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Heat Transfer Enhancement In A Rectangular Channel By Trapezoidal Vortex Generator.

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ABSTRACT

This project deals with experimental study of heat transfer and flow characteristics of air flowing through the trapezoidal vortex generator. An experimental work has been conducted to explore the influence of the combined V-rib and exchanger channel having a constant heat-flux on the top wall. Firstly, the V-shaped ribs were mounted on the plain top-wall with a view to creating multiple vortex flows inside. Passive methods using vortex generators (VGs) to enhance heat transfer have been a concern of researchers in recent decades. This study is intended to investigate the strength of the vortex generated by VGs by trying to reduce the pressure drop in the flow. The present work also takes into account the influence of the vortex intensity on the improvement of heat transfer, which can be indicated by the low value of the synergy angle. Experiments were carried out in the current investigation to validate the results of the numerical simulations in the Reynolds number range of 3102 to 16,132. The study results indicate that the observed heat transfer coefficients from the experimental and simulation results have a similar tendency with relatively small errors. A reduction in pressure drop is observed with the use of perforated concave rectangular winglets (PCRWs) against the no perforated ones although there was a slight decrease in heat transfer improvements.

Keywords: heat transfer enhancement in a rectangular channel by trapezoidal vortex generator.

A. INTRODUCTION

The improvement of heat transfer in heat exchangers is significant for energy efficiency these days. Increased heat transfer in heat exchangers is more effective through a passive method using vortex generators (VGs). VGs generate longitudinal vortices, which enhance fluid

Vortex is also able to over come the weaknesses heat transfer rate in the behind of tube region by placing VGs in that area. The LV produced by VG interacts with the boundary layer, enhancing the rate of heat transfer from the surface to the fluid. Awais and Arafat studied numerically and experimentally the effects of the arrangement, location, and angle of attack of VG on the heat transfer characteristics and pressure drop of the flow. Their work found that the delta winglet (DW) VG indicates better performance than the rectangular winglet (RW) VG. The use of delta and rectangular winglets VGs to increase heat transfer rate in solar energy storage. They observed that better thermal_ hydraulic performance was found in the use of DW VGs with an angle of attack of 30◦From their results, however, the corner vortex was only generated from RW VGs. The vortex generated by the curved rectangular winglet vortex generator (RWVG) was capable of providing a suitable thermal-hydraulic performance than that of the RWVG wavy-up. Their work indicated that the RWVG wavy-up yields the best heat transfer improvements. However, the j/f ratio shows a lower value than that of the curved RWVG. The best thermal-hydraulic performance was demonstrated by the curved arc winglet VG, as from the investigation results . They also observed that the heat transfer improvement was better with curved arc VGs than RWVG.

Based on this literature study, VG can increase heat transfer by generating vortices that enhance fluid mixing. However, this improvement in heat transfer is accompanied by an increase in flow resistance, resulting in high pumping power

B. RELATED WORK

We carried out work in the field of embedded vortices in internal flow for heat transfer and pressure loss enhancement. Results from study show that at all Reynolds numbers, longitudinal vortices are more effective than transverse vortices. **[1]** experimentally studied the heat transfer enhancement performance of delta wing vortex generators in a flat-plate flow by a naphthalene sublimation technique. The results indicated that the average heat and mass transfer could be enhanced by 50–60% at low Reynolds number over the unenhanced performance.**[2]**

determine the local heat transfer in case of plate and tube fin heat exchanger in staggered arrangement. The use of vortex generator can enhance the heat transfer for flat tube by a factor of two or more. Similarly pressure loss also increase by a factor of two or more. The flow losses are 50% smaller in case of flat tube and VGs compared to round ones.**[3]**

carried out experimental study on rectangular channel with modified rectangular longitudinal vortex generators. A modified rectangular longitudinal vortex generator (LVG) obtained by cutting off the four corners of a rectangular wing is used. . Results show that the modified rectangular wing pairs (MRWPs) have better flow and heat transfer characteristics than those of rectangular wing pair (RWP).**[4]**

carried out experimental investigations on thermal and flow characteristics of curved trapezoidal type vortex generators. The performance of a pair of new vortex generators – trapezoidal has been experimentally investigated and compared with traditional vortex generators - rectangular winglet, trapezoidal and delta using dimensionless factors - j/j0, f/f0 and R =(j/j0)/(f/f0).**[5]**

performed a numerical study on laminar convection heat transfer in a rectangular channel with longitudinal vortex generator. This study presents numerical computation results on laminar convection heat transfer in a rectangular channel with a pair of rectangular winglets longitudinal vortex generator punched out from the lower wall of the channel**. [6]**

performed numerical and experimental determination of flow structure and heat transfer effects of longitudinal vortices in a channel flow Their study determines the flow structure, in detail.**[7]**

carried out work for heat transfer enhancement accompanying pressure-loss reduction with winglet-type vortex generators for fin-tube heat exchangers. Their paper proposes a novel technique that can augment heat transfer but never the less can reduce pressure-loss in a fin-tube heat exchanger with circular tubes in a relatively low Reynolds number flow, by deploying delta winglet-type vortex generators.**[8]**

performed numerical simulation of turbulent flow in a rectangular channel with periodically mounted longitudinal vortex generators. The simulation shows that the secondary flow is stronger in the regions where the longitudinal vortices are more active**. [9]**

performed Experimental investigations of heat transfer enhancement by plane and curved winglet type vortex generators with punched holes. Rectangular, Delta and trapezoidal type (both plain and curved) winglet type were used for study. 60 degree attack angle was used for study.Winglets with holes at centre are also studied. Results from their work show that curved winglets gives better results. Also punching holes reduces friction factor and there by increases overall performance of winglets**.[10]**

C. OBJECTIVES

Proposed work aims at Heat Transfer Enhancement inside Rectangular Channel by Means of Vortex Generated by Perforated Concave Rectangular Winglets.

Project work includes:

1)To study the basic design of rectangular channel by means of vortex generated.

2)analyze the thermal behavior of fluid having rectangular vortices under unsteady state condition using CFD simulation.

3)To estimate Heat transfer from solar flex to fluid under dry condition.

4)To estimate receiver temperature at the end of non solar insolation period and developing temperature verses time profile under dry condition.

5)To analyze the process of Heat Transfer.

The proposed dissertation work will be carried out in following steps:

•Literature survey and its study.

•Developing geometry for the receiver.

•Analysis of temperature variation of fluid under unsteady state condition using CFD simulation.

•Analysis of heat transfer from the solar flex under dry condition.

D. METHODOLOGY

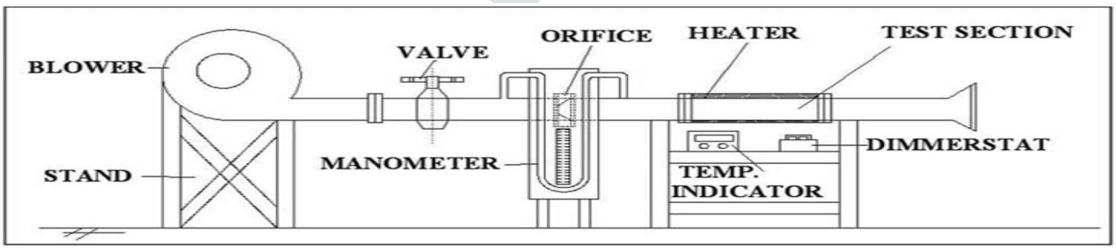


Figure 1: Schematic of the Proposed experimental set up.

Geometrical Parameter

In this research, the design geometry from experimental research conducted. It has the inline tube arrangement. The stream domain is 177.8mm×101.6mm size. The tube diameter is 10.6mm with a thickness of 0.375mm. As for the vortex generator, the rectangular winglet type is implemented and the geometry and placement are illustrated in the following figure. In Figure 1, the winglet angle of attack is 1650 which will be varied in 1700, 1650 and 1650. The single-row and three-rows of inline variations are applied as shown in Figure 2. This variation is implemented according to the results of numerical simulation.

Pre-processing

The pre-processing stage consists of geometric design, meshing, determination of boundary conditions and fluid properties. The applied geometric design is based on the specified reference

The variations of vortex generators in three rows arrangement with 1600 angle of attack. Inline arrangement for 28 tubes is also implemented. The number of vortex generators is 24 three rows configuration, while 8 for single configuration. The next step is creating small elements which, each element calculates various mathematical equations such as mass conservation, energy, and momentum.

E. WORKING PRINCIPLE

In the experiment, cold air at ambient condition will be passed through the test channel for different Reynolds number (Re).The volumetric airflow rate can be measured by the orifice plate, built according to ASME standard and calibrated by using a hot-wire/vane-type anemometer for measuring the flow velocities across the section.The test channel can be heated by an electrical heater plate attached on the absorber plate to provide a maximum uniform wall heat-flux and maintained using an AC power supply.The outer surface of the test channel will be well insulated to minimize convective heat loss to the surrounding.The Rectangular channel included a test section and exit employed after the settling tank.The inlet and outlet temperatures of the bulk air in the test duct can be measured by RTD- type (Pt100) thermocouples positioned upstream and downstream of the test channel while the wall temperatures (Tw) can be measured by T-type thermocouples mounted on the upper wall of the test channel at different position to measure the temperature variation along the absorber plate to obtain the mean wall temperature.Also, the pressure drops across the test channel fitted with VGs can be measured by a suitable manometer. Figure shows the schematic of the experimental set up which gives the clear idea of the air flow bench prepared to conduct the forced convection heat transfer tests.

F. COMPONENT

1. Blower:

Blowers are equipment or devices which increase the velocity of air or gas when passed through equipped impellers. They are mainly used for flow of air/gas required for exhausting, aspirating, cooling, ventilating, conveying etc. Blower is also commonly known as Centrifugal Fans in industry.

Figure: Blower

2. Orifice Plate:

An orifice plate is a device used for measuring flow rate, for reducing pressure or for restricting flow (in the latter two cases it is often called a restriction plate).It is used to measure the flow rate of fluids in their single state (i.e., gaseous state or liquid state). It can also be used to measure the flow rate of fluids in a mixed state (both gaseous and liquid states) such as, wet steam, or natural gas with water.

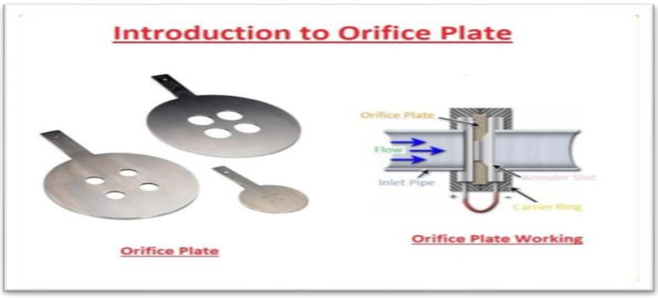


Figure: Orifice Plate

3. Thermocouple:

Type K Thermocouple provides widest operating temperature range. It consists of positive leg which is non-magnetic and negative leg which is magnetic. In K Type Thermocouple traditional base metal is used due to which it can work at high temperature and can provide widest operating temperature range.RTD PT-100 (4 wire) thermocouples were used for measuring the inlet and outlet bulk temperatures while thirty copper-constantan (Type-T) thermocouples for measuring the test channel temperatures at different locations, as shown in Fig. 1(b). The voltage outputs from thermocouples were fed into a data acquisition unit (Fluke 2680A) and then recorded by a notebook computer.

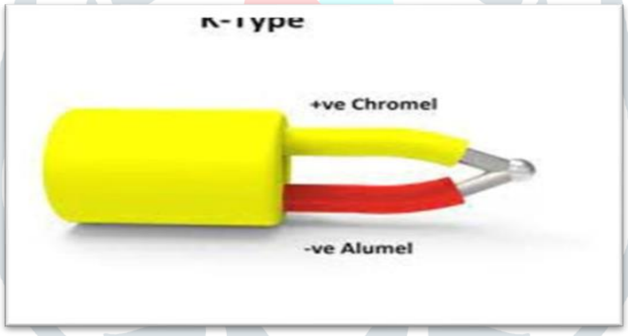


Figure: Thermocouple

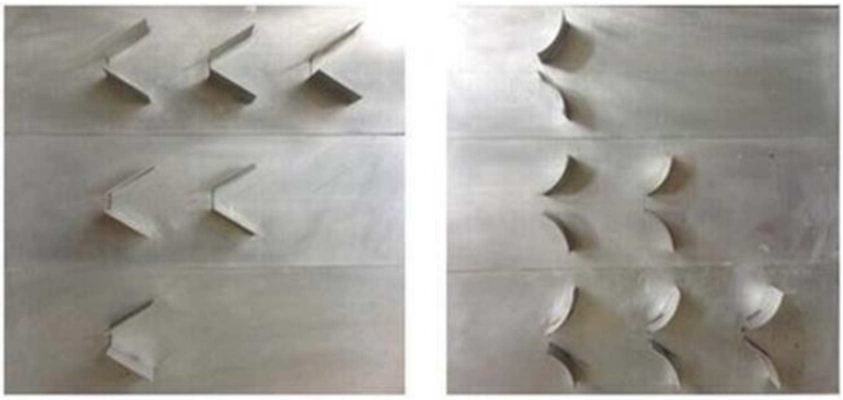
4. Temperature Indicator:

A time temperature indicator (TTI) is a device or smart label that shows the accumulated time-temperature history of a product. Time temperature indicators are commonly used on food, pharmaceutical, and medical products to indicate. exposure to excessive temperature (and time at temperature)

Figure: Temperature Indicator

5. Trapezoidal Vortex Generator:

A vortex generator (VG) is an aerodynamic device, consisting of a small vane usually attached to a lifting surface (or airfoil, such as an aircraft wing) or a rotor blade of a wind turbine. VGs may also be attached to some part of an aerodynamic vehicle such as an aircraft fuselage or a car.



(a) (b)

Figure: Trapezoidal Vortex Generator

6. U- Tube Manometer:

Manometers are designed to provide accurate pressure readings, often with a high degree of precision. Manometers can be used to measure a wide range of pressures, from low vacuum pressures to high-pressure systems. The simplest form of manometer consists of a U-shaped glass tube containing liquid. It is used to measure gauge pressure and are the primary instruments used in the workshop for calibration.

Figure: U-tube Manometer

7. Valve:

It is used to control the flow of air Valve Size : DN 40. It regulates, directs or controls the flow of a fluid or air by opening, closing, or partially. It is suitable for our project Its cost is low as compare to other valves.

Figure: Valve

G. NEED OF HEAT TRANSFER ENHANCEMENT

1. To make the equipment compact
2. To achieve a high heat transfer rate using minimum blower power.
3. Minimize the cost of energy and material.
4. Working fluids of low thermal conductivity and desalination plants.
5. Increase efficiency of process and system.
6. Design optimum heat exchanger size.
7. Transfer required amount of heat with high effectiveness.
8. Reduce the volume and weight.

H. FUTURE SCOPE

Heat transfer enhancement techniques generally reduce the thermal resistance either by increasing the effective heat transfer surface area or by generating turbulence. Sometimes these changes are accompanied by an increase in the required pumping power which results in higher cost

Heat transfer enhancement is the process of increasing the effectiveness of heat exchangers. This can be achieved when the heat transfer power of a given device is increased or when the pressure losses generated by the device are reduced.

Turbulators are mainly used to increase the thermal performance of the heat exchangers. But this comes up with pressure drop down increment on the system. The researchers have been focusing the different constructions and forms to minimize it. Even though geometrical parameters of the heat exchanger and turbulator design are changed, producibility and cost of the systems are considered. In the future, the design alternatives will be more than now as a result of more powered production methods and capability.

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J. REFFERENCE

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