International Journal of Scientific Engineering and Technology
Volume No.4 Issue No.11, pp: 541-544

ISSN:2277-1581
01 Nov.2015

Experimentally Study the Effects of Fins Height and Width H\W Ratio to the Fin Thermal Performance by Natural Convections

Prof Dr.Hazim A.M. Al-Jewaree, And Eng. Osama A.M. Alhamil
Deptt. of M.E.E., Academy of Graduate Studies School of Applied Science, Tripoli Libya
Email: drhaaljewary@yahoo.com

Abstract: ***The industry revolution in thermal engineering started with fixed the extended surface area named a fin. Therefore, a lot off research work done in this field to enhance the performance of heat transfer . All, previous work reach to that any increase of heat transfer coefficient and the fin surface area will increase the heat transfer rate by natural convection. The research work summarized in this paper presents an experimental investigation on the effect of fin heights –width (H/w) ratios on the fin performance using rectangular plate type fins. The steady-state natural convection heat transfer from vertical rectangular fins extending perpendicularly from horizontal square aluminum base was investigated experimentally at high range of temperatures from 60 to 110 ^{o}C. Four fin heights 30mm,40mm,50mm,60mm were employed under free convection heat transfer conditions. The heat transfer area was kept the same. The performance of the fin expressed in terms of fin efficiency, overall fin efficiency, fin effectiveness and thermal resistance as a function of fin height parameters has been study at fin height and width (H\w) ratios 0.2,0.35,0.55 and 0.8 respectively in this work. The dimensionless parameter Biot no. for different fin height-width (H\w) ratios to the fin heat transfer rate.Results show that's fin heat transfer performance increase with decreasing the fin heights and increasing the fin width for the range of temperatures used.***

Key Word: (Fin Height ,Fin Width, Fin H\w ratio, Rectangular Fin , Natural Convection, Heat Transfer Performance) .

I. Introduction:

The purpose of fins (extended surfaces) is to increase convective heat transfer from the hot surfaces. The primary mechanism behind the operation of fins is to increase the effective heat transfer area of a surface. They are commonly used in situations in which cooling is attained via free (or natural) convection – for which the heat transfer coefficients h are relatively small. Typically fins are much longer than they are thick. Because of this it is common, and fairly accurate, to assume that the temperature varies only in the lengthwise direction

Starner and McManus [**1**] concern they study experimentally very early in the heat transfer performance for arrays of rectangular fins by natural convection. They used four sets of fins array at different position (horizontal, 45 degree and vertical) based on the main heater. They found the heat transfer coefficient for vertical position less than others by 10 to 30%.

Leung and prober, [2] did another experimentally investigate the effect of fin height to the fin space for optimum ratio at two rectangular fins array positions (vertical and horizontal) . The results for the range used from 20 to 40 ^{o}C , shows the optimum fin spacing value were 9 to 11 mm . It was also found that not affect orientation considering to the change of fin height and base-to-ambient temperature difference.

Leung, Probert and Shilston [3] carried out experimental work for rectangular fins array at three different cases: vertical based on horizontal fins ,vertical based on vertical fins and horizontal based on vertical base . This work for a temperature range from 40 to 80 ^{o}C at three different heights, namely 32mm, 60 mm and 90 mm. There result showed no affect of fin height to the change of position, but the fin space is most effective for vertical fins based on vertical base. The effects of changing. fin length from 250 to 375 mm on the rate of heal transfer and the optimum fin spacing of vertical rectangular fins protruding from a horizontal or a vertical rectangular base have been investigated by **Leung. Probers and Shilston [4]** experimentally. Except fin length, other geometric parameters of several fin configurations were kept fixed for considered orientations. There result concerned at a constant base temperature,40°C above that of the ambient environment. The experimental measurements for vertical base showed that the increase in fin length caused reduction in the rate of heat dissipation per unit base area from the fin array. In addition, the optimal fin spacing rose from 10 ± 1mm to 11 ± 1 mm as a result of fin length increase. On the other hand, with horizontal base, large reduction in the rate of heat transfer per unit area occurred when the fin length was increased. The optimal fin. spacing of horizontally based fin array increased from 11 ± 1 mm to 1 4 ± 1 mm as the fin length was increased from 250 mm to 375 mm. All these consequences revealed that the effect of fin length on heal transfer performance of fin arrays is significant.**Walunj, Daund and Palande [5]** studies various experimental have been made to investigate effect of fin height, fin spacing, fin length and fin thickness over convective heat transfer. Effects of thermodynamic properties like heat input, base-to-ambient temperature difference are also studied by many researchers. Some investigators make known sets of correlations screening the relation between various parameters of heat sink.

II. Experimental methods:

It is decide to used a metal table rectangular dimensions (100 cm x60 cm) prove the base of the fins on the heater. So that the base of the fins has a constant area for four sets of fins and this base seek directly on the heater so that the transmitted heat conduction from the heater to the base of fins that contains a row

 ISSN:2277-1581
01 Nov.2015

of fins is working to expel heat to the surrounding environment, with an insulator between the heater and the base of the apparatus and demonstrate electrical panel containing gauges and switches in the front of the base of the apparatus as observed in figures 1 .

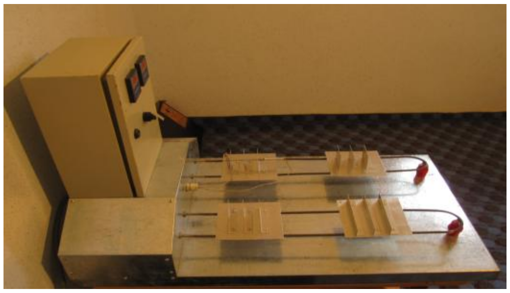


Fig. 1.The schematic diagram of the experimental setup.

The experimental data obtained from four different fin heights and width ratio,(0.2,0.35,0.55 and 0.8) with a constant fin surface area, fin number (3)as shown in figure (2), and square aluminum base (16cm length and 1mm thickness) for all types of configuration are presented in this work. These results are utilized to reveal the effects of geometric parameters, fin height, fin height-space ratio (H\w), and the effects of the fin base orientation performance of the steady-state heat transfer rates from finned surfaces. These (H/w) ratios are come from different fin heights and width as illustrated in the following table (1).

Set no.	Fin height (H),mm	Fin width(w) ,mm	Fin height-width ratio(H\w) ,cm
1	120	300	0.2
2	140	400	0.35
3	275	500	0.55
4	480	600	0.8

Table 1. Sets of fin heights and width (H/w) ratios.

To approach the real calculations of fin heat transfer performance need to estimated the heat transfer coefficient, thermal resistance, efficiency, Biot no. and effectiveness.

Figure 2. Four sets of fins height-width ratio (H\w).

The Two horizontal electrical U-heaters are placed on 60 mm above the experimental table to avoid ground effect. Electrical heating coil with 2.25 kW capacity is kept inside the tube. Thermal conductivity of aluminum is 233 W/mK

Heat transfer coefficients is important fin parameters measured from the following formula: The heat transfer coefficient (h, w\m^2 .K)) can be estimated from the following equation: [6,7]

$$h = \frac{Q_{fin}}{A_t * (T_s - T_\infty)} \quad ......(1)$$

Where: Q_{fin} is the heat transfer from the fin surface at T_s , A_t is the total fin surface area and T_∞ is the ambient temperatures.

The fin efficiency of a any fin ,η_{fin}, is defined as:

$$\eta fin = \frac{q fin}{q fin\,max} = \frac{Acual\ heat\ ftrnsfer\ rate\ from\ the\ fin}{Ideal\ heat\ transfer\ rate\ from\ the\ fin}) \quad ....(2)$$

. This relation enables us to determine the heat transfer from a fin when its efficiency is known. But the overall fins efficiency is express by the following formula:

$$\eta o = 1 - ((\frac{Afin}{At})(1 - \eta fin) \quad ....(3).$$

The performance of the fins judged on the basis of the enhancement in heat transfer relative to the no-fin case . the performance of fins expressed in term of the fin effectiveness ϵ_f is defined as :

$$\epsilon_f = \frac{q_f}{hA_{c,b}\theta_b} \quad ....(4)$$

Fin Thermal Resistance (R_{fin}) is defined as temperature rise per unit of power, analogous to electrical resistance, and is expressed in units of degrees Celsius per watt (°C/W). If the device dissipation in watts is known, and the total thermal resistance is calculated, the temperature rise of the die over ambient can be calculated as express in the following formula: [7]

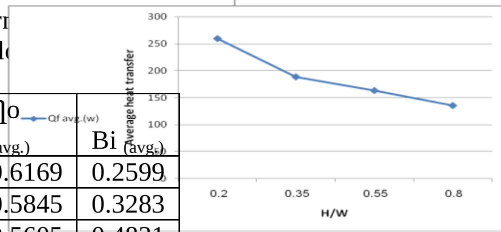
$$R_{fin} = \frac{1}{h * Af * \eta f} \quad ....(5) \quad .$$

This equation may be used to expression for the thermal resistance of a fin array. A small value of thermal resistance indicates a small temperature drop across the heat sink, and thus a high fin efficiency. R_o is an effective resistance that account of heat parallel flow paths for conduction-convection in the fins and by convection from the prime surface. The governing equation for one dimensional conduction with convection is applicable to systems in which the lateral conduction resistance is small relative to the convection resistance. Under these

International Journal of Scientific Engineering and Technolog
Volume No.4 Issue No.11, pp: 541-544

conditions the temperature profile is one dimensional. The conditions for which Eq. (6) is valid are deterr

foll



Set no.	H/w	h_f (avg.)	Losses energy%	ε_f (avg.)	η_f (avg.)	η_o (avg.)	Bi (avg.)
1	0.2	1986	88.46	16.16	0.2634	0.6169	0.2599
2	0.35	1889	90.9	16.71	0.1993	0.5845	0.3283
3	0.55	2229	92.7	15.62	0.153	0.5605	0.4831
4	0.8	2184	93.9	15.77	0.1278	0.5474	0.5672

$$Bi = \frac{R\ conduction}{R\ convection} \qquad \text{.............................(6)}$$

Where Bi is the Biot number based upon the maximum half thickness of the fin profile. The fin Biot number is simply the ratio of the lateral conduction to lateral convection resistance: [8]

III. Results and Discussions:

For approaching the real experimentally analyses of fin heat transfer performance , the averages of heat transfer coefficient(h), fin effectiveness (ε_f (avg.)), fin efficiency ($\eta_{f(avg.)}$) , overall fin efficiency ($\eta_{o\ (avg.)}$), losses energy % and Biot number for cross direction to all sets of (H/w) ratios must be measured. The results of this work is summarized in the next table..

Table 2. The average fin parameters at different fin height-width ratios (H/w) ratios to the all base temperature for cross direction.

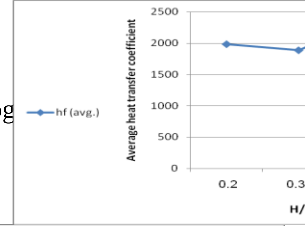


Figure 3. Average heat transfer coefficient at different (H\w) ratio at cross direction.

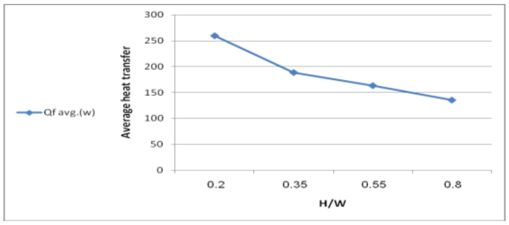


Figure 4. Average heat transfer rate at different (H\w) ratio at cross direction.

It is clear from these two figures the fin heat transfer rate depend on the fin height- width ratio (H/w) ratios and the fin heat transfer increase with increasing this ratio for all range of temperatures used.

Figure 5. Average heat transfer rate at different (H\w) ratio at cross direction.

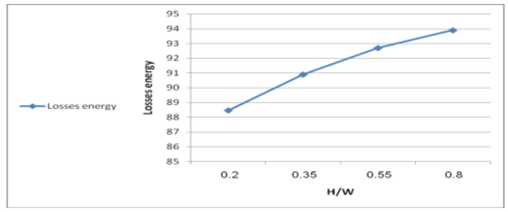


Figure 6. Percentage losses energy at different (H\w) ratio at cross direction.

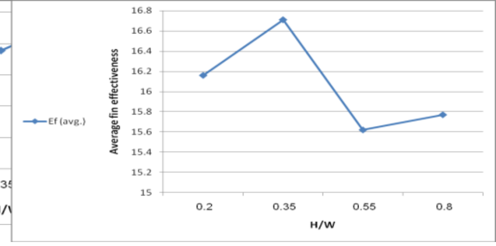


Figure 7.Fin effectiveness at different (H\w) ratio at cross direction.

It is found from the experimental result that's, the average percentage energy losses from the fins surface (E_{loss}.%) to the temperatures range from 60 to 110 ^oC is smaller in case of (H/w =0.2) has the average 88.2%, whereas in case (H/w =0.8) has a heights average about 93.6% for all fins base directions. The percentages increased of (E_{loss}.%) is 6% between the two fin height and width (H/w) ratios.

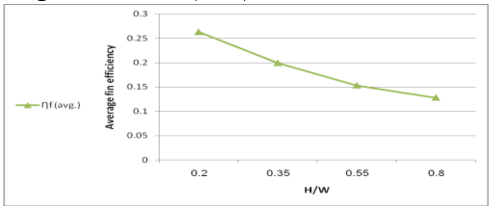


Figure 8. Average fin efficiency at different (H\w) ratio at cross direction.

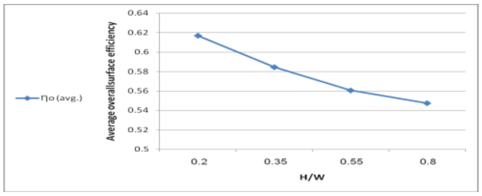


Figure 9. Over all fin efficiency at different (H\w) ratio at cross direction

It can be deduce from the above figures 7,8 and 9 the following points for cross direction:

ISSN:2277-1581
01 Nov.2015

1-There is may be an optimum point of fin effectiveness at set no.2 (H/w = 0.35).

2-The fin efficiency and overall fin efficiency decrease with increasing the different heights - width (H/w) ratios.

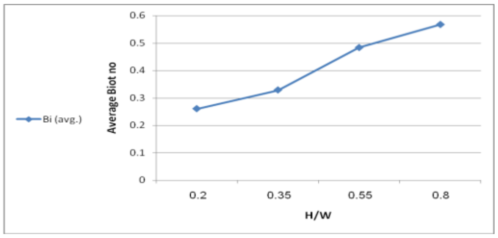


Figure 10. Biot number at different fin height-width (H\w) ratios at cross direction.

This above figure give an excellent first attempt to illustrate the relation of the conduction and convection thermal resistance change with fins height-width ratio at cross direction for temperatures used.

IV. Conclusion:

The experiments were performed for four sets of (H\w) height-width fins ratio (0.2, 0.35, 0.55 and 0.8) conditions at cross fins direct to the supplies heater and the following conclusion can deduced from the present work:-

1) In free convection heat transfer condition, the effect of change in fin height and width on fin performance is more significant. There was noticeable change in the fin base temperature ,fin efficiency , Biot no. and convection heat transfer coefficient with the change in fins height-width (H\w) ratio..

2) The percentage of energy losses is increase with increasing the fin height and width (H/w) ratios for all fins base direction used in the present work.

3-Losses energy during heat transfer has a huge application in the all research center in the world. So in the our present work concern to estimate the percentage of losses energy from the fin surface for all heights-width (H/w) ratios . The result observed very important aspect, this percentage increase with increasing the heights-width (H/w) ratios as shown in figure (8) at cross direction of fins base to the power supply

4) The range of average fin effectiveness for the range of temperatures from 60 to 110 ^{o}C at different fin (H\w) height-width ratio (0.2, 0.35, 0.55 and 0.8) is from 14.96 to 16.71 more than one.

5) It is found the average Biot no. increase with increasing the different fin heights - width (H/w) ratios ,that's mean Biot no. depend on the fin width rather than fin height . Also, the thermal resistance increase with increasing this (H/w) fin ratios at cross direction of the fins base.

6) Overall fin efficiency have range from 0.52 to 0.65 to the all fin height-width ratios at cross direction.

7) The fin heat transfer performance for the temperature used decrease with increasing the fin height-width (H\w) ratio

References:

i. *Starner K.E. and McManus H.N., "An Experimental Investigation of Free Convection Heat Transfer from Rectangular Fin Arrays", Journal of Heat Transfer, 273-278, (1963) .*

ii. *Leung C.W. and Probert S.D., "Thermal Effectiveness of Short-Protrusion Rectangular, Heat-Exchanger Fins", Applied Energy, 1-8, (1989) .*

iii. *Leung C.W., Probert S.D. and Shilston H.A., "Heat Exchanger Design: Thermal Performances of Rectangular Fins Protruding from Vertical or Horizontal Rectangular Bases", Applied Energy, 123-140, (1985).*

iv. *Leung C.W., Probert S.D. and Shilston H.A., "Heat Transfer Performances of Vertical Rectangular Fins Protruding from Rectangular Bases: Effect of Fin Length", Applied Energy, 313-318, (1986).*

v. *Walunj,A.A., Dound V.S. and Poland, D.D. , International Journal of Innovation and Applied Studies ISSN 2028-9324 Vol.6No.2June2014, pp.232-238.*

vi. *Incropera f.P., De witt D.P.(1996). fundamentals of heat and mass transfer. 4th Edition. john Wiley & Sons, No 147- 172.*

vii. *Cengel Yunus A.(2003).Heat transfer: A Practical Approach,2nd edition SI McGraw Hill Higher Education-ISBN 0-07-245893-3.*

viii. *Cengel Yunus A.and Boles Michael , (2007). Thermodynamics, An Engineering Approach.SI :McGraw HiLL International student edition-ISBN-13:978-007157718.*