Review on Twisted Pipe Heat Exchanger

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Abstract— Heat transfer augmentation techniques refer to different methods like Swirl-flow devices include a number of geometric arrangements or tube inserts for forced flow that create rotating and/or secondary flow. Coiled tubes, inlet vortex generators, twisted-tape inserts, and axial core inserts with a screw-type winding used to increase rate of heat transfer without affecting much the overall performance of the system. These techniques are used in heat exchangers which are used in process industries, air-conditioning equipment, refrigerators thermal. This research investigates application of nano fluids Al2O3/water and CuO/water nano fluids in heat exchanger with dual twisted tapes. The CFD simulation technique is being using for analysis and CAD model is developed using Creo 2.0. The CFD analysis package used is ANSYS CFX.

Keywords: ANSYS CFX, Nano fluids, heat transfer

I. INTRODUCTION

In heat exchanger thermal energy of one fluid is transferred to another fluid. The heat transfer may take place through surface to fluid or between solid particles to fluid. The main criteria of heat transfer between fluids or from surface to fluid is thermal gradient or temperature difference between the two. Heat exchangers are used widely for heating and cooling operations of fluid involves. The process involves evaporation, condensation etc. Some other application of heat exchangers involve sterilization, pasteurization. The fluids in heat exchanger are separated by wall thus fluids don't intermix. These heat exchangers are known as recuperator

II. LITERATURE REVIEW

The heat exchanger plays an important role in almost all of the mechanical industries and especially in case of process industries it is an key element. Heat exchangers are used in different processes ranging from conversion, utilization & recovery of thermal energy in various industrial, commercial & domestic applications. Some common examples include steam generation & condensation in power & cogeneration plants; sensible heating & cooling in thermal processing of chemical, pharmaceutical & agricultural products. Thus, from long time many researchers in this area are working to improve the performance of these heat exchangers in terms of heat transfer rate, keeping pressure drop in limit. In order to augment heat transfer and to increase thermal performance of the heat exchangers, heat transfer enhancement techniques are widely used. Increase in Heat exchanger's performance can lead to more economical design of heat exchanger which can help to make energy, material & cost savings related to a heat exchange process. The need to increase the thermal performance of heat exchangers, thereby effecting energy, material & cost savings have led to development & use of many techniques termed as Heat Transfer Augmentation. These techniques are classified in three groups, active, passive and compound techniques.

P. Eiamsa-ard, et al. [1] In this paper, the effects of regularly spaced twisted tape is analysed by comparing it with the full length twisted tape and plain tape. The twisted tapes used are of different pitches. Numerical simulation is used to visualize the flow. The experiment results show that heat transfer rate and friction increased with decreasing twist ratio and space ratio. The full length twisted tapes found to be more useful than regularly spaced tapes from the thermal performance point of view.

S. Naga Sarada et. al. [2] This experiment work shows the results obtained from experimental investigations of the augmentation of turbulent flow heat transfer in a horizontal tube by means of varying width twisted tape inserts with air as the working fluid. In order to reduce excessive pressure drops associated with full width twisted tape inserts, with less corresponding reduction in heat transfer coefficients, reduced width twisted tapes are used. Experiments were carried out for plain tube with/without twisted tape insert at constant wall heat flux and different mass flow rates. Both heat transfer coefficient and pressure drop are calculated and the results are compared with those of plain tube. It was found that the enhancement of heat transfer with twisted tape inserts as compared to plain tube varied from 36 to 48% for full width (26mm) and 33 to 39% for reduced width (22 mm) inserts. Correlations are developed for friction factors and Nusselt numbers for a fully developed turbulent swirl flow, which are applicable to full width as well as reduced width twisted tapes.

A.Rahul kumar et. al. [3] The objective of this paper is to investigate the swirl flow behavior and the laminar convective heat transfer in a circular tube with twisted-tape inserts. The fluid flow and thermal fields are simulated computationally in an effort to characterize their structure. Apart from this, issues like long term performance & detailed economic analysis of heat exchanger has to be studied to achieve high heat transfer rate in an existing or new heat exchanger while taking care of the increased pumping power. It was concluded from the experiment that for same twist ratio, twisted tape shows higher heat transfer coefficient & friction factor increase because of higher degree of turbulence created.

W.H.Azmi et. al. [4] This paper covers the experimental determination of heat transfer coefficients of SiO2/water and TiO2/water nanofluid up to 3% volume concentration flowing in a circular tube. The investigations are conducted in the Reynolds number range of 5000 to 25000 at a bulk temperature of 30 ^{0} C. The experiments are undertaken for flow in a circular tube with twisted tapes of different twist ratios in the range of 5< H/D< 93. It was found that the heat transfer enhancement is inversely increased with twist ratio. The heat transfer coefficient of

SiO2/water nanofluid at 3.0% volume concentration is 27.9% higher than water flow for the same twist ratio of five. However, the value of heat transfer coefficient of TiO2/water nanofluid evaluated at the same concentration is 11.4% greater than water for twist ratio five. Regression equations for Nusselt number estimation are developed valid for water and nanofluid flow with twisted tape inserts under turbulent flow conditions.

A.V.Gawandare et. al. [5] The present experimental work is carried out with copper twisted tape inserts 3mm with different twists respectively. The work includes the determination of friction factor and heat transfer coefficient for various twisted wire inserts with varying twists and different materials. Correlations for Nusselt number and friction factor are developed for the twisted wire inserts from the obtained results. The results of varying twists in square jagged tape with different pitches have been compared with the values for the smooth tube. The 3mm thick with 3.2 twists copper insert shows increase in Nusselt number values by 76% however there is increase in friction factor by only 19.5% as compared to the smooth tube values.

A. E. Zohir [6] In this paper, heat transfer haracteristics and pressure drop are studied for turbulent flow in a sudden expansion pipe equipped with propeller swirl generator. The experiments are performed for vaying Reynolds number for three locations for the propeller fan upstream the sudden expansion and three locations downstream the sudden expansion. Use of propeller at downstream gives better result than at upstream. Correlations for Nusselt number and thermal performance are presented for different fan locations and different Reynolds number.

S Eiamsa-ard et. al. [7] Here the combination of twisted tape and helical screw tape is used for generating swirl flow. The two tapes are arranged in co-swirl and counter swirl arrangement. Initially both the tapes are testes alone for

Agrawal et. al. [9] conducted an experiment study to determine the characteristic of friction and heat transfer for heating and cooling of Servotherm oil under uniform wall temperature with twisted tapes inserts. In experiment two double pipe heat exchangers is used, one pipe for hot and other is for cold in series. The prediction of isothermal friction factor and Nusselt number is given by new correlation for uniform wall temperature of viscous liquids when twisted tapes of twist ratio is less than or equal to 5. The results showed a growth in isothermal friction factor which was 3.13–9.71 times the values of plain tubes whereas at constant pumping power and constant flow rate increase in Nusselt number were found to be 1.21–3.70 and 2.28–5.35 respectively times the plain tube values. The relationship was developed to predict isothermal friction factor for (Re/y) ¼ 9-1000.

Al-Fahed et. al. [10] carried out an experimental investigation to study the effect of clearance between tube and tape on heat transfer characteristics for fully developed turbulent flow through a horizontal isothermal tube. The experimentation is conducted for fifteen different twisted tapes. 3.6, 5.4 and 7.1 these three different twist ratios were selected with five different widths of 10.8 mm, 11.4 mm, 12.0 mm, 12.6 mm and 13.2 mm. The results showed that with decrease in tube- tape clearance the enhancement of heat transfer rate increases. Result Also shows that, for twist ratio 3.6 and tape width 10.8 mm, heat transfer enhancement was nearly equal to 13.2 mm width of same twist ratio. Almost 17% difference in heat transfer enhancement was obtained from different widths with twisted tape of twist ratio 3.6, and same difference in heat transfer improvement for twisted tapes of twist ratio 5.4 and 7.1 was 9% and 5% respectively. The study concluded that with small twist ratio and tight fit tape are desirable to achieve high heat transfer improvement for turbulent flow in practical design of thermal systems.

Al-Fahed and Chamra L.M. [11] conducted an experimental study to study and compare heat transfer coefficients and pressure drop for a plain, twisted tape inserts and microfin in laminar flow region. By using a single shell and tube heat exchanger tThe experiments were performed, were steam as a heating source and oil was used as a working fluid. The twisted tapes of three different twist ratios 3.6, 5.4 and 7.1 for and two widths ratio 0.95 and 0.77 were selected in the study. The study shows that from the results that the use of twisted tapes is most effective method to improve heat transfer rate. It was also found that heat transfer rate increases with decreasing twist ratio. Higher values of heat transfer were obtained by using tight fit tapes for twist ratios 3.6 and 5.4 than loose fit tapes. But the high heat transfer rate was obtained by loose fit tapes than tight fit tapes for twist ratio of 7.1. The comparison of friction factor of microfin tube with that of plain tube was done using Friction Loss Ratio. The friction loss ratio of microfin tube was approximately unity due to which pressure drop in microfin tube was almost same as that of plain tube. A small increase in heat transfer and pressure drop coefficients was obtained by using microfin tubes over the plain tubes therefore, the studied microfin tubes were not found useful for laminar flow.

Liao et. al. [12] carried out an investigation on tubes with three dimensional internal extended surfaces. Experiments were performed to investigate heat transfer and friction characteristics for ethylene glycol, water, and ISO VG46 turbine oil with laminar, transitional and turbulent flow through four tubes with three dimensional internal extended surfaces and copper continuous or segmented twisted tape inserts. On three copper, continuous twisted tapes insert the experiments were conducted with twist ratio 5, 10 and15 along with two copper segmented twisted tape inserts with a twist ratio of 10 and 15. The range of Prandtl number (Pr) and Reynolds number (Re) was 5.5–590 and 80–50,000 respectively. The results showed that by using 3 DIEST tubes technique with twisted tape inserts to increase heat transfer rate is suitable for laminar flow of highly viscous fluid flowing through tube. Also, there was found a small increase in heat transfer for transitional and turbulent flow but friction factor increases considerably.

C. Thianpong et. al [13] conducted an experimental investigation for heat transfer and pressure drop analysis for turbulent flow with perforated twisted tapes in heat exchanger. The experimentation is carried out for perforated twisted tapes of having hole diameter ration d/W is 0.11, 0.33 and 0.55 with wing depth ratio w/W is 0.11. 0.22 and

0.33. Experimental result shows that the heat transfer enhancement in perforated twisted tube and twisted tube is be up to 208% and 190% as compared to plain tubes. Perforated twisted tube with same pumping power having d/W ratio 0.11 and 0.33 gave the maximum thermal performance factor of 1.33 at Reynolds number of 5500. The empirical relations for friction factor, heat transfer and thermal performance for perforated twisted tube were also developed.

Bodius Salam et. al. [14] carried out experiments for measuring tube side heat transfer, friction factor, heat transfer enhancement using twisted tapes with rectangular cut. A stainless-steel tape with rectangular cut with twist ratio 5.25 is used as insert in tube heat exchanger. The rectangular cut had 8 mm depth and 14 mm width. The experimentation is carried out for uniform heat flux which is maintained with the help of nichrome wire. The heat flux variation 14 to 22 kW/m2 for smooth tube, and 23 to 40 kW/m2 for tube with insert with varring Reynolds numbers between 10000-19000. Nusselt numbers obtained from smooth tube were compared with Gnielinski correlation and errors were found to be in the range of -6% to -25% with r.m.s. value of 20%. Nusselt numbers in tube with rectangular-cut twisted tape insert were enhanced by 2.3 to 2.9 times at the cost of increase of friction factors by 1.4 to 1.8 times compared to that of smooth tube as compared to Reynolds number. Heat transfer enhancement efficiencies were found to be in the range of 1.9 to 2.3 and increased with the increase of Reynolds number.3.

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