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Heat Augmentation in Duct with Zig-Zag Ribs

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Abstract- Different heat augmentation techniques used for increasing the heat transfer without affecting affecting the performance. This study the overall performance of duct is studied with passive heat augmentation technique. In this different Zig-zag ribs are used in rectangular duct. The experimentation study is to investigate the heat transfer characteristics and friction factor in duct with flat and zig-zag shaped ribs. A constant surface heat flux is provided on hot surface and other surface are maintained at adiabatic conditions. The Reynolds number taken for this experimentation is varied between 8000 to 22000.The increase in heat transfer coefficient of air is found to be 12.50% higher for flat ribs,60% for zig zag ribs

Keywords*:* Heat augmentation, Zig zag ribs, duct.

1. INTRODUCTION

The operation of many engineering systems results in generation of heat. This unwanted by product cause serious overheating problems and sometime lead to failure of system. The heat augmentation with the help of Zig zag-shaped ribs has been used for various applications , such as cooling of gas turbine blades, process industries, cooling of evaporators, thermal power plants, air conditioning equipment radiators of space vehicle and automobiles and modern electronic equipments. The experiments are conducted on test rig initially without using any ribs and with using Zig zag-Shaped ribs.

2. LITERATURE SURVEY

Monsak Pimsarn, et al. [1] Investigated the heat transfer characteristics and associated friction head loss in rectangular channel with Z-shaped ribs. These ribs were set on the rectangular duct at 30º,45 º,60 ºof flat rib was set at 90 º relative to air flow directions. These ribs were fitted in Z-shape (Z-rib) aligned in series on whole surface of upper plate. The constant heat flux was provided to top surface only .The comparison of the result of Z-ribs with 30º,45 º,60 º and flat rib with same rib height ,pitch ratio and smooth channel is done. The thermal enhancement factor of all Z-ribs are higher than flat rib. The 45º Z-rib provide highest increase in heat transfer rate and best thermal performance.

Soo Whan Ahn,et al. [2] Investigated the heat transfer and friction factor characteristics in rectangular duct with one side roughened by five different shapes. In this they examined the effect of rib shape geometries as well as Reynolds number on heat transfer .They used five different shape of ribs e.g. square, triangular, circular, semicircular and arc. These ribs were sequentially installed at bottom wall of duct. To understand the characteristics of heat transfer enhancement the friction factor is also measured. The square rib has highest value of friction factor ,while triangular type rib has a substantially higher heat transfer performance than any other one.

Paisarn Naphon [3] investigated the heat transfer characteristics and pressure drop in a channel with V corrugated upper and lower plates under constant heat flux. He has carried out the analysis on channel with two opposite corrugated plate on which all configuration peaks lie in staggered arrangement. Corrugated plates with three different corrugated angles of 20º,40ºand 60º for Reynolds number and heat flux in the ranges 2000-9000 and 0.5 -1.2KW/m^2 respectively. He found that the heat transfer rate increases as air flow rate increases. For a given Reynolds number and heat flux ,the average plate temperatures at higher wavy angle are lower than those from lower wavy angles.The pressure drop is continuous to increase with Reynolds number, the pressure drop obtained from channel with higher wavy angle are higher than those with lower wavy angles. The measured pressure drop obtained from channel with corrugated surfaces are 1.96 times higher than those from plane surface.

Smith Eiamsa-ard, et al. [5] Investigated the effect of helical tapes in tube over the heat transfer. Helical tape inserted in tube with a view to generate swirl that helps to increase the heat transfer rate. Reynolds number considered between 2300-8000. The swirl devices consist of

1. Full length helical tape with and without centered rod.
2. Regularly spaced helical tape without rod.

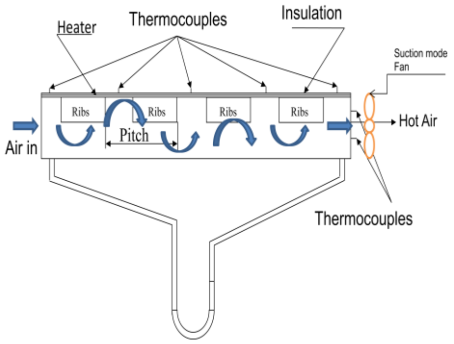
Hot air flowing through the tube and cold water in annulus space. Experimental data was compared with that of plain tube and found that full length helical tape with rod provides higher heat transfer rate over without rod but increased pressure drop. The maximum mean Nusselt number increased by about 160% for full length tape with rod,150% for full length helical tape without rod and 145% for regularly spaced helical tape.

3. EXPERIMENTAL SET-UP

The rectangular duct used for this experimentation.. The air is allowed to flow through the duct with the help of high speed exhaust fan. Due to use of ribs turbulence is created and exchange of heat is occur between heated surface and air by convection.

Parameters	Dimensions
Length of duct	1000mm
Width of duct	300mm
Height of duct	150mm
Rib thickness	3mm
Height of rib	35mm
Length of test section	600mm

Manometer is used in experimental set up to measure pressure drops across the channel. The mass flow rate and velocity of incoming air is measured by anemometer. Four thermocouples are used on top surface of heater to measure the heater wall temperature, one thermocouple is used to measure the inlet bulk temperature and three thermocouples are used in exit in order to measure exit bulk temperature. At the constant heat flux sets of reading are taken at steady state condition.



U-tube Manometer
Figure1: Front view of experimental set up

4. EXPERIMENTATION

A series of experiments carried out with rectangular duct. A suction fan is used to draw the air in rectangular duct.At the inlet $Tb_1$is the inlet bulk temperature measured by thermocouple and Tb_2 exit bulk temperature.

The heat transfer rate $Q=m*cp*(Tb_2- Tb_1)= (h*A*(Tw- (Tb_1+ Tb_2)/2)$

While the experimentation procedure is firstly validated by running the experiment through rectangular duct without any rib and with zig-zag ribs.
1.Experimentation is carried out without using any rib.
2. Experimentation is carried out with Zig zag rib.

5. RESULTS AND DISCUSSIONS

The experimentation is carried out with the duct with and without using heat transfer augmentation methods. Heat transfer coefficient and friction factors are calculated for all conditions. Parameters were plotted for different values of Reynolds number.
For the arrangement without rib and with flat, and Zig-Zag shaped rib

1. It is observed that the heat transfer coefficient increases with increase in Reynolds no. As Reynolds no. increases, the air flow will cause more turbulence, so due to which the heat transfer rate will increase. It is observed that the rectangular duct without using ribs gives less heat transfer coefficient than with the use of Zig zag -shaped ribs.
2. It is observed that there is increase in Nusselt number with Reynolds number. As Reynolds number increases the air will cause more turbulence due to which heat transfer rate will increase.
3. It is observed that as the mass flow rate increases the Nusselt number increases. There is increase in Nusselt number with Zig-zag-
4. It is observed that as Reynolds increases there is decrease in friction factor is observed. This is because friction factor is inversely proportional to the velocity.

6. CONCLUSIONS:

Experimental investigations have been carried out in the duct to study the effect of Zig zag shaped ribs on heat augmentation. It is observed that the heat augmentation increases with zig zag shaped ribs as compared to duct without ribs because it increases the turbulence in the flow which help to increase heat transfer rate but at same friction loss is more in Zig zag shaped ribs as compared to duct without rib.

NOMENCLATURE:

D_h – Hydraulic diameter of channel in m where,
D_h 4A/P
A Cross sectional area of rectangular channel, m^2
P Perimeter of rectangular channel
f frictional factor
m mass flow rate , kg/s
ΔP pressure drop , N/m^2
Q Steady state heat transfer rate from heater Watt
H heat transfer coefficient, W/m^2K
T_{b1} Bulk temperature of air at inlet ,°C
T_{b2} Bulk temperature of air at outlet ,°C
Tw Wall temperature , °C
Re Reynolds no. $Re=(\rho * D_{h*} v)/\mu$
ρ Density of air , Kg/m^3

v Velocity , m/s
μ dynamic viscosity of air , N/m-s
Nu Nusselt no., $Nu=h*D_h/k$
K Thermal conductivity of air, W/mK

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