Review of Heat Transfer Parameters using internal threaded pipe fitted with inserts of different materials

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Abstract

Many heat transfer enhanced techniques have simultaneously been developed for the improvement of energy consumption, material saving, size reduction and pumping power reduction. Screw tape inserts in tubes are a typical technique that offers a higher heat transfer increase and, at the same time, only a mild pressure drop penalty. This study investigates the heat transfer characteristics of a horizontal tube-in-tube heat exchanger having internal threaded pipe with Screw tape inserts of different materials i.e. Mild steel screw tape and Aluminum screw tape inserted in the inner tube. Heat transfer, flow friction characteristics in a threaded tube fitted with screw tape, using oil as working fluid are investigated experimentally. Influences of the changing material i.e M.S screw tape and Aluminum screw tape arrangements are also described. The experiments are conducted using the tapes with same twist ratios and pitch over a Reynolds number range less than 2,000 in a heat exchanger.

Introduction

To achieve high heat transfer rate in an existing or new heat exchanger several techniques have been proposed in recent works. Screw tapes a type of passive heat transfer have shown good results in past studies. For experimental work different types of screw tapes of different materials of same dimensions(pitch 9mm ,depth 2.5mm, thickness of tape t= 1mm) combined with internal threaded copper pipe (ID= 13mm OD= 19mm, W= 8 mm, d= 3mm L=550 mm) have been studied. The technique of improving the performance of heat transfer system is referred to as heat transfer augmentation or intensification. This leads to reduce the size and cost of the heat exchanger. Heat transfer enhancement technology has been developed and widely applied to heat exchanger applications; for example, refrigeration, automotives, process industry, chemical industry etc. Many techniques of active and passive techniques are available for augmentation. Some common examples include steam generation, condensation in power & cogeneration plants, sensible heating and cooling in

thermal processing of chemical pharmaceutical &agricultural products, fluid heating in manufacturing and waste heat recovery etc.

Laminar flow is encountered in many industrial applications. Flow of solar thermal mass of viscous oil in a parabolic trough solar collector in solar electric thermal power plant is an example. In Such case of laminar flow, there is major thermal resistance in the bulk flow in addition to the dominant thermal resistance in the thin boundary layer adjacent to the flow. Twisted-tape inserts are, therefore, used to mix the gross flow effectively in laminar flow to reduce the thermal resistance in the core flow through the helical screw inserts also tabulators. Use of heat transfer enhancement techniques lead to increase in heat transfer coefficient at the cost of increase in pressure drop, while designing a heat exchanger using any of these techniques, analysis of heat transfer rate, and to perform experimental work on considered arrangement to develop characteristics equation for predicting thermo hydraulic performance of heat exchanger.

Literature review:

Hussein [1] different inlet geometries for laminar air flow combined convection heat transfer inside a horizontal circular pipe, through careful measurements, was experimentally studied under a constant wall heat flux boundary condition. It was found that the surface temperature values along the pipe dimensionless axial distance were higher for low Re number than that for high Re number due to the free convection domination on the heat transfer process

Naphon et al. [2] studied the heat transfer characteristics and the pressure drop of the horizontal concentric tube with twisted wires brush inserts are investigated. The swirl flow is generated as fluid flowing through the plain tube with twisted wires brush insert. Due to the presence of swirl flow, the convective heat transfer obtained from the plain tube with twisted wires brush insert is higher than that with the plain tube without twisted wires brush insert. Twisted wire brushes inserts have a significant effect on the enhancement of heat transfer; however, the pressure drops also increase too.

Bhattacharyya et al. [3] presented experimental friction factor and Nusselt number data for laminar flow through a circular duct having integral transverse ribs and fitted with centre-cleared twisted-tape have been presented. Predictive friction factor and Nusselt number correlations have also been presented. The thermo hydraulic performance has been evaluated. The major findings of this experimental investigation are that the centre-cleared twisted tapes in combination with transverse ribs perform significantly better than the individual enhancement technique acting alone for laminar flow through a circular duct up to a certain amount of centre-clearance. This result is useful for the design of solar thermal heaters and heat exchangers.

Chowdhury et al. [4] demonstrated An experimental study has been carried out to investigate the flow friction and heat transfer characteristics in a circular tube fitted with perforated twisted tapes of different porosities (Rp = 1.6, 4.5, 8.9 and14.7%). It has been found that the perforated twisted tape inserts enhanced the heat transfer rate significantly with corresponding increase in friction factor in comparison to that of the plain tube based on the experimental results.

Bas et al. [5] presented Heat transfer enhancement in a twisted tape inserted tube is studied experimentally in this present study. The twisted tapes are placed separately from the tube wall to obtain only heat transfer increase depending on laminar sub layer destruction near the tube wall.

Salam et al. [6] an experimental investigation was carried for measuring tube-side heat transfer coefficient, friction factor, and heat transfer enhancement efficiency of water for turbulent flow in a circular tube fitted with rectangular-cut twisted tape insert

Saha et al. [7] had calculated experimentally friction factor and Nusselt number data for laminar flow through a circular duct having integral helical ribs and fitted with helical screw-tape inserts have been presented. Predictive friction factor and Nusselt number correlations have also been presented. The thermo hydraulic performance has been evaluated.

Remarks:

Many researchers have worked the Nusselt number, friction factor, and thermal performance factor increased with the increase of twisted wire densities.

1. Some of researchers worked on Heat transfer enhancement in a twisted tape inserted tube and convection heat transfer inside a horizontal circular pipe, through careful measurements. Very less Researchers are working on heat transfer in tube in tube heat exchanger with helical screw tape insert.
2. There is no recent work on heat transfer in tube in tube heat exchanger with helical screw tape insert for different materials also there is no any such comparison for different materials.

Proposed work:

Scope:

The scope for this study would encompass all necessary activities for benchmarking the existing application like solar power plant with the current performance level and performance standards to be set for arriving at the objectives of the dissertation work. Recommendation of the best alternative would follow the comparison of the results. Data over Testing to be shared through a Test report for the experimentation phase.

Objectives:

1. To design and manufacture internal threaded pipe, helical screw tape inserts of different materials and built up setup.
2. To perform experimental work on considered arrangement to develop characteristics equation for predicting thermo hydraulic performance of heat exchanger.
3. To study different materials of same dimension screw tape inserts at variable flow rates of oil.
4. Comparative study of proposed arrangement with and without inserts to determine the economical and thermal effectiveness.

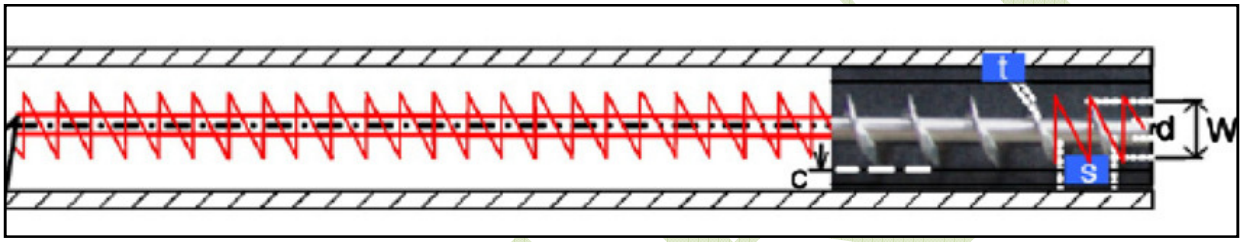

Fig. 1 Helical Screw Tape Insert (In pipe)

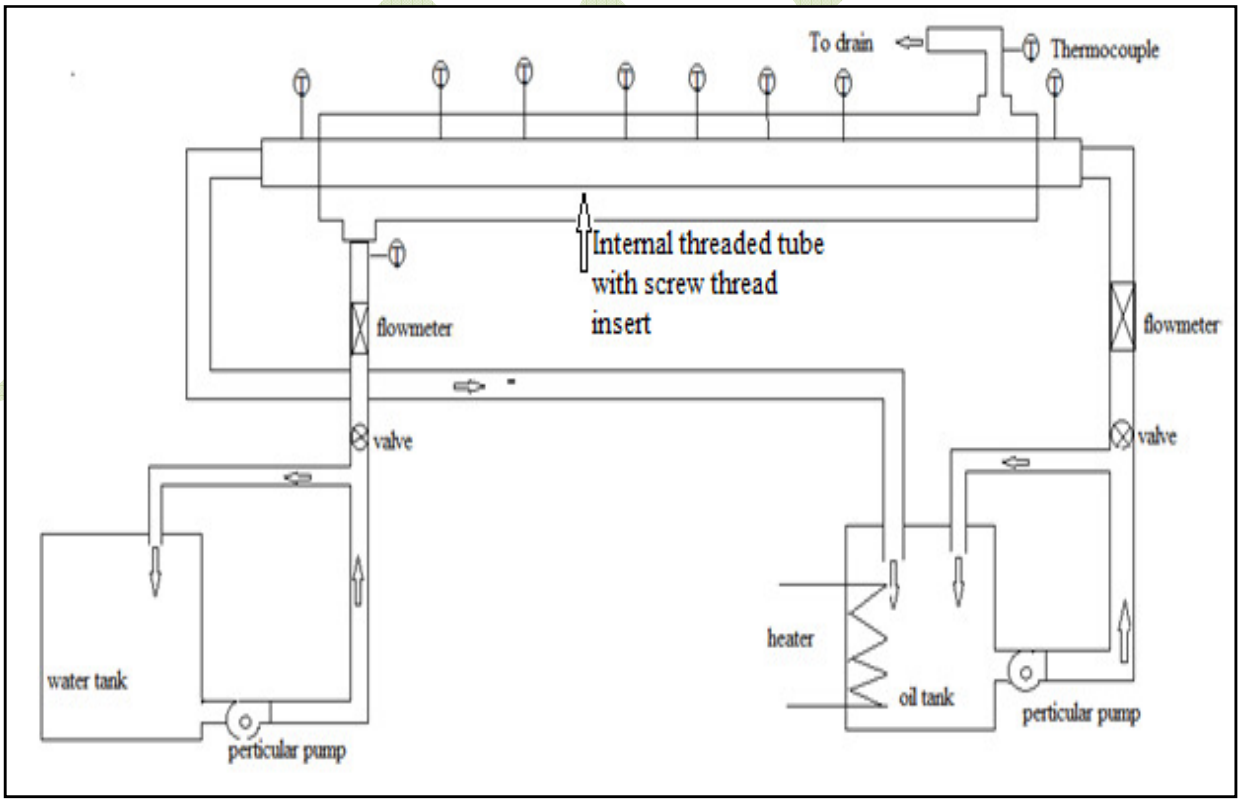

Fig.2 Experimental Setup

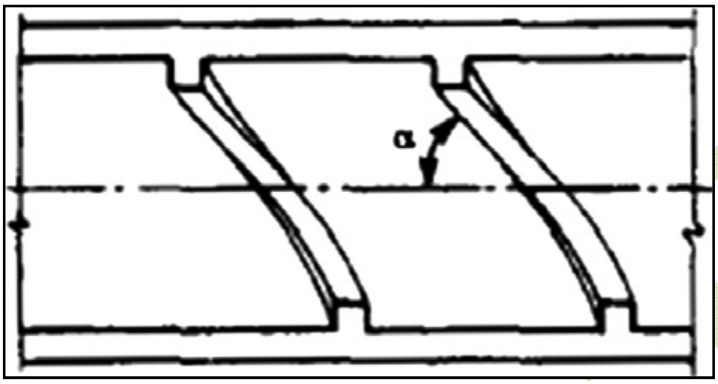

Figure.3 Internal helical Threaded Tube

Tube in Tube Heat Exchanger with Internal Threaded Pipe:

Development of test section is the main task of work here copper tube is used at the inner side of test section having 550 mm length and 13 mm inside diameter. Inside copper pipe is internally threaded ($\alpha = 60^0$, e/Dh = 0.1026,).At the outer side pvc pipe is used having length 600 mm length and 24 mm inner diameter. And 6 thermocouples fitted on inner pipe to measure the surface temperature. At the one end of outer pipe opening for cold water and opposite end of outer pipe outlet for cold water is provided. For avoiding heat loss to surrounding heatlon insulation is wound on heat exchanger having thickness 100 mm. Engine oil is used as a hot working fluid.

Conclusion

The effects of the materials on the heat transfer enhancement and friction factor behaviors in laminar flow regimes (Re < 2,000) are described. The Screw tapesof MS and Aluminum insert with same dimensions (W= 8mm,d=3mm,H=9mm) at different temperatures and different cold fluid flow rates are tested using the oil as the hot working fluid and other is water.

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