Experimental Study on Heat Sink Using Screw Thread

[1]S. Sharbuddin Ali, [2]Bharathi. D

[1.] Assistant Professor Mechanical Department, Jeppiaar SRR Engineering College
Old mamallapuramroad, I.T Highway, Padur, Chennai,TamilNadu

[2.] Final Year Student , Mechanical Department , Jeppiaar SRR Engineering College

Abstract—The fins increase the effective area of the surface thereby increase the heat transfer by convection. In this be project experimental investigation on threaded pin fin solid and hollow with and without perforated. The pin fin is made out of copper having dimension of 40 mm length, 16 mm diameter and rectangular base of required dimensions. The number of pin fin used in inline arrangement 2, 4 and 6 respectively. The heat transfer takes place through a rectangular base plate with fin held in rectangular tunnel. The Nusselts number and Reynolds numbers consider as performance parameter. By concluding all the result perforated solid thread inline pin fin have higher rate heat transfer capacity.

Keywords— Threaded Pin Fin, Perforation, Nusselts No, Reynolds Number, Heat Transfer Co Efficient.

I. INTRODUCTION

Convection heat transfer is in between of surface and fluid surrounding. The attaching thin strip to the heat surface is called fins. The small area are dissipate more heat transfer in many engineering application.fins available in different models depends upon applications. The requirement of engineering applications is high performance of heat transfer components are expected. Heat exchanging device like fins are used to increase heat transfer rate. The factor influence for increase heat transfer is depend on surface area of fins. The increase of contact surface area as well increase the heat transfer The heat conducted through solids, walls or boundaries have been continuously dissipated to the surroundings or environment to maintain the system in steady state conduction. The heat transferred through the fins provides the problem of determination of heat flow through a fin requires the knowledge of temperature distribution through it. This can be obtained by regarding the fin as a metallic plate connected at its base to a heated wall and transferring heat to a fluid by convection. The heat flow through the fin is by conduction. Thus the temperature distribution in a fin will depend upon the properties of both the fin material and the surrounding fluid. In this section, we will analyze certain basic forms of fins, with respect to heat rate, temperature distribution and effectiveness.

The experimental is conduct to investigate the effect of heat transfer characteristics and pressure drop in Pin Fin using screw thread and helical thread. A copper Pin Fin with various dimension and shapes which is 20mm diameter, 40 mm length solid, and hollow, solid with perforated, hollow with perforated, without thread. In this present work base plate and pin fin is made on copper plate. Variation of Nusselts number with Reynolds number is investigated with various parameter combinations. The experimental result gives high rate of heat transfer rate than other type of Pin Fin.

In this the heat transfer rate and efficiency for solid, hollow, perforated pin fins were analyzed for different environmental conditions.

II. LITERATURE REVIEW

T.L. Allan Harry Richard et al [1] the aim of the present study is to improve the heat transfer characteristics and to investigate the performance of fin efficiency by using fins of different materials in pin fin apparatus. Here the system follows forced convection as the mode of heat transfer and it is the principle used in it. This project, increase of heat transfer and fin efficiencies of materials is achieved. Moreover, among these materials from the analysis that copper has high thermal conductivity than brass and aluminium.

In the present study, Experimental Investigation on Tapered Cylindrical with and without Perforated Pin Fins with Inline and Staggered Fins Array using Natural and Forced Convection, for a constant heat flux of 85 Watts over all the arrangements at varying air velocity from 1m/s to 5m/s. The taper pin fin is made out of Aluminium 6061 having dimensions of base diameter 20mm, top diameter 10mm and length 80mm. The number of pin fin used in inline and staggered arrangement are 9 and 8 respectively. Constant clearance ratio (C/H) and inter fin distance ratio (Sy/D) 1.25 were used. As the Reynolds Number increases Nusselts number also increases. Varying Reynolds Number in terms of Heat Transfer Performance. The perforated taper cylindrical inline pin fin gives higher heat transfer rate. Effectiveness increased with decreasing Reynolds number. Therefore, relatively lower Reynolds number lead to an improvement in the heat transfer performance. In natural convection heat transfer will be more on perforated pin fins in inline arrangement.

Samudrala Mohan Venkatesh et al [3] Fins improve the heat transfer rate through the surface by increasing the exposed area. In this study a threaded pin fin is analyzed numerically. A cylindrical pin fin is fabricated and experiments are done under forced convection conditions. The experiment results are used for validating the numerical model. The numerical analysis for the threaded fin is done by varying pitch of thread and air flow velocity. The threaded pin fin found to enhance the heat transfer rate, when compared to an ordinary cylindrical pin fin with less material being used. Also an optimal pitch at which the minimal base temperature is obtained is also found out. The numerical model is designed and simulated using ANSYS FLUENT package. It is found that when compared to a solid pin fin of a same diameter the threaded pin fin is found to enhance the heat transfer by increasing the surface area available for convection heat transfer. It is found that for 15 mm major diameter of fin a pitch of 2 mm has the best heat transfer characteristics.

Y. Pratapa Reddy et al [4] In the present work, experiments have been conducted to find the temperature distribution within the pin fin made of composite metal and steady state heat transfer analysis has been carried using a finite element software ANSYS to test and validate results. The temperature distributions are evaluate by FEM and compared the results with experimental work. In simulation analysis, solid aluminium and copper cylindrical pin fins shows the heat transfer more at the end (tips) of the pin fin In simulation analysis the composite pin fin shows less rate of heat transfer at the end (tip) of the pin fin than solid pin fins.

Saurabh D. Bahadure [5] a comprehensive theoretical and experimental study was carried out on the thermal performance of a pin fin heat sink. Several different type of experimental test was run out with corresponding variation including the material of pin fin and different perforation on pin fin. Perforation with circular cross section is along the height of pin fin and there number varies from 1 to 3. The result indicates that the material having higher thermal conductivity with higher number of perforation on heat transfer was investigated. The experimental study of free convection heat transfer with perforated fins was made. Average heat transfer coefficient for three perforations is higher than solid, one perforation and two perforations respectively. Increasing with increasing perforation number obtain more heat transfer.

III. EXPERIMENTAL SETUP

Fig 1 Experimental Setup For Pin Fin Apparatus

A rectangular duct is made up on mild steel. Dimension of duct is length 800 mm,150 mm breath and 100 mm height. The test rig consists of thermocouple, digital voltmeter, ammeter, manometer and blower. The blower used in this setup is maximum air pressure of 400 mm of WC; air volume of 2.3 m3 .blower has a power of 330 W, 230 V, 13000 RPM, 0.3 HP. Ceramic band heater are used, heater capacity of 250 W, 35 mm diameter. It place in base of duct. J type thermocouple are used 8 channel used to determine temperature

A. Material of fin

The fin and base plate made up of copper. It has good thermal properties and mechanical properties

Properties	Values
Thermal conductivity	386 W/mk
Density	8954
Young's modulus	1.230*10^5 N/mm^2
Modulus of rigidity	0.390* 10^5 N/mm^2
Melting point	1083^o C
Tensile stress	220 Mpa
Yield stress	70 Mpa
Thermal diffusivity	112.34*10^-6
Specific heat	383 J/Kg k

Table 1

B. Design and Fabrication of Pin Fin

Selection of material based on thermal and mechanical properties. After design and fabrication process done. The thread is made on Thread Rolling Machine to a dimension of 1.25 mm pitch, diameter of 14 mm, 16 mm diameter and 40mm length. Hollow are produced in Traup machine for 10 mm internal diameter for 40 mm length. Perforated hole is created in using of vertical milling machine. After machining completed the arrangement of fins are 2 specimens, 4 specimens, 6 specimens are inline position.

C. Design Parameter

Copper are choose for analysis. Because it is higher Thermal conductivity(386 w/mk). For experimental
2 specimens
4 specimens
6 specimens are used.
Fin dimension

Height	40 mm
Diameter	14 mm, 16mm
Pitch	1.25 mm
Diameter of perforation	5 mm
No of perforation holes	5
Base plate 1	25*40 mm^2
Base plate 2	50*40 mm^2
Base plate 3	70*40 mm^2

Table 2

D. Threaded Solid

Fig 2 for 2 Specimen Setup

Fig 3 for 4 Specimen Setup

Fig 4 For 6 Specimen Setup

E. Threaded Hollow

Fig 5 For 2 Specimen Setup

Fig 6 For 4 Specimen Setup

Fig 7 For 6 Specimen Setup

F. Threaded Solid With Perforation

Fig 8 For 2 Specimen Setup

Fig 9 For 4 Specimen Setup

Fig 10 For 6-Specimen Setup

G. Threaded Hollow With Perforation

Fig 11 For 2 Specimen Setup

Fig 12 For 4 Specimen Setup

Fig 13 For 6 Specimen Setup

H. Mathematical Relationship

The convective heat transfer rate Q convection correlation calculated by using [1] [6]

$$Q_c=(h_{bp}\ A_{bp}+h_f A_f\ \eta_f)\ \ (T_{bp}-T_a)\ \ldots\ldots\ldots\ldots\ (1)$$

h_{bp}- convective heat transfer coefficient of base plate (W/m^2K)

A_{bp}-Area of base plate (m^2)

h_f - convective heat transfer coefficient of fin (W/m^2K)

A_f-Surface area of fin (m^2)

T_{bp}-Temperature of base plate (K)

T_a –Temperature of air (K)

Introducing overall fin effeciencies, η_o into the above equation and considering that $h_{bp}=h_f=h$

$$Q_c=h\ A_t\ \eta_f\ (T_{bp}-T_a)\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

h- average heat transfer coefficient (W/m^2K)

A_t-total surface area

η_o-overall efficiency

$$\eta_f=\frac{\tan h\ (ML)}{(ML)}\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

$$A_t= A_{bp}+A_f\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (4)$$

$$A_{bp}=WL- A_{fp}\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (5)$$

A_{fp}-projected area of pin fin

$A_{fp}=N_f\frac{\pi}{4}(D-0.938194P)^2$

where

D- Diameter of pin fin (m)

P- Pitch of the thread (m)

Surface area calculations

Threaded solid

$A_f=N_f\ \pi(D-0.938194P)L_f$

Threaded hollow

$A_f=N_f\ \pi\{(D-0.938194P)-(ID)\}L_f$

Threaded perforation

$A_f=N_f[\frac{\pi}{4}(D-0.938194P)^2+(\pi(D-0.938194)L_f - n\frac{\pi}{4}d_p^2) + n\pi d_{p*}(D-0.938194P)]$

Threaded hollow

$A_f=N_f[\frac{\pi}{4}\{(D-0.938194P)^2-(ID)^2\}+(\pi(D-0.938194)-(ID)\}L_f - n\frac{\pi}{4}d_p^2)+n\pi d_{p*}(D-0.938194P)]$

Where

L_f – length of the pin fin

d_p – diameter of perforation

n – Number of perforation

N_f – total number of pin fin

The heat transfer co efficient for pin fin is derived from abov equations

$Q_f=\eta_f\ h\ A_f(T_{bp}-T_a)$

IV. RESULT AND DISCUSSION

A. Threaded Solid

In this model setup as per the result the four specimen pin fin give high heat transfer coefficient compare other two specimen setup the increase of heat transfer coefficient and heat transfer is 18.32% and 35.19% compare six specimen setup. Because the six specimen setup have less velocity for various velocity comparisons and two specimen setup low heat transfer coefficient.

In this setup 4 specimen set up give high heat transfer.

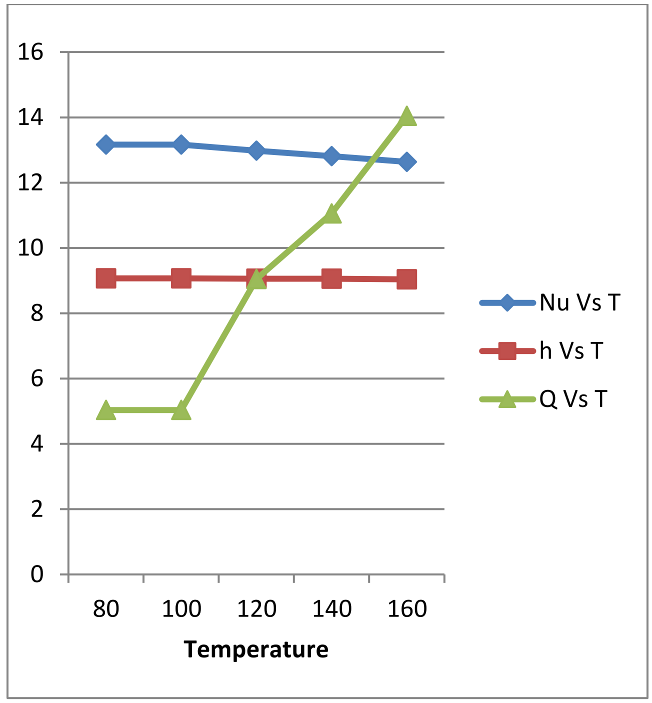

Chart 1 For Six-Specimen Setup Threaded Solid

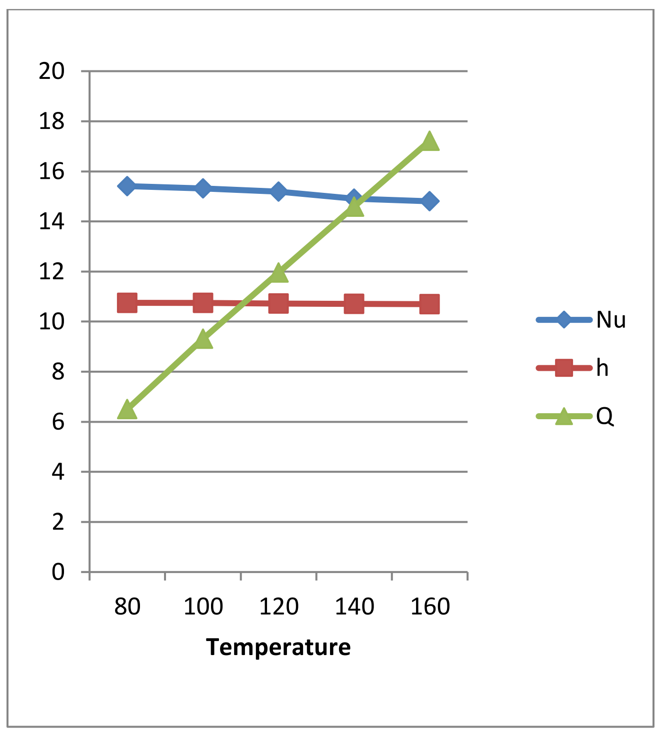

Chart 2 For Threaded Solid 4 Specimen

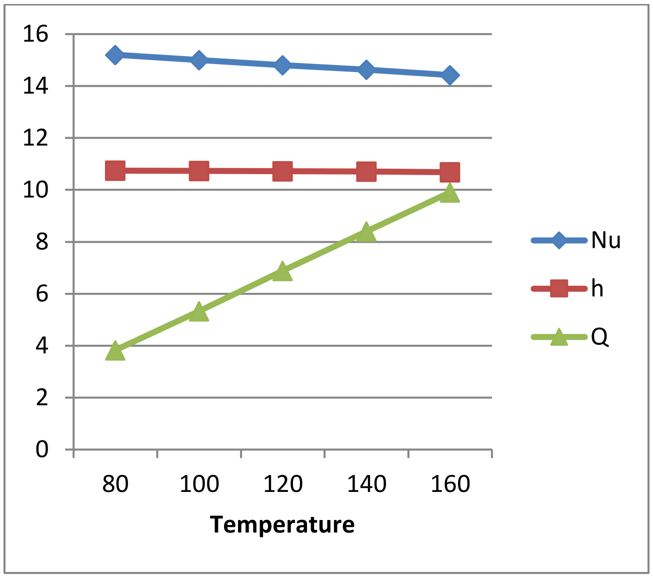

Chart 3 For Threaded Solid 2 Specimens

B. Threaded Hollow

In this model setup as per the result the heat transfer coefficient is high in four specimen setup compare other two setup and the heat transfer is high in six specimen setup. The increasing percentage of heat transfer coefficient is 11.01% and 2.379% six and two specimen setup respectively. The heat transfer increased in six-specimen setup is 22.43% and 92.08% compare four and two specimen setup.

In this setup 4 specimen, have high heat transfer coefficient and 6 specimen have high heat transfer.

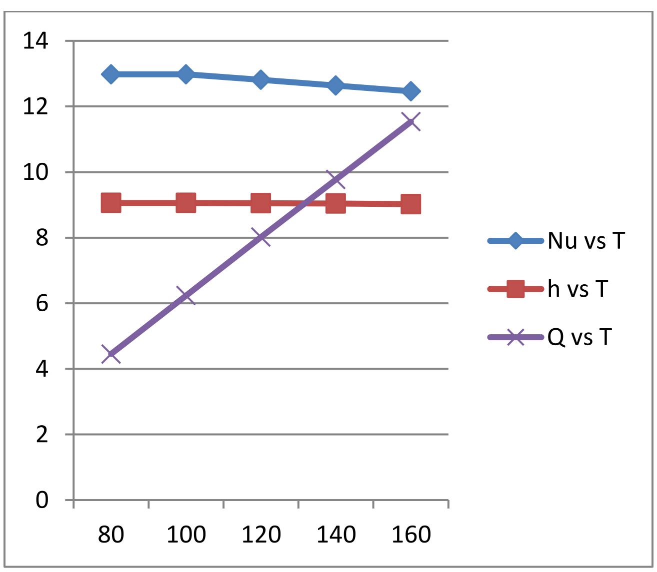

Chart 4 For Threaded Hollow 6 Specimen Setup

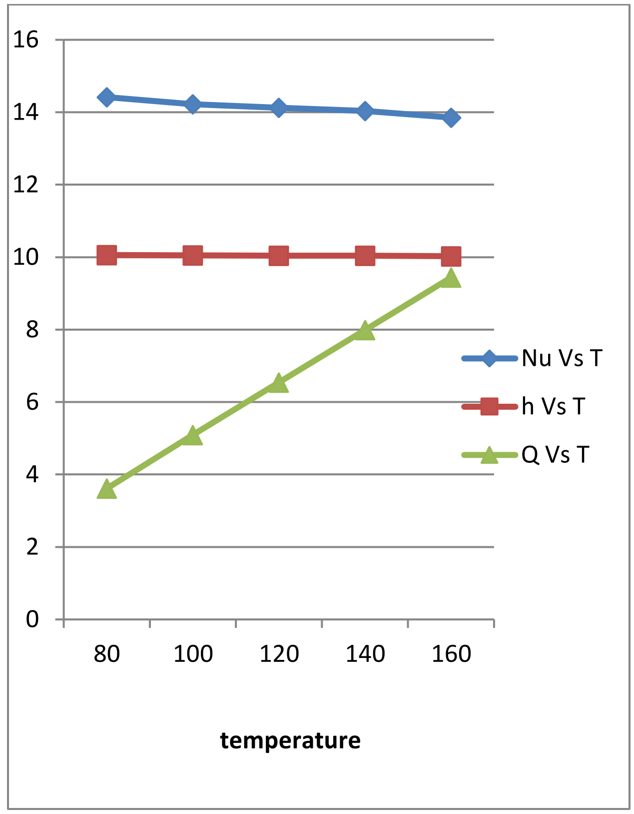

Chart 5 For Threaded Hollow For 4 Specimen Setup

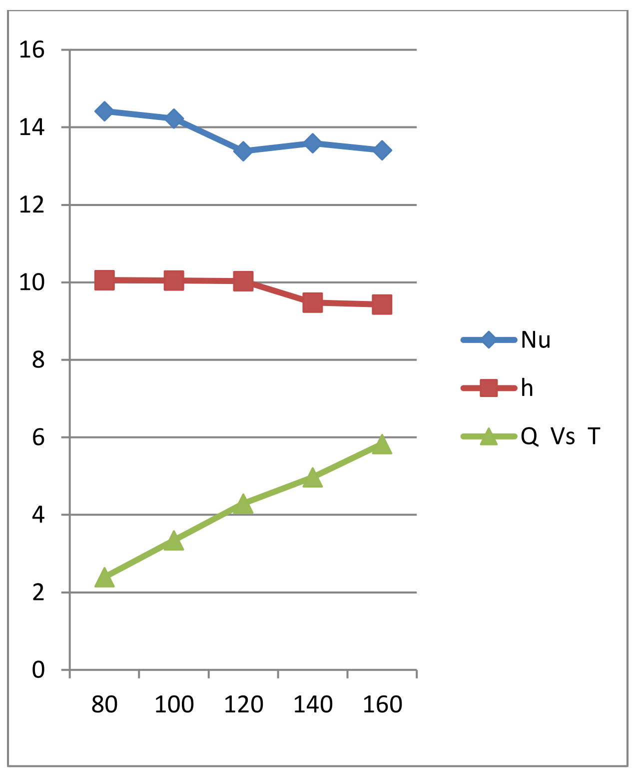

Chart 6 For Threaded Hollow For 2 Specimen

C. Threaded Solid With Perforation

In this setup the heat transfer and heat transfer coefficient is high for four specimens setup compare other two setup. The increasing percentage of heat transfer coefficient 18.59% and heat transfer is 12.836% is increased compare other setups.

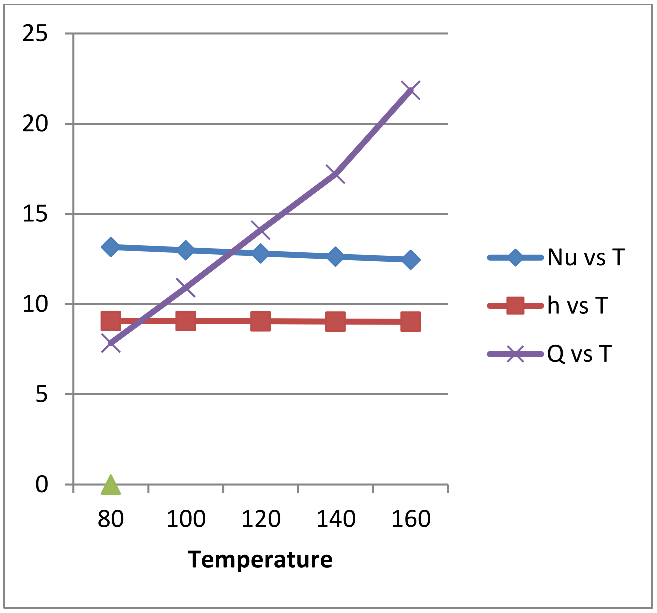

Chart 7 Threaded Solid With Perforation 6 Specimen Setup

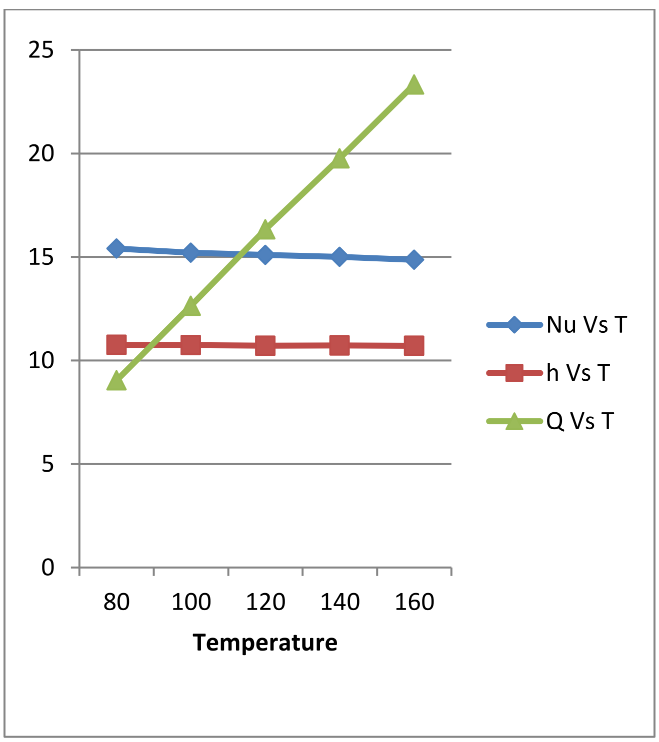

Chart 8 threaded solid with perforation for 4 specimen setup

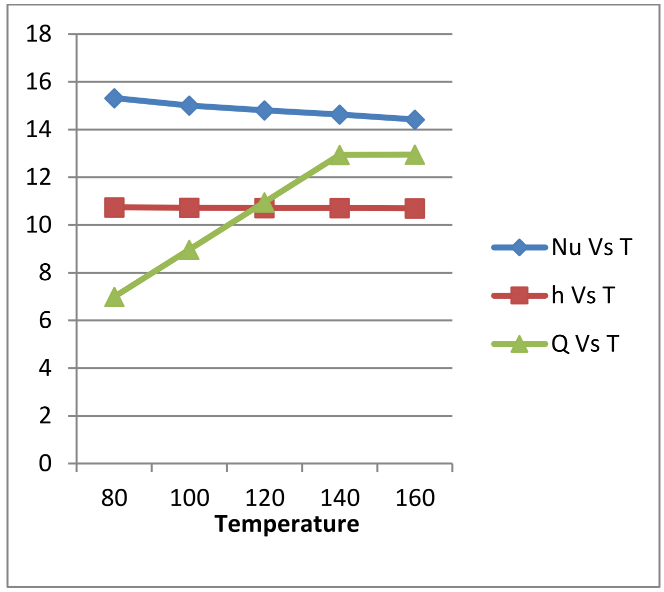

Chart 9 Threaded Solid With Perforation For 2 Specimen

D. Threaded Hollow With Perforation

In this setup four specimen setup have high heat transfer coefficient and six specimen setup have high heat transfer. The increasing percentage of heat transfer coefficient is 4.48% and 0.104% of six specimen setup and two specimen setup. The heat transfer increased for 26.7158% and 152.56% of six specimen setup compare to four specimen and two specimen setup.

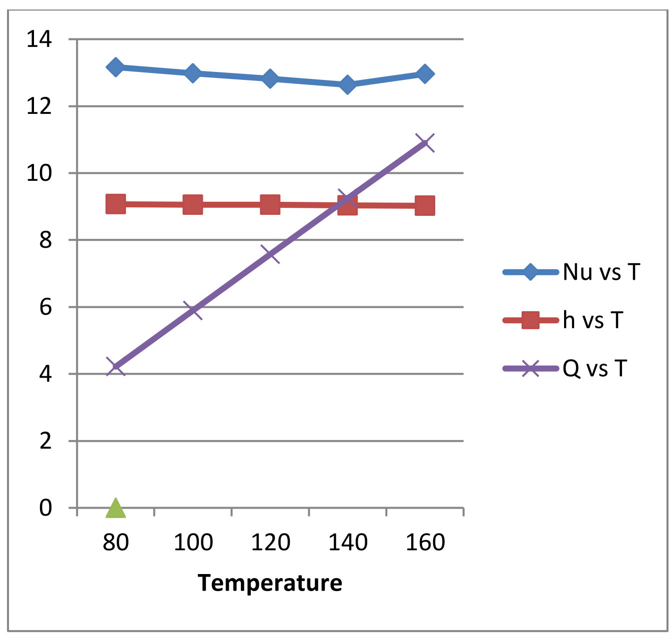

Chart 10 Threaded Hollow With Perforation For 6 Specimen Setup

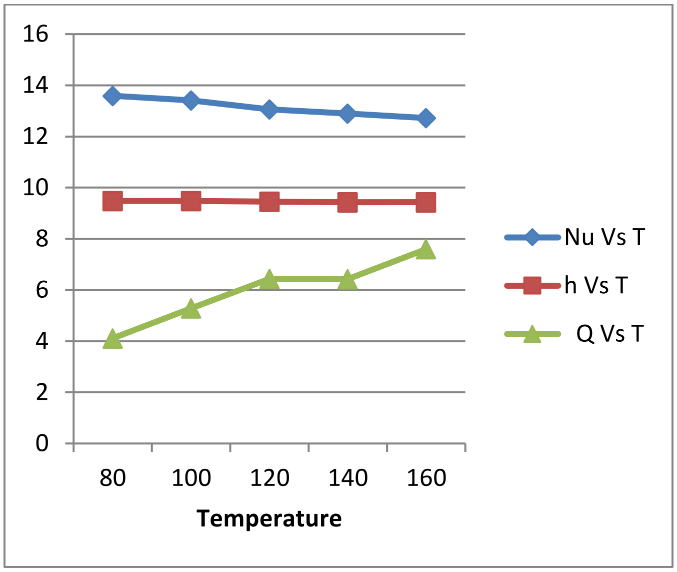

Chart 11 Threaded Hollow With Perforation For 4 Specimen Setup

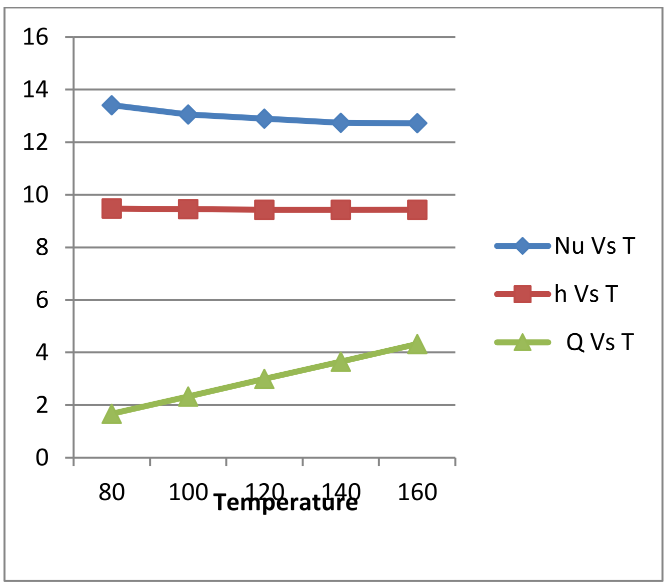

Chart 12 Threaded Hollow With Perforation For 2 Specimen Setup

V. CONCLUSION

In this experimental analysis both solid and hollow with and without perforation threaded pin fin with inline arrangement are analysed and thermo physical properties of Reynolds no, Nusselts no, heat transfer coefficient, heat transfer, efficiency of fin obtained by experimental investigation. Increasing temperature the Reynolds no is found to decrease with heat transfer coefficient also decreased. As per the analysis of various model the heat transfer coefficient is high 10.7304 W/m^2 K for four specimen setup perforation solid and the heat transfer is high. 14.3804 W for six-specimen setup perforation solid. From observed condition heat transfer will be more on perforation solid pin fin for compare other model after careful observation of velocity more than 0.4 m/s due to adverse velocity gradient along the length of duct vibration is observed. So, it is preferred to optimize the flow for six specimen setup with the velocity range of 0.4 m/s. for low velocity four specimens setup is optimized condition for setup.

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