A Review on Heat Transfer from Combined Conduction and Convection through Perforated Fins

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Abstract

This paper gives a review on enhancement of heat transfer over a flat surface equipped with rectangular perforated fins in staggered arrangement in a rectangular tunnel. The range of Reynolds number is fixed and about 13,500– 42,000.Heat transfer enhanced in fin array by porous fins. Experiments were conducted to analyze the natural convection heat transfer of solid and perforated fin array .This paper is result of experimental study to compare the rate of heat transfer with solid and porous fins . .For the analysis of natural convection heat transfer solid and permeable fin blocks are kept inside an isolated chamber .The variation of steady state temperature of base and tip ,the natural convection heat transfer was compared through each of these blocks .The steady state temperatures were noted at constant heat flux .Steady state temperature were recorded at the same time for different angle of inclination . Fin cylinder block having permeable and solid fin were tested for different inputs (15W ,30W , 45W ,60W, 75W) It was seen that permeable fin block average heat transfer rate improved by about 5.63% and average heat transfer coefficient about 42.3% as compared to solid fins with reduction of coast of the material 30%.

Keywords: *Heat transfer enhancement; perforated fin; Performance analysis; Staggered arrangement*

I. INTRODUCTION

It is very significant situation where heat is to be transferes between a fluid and a surface of object. In these cases the heat flow depending upon three main factors (*i*) surface area (*ii*) Temperature difference (*iii*) and convective heat transfer coefficient. The surface area of the base is limited by the design of the system and temperature difference depends on the process carried out and can not be changed. The choice only appears to be the convection heat transfer coefficients and this also cannot be increased beyond a certain limits. Any of such increase will be at the use of power for fans or pumps. So the possible option is to increasing the base area by the so called extended surfaces or fins Fins are projections protruding from hot surface and they are designed to enhance the heat transfer rate of the body with increase in the convective surface area. By adding fin array to an object, increases the surface area and can sometimes it is an economical solution to heat transfer problems. Fins are widely used in electronic devices, electrical transformers, automobile engine blocks .By enhancement of the heat transfer rates results the saving in power supplied, increasing the efficiency in automobiles, computer chips etc. Fins are protruding from either rectangular or cylindrical base. Various types of fins are used such as rectangular, square, cylindrical and a combination of different geometries have been used. The various important parameters in the analysis of fins are (a).Heat transfer coefficient (h) , (b). Cross sectional area of the fin(c) Length of the fin, ,(d). Thermal conductivity of fin,(e). Efficiency (f). Effectiveness of the fin . A fin is different geometries such as cylinderical, square or other shaped elements are attached perpendicular to a wall of the surface the transfer fluid passing through cross flow over the surface. Fins having a height-to-diameter ratio, H/D, between 0.5 and 4 are accepted for short fins, whereas long fins have a pin height-to-diameter ratio H/D, exceeding more. When the fin has been analyzed we consider steady state.

II. LITERATURE REVIEW

A. *Bayram Sahin, Alparslan Demir*

In this paper studies the Performance of a heat exchanger having perforated square fins in this paper the condition is take square fins having different in numbers of Fins that is depend of inter fin distance and in this paper give the perforation due to the perforated internal surface is take outer air which come from atmosphere through the tunnel and Fin molecules will be donated heat energy to air molecule by convectively. There have been many investigation regarding heat transfer and pressure drop of channels with pin fins, which are restricted to pin fins with circular or few different cross sections. The Heat transfer through the solid to the surface of the solid by conduction is major heat transfer mode and also the major heat transfer by conduction followed by convection where as from the surface to the surroundings takes place by convection.

Many investigations have been done regarding pressure drop and heat transfer true the channel with different cross section of fins that is circular or other shape. The conductive heat transfer means solid to solid surface from one end to another end in which major heat transfer rate in pin fin and the conduction followed by convection also major heat transfer, where as in surrounding take place of surface by convection the attaching of extended surface over the flat plate by increasing surface area is called Fins . The material of fin takes highly conductive like Aluminum, copper, etc. The cooling of electronic equipment and stationery engine for this specially designed fin surface called heat sink. The minimum material and maximum heat transfer give of this type of design

In this paper the experimental range of some parameter fixed like inter fin distance ratio (Sy/D) 1.208, 1.524, 1.944 and 3.417, clearance ratio (C/H) 0, 0.33 and 1 and Reynolds number 13,500–42,000. Enhancement efficiencies depending on the clearance ratio and inter- fin spacing ratio and it's varied between 1.1 and 1.9. The effects of the flow and geometrical parameters on the heat transfer and friction factors were determined, and the enhancement efficiency correlations have been obtained. [1] Bayram Sahin, Alparslan Demir analysis that the maximum heat transfer rate was observed at 42,000 Reynolds number, 3.417 Sy/D and 50 mm fin height.

B. O.N. Sara, T. Pekdemir, S. Yapici, M. Yılmaz

In existing studies, Heat-transfer enhancement in a channel flow with perforated rectangular blocks. The heat transfer and pressure-drop affected all the parameters. In this paper the heat transfer rate enhance by perforations, certain degree of porosity and slots which allow flow to go through the blocks in case of perforated the heat transfer rate is increase and give improvement in the flow. Due to perforation the multiple jets-like flows.

C. G.J.Vanfossen and B.A.Brigham

The paper reported that this paper describes the analysis of the heat transfer by short pin-fins in staggered arrangements. By short pin-fins the heat transfers in staggered arrangements. According to results, more heat transfer is longer pin-fins having (H/d = 4) but shorter pin-fins having (H/d = ½ and 2) less heat transfer as compare to the above ratio and the slightly exceeds that with only four rows when array-averaged heat transfer with eight rows of pin-fins. The another point in as results is the average heat transfer coefficient on the pin surface is around 35% more than that on the end walls is established.

D. Amol B. Dhumne and Hemant Farkade

In this paper the heat transfer of analysis on cylindrical perforated fins in staggered arrangement, in this type ofarrangement and shape have analysis that heat transfer on cylindrical fin more heat transfer rate. In which the Reynolds number taken as fixed range but it have to change in shape of the fin and give staggered arrangement. Change is only shape. In this paper they have analysis on both staggered and in line arrangement of fin the after the result obtain the cylindrical and also this solid and perforated pin fins. In staggered arrangement better heat transfer enhancement than the solid cylindrical fins the result obtain of compared to in line staggered arrangement and perforated with solid fins and also given to lower Reynolds numbers are suggested for higher thermal performance. Enhancement efficiencies vary depending on the clearance ratio and inter-fin spacing ratio.

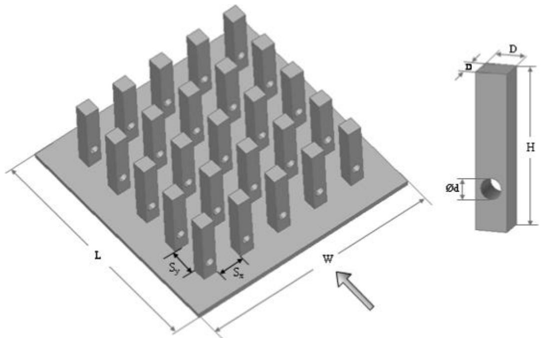
E. R. Karthikeyan and R. Rathnasamy

This report is that the pin-fins have designed staggered and inline manner, in line and staggered arrangement they affected fiction factor and heat transfer rate. The convective heat transfer through a rectangular channel with cylindrical and square cross-section pin-fins attached over a rectangular duralumin flat surface. The fins designed with different inter fins distance ratio (Sx/d and Sy/d) and different is clearness ratio (C/H=0.0, 0.5&1.0) both the inter fins distance ratio are variable i.e. (Sx/d and Sy/d). The paper is take some standard parameter i.e. various mass flow rate of air, range of Reynolds number from 2000-25000. The result of this paper is the lower clearance ratio, inter fins distance in staggered arrangement give more heat transfer rate and lower Reynolds numbers should be in staggered as comparative with in line.

III. EXPERIMENTAL PLAN

The all above references are used in this experiment and we arrange the Rectangular fins. In this experiment we have taken the rectangular shape structure. Rectangular with perforation as well as staggered arrangement is done .The improvement in the flow (so the enhancement in the heat transfer) is brought about by the multiple perforations and the staggered arrangement creates more turbulence due to that all molecule present in air which collides with the rectangular Fins gives the heat energy to the air molecule by force convection mathods. In this Experiment same parameter are taken into consideration as in reference papers [4] [1] like Reynolds numbers ranges 13,500–42,000. When the Reynolds number is increases the Nussult Number is also increases same .

The base plate consisting rectangular fins in staggered arrangment are shown in following related fig.1 in which the base plate used is also having a rectangular shape. The collection as per the inter fin distance is shown in fig.2, In which having the inter fin spacing distance is $S_y/D=1.208$ and for this spacing distance the number of fins on the base plate having magnitude 250mm x 250mm is 25 in number.



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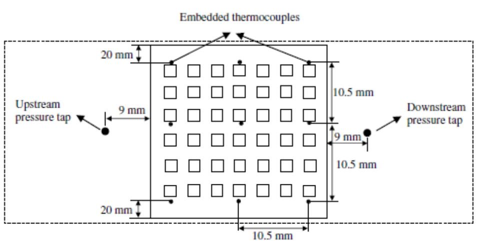

Fig. 2c. Pressure taps and surface thermocouples locations.

IV. PERFORMANCE PARAMETERS

A. Input Parameters

1) Base plate Temperature

The base plate temperature is to be maintained at a constant temperature At 100 °C with the help of temperature controller by using RTD sensors. By Switching on the heater, earlier temperature of the base plate reached upto 100˚C,and the temperature of the controller of RTD sensors carry in the operation and it will cut off the power supply of the heater input.

2) Area

It consist of square plate at the base related dimension 250mm x 250 mm,and thickness is 6mm and fins are parpendicullar set on the base plate of rectangular shape fin. Number of on base plate is 25,21,18 and 11 with its different in S_y/D ratio and different in lengths, in corresponding to C/H (Clearance ratio) values of the 0, 0.333 and 1 they have to give different in heights are 100,75,50 [1].

3) Voltage, Current and Resistance

Voltage is V, Current is I and Resistance is R. Input electric system is $Q_{elect} = =I^2 \times R$

4) Air Velocity

The effects of the air movement upon sensible heat loss from individual birds at ambient temperatures. The air velocity is approximate 2 m/s to 5 m/s.

B. Output Parameters

1) Temperature

The input and output temperature differences are affects the heat transfer coefficient.

2) Nussult Number

In heat transfer at a surface within a fluid, the Nussult number is the ratio of convective heat transfer to conductive heat transfer across the boundary. In this convection includes both advection and conduction. After the name of Wilhelm Nusselt, it is dimensionless number. The conductive component is measured under the same conditions as the heat convection component but with a (hypothetically) stagnant fluid [4].

$$\mathbf{Nu=hL/k_f}$$

3) Reynolds Number:

Reynolds number can be defined for a fluid is in relative motion to a surface. These definitions generally include the fluid properties as density, viscosity and a velocity and characteristic length [10].

$$\mathbf{Re= \rho vL/\mu}$$

V. SET UP ARRANGEMENT

Reynolds number used in our experiment is 13,500–42,000, the average velocity is (U) and hydraulic diameter of the tunnel over the test section (D_h) these two parameters are helping us to calculate the Reynolds number. The outlet and inlet temperatures of the air stream is to be measured by RTD Sensors which is mounted inside wind tunnel. One RTD is located in outer surface temperature of the heating section and other one is for ambient temperature is employed the pressure drop over the test section is measured by using two pressure transducers that can take measurements between 0 and 150 Kg/cm² which is mounted inside the wind tunnel.

Tunnel is constructed of wood of 20 mm thickness, has an internal cross-sectional dimensions are 250 mm 250 mm and 100 mm the total height of test tunnel of the length is 1030 mm. The air supplied into the tunnel over the Fin with the help of blower, which have adjustable speed i.e. 1, 2, 3, 4, 5, 6 m/second range of rotational speed is 0 to 16000 rpm and it is fitted at entry section of the tunnel i.e. at convergent part of the tunnel and positioned at horizontally. It has a converging and diverging section at both ends having the inclinations of 30°. An anemometer measures the average inlet velocities of the flowing air enters to the test section of the anemometer is mounted at the inlet section of the tunnel and the range of this anemometer is 0 to 15 m/sec.

VI. EXPERIMENTAL PROCEDURE

1. First of all attached all the related measuring instruments on the specified positions i.e. Display control panel, Heater RTD sensors etc.
2. Put the aluminum finned base plate on the heater unit.
3. Moving the heater unit and base plate upward directions with the help of screw jack.
4. The base plate touching the RTD sensor and check the positions of two other sensors i.e. inlet and outlet RTD sensor.
5. Then Switch on the main supply of the tunnel, the heater gets ON and heated the plate , As the temperature raising up to 100˚C, the controller of RTD sensors is get activated & it will automatically cut off the power supply.
6. In the next step is to start the blower and by using digital anemometer and measuring the velocity of inlet air and maintain inlet air velocity constant rate as per specified (i.e. 2, 3, 4, 5 and 6 m/s) with the help of blower.
7. Now through tunnel air flows over the heated Fin plate.
8. Measuring the temperature of outgoing warm air with the help of RTD senseor at outlet .
9. As soon as the temperature of base plate going to decrease, due to forced convection effect.so that the heater gets started to achieve constant temperature of 100˚C.
10.And apply the same procedure for velocities 3m/s, 4m/s, 5m/s, and 6m/s and take down the readings as same.

VII.PROCESSING DATA

A. Heat Transfer

$Q_{conv.}=Q_{elect.}-Q_{cond.}-Q_{rad.}$---------------(1)

Wheres: Q_{conv}, Q_{elet}, $Q_{cond,}$ Q_{rad} indicated that heat transfer rate by convection, electrical, conduction and radiation.

The electrical heat input is to be calculated from the electrical potential and current supplied to the surface.[1][4]

$$Q=I^2XR$$

Total area = Projected area + Total surface area contribution from the blocks [2][4]

$$Q_{conv.}=h_{av}A_s\left[T_s-\left(\frac{T_{out}+T_{in}}{2}\right)\right]$$

Reynolds Number: [10]

$$R_e=\frac{D_h U}{v}$$

Nussult number smooth surface (Nu_s) For without Fin:[4][1]

$$Nu_s=0.077Re^{0.716}Pr^{1/3}$$

Nussult number: [1][4]

$$Nu_{p2}=45.99Re^{0.396}\left(1+{C}/{H}\right)^{-0.608}\left({S_y}/{D}\right)^{-0.522}Pr^{1/3}$$

B. Friction Factor

The Pressure drop is to be calculated by the experiment this pressure drop is finding out in duct with manometer or measured under the heated flowing conditions. The experimental pressure drops will be converted to the friction factor 'F' using the experimental data. Friction factor was correlated as a function of the duct Reynolds number Re, and geometrical parameters which are used. The pressure drops in the tunnel without fins is so small that they could not be measured with the help of the Manometer.[4]

$$F=2.4Re^{-0.0836}(1+C/H)^{-0.0836}\left(S_y/D\right)^{-0.0814}$$

C. Efficiency Enhancement

The effectiveness of the heat transfer for a constant pumping power, it is used to determine enhancement of a heat transfer. The enhancement efficiency is defined as the ratio of heat transfer coefficient with Fins to without Fins. [4][1]

$$\eta=\frac{ha}{hs}=51.09\,Re^{-0.358}\left(1+{C}/{H}\right)^{0.1028}\left({S_y}/{D}\right)^{0.0812}$$

Where,

h_a = convective heat transfer coefficient with Fins and

h_s = convective heat transfer coefficient without fins

VIII. CONCLUSION

By the experiment, we studied about the rectangular Shaped Fin. The rectangular area is more than that of the others due to the effect of the various parameters, i.e. overall heat transfer and friction factor . The rectangular fins cover more flue gases here easily therefore more heat transfer by convection is taking place. And we are also using staggered arrangement therefore turbulence will be more & the perforation will give the jet like flows of air which will be very much helpful for the enhancement of the heat transfer. The geometrical parameter which enhances efficiency by the heat transfer rate increase and friction characteristics will determines and enhancement efficiency & the correlations have been obtained.

The inter-fin spacing ratio and clearance ratio is decreases due to that friction factor will increases. The projected area is helpful for calculating the average Nusselt number and decreasing clearance ratio, and as inter-fin spacing decreases as the number of the fins on the base plate increases.

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