat recovery processes, air conditioning and refrigeration systems cooling of modern electronic appliances, chemical reactors, food and dairy processes [3]. Wongcharee and Eiamsa-ard [4] presented the effects of twisted tapes with alternate-axes and wings on heat transfer, fluid friction and thermal performance characteristics in a circular tube.

It was illustrated from the results that both heat transfer rate and friction factor associated with all twisted tapes were consistently higher than those without twisted tape. Hieber [5] developed a semi-analytical correlation for laminar mixed convection in an isothermal horizontal tube to describe all the available heat transfer data with an RMS deviation of 11.7% based upon log-mean Nusselt number, 11.0% based on arithmetic mean Nusselt number and 9.8% based on fractional bulk-temperature rise. Coutier and Grief [6] studied both experimentally and numerically laminar flow heat transfer within a horizontal tube surrounded by a liquid medium. It was found that the variable wall temperature has a marked effect on the secondary flow patterns within the tube as well as on the heat transfer. Moon et al. [7] investigated numerically. Mixed convection heat transfer in horizontal cylinders by solving the elliptic partial differential equations and transformed into finite difference equations using a non-uniform grid.

Twisted tapes with gradually decreasing pitch perform worse than their uniform-pitch counterparts Patil [8] have worked with varying width twisted tape inserts for which both friction factor and Nusselt number are lower than those with full-width twisted tapes. Saha et al[9,10] have introduced regularly spaced twisted- tape elements which are better than full-length twisted tapes under certain circumstances.

III. CLASSIFICATION: AUGMENTATION TECHNIQUES

They are broadly classified into three different categories:

1. Passive Techniques
2. Active Techniques
3. Compound Techniques.

1.Passive Techniques: These techniques do not require any direct input of external power; rather they use it from the system itself which ultimately leads to an increase in fluid pressure drop. They generally use surface or geometrical modifications to the flow channel by incorporating inserts or additional devices like twisted tapes, twisted wires, circular rings etc. They promote higher heat transfer coefficients by disturbing or altering the existing flow behavior except for extended surfaces. Heat transfer augmentation by these techniques can be achieved.

(i) Treated Surfaces: Such surfaces have a fine scale alteration to their finish or coating which may be continuous or discontinuous. There are various treated surfaces available like coiled wire, twisted wire, spring wire and one such type treated surface, twisted tape is shown below.

Fig.1 Twisted tapes

(ii) Rough surfaces: These are the surface modifications that promote turbulence in the flow field in the wall region, primarily in single phase flows, without increase in heat transfer surface area.

Coiled tubes: These lead to relatively more compact heat exchangers. It produces secondary flows and vortices which promote higher heat transfer coefficients in single phase flows as well as in most regions of boiling . As explained in treated surface an another type of insert named coiled wire is shown below:

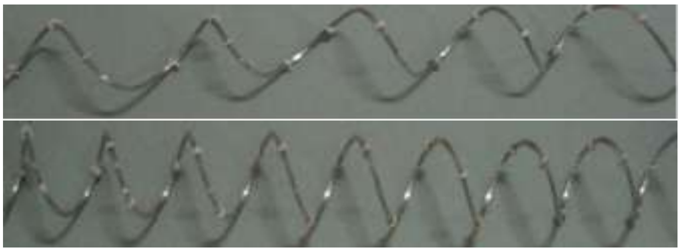

Fig.2 Coiled wire inserts

Turbulators: These are primarily used in single phase flows and are considered to be perhaps the most practical type of vibration enhancement technique .The turbulators comes under active technique and hence require external power for heat enhancement. The conical turbulators shown below gives the vibratory action to the fluid particles and hence create turbulence.

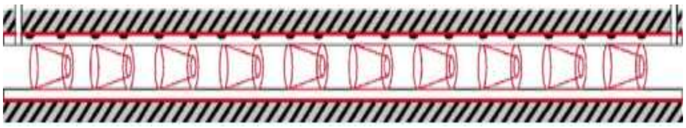

Fig. 3 conical turbulators

IV. RESEARCH OPPORUTUNITIES

The aim of insert is to enhance heat transfer rate by reducing the size and cost of heat exchanger but not with the increase in pumping power. By referring the above literature it was observed that the objective can be achieved if one goes for passive techniques. After referring the results obtained from the twisted tape inserts, they are offering less pressure drop than the other techniques mentioned in above literature. There exists a lot of work on twisted tape by various researchers by varying various pitch by diameter ratios or by varying thickness to pitch ratio. The material used by them is normally teflon which is a non metal also the material is solid in shape. The inserts can be modified by giving new design as it can be made hollow, as if a material becomes hollow the friction factor may reduce as it will reduce the obstruction to fluid flow. Also if it is given a twisted wire shape then due to hollow nature of inserts an extensive contact surface between solid and fluid surfaces are generated. The extensive contact surface enhances the internal heat exchange between the phases and consequently results in an increased thermal diffusivity

Change of phase—boiling and evaporation

Study on boiling change of phase have been explained as follows Those that focus on droplet and film evaporation, bubble characteristics, pool boiling, film boiling, flow or forced convection boiling, and two-phase thermo-hydrodynamic effects. Some discuss surface geometry effects, such as micro porous coatings, micro fins, or tube inserts. Some deal with interface characteristics, such as contact angle.

Experimental studies were carried out on the heat transfer enhancement and pressure drop characteristics in presence of twisted tape inserts, during flow boiling of R-134.a inside a horizontal evaporator for plain flow and four tubes with twisted tapes of 10, 14, and 18 twist ratios and four refrigerant mass velocities of 54, 85, 114 and 136 kg/s m^2 for each tape. It has been found that the twisted tape inserts enhance the heat transfer coefficient on relatively higher pressure drop penalty, in comparison to that for the plain tube.

It was found that the maximum thermal stress ratio occurred in the case of p = 2d for 3 m/s mean water velocity. The effect of different coiled wire geometry on pressure drop during condensation of R-134 a vapor inside a horizontal tube was experimentally investigated by Akhavan-Behabadi. Finally, they developed a new correlation based on the experimental data for predicting the pressure loss in coiled wire inserted tubes. The correlation is given as follows:

$$Nu = 0.81 Pr^{\frac{1}{5}} Re^{.661} \left\{ \frac{\left(\frac{\rho 1}{\rho m}\right) in^{0.5} + \left(\frac{\rho 1}{\rho m}\right) out^{0.5}}{2} \right\}^{0.90} \left(\frac{XD}{L}\right)^{0.29}$$

Where,
Nu= average Nusselt number=h D/k
Pr= liquid Prandtl number = mCp/k
Re= liquid Reynolds number = GD/m
G= liquid mass velocity considering total refrigerant is flowing inside the tube as liquid.
m,C_p,k= Absolute viscosity, specific heat and thermal conductivity of liquid refrigerant calculated at the saturation temperature corresponding to the average pressure existing in the test section length

Boundary Layers and External Flows:

Study on boundary layers and external flows have been categorized as flows influenced externally, flows with special geometric effects, compressible and high-speed flows, analysis and modeling techniques, unsteady flow effects, flows with film and interfacial effects and flows with special fluid types or property effects. External effects on boundary layers including swirl, oscillation, and unsteadiness imposed by forcing the flow, elevated external turbulence levels are included in literature below. Many papers deal with variations in geometry. Such geometric features include surface roughness elements, embedded micro channels or grooves, porous heat transfer walls(with suction or injection); baffles, solid and porous, vortex generators, turbulators, twisted tape, corrugations, fins of various shapes, cylinders of various shapes, spheres, rod bundles and rod bundle support structures.

Use of nano-fluids for heat transfer enhancement:

The literature review is carried out in order to see the present research in this area which elaborated under present status. Many experimental and less theoretical works have been attempted in the nano-fluids area. Some of these works are focused on use of nano-fluids in the circular pipes or in the heat exchangers. The following is a brief description of the work and research completed by some prominent researchers in the field of nano-fluids, specifically related to this work. This review illustrates the current schools of thought on the factors involved in influencing the properties of nano-fluids.

V. OBJECTIVES

1. To investigate the effect of various thickness and pitches of copper and aluminum inserts on heat transfer rate.
2. To correlate theoretical and experimental results of parameters like heat transfer coefficient, Nusselt number, Friction factor between Copper and Aluminium.
3. To find out the optimum result with pressure drop.
4. To develop an experimental facility for studying turbulent flow heat transfer and fluid friction in a test pipe with twisted wire inserts.
5. To analyze the heat transfer performance.
6. To compare the results obtained from both cases (Test pipe with and without inserts).

To choose the material between Copper and Aluminium depending on the material properties like thermal conductivity, density along with the properties like heat transfer rate and pressure drop.

VI. MATLAB PROGRAMMING

The aim of using MATLAB in this study is to consider the effect of two main factors, Reynolds number , Number of twists and the surface temperature of the tube through which the heat exchanges. In order to perform MATLAB program, input and output variables and their levels must be determined. MATLAB program in its any form has three basic parts as:

1. Input steps: All input parameters are entered
2. Processing steps: Entered values are used in processing by MATLAB functions.
3. Output steps: The results obtained from calculations are displayed to user.

VII. PERFORMANCE EVALUATION CRITERIA

a In many practical applications of enhancement techniques, the following performance objectives, along with a set of operating constraints and conditions, are usually considered for evaluating the thermo-hydraulic performance of a heat exchanger.

VIII. EXPERIMENTAL WORK OF INSERTS

a From the above study the experimental work is carried out on the basis of fixed geometry. As per the requirement of our experiment, the study is categorized into boundary layers and external flows, change of phase and channel flows,

• Increase in the heat duty of an existing heat exchanger without altering the pumping power or flow rate requirements.

• Reduction in the approach temperature difference between the two heat exchanging fluid streams for a specified heat load and size of exchanger.

• Reduction in the size or heat transfer surface area requirements for a specified heat duty and pressure drop.

• Reduction in the process stream's pumping power requirements for a given heat load and exchanger surface area.

IX. EXPERIMENTAL SETUP

01	Hot water tank	07	Test Section	13	Control pannel
02	Hot water Pump	08	Hot water outlet	14	Temp.Indicator
03	By Pass Valve	09	Cold water tank	15	Temp.Controller
04	Flow control valve	10	Cold water pump	16	U manometer
05	Rotameter	11	Cold water inlet	17	Stand
06	Hot water inlet	12	Cold water outlet	18	Table

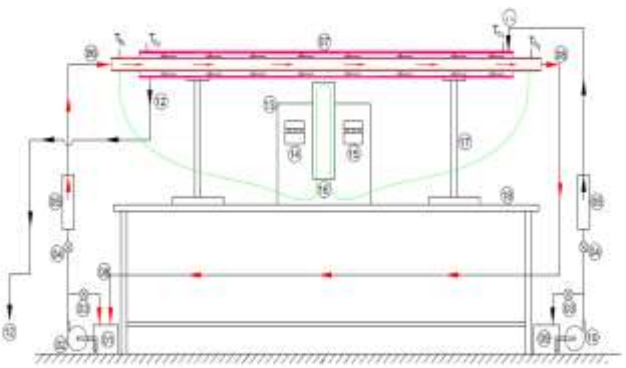

Fig 4. Experimental setup

X. CONCLUSION

An experimental study was conducted to investigate the heat transfer performance & friction factor characteristics for turbulent flow through a tube by means of twisted tape square jagged inserts provided significant enhancement of heat transfer with the corresponding increase in friction factor .It was found that Nusselt number, friction factor and thermal performance factor increased with the increase of twisted wire densities. Based on experimental results, key finding of these studies and could be summarized.

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