Abstract
The work takes up the cause of heat dissipation from the working fluid to its surroundings. This is being brought about through the enhancement of the rate of heat transfer while allowing the working fluid to pass through a channel in a spiral form effected with a metal insert. Since the fluid is made to contact a larger surface area during its passage from the tube, the rate of heat transfer gets higher than a plain tube. Mathematical model is built to analyze the heat transfer while varying the Pitch of the spiral channel as also the Material of the insert. Experimentation is carried out using a physical working setup. The results are compared for validation. The dissertation work aims to find out the best alternative in terms of material and geometry of the spiral channel that would maximize the rate of heat transfer from the working fluid to the secondary fluid.
1. INTRODUCTION

Thermal performance improvement of many heat exchanger systems utilized in engineering and industrial work is needed for energy saving and reduction of operating cost. Heat transfer augmentation methods are often used in the heat exchanger systems in order to enhance the heat transfer rate and increase the thermal performance. In general, a turbulent promoter (called “turbulators”) which is one of the passive methods is widely employed in heat transfer enhancement in the form of swirl/vortex flow devices such as rib/fins/baffle/winglet/propeller/groove-roughened surfaces. Several types of turbulators inserted into the duct flow are to provide an interruption of thermal boundary layer development, to increase the heat transfer surface area and to cause enhancement of heat transfer by increasing turbulence intensity or fast fluid mixing. Therefore, more compact and economic heat exchanger systems with lower operation cost can be obtained. Many attempts have been made to examine the application of various tabulators with different configurations to heat transfer improvement in the heated tube of heat exchanger, for example wire-coils, twisted-tapes, combined/compound tabulators, dimpled/ corrugated/ grooved tubes.

Several modified twisted tapes have been extensively studied by focusing on the rise in heat transfer rather than the reduction of pressure drop. Because of lower pressure loss, the heat transfer enhancement by the modified twisted-tape insert has been extensively investigated. The present investigation is aimed at studying the frictional and heat transfer characteristics in turbulent region using varying pitch of twisted tape inserts under constant wall heat flux. The objective of using varying pitch twisted tapes is to reduce the pressure drops associated with alternative material and pitch of the twisted tapes without seriously impairing the heat transfer augmentation rates.

2. LITERATURE REVIEW

[1] M.Yilmaz et al. investigated the heat transfer and enhancement efficiency characteristics of decaying swirl flow generated by three radial guide-vane swirl generators viz. swirl generator with conical deflecting element, with spherical deflecting element and with no deflecting element. Air is used as a working medium. Experimentation is carried out using a physical working setup. In this experiment, five inlet swirl conditions were selected which were generated by setting the guide vane angles at 15°, 30°, 45°, 60° and 75°. The Reynolds number of air ranged from 32,000 to 111,000. Some energy correlation equations and heat transfer enhancement efficiency correlation are taken from the table present in research paper. It is observed that, the increase in vane angle increased the heat transfer coefficient. Also, heat transfer coefficient increased with increasing energy dissipation parameter. Moreover, enhancement efficiencies increased with decreasing Reynolds number and increasing vane angle. Swirl generator with no deflecting element was found to have the highest heat transfer enhancement efficiency compared with other two swirl generators.
M.M. Abu-Khader investigated the characteristics and performance of twisted tapes imposed at various flow rewash regimes. An industrial case study was selected from the open literature to evaluate heat transfer enhancement. Ethylene glycol is used as a cooling medium and the heating medium is low pressure steam condensing at 115ºC in a horizontal tube heat exchanger. After examining all the three flow regions closely it is observed that at the laminar region, using large tube diameter, the twist ratio has approximately no effect on local heat transfer coefficient. On the other hand, when decreasing the inside tube diameter the effect of twist ratio appears significantly and the local heat transfer coefficient rises sharply. This is due to the decrease in the twist pitch. Even though decreasing the tube diameter seems to be in favour of enhancing the local heat transfer but the sharp rise in the pressure drop should be taken into consideration. After studying the literature we came to conclusion that the tube insert technology is more effective in laminar region. When designing for various flow-rates and pressure drop was not taken into consideration, using tube with twisted tape will be will be cheaper in terms of overall cost. As the twist ratio increases both the local heat transfer coefficient and the friction factor decreases.

A.Klaczak presents the results of laboratory research on heat exchange while heating water in horizontal and vertical tubes with twisted-tape inserts in laminar flow conditions within certain range. The method of direct measurement of test tube wall temperature is used to calculate the mean heat transfer internal heat transfer coefficient experimentally. The boundary conditions are limited to uniform axial wall temperature. Water is used as a working medium. Turbulators or twisted tape are made up of copper were put snug in the test tube with varying twist ratios. The tests were taken for three cases viz.. horizontal test tube; vertical test tube, the direction of flow according to the free convection vector; and vertical test tube, the direction of flow not in accordance with the free convection vector. To present all the results, a tool dispersion of measuring points is used to analyze the heat transfer between the liquid and inner side of test tube. The research showed the heat transfer intensity has different characteristics in each case. For slow flows and twist ratio 1.6, the results obtained for the cases 1 and 3 are most convenient. For flows at Gz=500, the most favorable is the case 2 while the case 1 is less favourable. It is observed that the best results were received using the twisted tape with twist ratio of 1.62. Constructing heat exchangers with vertical pipes at Re ≤ 1500 it is better to use case 3. When Re ≥ 1500 case 2 gives slightly better results. There was about 200% increase in heat transfer in relation to a smooth tube.

M.A.Habib et al. investigated experimentally the heat transfer characteristics of pulsated turbulent pipe under different conditions of pulsation frequency, amplitude and Reynolds number. Air as a working fluid is pumped by an air blower near atmospheric pressure and is discharged to the atmosphere through the test section after being heated by insulated heating taped equally wound throughout the length of test section pipe. The flow is considered to be incompressible and the fluid properties assumed to be constant so that, the effect of pulsation on average heat transfer coefficient is the combined entrance and
fully developed regions of a turbulent pulsating pipe flow. Flow Reynolds number was varied between 5032 and 28,984 while pulsation frequency ranged from 1 Hz to 8 Hz. The amplitude of induced pulsation varied between 0.0127 to 0.0381 m. Pulsating mechanisms is used as a four bar slider crank mechanism. It is observed that the increase in heat transfer coefficient is noticeable in the entrance region than in the fully developed region. Overall reduction on the mean Nusselt number was ascertained for the whole Reynolds number with maximum reduction of about 13%. However, local heat transfer enhancement did occur in the entrance region for Reynolds number of 5032 at frequency ranges of 2 Hz to 6 Hz. The results reveal negligible effect on pulsation frequency on the mean Nusselt number at low Reynolds number.

[5] P. C. Mukeshkumar et al. investigated the heat transfer and pressure drop analysis of a shell and helically coiled tube heat exchanger under turbulent flow regime using Al2O3/water nanofluid with varying particle volume concentration processed by using two step methods. The particle volume concentration was made to get the tiny agglomeration of Al2O3nanoparticles and water as base fluid. The experimental setup consists of shell side loop carries hot water and helical coiled tube loop handles Al2O3/water nanofluid contains counter flow configuration. Nano fluid at 0.1%, 0.4% and 0.8% volume concentration is circulated through the tube side. The tests were conducted in the range of Reynolds number 9500-13,000. Flow rate is in the range of 0.05 to 0.07 kg/sec. Critical Reynolds number, overall heat transfer coefficient and inner heat transfer coefficient of coiled tube are calculated from basic empirical equations. From this experiment, it is found that pronounced improvement in overall heat transfer coefficient, inner heat transfer coefficient and inner Nusselt number higher than water at 0.8% volume concentration. These are due to higher thermal conductivity of fluid due to agglomeration which carries more heat energy. Further, it is also noticed that the pressure drop is higher than water at 0.8% concentration at maximum Reynolds number.

[6] S.V Patil et al. conducted an experiment for plain square duct with twisted tape inserts of different twist ratio to the heat transfer characteristics and friction factor at uniform wall temperature boundary conditions. The test is conducted in a double-pipe heat exchanger consists of two concentric tubes; inside square duct for cold water flow made up of copper and outside circular stainless steel annulus. A full length twisted tapes used with different twist ratios are inserted diagonally in a square duct. A constant flow rate of hot water is permitted to flow through annular channel. It is observed that the friction factor increases with decreasing twist ratio and decreases abruptly with increasing Reynolds number. This is due to smaller twist ratio generates high swirling flow and flow velocity. Nusselt number of plain duct increases with increasing Reynolds number showing an enhanced heat transfer coefficient due to forced convection. The empirical correlations for friction factor and Nusselt number are generated by using non-linear regression analysis. Thermo hydraulic performance ratios R1 and R3 for constant flow rate and constant pumping power respectively. R1 increases with increasing augmented Reynolds number of 2140 for all twisted inserts. R3 increases with increasing augmented...
Reynolds number of 1050 for all twisted tapes. The performance ratio decreases sharply as Reynolds number increases beyond 1050.

3. PROBLEM DEFINITION
There are scores of applications that mandate a high rate of heat transfer within the system elements either to heat or cool the working fluid in the minimum time possible. While doing so, the pressure drop is desired to be kept low (minimum). The pressure observed for the benchmark i.e. the plain tube, could be used for reference. The drop in this pressure may not fall below 20% of the benchmark while gaining or losing heat of about 3% based on the application or the problem area identified for the dissertation work. For a typical application for a ‘Radiator’ in an Automotive, the heat is lost by exposing the tubular channels to the environment. The air that flows over the tubes, pick up the heat and eventually cools down the tube. Besides other factors, for a given configuration, the performance is based on the ‘Mass flow rate’ of the working fluid and the flow of the atmospheric air around the tube.

Further to this typical study, the work should focus on using fluid with higher latent heat than air. Water could be used as an alternative for cooling while allowing the same to flow around the working medium using tube-in-tube type of construction. Higher rate of heat transfer is expected in this case. The problem for realizing increased rate of heat transfer could be considered with the introduction of spiral insert while varying the pitch of the test samples. The material of the insert could have alternatives like Copper, Aluminium or Brass. The configuration for the test pieces could have smaller, medium, and higher Pitch between the turns of the spiral insert. A suitable Reynolds number could be considered for determining the diameter and length of the tube in which the insert is to be placed.

3. SCOPE AND OBJECTIVE
   i.)  Study the existing system for heat transfer.
   ii.) Identify the parameters contributing more in heat transfer rate and classify them into two categories as input and response parameters.
   iii.) Identify the levels of different parameters to study the Statistical method such as Taguchi and Regression analysis
   iv.)  Experimentation based on combinations of different input parameters
   v.)   Taguchi and Regression analysis using MiniTab interface.
   vi.)  Mathematical calculations
   vii.) Validation and recommendation of best variant

4. METHODOLOGY
   • Mathematical Calculations: As per experimental details mathematically pressure drop and heat enhancement would be calculated using standard empirical formulae.
- **Statistical method:** In this method, Minitab interface would be used for statistical analysis. Taguchi, ANOVA and Regression analysis methods would be deployed for the heat enhancement study

**Flow chart for Methodology**

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Benchmark Existing System

Numerical Model for existing system (plain tube)

Experimentation using twisted tape

Taguchi analysis and Regression analysis

Mathematical model for twisted tape inserts

Identify the best geometry

Validation through physical experimentation)
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5. Experimentation

The apparatus would consist of a tube-in-tube type concentric tube heat exchanger. The hot fluid shall be hot water which would obtain from an electric geyser and it will flows through the inner tube while the cold fluid shall be cold water flowing through the annulus. The hot water shall flows in one direction and the flow rate of which will be controlled by means of a valves. The cold water could be admitted at one of the end enabling the heat exchanger to run as a parallel-flow apparatus or a counter-flow apparatus.

The main objective of this experiment is to study is:

i.) Temperature distribution in parallel-flow and counter-flow heat exchanger without insert and with insert as twisted tape.

ii.) Heat transfer rate using plain tube and twisted tape of different pitch and material.

iii.) Overall heat transfer coefficient

iv.) To obtain the effectiveness of the given heat exchangers using different configuration of twisted tape

The experiments shall be conducted by keeping the identical flow rate while running the unit as a counter flow. The temperature shall be measured by mercury in glass thermometer and the flow rates by a graduated measuring flask and stop watch. The readings would be recorded when steady state will reach. The outer tube would be provided with adequate thermo Cole insulation to minimize the heat losses.

6. CONCLUSION

For the validation, results derived from two differing methodologies are compared. In this thesis, computational and/or numerical and/or experimental results would be validated through comparison. On the basis of experimentation, the variant with suitable geometry in terms of pitch and the material of the spiral tape shall be proposed.

7. REFERENCES


Biography
Mr. Prashant M. Savant - M. Tech Student - Thermal and Power Engineering at MGMCOE, Nanded.

Dr. HARKARE MAHESH GURUNATHPPA - He is completed Ph.D. (Mech.) on “Thermostructural Analysis, Design & Fabrication of mobile blancher for T.P.P". Masters in Thermal Power. Currently working as Asst. Professor and H.O.D., at MGMCOE, Nanded.He has 25 years of experience in this field.

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