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"HEAT TRANSFER ENHANCEMENT IN HEAT EXCHANGER BY PASSIVE METHOD TECHNIQUE: A REVIEW"

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ABSTRACT

This paper is a comprehensive review of research work of heat transfer Enhancement in Heat Exchanger by passive methods. This are employed for increasing the heat transfer coefficient in circular tube of heat exchanger. Passive methods are widely used in both experimental and numerical applications when investigating heat transfer enhancement and friction losses to save energy and costs. The many passive methods for increasing heat transfer rate include various components located in the fluid flow path, such as twisted tapes, coiled or tangled wires, and nozzle tabulators. Passive techniques of heat transfer augmentation can play an important role if a proper passive insert configuration can be selected according to the heat exchanger working condition. The thermo hydraulic behavior of an insert mainly depends on the low conditions means flow is laminar or turbulent apart from the design of insert. To Review the performance of various geometry employed for Enhancement of heat transfer, this attempt is formed. Based on correlations observed by different researchers for friction factor, and heat transfer coefficient, Improvement of heat transfer coefficient and reduction of friction factor is considered. It has also reviewed and presented the thermo- hydraulic performance of different geometry on its absorber surface of heat transfer tube has been compared.

Key Words: *Heat transfer Enhancement, Wavy twist tab, Heat Transfer Coefficient, Friction factor.*

I. INTRODUCTION

Heat transfer Augmentation" means Increase in heat exchanger's performance with the help of augmentation techniques, this can lead to more economical design of heat exchanger that can also help to make energy, material and cost savings related to a heat exchange process. In this review paper emphasis is given on inserts used in for the augmentation of heat transfer in tube. The subject of heat transfer growth in heat exchanger is of serious interest in the design of effective and economical heat exchanger Bergles et al., identified about 14 augmentation techniques used for the heat exchangers. These augmentation techniques can be classified into passive, active and compound techniques. Passive techniques do not require any type of external power for the heat transfer augmentation such as coating of Surface, rough surface, extended surface, displaced insert, swirl flow device, surface flow device, surface tension, additives for liquid, and additives for gases. Whereas, the active techniques need some power externally, such as electric or acoustic fields, surface vibration, mechanical aid, fluid vibration, injection, suction, jet impingement, etc.,

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and compound technique are the combination of this two method. In most practical applications of augmentation methods, the following performance Objectives, along with a set of operating constraints and conditions are usually considered for optimizing the use of a heat exchanger

1. Increase the heat duty of an existing heat exchanger without altering the pressure drop or flow rate.

2. Reduce the approach temperature difference between the two heat exchanging fluids Streams for a specified heat load and size of exchanger.

3. Reduce the size or heat transfer surface area requirements for a specified heat duty and pressure drop.

4. Reduce the process stream pumping power requirements for a given heat load and Exchanger surface area.

Different Criteria used for evaluating the performance of a single phase flow are:
Fixed Geometry (FG) Criteria: The area cross section (N and di) and tube length L are kept constant. This criterion is typically applicable for retrofitting the smooth tubes of an existing exchanger with enhanced tubes, thereby maintaining the same basic geometry and size (N, di, L).
Fixed Number (FN) Criteria - The flow cross sectional area (N and di) is kept constant, and the heat exchanger length is allowed to vary. Here the objectives are to seek a reduction in either the heat transfer area A×L or the pumping power P for a fixed heat load.
Variable Geometry (VN) Criteria – The flow frontal area (N and L) is kept constant but their diameter can change. A heat exchanger is often sized to meet a specified heat duty Q for a fixed process fluid flow rate . Because the tube side velocity reduces in such cases so as to accommodate the higher friction losses in the enhanced surface tubes, it becomes necessary to increase the flow area.

II. TWISTED TAP IN LAMINAR FLOW

Several researchers have studied various configurations of twisted tape, such as full- length twisted tape, short-length twisted tape, full-length twisted tape with varying pitch and regularly spaced twisted tape. This section discusses which configuration of twisted tape is suitable for laminar flow.

[1] Jagpreet Singh et al., Convective heat transfer characteristics within a heat exchanger with twisted tapes of different cuts and materials have been investigated experimentally. Effect of twisted tape of different cuts (inside the inner tube of single unit on heat transfer and friction factor for heating of water for Reynolds number range 500-3000 was studied experimentally.

[2] S. Eiamsa-ard, K. Wongcharee, P. Eiamsa-ard , C., Heat transfer, flow friction and thermal performance factor characteristics in a tube fitted with deltawinglet twisted tape, using water as working fluid are investigated experimentally. Influences of the oblique delta-winglet twisted tape and straight delta- winglet twisted tape arrangements are also described.

[3] W.H. Azmi , K.V. Sharma, P.K. Sarma , Rizalman Mamat , G. Najafi., “Heat transfer coefficient and friction factor of TiO_2 and SiO_2 water based nanofluids” Flowing in a circular tube under turbulent flow are investigated experimentally under constant heat flux boundary condition. TiO_2 and SiO_2 nanofluids with an average particle size of 50 nm and 22 nm respectively are used in the working fluid for volume concentrations up to 3.0%.

[4] Pratik P. Ganorkar et al., Performance of heat exchanging devices for reducing material cost and surface area for heat transfer. The Reynolds numbers were varied in the range 5000-22000. Nusselt numbers obtained from smooth tube were compared with Gnielinski and Dittus-Boelter correlation and errors were found to be average of 12.2% and

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9.2% respectively. Friction factor obtained from experiments were compared.

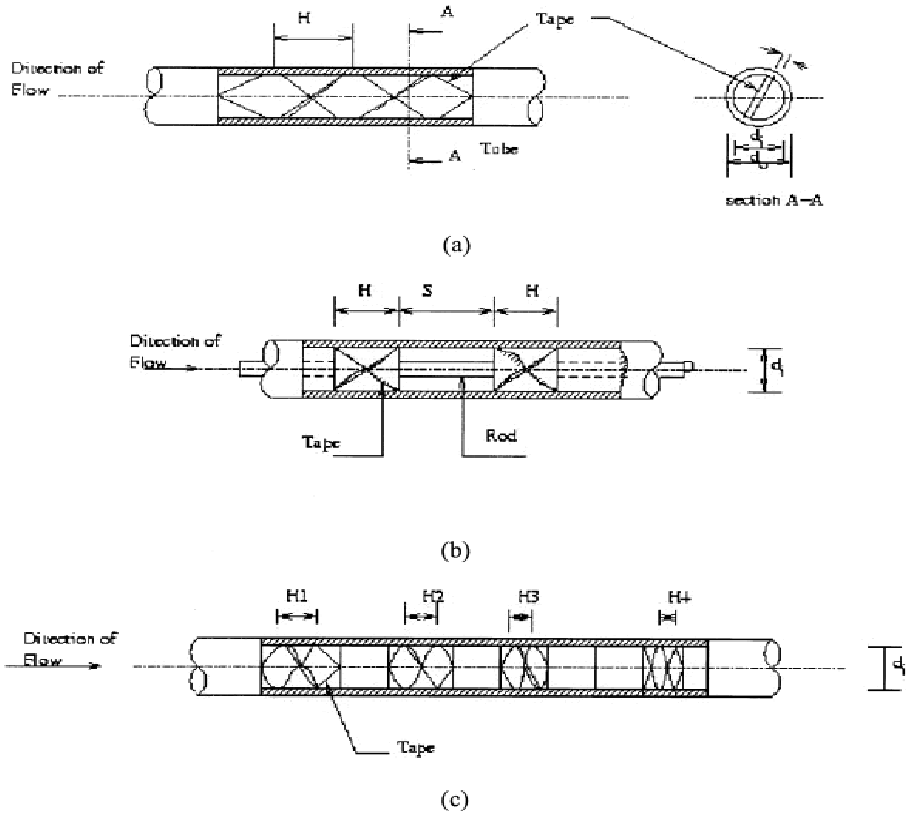

Fig:-1 (a) full-length twisted tape, (b) regularly spaced twisted tape and (c) smoothly varying (gradually decreasing) pitch full-length twisted tape

[5] Kurhade Anant Sidhappa et al., Heat transfer and friction factor properties were experimentally investigated by using copper wavy twisted tape inserts with circular holes in forced convection. The turbulent flow was created by inserting the wavy twisted tape inserts into the test pipe creating high rate of turbulence in pipe, which results in increasing heat transfer enhancement and pressure drop.

[6] Riddheshwar R. Bilawane, Mahendra P. Nimkar, Heat transfer augmentation techniques refer to different methods used to increase rate of heat transfer such as active, passive and compound technique. The present paper is a review of one of the passive augmentation techniques used in a concentric tube heat exchanger using inner wavy tube. The performance of counter flow heat exchanger will be studied with inner plain tube and inner wavy tube.

[7] Lokanath and Misal., studied the performance of a plate heat exchanger and augmented shell and tube heat exchanger for different fluids. They found that twisted tapes of tighter twists are expected to give higher overall heat transfer coefficients in the augmented shell and tube heat exchanger.

[8] Shah and Skiepko., investigated the existence of entropy generation extreme and a relationship between the extreme and the heat exchanger effectiveness.

[9] Saha et al., found that pinching of twisted tape in a tube performs better than a twisted tape inserted by a loose fit. They further showed that a non- zero phase angle in between the segmented twisted tape gives poor results because the swirl will break easily in between the two segmented twisted tapes.

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III. TWISTED TAP TURBULENT FLOW

The inserted with a twisted tape produces swirl and cause intermixing of the fluid which leads to better performance than a plain tube. Heat transfer rate is improved effectively with the increase in the frictional losses.

[10] Younes Mennl et al . Discussed baffles, fins, ribs, bars, and blocks, inside the thermal solar receiver ducts, is among the most effective mechanisms for important thermal exchange by creating the turbulence, extending the trajectory of the flow, increasing the surface of heat exchange and hence a high thermal exchange.

[11] Archit Sharma et al., Found utilized for many decades by evaluating different parameters of heat exchangers. Various types of configuration of heat exchanger are analyzed so far with various types of mechanical turbulators.

[12] M.M.K. Bhuiya , was investigated experimentally in the present work. The effects of insertion of the helical tape turbulators with different helix angles on heat transfer and pressure drop in the tube for Reynolds number. Experimental results showed that the heat transfer and thermal performance of the inserted tube were significantly increased compared to those of the plain tube.

[13] Birendra Kumar, was investigated the theoretical study on heat transfer characteristics and the performance of a cylindrical parabolic solar water heater with twisted tape inserted inside the absorber tube. The absorber tube equipped with twisted tape with six different twist ratios 5, 6, 7, 8, 9 and 10.

[14] Royds., observed that twisted tape insert with a tight twist ratio provides an improved heat transfer rate at a cost of increase in pressure drop for low Prandtl number. This is because the thickness of the thermal boundary layer is small for a low Prandtl Number fluid. And a tighter twist ratio disturbs the entire thermal boundary layer, thereby increasing the heat transfer which drops the pressure.

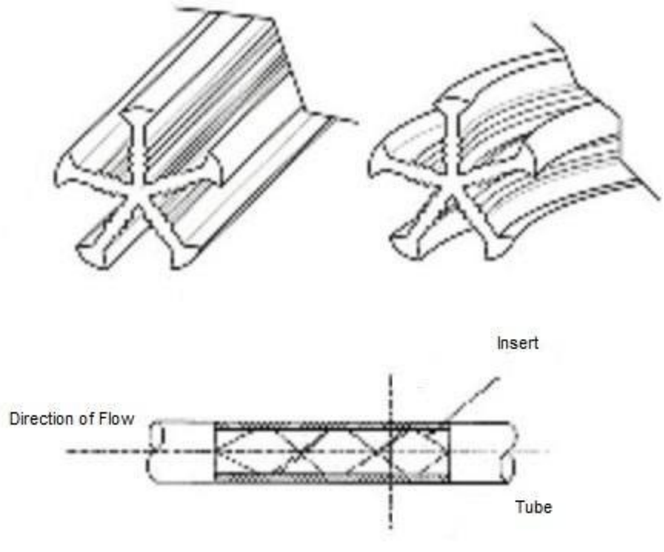

Fig:-2 Turbulent flow generator

[15] Smithberg and Landis., gave an analytical model of the tape- generated swirl mechanism.

[16] Cresswell., conducted an experiment in circular tube and observed that ratio of maximum velocity to mean velocity is smaller in swirl flow compared to straight flow.

[17] Kreith and Margolis., found in their observation that twisted tape leads to high friction factor, which is due to the

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fact that twisted tape disturbs the local boundary layer of fluid flow.

[18] Thorsenand and Landis., concluded their experiment with the observation that overall enhancement ratio increases with tighter twist ratio and decreases with increase in Reynolds number

[19] Gambill and Bundy., investigate in their observation that if pressure drop is not consider. then twisted tape is good option to use in turbulent flow.

[20]Lopina and Bergles., observed that the difference between isothermal and heated flow friction factors for the swirl flow of liquids is substantially less than the plain tube. In turbulent flow, insertion of a twisted tape increases the heat transfer, but the pressure drop also increases significant.

[21] Colburn and King et. al., used baffled tube and short length twist tape in circular tube and observed that Isothermal friction factor for swirl flow of liquids is substantially less than a plain tube.

[22]Seigel., investigated the experimental work in horizontal tube and founded that Isothermal friction factor for swirl flow of liquids is substantially less than a plain tube.

IV. COMPUTATIONAL INVESTIGATION IN LAMINAR AND IN TURBULENT FLOW

The investigation on heat transfer and flow friction in tubes with twisted tape inserts have been conducted either experimentally and numerically in many researches. The first numerical investigations bring attention to laminar and turbulent flows. Computational technology advancement during the past decades has extended the ways of finding solutions of the complicated mathematical equations by numerical analysis, especially Computational Fluid Dynamics. It should be mentioned that nowadays swirling flows are one of the most challenging aspect in CFD. That is why the results received in CFD for swirling flows should be accurately verificated and validated with experimental data or existing correlations.

[23] Chung and Sung., performed a direct numerical simulation for turbulent heat transfer in a concentric annulus and they observed that the thermal structure is more effective near the outer wall than near the inner wall.

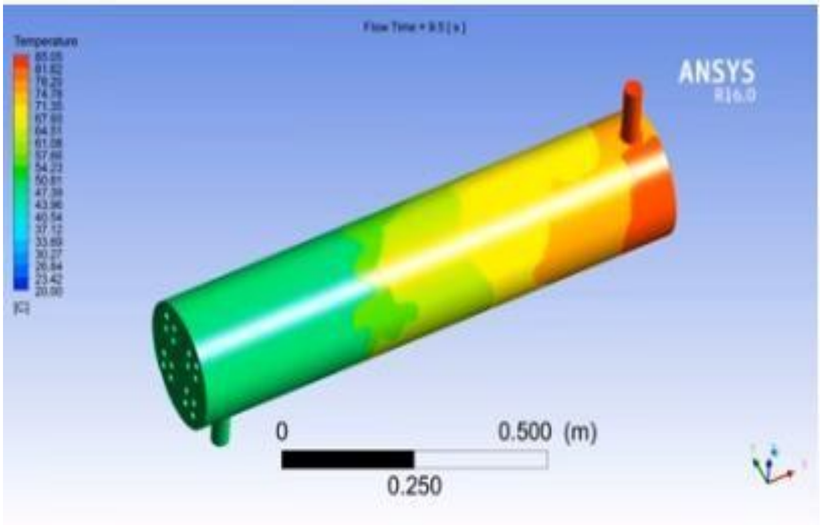

Fig. No. 3. Heat transfer analysis by CFD Method

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[24] Yang and Hwang., observed that a porous type of baffle is good for thermo hydraulic performance and there is an optimum height of the baffle.

[25]Liu et al., developed a neural network to evaluate and predict boiling heat transfer enhancement using additives. Their model can select the additives for particular working fluid.

[26] Nasser et al., Worked to simulate the crystallization fouling process in a heat exchanger by developing a C++ program and adopting UDF functions through fluent software and hence evaluate all the given models and consequently implemented the model which would best suit our particular case. The findings of this study would enable us to evaluate the thickness and fouling rate in the heat exchangers.

[27] Mofid Gorji et al., steady incompressible and turbulent fluid model and found that the effects of vortex generators in a compact heat exchanger in a curvilinear coordinate system is more.

[28] Pasaladi Madhu Kumar et al., Study was undertaken for investigating the heat transfer enhancement in a tube with the circular cross sectional rings and they found that the variation of Nusselt number, friction factor and overall enhancement ratios for the tube with rings were presented and the best overall enhancement of 18% was achieved for Reynolds number = 15,600.

[29] Veysel Ozceyhan et al., studied the Heat transfer and pressure loss characteristics of a square duct inserted with twisted tape along with transverse ribs on two opposite walls of the duct as well as the case with twisted tape without any ribs were studied and compared in this work and found that the numerical investigation are better the experimental work.

[30] Kumar and Nigam., introduced a new device based on the flow inversions by changing direction of centrifugal force in helically bent coiled tubes , Bent coil configuration showed a 20-30% enhancement in Heat transfer due to chaotic mixing while relative pressure drop was found as 5-6%.

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