An Experimental Analysis of the effect of Different Inlet Condition of air by using Forced Convection Heat Transfer

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***Abstract* - This paper is based on the experimental analysis of the effect of various types of inlet condition of air (0^0,45^0,90^0) and different height of baffle arrangement. The utilization of baffles in channel is usually used for passive heat transfer enhancement Techniques in single phase internal flow. Heat transfer enhancement technology is that the technique of rising the performance of a heat transfer by increasing the convective heat transfer coefficient. Heat transfer techniques for enhancing is divided in two classes. First is Passive Methodology like rough surfaces, extended surfaces, baffles, twisted tapes, whorled screw tape inserts, additives for liquid and gases. Another is Active methodology, which needs additional external power, for instance mechanical aids, surface fluid vibration, use of electricity fields. Active heat transfer strategies have been found more expensive as compared to Passive strategies. In most of the earlier numerical and experimental studies empirical correlations for duct flow with straight channel has been investigated and corresponding heat transfer and pressure drop are reported, only a few projects are presented for channel with turned flow therefore an experimental study is required to be carried during a rectangular channel with turned flow (45^0,60^0, 90^0) varying the Reynolds number which indicates turbulence flow. The Reynold number is in range of 15000 to 37000 which indicates turbulence flow. The Rectangular channel has been heated from bottom with a constant heat flux (V x I) through the dimmer. A Independent heater arrangement has been made at the entrance to vary the inlet temperature. Also the inlet temperature is varied and air is supplied at four different temperatures i.e. 30^0, 35^0, 40^0C, and 45^0C in order to study the effect of temperature on heat transfer. Typically, the main motto of this analysis is to cut back the dimensions and prices of heat exchanger. Considering the faster rise in energy demand, most effective heat transfer enhancement techniques became important task for the globe. Experimental and empirical correlations for duct flow are given for hydro dynamically and thermally developed flow in most of previous studies. How-ever the effect of baffle height and different inlet condition on heat transfer and pressure drop have been examined.**

***Index Terms* - baffle height, convective heat transfer coefficient, inlet angle, heat transfer enhancement, Nusselt No., Rectangular channel, Reynolds number, Turbulent, uniform heat flux.**

INTRODUCTION

Forced convection is the mechanism obtained when the fluid motion is generated by any external source like fan, suction pump, devices etc. This study is mainly focused on finding the various parameters regarding heat transfer through different inlet angle. Rectangular channel is one of simplest duct which is widely used device in heat exchangers in which heat is being changed between the heated wall and therefore the air flowing through the system. In this paper, experiments have been conducted to study heat transfer enhancement in a rectangular channel with/without baffle with varying inlet angle. The baffle is mounted at the middle of the test section on the bottom surface with constant heat flux. The design of Rectangular channel needs exact analysis of heat transfer rate and pressure drop estimations. Heat exchangers have been widely used in several industrial and engineering usage. The major challenge in designing a channel is to make the equipment compact and achieve a high heat transfer rate using minimum input power. Baffle, Ribs are a popular heat transfer enhancement device used in various heat-exchanging channels which block the flow and increase the turbulence. The heat transfer rate can be improved by inserting a disturbance like baffle in the fluid flow.

Rectangular ducts are mainly used in heat transfer equipment such as in gas turbine cooling systems, compact heat exchangers and nuclear reactors. The flow over baffles has different fluid flow and heat transfer characteristics. Heat-transfer Enhancement strategies has a crucial role to increase the efficiencies of heat exchangers in ducts, pipes and channels. Hardly few studies have been done in inclined or varying inlet geometry other than straight channel. So, in this project, have introduced a different technique by changing the inlet angle such as 450,900 others than 00.

II.EXPERIMENTAL SETUP

Fig.1.1- Actual Experimental Setup of Rectangular Channel 90^0 Inlet

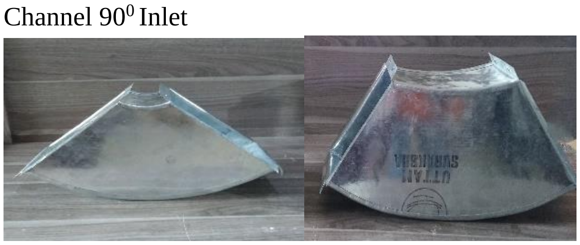

Fig-1.2 90^0 Duct inlet 45^0 Duct inlet

Fig1.3.- Anemometer Fig.1.4- J type thermocouple

Fig.1.1 shows experimental setup from front view of 90^0 inlet. The baffles with straight angle and same thickness is as shown in fig.1.1. Baffle made up of aluminum material

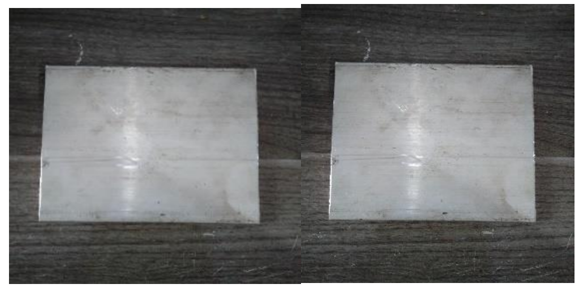

Fig.1.5- Different Height Baffle

Fig.1.6- Ammeter and Voltmeter

Experimental set-up for investigation of forced convection heat transfer in a rectangular duct provided with baffle for different inlet conditions (0^0,45^0,90^0). In this set-up, Different inlet condition of Rectangular duct has been provided with the different configurations and Height of baffle. The rectangular duct is surrounded by Coil type heater. Four thermocouples are embedded on the test section and one thermocouple and two thermocouples are placed in the air stream at the entrance and exit of the test section to measure air inlet and outlet temperatures. The temperatures can be read directly from the temperature indicator by using selector switch of Digital Temperature indicator. Air flow is controlled by a Fan Regulator and is measured with the help of Anemometer and U Manometer. Heat input can be set with the help of Dimmer provided on control panel and same can be read out digitally with the help of voltmeter and ammeter. A centrifugal fan is used to draw the air from inlet to exit section. The constant heat flux Coil type heater is fabricated from Nicrome wire. This heater is connected in series with dimmer stat in order to provide the same quantity of heat to heater i.e.- (VxI). The heater is provided at bottom of the channel and other side are unheated as well as insulated with cerawool. (i.e. Adiabatic surface). A independent heater arrangement would be made at the inlet to vary the inlet temperature. Cerawool Material is used for insulation on external surface to prevent the heat loss due to conduction and radiation. For Surface temperature measurement, four thermocouples are fixed at different place of heating surface. Moreover, one thermocouple is fitted at inlet and two thermocouples are fitted at outlet to measure the inlet and outlet bulk temperatures, respectively. U-Manometer is used to measure the pressure drop within the rectangular channel with the help of pressure tap. In present study both flat solid baffles of straight angle of same thickness and height (t=5mm, h=100 mm,150mm,) has been used. Two different height baffles are used in this experiment of same angle one by one. This baffle was fixed in contact with the bottom surface. After this all arrangement temperatures measurements were performed under steady state conditions. When the variations of Test section or wall temperatures during an interval of 10 min. were less than 3⁰C, the system was assumed to be in a steady state. The temperatures and pressure drop were recorded simultaneously after the beginning of test run to achieve steady state. To examine the experimental data such as temperature, velocity, and pressure drop, the experimental results were recorded four times at a time interval of 5 min under steady state conditions. The average of wall Temperature is calculated by taking average of four temperature at test section. Thermo physical properties required for the heat transfer calculations were evaluated at the mean fluid temperature, defined as

$$T_f = \frac{T_i + T_o}{2}$$

All value of properties was used for calculating of depended parameters. By using all the data, observation & calculation have been done. Finally compared the results of experimental investigation with the results obtained by using correlation method have been done.

To calculate Hydraulic Diameter ($D_{h)}$ of channel

D_h = 4A/P

Where, A = Area of channel, P = Perimeter of channel

EXPERIMENTAL PROCEDURE

1. Switch on the Power Supply and then console on switch to activate the control panel.
2. Switch on the Fan unit first and adjust the flow of air using wheel valve of Fan to a desired difference in manometer.
3. Start the centrifugal fan after keeping the valve open, at desired rate.
4. Switch on the heater and set the voltage (say 90V) using the heater regulator or Dimmer.
5. Put on the heater and adjust the voltage to a desired value through the Dimmer and maintain it as constant.
6. Wait for reasonable time to allow temperatures to reach steady state & Allow the system to stabilize and reach a steady state.
7. Measure the voltage, current and temperatures from T_1 to T_7 at known time interval.
8. Note down all the temperatures T_1 to T_7 voltmeter and ammeter readings, and manometer readings.
9. Calculate the convective heat transfer co-efficient using the procedure given.
10. Repeat the experiment for different values of power input to the heater and Fan air flow rates.
11. Repeat the experiment for different, Inlet Temperature with the help of independent Heater through thermostat, heat input and flow rates.
12. After completion of the Experiment to all switches of control panel should be off.

III. SPECIFICATION OF COMPONENTS

Sr.No.	Name of component	Specification
1	Wall Heater	1600Watt Coil type Nicrome wire heater
2	Independent Heater	600 Watt
3	Centrifugal fan	2600RPM,50 Watt.Standard
4	Ammeter	0-50A
5	Voltmeter	0-500 Volt AC
5	Dimmer	0-8A
6	Digital Temperature indicator	Digital 8 Channel range (0-600° c)
7	U-tube manometer	Standard
8	Thermocouple	7- J Type

IV. CONCLUSION

Form the above experimental & Numerical study, it is concluded that:

1. Heat transfer rate is increased by using varying inlet of Rectangular channel with baffle, because Baffle increase the turbulence of the flow.

2. Reynolds number is directly proportional to Nusselt no. As the Reynolds number increases, the Nusselt no. also increases.
3. In this experiment, the inlet temperature is varied, and air is supplied at four different temperatures i.e. 30^0C,35^0C,40^0C, and 45^0C in order to examine the effect of temperature on heat transfer. Simultaneously the heat transfer, Nusselt number, heat transfer coefficient is Calculated. Experimental procedure was validated by comparing the data with straight inlet geometry ($\theta = 0^0$) without/with baffle in the test section.
4. The result showed for different inlet condition of channel that heat transfer is increased for air entering at 45^0C and at an inclination of 90^0 to that of 0^0 inclination at same temperature Simultaneously the increase in pressure drop between 90^0 inclination and 0^0 inclination with baffle of maximum height in the test section thus it has been observed that pressure drop increases with increase in inclination and is highest at 90^0 inclination of inlet section.
5. As the velocity of air increases the rate of heat transfer increases.
6. The heat transfer rate is significantly influenced by geometry of different inlet configuration.
7. Heat transfer Enhancement techniques is a subject of essential importance in increasing heat transfer rate and achieving higher efficiency
8. Changing of the entry angle of channel (θ) results in a heat transfer rate at entrance of the test section.
9. Baffles increase the pressure drop due to flow blockages and ends up in augmented viscous impact owing to reduced fluid flow space.

V. FUTURE SCOPE

1. This type of forced convection heat transfer enhancement with passive heat transfer strategies has been used for various types of industrial application and process of equipment such as heat exchanger, furnace design, nuclear reactor electronic cooling devices, thermal regenerators, internal cooling system of gas turbine blades and turbo machines.
2. So that the main target is to design the channel geometry that will yield maximum enhancement in heat transfer rate with minimum increase in pressure drop and minimum decrease in flow rate.
3. Heat transfer augmentation is a subject of vital importance in increasing heat transfer rate and achieving higher efficiency.
4. Heat transfer may be more efficient in a small rectangular channel than in a circular channel of approximately the same hydraulic diameter
5. Baffle may be a standard heat transfer improvement device employed in numerous heat-exchanging channels.

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