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A Review Analysis of Heat Transfer on Compound Square Cylindrical Fins of Perforated having Staggered Arrangements.

Md Maroof Md Nayeem
Mechanical Engineering Department
Everest College of Engineering and Technology
Aurangabad, India
e-mail: m.maroofnaeem@gmail.com

Mohammed Javed
Mechanical Engineering Department
Everest College of Engineering and Technology
Aurangabad, India
e-mail: javed.mohammed996@gmail.com

***Abstract*—** The paper gives the review on heat transfer enhancement over a flat surface equipped with Compound Square cylindrical perforated pin fins in a rectangular channel. The Fin dimensions are 25mm to 100mm in height with half square and half cylindrical. The range of Reynolds number is take fixed about 13,500– 42,000, the clearance ratio (C/H) 0, 0.33 and 1, the inter-fin spacing ratio (Sy/D) 1.208, 1.524, 1.944 and 3.417. Sy distance is varies and S_x distance is constant. The enhancement efficiency, friction factor and heat transfer correlated equations with each other. Due to the arrangement and this like shape i.e. half square and half cylindrical staggered and perforated that will be enhance the heat transfer rate. Clearance ratio and inter-fin spacing ratio effect on Enhancement efficiencies varies. Both lower clearance ratio and lower inter-fin spacing ratio and comparatively lower Reynolds numbers are give higher thermal performance. Nusselt number and friction factor are working parameter which related with enhancement efficiencies and heat transfer rate.

Keywords- *Force Convection Heat Transfer;Square Cylindrical perforated Fins;Staggered Arrangement;Turbulance Flow.*

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I. INTRODUCTION

In the foregoing development we derived relations for the heat transfer from a rod or fin of uniform cross-sectional area protruding from a flat wall. In practical applications, fins may have varying cross-sectional areas and may be attached to circular surfaces. In either case the area must be considered as a variable in the derivation, and solution of the basic differential equation and the mathematical techniques become more tedious. We present only the results for these more complex situations [8]. The term of extended surface is commonly used in reference to a solid that experiences energy transfer by conduction and convection between its boundary and surroundings. A temperature Gradient in x-direction Systems heat transfer by convection internally, at the same time, there is energy transfer by convection into an ambient temperature from its surface at temperature. When the surface temperature and ambient temperature are fixed by design consideration, then there are only two ways to increase the heat transfer rate [1] to increase the convection coefficient h, or [2] to increase the surface area A. for heat transfer from a hot fluid to a gas through a wall, the value of heat transfer coefficient on gas side is usually very less compared to that for fluid. To compe1nsate low heat transfer coefficient, the area on the gas side may be expended for a given temperature difference between surface and its soundings these extended surface is called Fin. To indicate the effectiveness of a fin in transferring a given quantity of heat, a new parameter called fin efficiency is defined by [8]

$$\text{Fin efficiency} = \frac{\textbf{Actual heat transferred}}{\textbf{Heat transfered if Fin area at base temperture}} = \eta f$$

Extended surfaces, which are popularly known as fins, are extensively used in air-cooled automobile engines and in air-cooled aircraft engines. Fins are also used for the cooling of computer processors, and other electronic devices. Fins are used in the cooling of oil carrying pipe line which runs several hundreds of miles. In various applications heat from the fins is dissipated by natural as well as forced convection and radiation. Various types of fins are rectangular, square, cylindrical, annular and tapered or pin fins, to a combination of different geometries, have been used. These fins may protrude from either a rectangular or cylindrical base. One of the commonly used heat exchanger fins is the pin fin. A pin fin is a cylindrical square or other shaped element attached perpendicular to a wall with the transfer fluid passing in cross flow over the element. Fins are widely used in the trailing edges of gas-turbine blades, in electronic cooling and in the aerospace industry. The Fins are different in shape with different ratio of height diameter i.e. H/d. The heat-exchanger applications are large ratio of height-diameter (H/d). Other parameters are affected heat transfer rate of flow from system to surrounding, these affected parameter are velocity, inlet/outlet Temperature, viscosity, density.

II. SQUARE CYLINDRICAL FIN

A. Bayram Sahin, Alparslan Demir [1]

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. Tzer-Ming Jeng, Sheng-Chung Tzeng[2]

In this paper studied the square pin-fin array in a rectangular channel. In which pressure drop and heat transfer in square fin having staggered arrangement. The two parameters are variable longitudinal pitch (XL = 1.5, 2, 2.8), transverse pitch (XT = 1.5, 2, 2.8) both longitudinal and transverse pitch are relative and in-line and staggered arrangement of Fins are taken. To compare circular Shape Fin with square shape Fin performance of cooling is more in square shape Fin in the open articles; the smaller present relative pitches and variable are independent. Pressure dropped formulas related with the heat transfer are suggested. The largest Nusselt number are obtained due to the inter Fin pitches under the same pumping power. The large Nusselt number are given with this inter fins space i.e. XT = 1.5 and XL = 1.5 in staggered arrangements as well as XT = 2 and XL = 1.5 in in-line arrangements Finally the result obtained that, arrangement of fins in-line square pin-fin has smaller pressure drop than the in-line circular pin-fin array at high XT (XT = 2.0 or 2.8) but pressure drop at low XT (such as XT = 1.5) an equivalent (or even slightly higher). Without fins Thermal performance for a rectangular channel showed that the presence of the diamond-shaped elements enhanced heat transfer by a factor of up to 4.4 for equal mass flow rate and by a factor of up to 1.65 for equal pumping power.

C. G.J.Vanfossen and B.A.Brigham [3]

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 [4]

In this paper the heat transfer of analysis on cylindrical perforated fins in staggered arrangement, in this type of arrangement 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 it has same as the reference paper [1] 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. Saad A. El-Sayed , Shamloul M. Mohamed, Ahmed M. Abdel-Latif, Abdel-Hamid E. Abouda [5]

The Investigation of turbulent heat transfer and fluid flow in longitudinal rectangular-fin arrays of different geometries and shrouded fin array the paper suggested about the more turbulence created that of it the friction will increase their of the pressure drop exist there fore more heat transfer occurs. The effects of the fin arrays geometries and also the fin tip-to-shroud clearance on the heat transfer, the fluid flow and the pressure drop characteristics of longitudinal rectangular-fin arrays have been investigated. During the experiments, different geometrical parameters were varied such as the fin height (H), the fin thickness (t), the inter-fin space (W), the fins number and the fin tip to-shroud clearance (C) was varied parametrically; starting with the no-clearance case (clearance ratio zero).

The presence and absence of clearance corresponding the heat transfer coefficient the condition compared with equal air flow. The results is found that the tested model mean Nusselt number (Num) increases with increasing the Reynolds number, the inter-fin space, and the fin thickness and with decreasing the fin height. the axial pressure drop along the tested model is increased as the flow travels in the inter-fin region deeply in the stream-wise (X) direction, with increasing the fin height, the Reynolds number, and with decreasing the inter-fin space and the fin thickness.

F. R. Karthikeyan and R. Rathnasamy [6]

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.

G. O.N. Sara, T. Pekdemir, S. Yapici, M. Yılmaz [7]

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.

III. EXPERIMENT ON COMPOUND SQUARE CYLINDRICAL FINS

The all above references are use in experiment and make the compound Fin like structure. In the experiment we have taken the compound shape structure. In square cylindrical fin as well as perforation and take staggered arrangement because of this parameter the square area is more then of cylinder but at sharp adage the heat loss is more then of the smooth and flat surface in square shape all the flue gases or air which is intersect with Fins only one direction but in case of cylindrical fins the area or face caver by flue gases or air is elliptical than there fore the area of the elliptical surface is more then of one side of square [4]. The area is depending on the heat transfer rate. The improvement in the flow (thus the enhancement in the heat transfer) is brought about by the multiple jet-like flows through the perforations [7]. The staggered arrangement is create more turbulence due to that all molecule present in air which are collide with Fins molecule they give the heat energy to the air molecule by force convections. In this Experiment same parameter takes fixed with reference paper [4][1] like Reynolds numbers 13,500–42,000. The Reynolds number increase the Nussult Number is also increase.

The both way can analysis of like first base surface on bottom surface is take square and upper is cylindrical as shown in figure.1 in this type the bottom side the more temperature due to that the square shape the sharp edge or corner the more heat transfer occur.

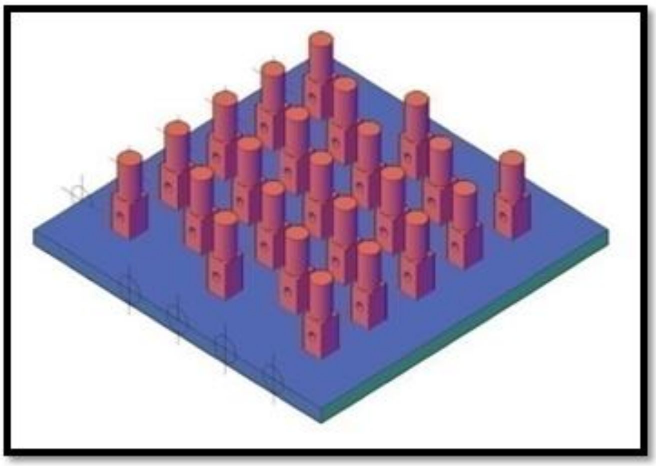

Figure 1. Base Plate of Compound Fins having bottom Square cross-section

The other arrangement is cylindrical shape take bottom side. The cylindrical fins are gives elliptical area due to that the heat transfer rate will enhance. The molecule level, molecule vibrate and transfer heat to nearer molecule which is circularly transfer band created and smooth heat transfer in circular shape. The bottom having cylindrical due to this parameter heat are exchange fast or cooling rate is more which is shown in Figure. 2.

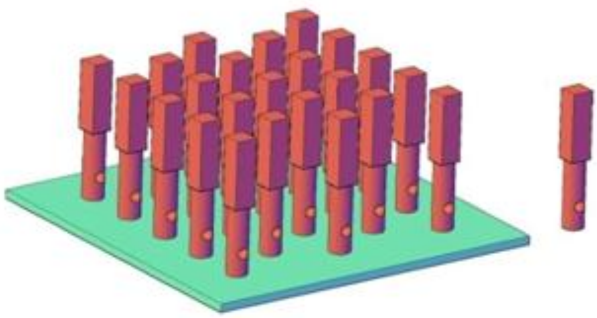

Figure 2. Base Plate of Compound Fins having bottom Circular cross-section

IV. EXPERIMENTAL PARAMETER

A. Input Parameter

1) Base plate temperature: The base plate temperature is maintaint constant temperature At 100 ^{o}C with the help of temperature controller of RTD sensors. Switch on the heater, as soon as base plate temperature reached upto 100˚C, the temperature controller of RTD sensors comes in operation and it will cut off the power supply of heater.

2) Area: It consist of square plate at base having the dimension 250mm x 250 mm, thickness is 6mm and fin is parpendicullar set on the base plate of cylinderical square compound 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, corresponding to C/H (Clearance ratio) values of 0, 0.333 and 1 they have to give different in hieght i.e.100,75,50 [1].

3) Voltage, Current and Resistance: Voltage=230V, Current(I)=8.25Amp, Resistance(V)=V/I=27.67Ω Input electric system is $Q_{elect.}=I^2 \times R$ [4].

4) Air Velocity : The effects of air movement upon sensible heat loss from individual birds at ambient temperatures. The air velocity is about 1 m/s to 5 m/s.

B. Output Parameter:

1) Temperature: The output and input temperature diffraces is affected the coefficient heat transfer.

2) Nussult Number: In heat transfer at a boundary (surface) within a fluid, the Nussult number is the ratio of convective to conductive heat transfer across (normal to) the boundary. In this context, convection includes both advection and conduction. Named after Wilhelm Nusselt, it is adimensionless number. The conductive component is measured under the same conditions as the heat convection but with a (hypothetically) stagnant (or motionless) fluid [4].

$$Nu_L = \frac{hL}{k_f}$$

3) Reynolds Number: Reynolds number can be defined for a number of different situations where a fluid is in relative motion to a surface. These definitions generally include the fluid properties of density and viscosity, plus a velocity and a characteristic length or characteristic dimension [10].

$$Re = \frac{\rho v L}{\mu} = \frac{v L}{\nu}$$

V. Experimental Set-up Facility

The range of Reynolds number used in this experiment 13,500–42,000, the average velocity (U) and hydraulic diameter of the channel over the test section (Dh) these two parameter are use to calculate the Reynolds number. The inlet and outlet temperature of the air stream will be measured RTD Sensors which mounted in wind tunnel. One RTD Sensors for the outer surface temperature of the heating section and one for the ambient temperature is employed The pressure drop across the test model is measured using two pressure transducers that can take measurements between 0 and 150 Kg/cm^2 which mounted in wind tunnel.

Tunnel constructed of wood of 20 mm thickness, had an internal cross-section of area 250 mm × 250 mm and 100 mm the total height of tunnel the length channel is 1000 mm. The air supplied into the tunnel over Fin with the of blower, which have adjustable speed i.e. 1,2,3,4,5,6 m/s and range of rotation 0 to 12000 rpm and it is fitted at entry of tunnel i.e. at convergent part of tunnel and positioned horizontally. It has a convergent and divergent section at both ends having the inclination of 30°. A anemometer measured the average inlet velocities of the air flow entering to the test section the anemometer is mounted inlet of a tunnel the range of this anemometer is 0 to 6 m/sec.

VI. Exrimental Procedure

1. First of all attached all the measuring instrument of its specific positions i.e. RTD sensors, Display control panel, Heater etc.
2. The aluminum base plate put on heater.
3. With the screw jack heater unit and base plate move upward.
4. The RTD sensor is touch to base plate and two other sensor i.e. inlet outlet RTD sensor check its positions.
5. Then Switch on the heater, the temperature raised up to 100˚C. When the heater reached at 100˚C the controller of RTD sensors is get activated it will cutoff the power supply.
6. Next step is to start the blower and by using digital anemometer measure the velocity of inlet air and maintain inlet air velocity constant as per specified (i.e.2, 3, 4 and 5 m/s) with the help of blower regulator.
7. Now through tunnel air will be pass over heated Fin plate.
8. Measure the outgoing warm air with the help of RTD outlet temperature sensor.
9. The temperature of base plate gets decreased due to forced convection. After that heater gets start to achieve constant temperature of 100˚C.
10. Respectively these are applicable for velocity 3m/s, 4m/s, and 5m/s and take the similar readings.

VII. Empirical Relationship

A. *Heat Transfer*

$$Q_{conv.} = Q_{elect.} - Q_{cond.} - Q_{rad.} \qquad [1]$$

Where: Q_{conv} ,Q_{elect}, Q_{cond} , Q_{rad} indicates the heat transfer rate by convection, electrical, conduction and radiation.

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

$$Q_{elect.} = I^2 \times R$$

Total area = Projected area + Total surface area contribution [2][4]

$$A_s = WL + 4N_pHD + \pi N_p[dD - 0.5d^2] + \pi N_pDH$$

The heat transfer from the test section by convection can be expressed as [9][10]

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

Reynolds Number:[10]

$$R_e = \frac{D_hU}{\nu}$$

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

$$Nu_{s2} = 0.077Re^{0.716}Pr^{1/3}$$

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

$$F_2 = 2.4Re^{-0.0836}(1 + C/H)^{-0.805}(S_y/D)^{-0.0814}$$

C. *Enhancement Efficiency:*

The effectiveness of the heat transfer for a constant pumping power, it is useful to determine enhancement of a heat transfer. The enhancement efficiency is the ratio of heat transfer coefficient with Fins to without Fins. [4][1] [2]

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

Where h_a= convective heat transfer coefficient with Fins and h_s= convective heat transfer coefficient without fins.

VIII. Conclusion

In this Experiment, we shall have been studied that the square Shape of Fin on bottom side shown in figure no. 1. The bottom temperature is fast heat equipped because the base side is heater. The square area is more then of other due to that the effect of the various design parameters, overall heat transfer and friction factor on the heat transfer. The square cylindrical

Fins cover more flue gases there fore more heat transfer convectively and cylindrical square cross-sectional perforated pin fins will investigated friction factor for the heat equipped with experimentally. The geometrical factor which enhances enhancement efficiency by heat transfer rate increase and friction characteristics will determine and enhancement efficiency the correlations have been obtained.

The other designed parameter is vies versa, the circular shape is bottom side and upper side is square as shown in figure no.2. The cylindrical shape is cover more area its cover actually in elliptical like area therefore the give more effectiveness. After performing the experiment I shall be finding out Reynolds number decrease due to Enhancement efficiencies increased, the relatively lower Reynolds number to an improvement in the heat transfer performance. The inter-fin distance ratio and clearance ratio is decreases due to that friction factor increased. The projected area is help full for calculating average Nusselt number and decreasing clearance ratio and inter-fin spacing ratio projected area increased.

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