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HEAT TRANSFER AUGMENTATION THROUGH DIFFERENT PASSIVE INTENSIFIER METHODS

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ABSTRACT

In most of the previous experimental and numerical studies empirical correlations for duct flow with straight channel has been investigated and corresponding heat transfer and pressure drop are reported, very few paper have been presented for channel with turned flow therefore an experimental study is needed to be carried in a rectangular channel with turned flow (45^0, 60^0, 90^0) varying the Reynolds number which indicate turbulence. The bottom wall of the channel is mounted with a baffle, the channel would be heated from bottom with a constant heat flux, a separate heater arrangement would be made at the inlet for varying the inlet temperature .furthermore the effect of baffle height on heat transfer and pressure drop will be investigated and finally empirical correlations including several dimensionless parameters for average Nusselt number and friction factor will be obtained and presented.

Keywords: Baffle, Friction Factor, Nusselt Number, Reynolds Number, Straight Rectangular Channel

I. INTRODUCTION

Necessity of saving energy and material imposed by the diminishing world resources and environmental concerns has prompted the development of more effective heat transfer equipment with improved heat transfer rate. The use of serpentine type or baffle type channel is commonly used heat transfer enhancement strategies in signal phase internal flow. However an attempt has been made to overcome the thermal problems subject to high heat flux and to increase the heat transfer rate using the detail exploration of turned flow in channel. Since very few studies have been addressed in this issue it needs more effective study in this method. We are employing a new method by varying the inlet condition by incorporating the heater at the inlet and also by varying the inlet geometry of the channel. After reading the several papers, I came to know to improve the performance heat transfer rate that varying the inlet condition with respect to test section and inserting the baffle inside the test section.

II. EXPERIMENTAL SETUP

The main flow of air would be supplied using a High speed Exhaust fan. The flow rate would be adjusted and controlled by an AC inverter or regulator the air would pass through a flow-meter. The flowing air enters the test section through a straight angular entry or perpendicular entry. The top and two side walls of the channel would be made of non-tempered glass (Piexy Glass) while the bottom wall is made up of EN8 sheet and the baffle were made of aluminum plate. The bottom surface of the test section received a constant heat flux, q, while the upper and side surfaces were adiabatic. The heat flux was set by adjusting the electrical voltage with the help of AC variable electric power supply. The temperature of the heated surface is measured by 10 calibrated and electrically insulated diameter T-type thermocouples fixed at selected locations in the test section.

Straight Channel , Turn the flow by varying the inlet angle by 45^0 & Turn the flow by varying the inlet angle by 90^0 with or Without baffle and with inlet at Atmospheric temperature or Varying the inlet temperature (by 5^0C -)

a) Vary the heat flux (attain the steady state of heater between every interval)

b) Vary the mass flow rate of the high speed exhaust fan with the regulator and thus vary Re

c) Calculate the heat transfer coefficient (h)at different heat flux and mass flow rate

d) Plot the graph of Re Vs h

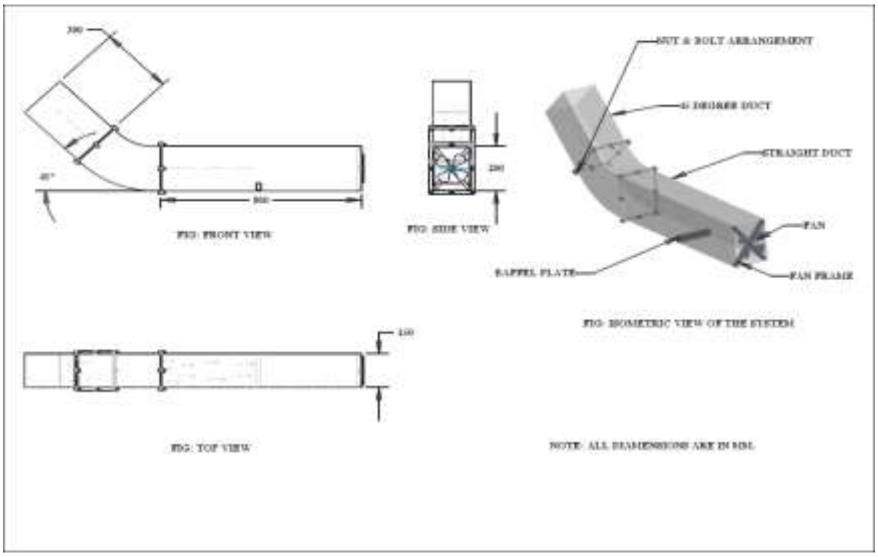

Fig. 2.1 Turn the flow by varying the inlet angle by 45^0 with or without baffle and at the same time Varying the inlet temperature by 5^0C (i.e. at 35^0C , 40^0C , 45^0C)

Fig. 2.2 Experimental Setup (Inlet at 45^0 Inclination)

2.1 Mathematical Formulation

Sample Calculation

For inclination θ = 0^0 and Inlet temperature ambient (45^0C) without baffle

Sr. No.	Inlet heater (W)	Test section heater (W)	velocity (m/s)	Pressure drop (mm of water)	Temperature ^{0}C (Without Baffle) and inlet temp- Ambient										
					T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11
1	0	72	0.5	0.5	45.2	46	45.6	45.4	100.7	45.8	45.9	46.4	46.2	52.1	103.6

The velocity of air is found with the help of Digital Anemometer

Mass flow rate, m = ρ*A*V

Heat Input to air

$Q = m*cp*(Tb_2-Tb_1)$

But

$Q = h*As*(Tw-(Tb_1+Tb_2)/2)$

$D_h = 4A/P$

III. RESULT & DISCUSSION

In the experimentation Reynolds number (Re), the non-dimensional parameter is used to indicate the flow regime. The effect of air entering at different entry angles and at different temperature on the forced convection heat transfer from a channel is studied for different velocities. Calculations are carried out at five different mass flow rates.

3.1 Convective Heat Transfer Coefficient Vs Mass Flow Rate for Various Inlet Angles.

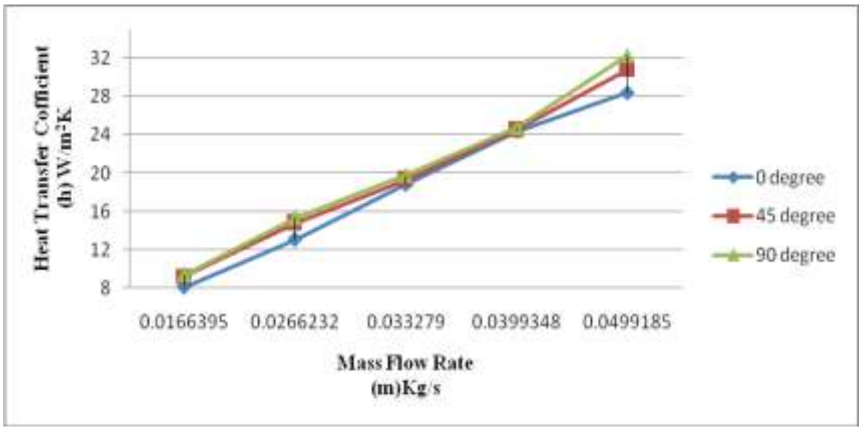

Fig. 2.3 Comparison of Convective heat transfer coefficient with Mass flow rate for ambient temperature (45^0C) without baffle

Fig.2.3 shows the variation of Convective heat transfer coefficient with Mass flow rate for ambient temperature without baffle in the test section. It also shows the effect of various entry angles with respect to straight entry on convective heat transfer coefficient for different mass flow rate. From fig. 2.3 for increase in entry angle (from 0^0 to 90^0) there is increase in convective heat transfer coefficient. For 90^0 turned flow, have the highest convective heat transfer coefficient.

3.2 Heat Transfer vs Mass Flow Rate for Various Angles

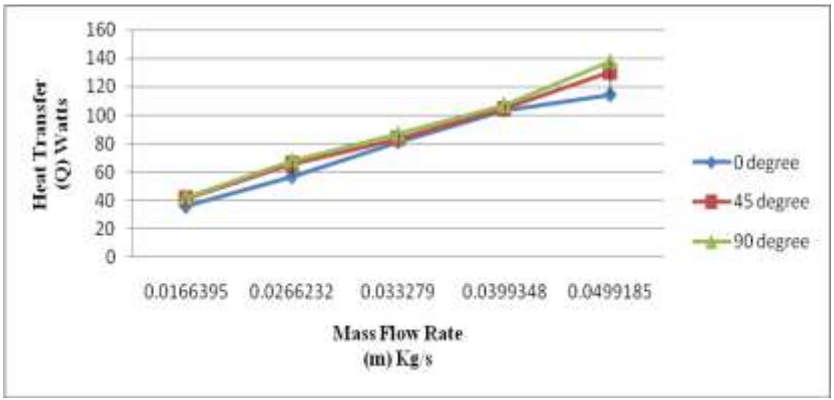

Fig. 2.4 Comparison of heat transfer with Mass flow rate for ambient temp (45^0C) without baffle

Fig. 2.4 shows the effect of air entering at various angles at ambient temperature (45^0C) on heat transfer rate at different mass flow rate without baffle in the test section. From fig. 2.4 it is seen that for increase in entry angle (from 0^0 to 90^0) there is increase in heat transfer. For 90^0 turned flow, have the highest heat transfer.

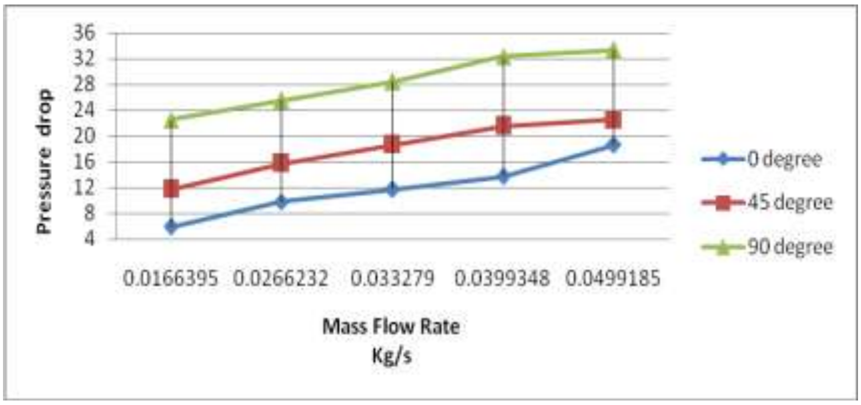

Fig. 2.5 Pressure drop Vs mass flow rate for various inclination with baffle

Fig. 2.5 shows that pressure drop increases with increase in mass flow rate. It also shows the effect of air entering at various angles on the pressure drop. From fig. 2.5 pressure drop is highest for 90^0 inclinations. Percentage increase in pressure drop for 0.049918 mass flow rates between 45^0 turned flow and 0^0 turned flow is 0.21056. The percentage increase in pressure drop between 90^0 turned flow and 45^0 turned flows is 0.4782. Similarly the percentage increase in pressure drop between 90^0 turned flow and 0^0 turned flow is 0.78947.

IV. CONCLUSION

In the experimentation Reynolds number (Re), the non-dimensional parameter is used to indicate the flow regime. The effect of air entering at different entry angles and at different temperature on the forced convection heat transfer from a channel is studied for different velocities. Calculations are carried out at five different mass flow rates.

Also the enhancement of ratio of Nusselt number with baffle to Nusselt number without baffle for 90^0 turned flow is highest. From the experimental results it is seen that in case of 90^0 turned flow enhancement of heat transfer coefficient is more as compared to straight entry. In this experimentation three sets of inlet sections were used and each inlet supplies air at three different temperatures. As the air enters the test section at various angle viz. 0^0,45^0,90^0 due to which turbulence of air is created and which causes the increase in convective heat transfer. Further due to insertion of baffle in the test section, laminar boundary layer is broken and more turbulence is produced, thereby causing more convective heat transfer. It is observed that percentage increase in heat transfer for air entering at 55^0C and at an inclination of 90^0 to that of remaining two sections at same temperature is maximum. Further, if we consider the effect of temperature it is observed that by increasing the temperature of the air entering the test section, its heat transfer coefficient increases and maximum heat transfer coefficient is observed at inlet temperature of 55^0C. At the same mass flow rate pressure drop increases with increase in inclination of the inlet ,and it is observed that highest pressure drop is obtained at 90^0 inclination of inlet section as compared to the remaining other two inlet sections.

V. NOMENCLATURE

Bulk temperature at inlet

$Tb_1=T_1$

Bulk temperature at exit

$Tb_2= (T_7+T_8+T_9+T_{10})/4$

A_s = Heating Surface area

Where,

h = avg. convective heat transfer coefficient W/m^2-K

Q = steady state convective heat transfer from heater fixed at 72 Watts

Tb_1 = bulk temperature at inlet ^{0}C

Tb_2= bulk temperature at exit ^{0}C

T_1 =Ambient temperature of air at inlet ^{0}C

T_2 = Surface temperature of Inlet heater ^{0}C

T_3 and T_4= temperature of air at entrance of Test section ^{0}C

T_5 and T_{11} = Surface temperature of heater of Test section ^{0}C

T6 = temperature of air inside the Test section ^{0}C

T_7, T_8, T_9, T_{10} = temperature of air at the exit ^{0}C

T_w = Wall temperature of channel

L= Length of baffle

t= Thickness of baffle

H = height of baffle

A = Cross sectional area of test section m^2

As = Surface area of heater

h = avg. convective heat transfer coefficient w/m^2k

Hydraulic diameter D_h of channel

D_h = Hydraulic diameter in mm

A = Cross sectional area of channel m^2

P = Perimeter of channel m

To find mean bulk temperature,

$T_f = (Tb_1+Tb_2)/2$

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