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An experimental study of heat transfer intensification in a channel having corrugated plate by using twisted tape as an obstacle

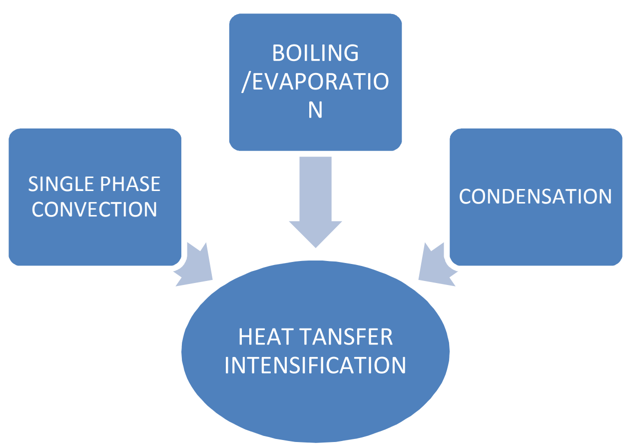
[1]Raman Kumar and [2]Ishu Monga

[1]M .Tech. Scholar, P.P.I.M.T, Hisar
[2]A.P, Department of Mechanical Engineering, P.P.I.M.T, Hisar

***Abstract:* At present, the technology of the twisted-tape inserts is widely used in various industries. Twisted tapes are inserted in a channel which is a passive method for enhancing the heat transfer. Swirls are generated in the flow and by disturbing the boundary layer the heat transfer can be increased. The proposed research paper is an attempt to explain that such tapes induce turbulence and superimposed swirl flow causing a thinner boundary layer and consequently resulting in a high heat transfer coefficient and Nusselt number due to repeated changes in the twisted tapes with different twist ratios.**
***Keywords:* Heat Transfer Intensification, Twisted tape, Nusselt number.**

I. INTRODUCTION

In this modern era, requirement for heat transfer intensification without increasing the size of the equipment or device are increasing day by day. Engineers are trying to simplify and improve the processes to increase efficiency. The major factors which produce difficulty in achieving high heat transfer rate are the cost and fouling problems. Introduction of irregular surface in the geometry increases the fouling rate and also the cost is also increases. The way to improve heat transfer performance is referred to as heat transfer intensification. The goal of intensification may be quite different. For example a reduction in heat exchanger size may be desired and with the size a reduction in its fluid content. The development of heat transfer enhancement during the 2-3 past decades is such that enhanced surfaces are used routinely in refrigeration, automotive, electronic industries and even more and more often in process industries. The aim of enhanced heat transfer is to encourage or accommodate high heat fluxes. This result in reduction of heat exchanger size, which generally leads to less capital cost. Two methods are generally employed for the heat transfer enhancement. First one is the active method which uses external power and second is passive method which did not require any external power. A combination may also be there to increase the heat transfer rate from a surface. The improvement of the heat transfer coefficient requires quite different approach according to the phase of the fluid either gas or liquid and to the process type: techniques are quite different for only sensible heat transfer or for phase change such as evaporation or condensation.



A possible classification for heat transfer intensification

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Twisted tapes are the most commonly used passive heat transfer augmentation tools. A twisted tape provides an improved heat transfer rate at a cost of increase in pressure drop.

II. LITERATURE REVIEW

J. E. O'Brien et al. [1] made an attempt for combined experimental and numerical investigation is under way to investigate heat transfer enhancement techniques that may be applicable to large-scale air-cooled condensers such as those used in geothermal power applications. Comparisons of heat transfer and pressure drop results for the elliptical tube versus a circular tube with and without winglets are provided. Heat transfer and pressure-drop results have been obtained for flow Reynolds numbers based on channel height and mean flow velocity ranging from 700 to 6500. Yongmann M. Chung et al. [2] studied numerically unsteady heat transfer enhancements in grooved channel and sharp 180° bend flows of especial relevance to electronic systems. Active flow control is also studied for several inlet amplitudes and forcing frequencies. Jorge Facão et al. [3] studied flow and convective heat transfer in a curved rectangular channel was modeled and the heat transfer coefficient assessed, using the FLUENT code. The conditions considered are representative of an application to solar collectors with heat pipes. Paisarn Naphon [4] studied the results of the heat transfer characteristics and pressure drop in the corrugated channel under constant heat flux. Effect of relevant parameters on the heat transfer characteristics and pressure drop are discussed. Due to the presence of recirculation zones, the corrugated surface has significant effect on the enhancement of heat transfer and pressure drop. Tae Ho Ji et al. [5] Performed experiments to investigate heat dissipation from a heated square cylinder in a channel by oscillating flow. The time-averaged Nusselt number and the Strouhal number were determined for each oscillating condition. The heat transfer enhancement is pronounced as the Reynolds number increases. Paisarn Naphon [6] in his study, the numerical results of the heat transfer and flow developments in the corrugated channel under constant heat flux conditions are presented. R. Tauscher et al. [7] presented the experimental and numerical investigations of the forced convection heat transfer in flat channels with rectangular cross section. To increase the accuracy of the numerical calculations for problems with simultaneous laminar and turbulent flow regimes, an empirical procedure is proposed. Paisarn Naphon et al. [8] studied the numerical analysis on the heat transfer and flow developments in the channel with One-side corrugated plate under constant heat flux conditions. Effects of relevant parameters on the heat transfer and flow developments are considered. Abdullah H. alessa et al. [9] studied the enhancement of natural convection heat transfer from a horizontal rectangular fin embedded with rectangular perforations of aspect ratio of two has been examined using finite element technique. The heat transfer enhancement of the perforated fin increases as the fin thickness and thermal conductivity increase. Paisarn Naphon [10] studied the numerical investigation on the heat transfer and flow distributions in the channel with various geometry configuration wavy plates under constant heat flux conditions. The results of this study are expected to lead to guidelines that will allow the selected wavy plate geometry configuration for designing heat exchanger which increase thermal performance. Pongjet Promvonge et al. [11] investigated to examine laminar flow and heat transfer characteristics in a three-dimensional isothermal wall square channel with 45° angled baffles. The computations are based on the finite volume method, and the simple algorithm has been implemented. The maximum thermal enhancement factor of the 45° baffle in the Re range studied is found to be about 2.6 or twice higher than that of the 90° transverse baffle. Pongjet Promvonge et al. [12] studied the effects of combined ribs and winglet type vortex generators (WVGs) on forced convection heat transfer and friction loss behaviors for turbulent airflow through a constant heat flux channel. In common with the WVGs, the in-line rib yields the highest increase in both the Nusselt number and the friction factor but the rib with staggered array shows better thermal performance than the others.

III. EXPERIMENTAL SET UP

The main aim of this experiment is to investigate the variation of average surface temperature of the test plate at different heat flux conditions with different Reynolds number. In this experimental set up, four experiments will be performed to analyze the heat transfer rate in various situations. First and second experiment will be performed with and without twisted tape of different twist ratios along with rectangular aluminium plate. Third and fourth experiment will be performed with corrugated plate along with and without twisted tapes of different twist ratios. Heat flux conditions and Reynolds number will be varied for comparison. Instruments like hot wire anemometer will be used to measure the velocity, temperature of

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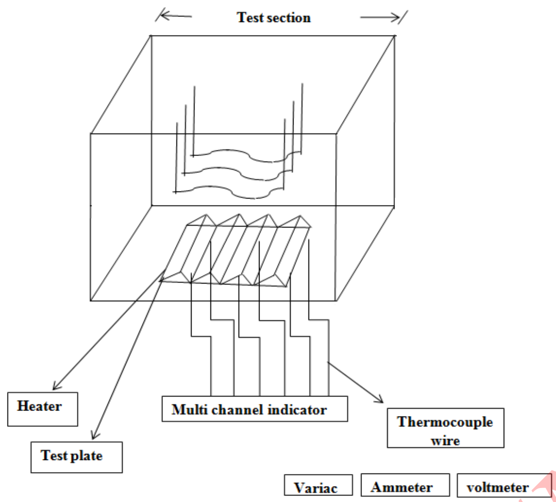
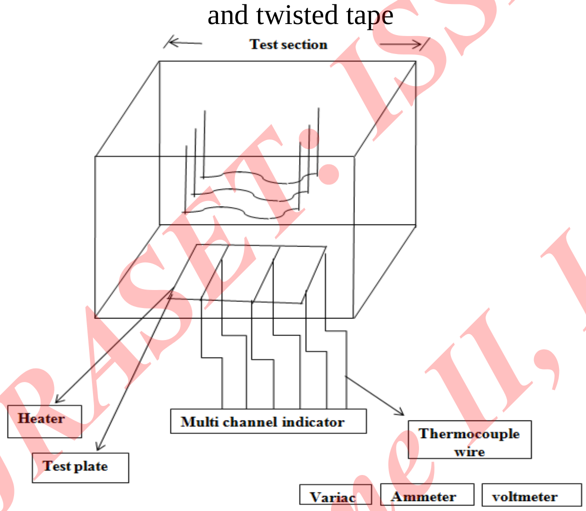
inlet and outlet air. Dual port pressure manometer will be used to measure the pressure difference with and without twisted tape. Multi channel indicator, voltmeter, ammeter are used to analyze the experimental readings. A compact fan is used to suck the air at exit section. K type thermocouple wires will be used to measure the surface temperature.



Schematic Diagram of the Test Section with Corrugated Plate and twisted tape



Schematic Diagram of the Test Section with Rectangular Plate and twisted tape

IV. PROPOSED RESULTS & DISCUSSION

- ✓ Effect of corrugated plate on heat transfer intensification, as compared to rectangular plate will be investigated.
- ✓ Effect of Reynolds numbers on average surface temperature of the test plate at different heat flux condition will be investigated.
- ✓ Effect of twisted tape inserts will be investigated on heat transfer intensification.
- ✓ Effect of Reynolds numbers on average surface temperature of the test plate at constant heat flux condition will be investigated.

V. CONCLUSION

A channel inserted with a twisted tape performs better than a rectangular plate without twisted tape, and a twisted tape with a different twist ratio provides an improved heat transfer rate but at a cost of increase in pressure drop and twisted tape with different twist ratio disturbs the entire thermal boundary layer, thereby increasing the heat transfer with increase in the pressure drop. Use of corrugated plate can increase the fouling problems which may lead to low heat transfer rate after long time.

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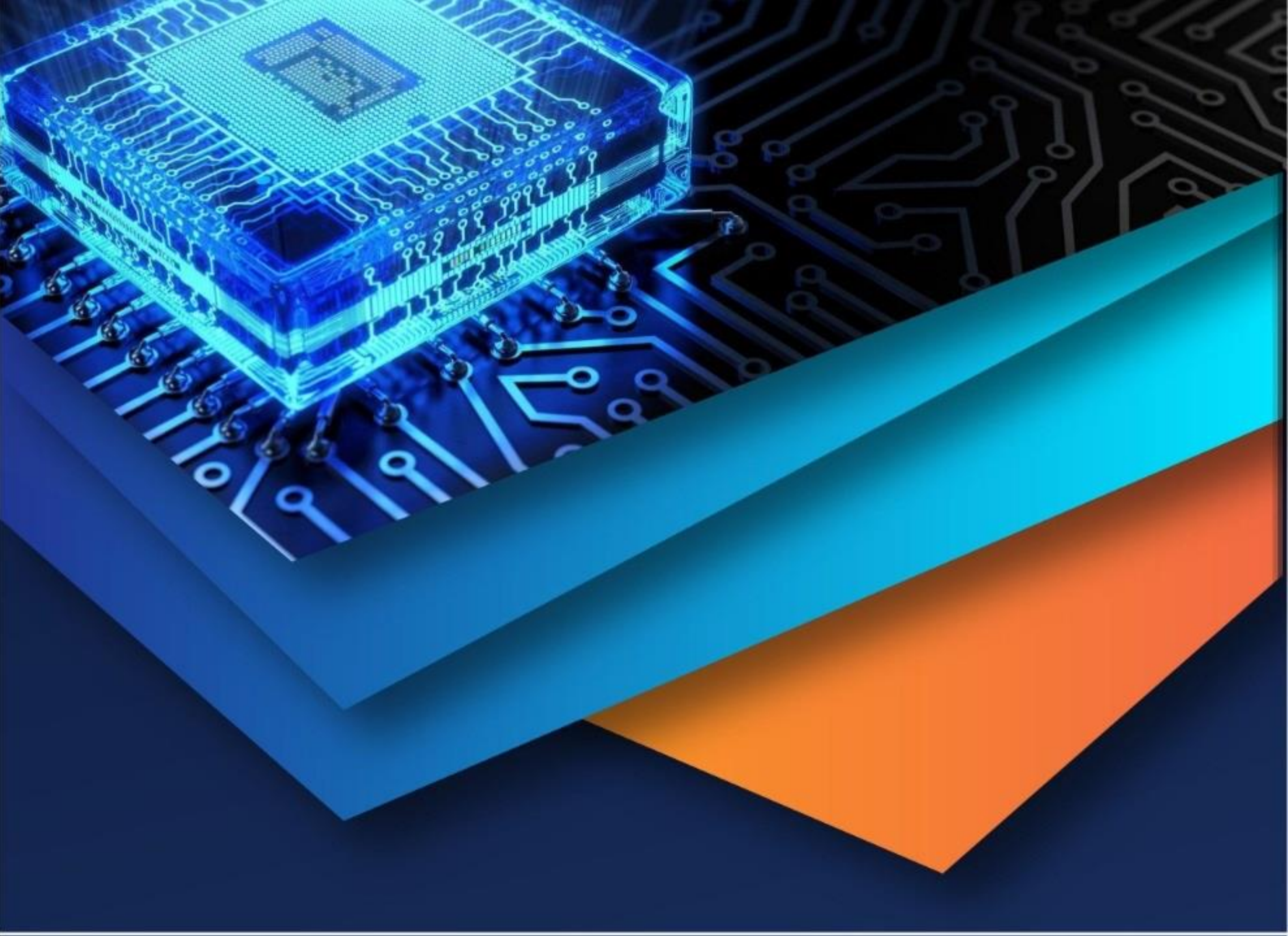

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