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Heat Transfer Rate Enhancement by Using Perforated Fins

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Abstract: Heat dissipation is one of the main problems which we come across while dealing with engineering systems which operates at higher temperature. The heat which exists inside the system heat has to be transferred outside the system to obtained efficient output. If it is not done, then this heat may cause damage to machine parts. To do this, fins are used. Main purpose of fins is to increase surface area of heat transfer. In current work heat transfer rate with and without perforations is calculated. Fin arrays are used. Perforations are of Circular, triangular, rectangular and square shapes are used. Also temperature at various points along the length of fin temperature is recorded. It is found that heat transfer rate with perforations is greater as compared to heat transfer rate without perforations. Also heat transfer rate is different for different types of perforations.

Keywords — Natural convection, fins, fin arrays, Heat Transfer rate, perforations, solid fin.

I. INTRODUCTION

Fins, commonly termed as extended surfaces are used to increased rate of heat transfer from the surface of any engineering systems [1,2,4]. Cooling of a electronic component is very important to avoid overheating [3,5,6]. It has been stated that rate of heat transfer can be improved by performing perforations [5]. The convective heat transfer coefficient again depends on many factors like nature of the surface, fluid properties, temperature of a system, fluid velocity etc. Rate of heat transfer can be increased by increasing surface area of heat transfer [1, 2], by using fins of higher thermal conductivity material [1,2], increasing heat transfer coefficient between fins and surrounding fluid [1, 2]. From experimental studies it is found that rate of heat transfer can be improved by using perforated fins with increased in thermal efficiency in the range of 1 to 4% as compared to solid fins [3]. In current paper attempt is made to increased rate of heat transfer by proving fins with and without perforations in natural convection mode. Heat transfer rate with fins is compared with heat transfer rate without fins. And it is concluded that there is improvement in the rate of heat transfer because of perforations as compared to solid fins.

II. LITERATURE REVIEW

Alhassan Salami Tijanni et.al [3], investigated the effect of effect of perforations on the thermal performance of heat sink under forced convection and concluded that there is improvement in the fin efficiency with perforations as compared to solid fins. Shitole Pankaj et.al. [4] has studied the heat transfer in natural convection mode with perforated fins and investigated the effects of fin spacing, perforation angle, perforation diameter etc and found out the optimum fin array. Md. Farhad Ismail et.al. have investigated numerically heat transfer from an array of solid fins and fins with perforations and concluded that fins with circular perforations have remarkable increases in heat transfer rate as compared to soild fins [5]. Mehedi Eteshum et.al have investigated the thermal performance of rectangular fin arrays with solid fins and circular fins. Their investigation shows that there is remarkable improvement in heat transfer rate with perforations as in comparison with solid fins along with reduction in the weight of fins [6]. Assel Sakanova investigated the performance of perforated pin heat sink and concluded that heat transfer rate with perforations is good as compared to solid fins [7]. Mohammad Reza Shaeri et.al. Concluded that perforated fins plays important role in applications where weight is important parameter [8]. Zan WU et. al. staggered pattern perforations on natural convection heat transfer and found that staggered pattern perforations increases the heat transfer rate [9]. Ambarish Maji et.al. Studied numerically the effect of perforations with linear and staggered arrangement. It is found that effect of perforations is to increased rate of heat transfer up to certain number of perforations and size and better than solid fins [10]. Amir Abbas Rezaei et.al. investigated the effect of perforations on natural convection heat transfer and found that rate of heat transfer improves significantly by using fins [11].

III. EXPERIMENTAL SET-UP

The setup consist of wooden box in which glass wool is fitted. This is for precaution because asbestos and glass wool are heat resistance substance due to this it cannot transfer heat of heating coil. Heater coil is mounted on asbestos sheet. Heat input to the heater is measured by ammeter and voltmeter. Heat input can be varied by dimmerstat. Heat input to base plate is given with the help of dimmerstat.

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Figure: Experimental Set-up

IV. FIN ARRAYS AND FIN PERFORATIONS

Heat transfer rate can be increased with increased in surface area. Hence perforations are provided on fins to increase the surface area, to increase the rate of heat transfer.

Solid fins dimensions are

- Dimensions of fin =100x50x6mm
- No of fins = 5
- Dimensions of base plate = 110x100x5mm
- Materials = copper and cast iron
- Surface area of fins = 11200mm^2

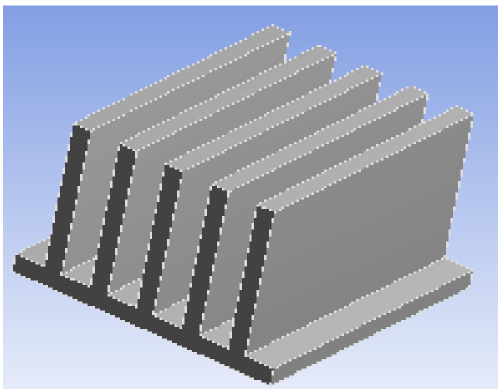

Fig: Solid fins

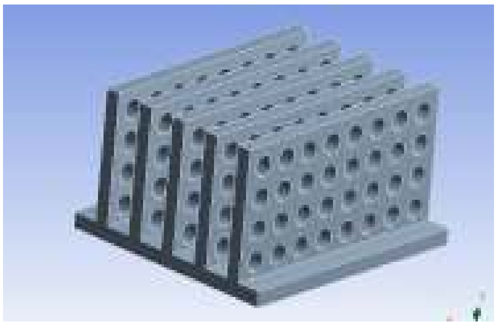

Fig: Cicular Fins

- Radius of perforation= 4 mm
- No. of perforations = 32
- Surface area= 47952.21316mm^2

V. INSTRUMENT SPECIFICATIONS

a. Dimmerstat

Make	Automatic Electric Ltd
Range	0-230 V
Accuracy	$\pm$ 2 V

b. Ammeter

Make	Automatic Electric Ltd
Range	0-2 A
Accuracy	$\pm$ 0.1 A

c. Multimeter

Make	RISHAB
Range	0-300 V

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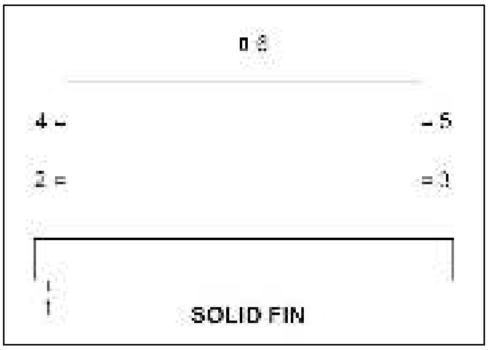
Accuracy	$\pm$ 0.1 V

d. Temperature Indicator

Make	Alphatech
Range	-50 C to 150 C
Accuracy	$\pm$ 0.1 V

VI. EXPERIMENTATION, CALCULATIONS, AND RESULTS

Experimental set up with positions of different thermocouples are shown below.



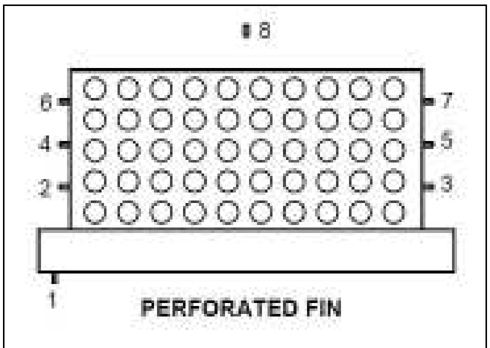


Table: Fin array data for circular fins

Particulars	Solid fin	Fins (32 circular perforations)	Fins (36 circular perforations)
No. of fin (n)	5	5	5
No. of perforations (N)	0	32	36
Dia. Of perforation 'dp' (mm)	0	8mm	4mm
Length of Base Plate' l' (mm)	100mm	100mm	100mm
Width of Base Plate 'w' (mm)	90mm	90mm	90mm
Thickness of Base Plate 't' (mm)	5mm	5mm	5mm
Fin Length' L' (mm)	100mm	100mm	100mm
Fin Height 'h_f' (mm)	50mm	50mm	50mm
Fin thickness 't_f' (mm)	6mm	6mm	6mm
Fin Spacing 's' (mm)	5mm	5mm	5mm
Heater Input' W'	97.5	97.5	97.5

Table: Experimental data for solid fins

Ambient Temperature = 21 °c

Thermo -couples	T_1	T_2	T_3	T_4	T_5
1. Voltage: 50V, Current 0.75 A					
Temp.	29.5	27.4	26.8	24	24.3
	32	29.3	29.8	26.6	27.8
	34.5	30.6	30.1	28.5	29.4
	36.6	33.2	33.9	31.3	31.2
	40.7	35.1	34.5	32.1	33.3
	43.6	38.5	39.2	34.2	34
	45.1	41	42.3	35	35.3
Thermo couples	**T_1**	**T_2**	**T_3**	**T_4**	**T_5**
2. Voltage: 75 V, Current 1.3 A					
Temp.	46.3	42.1	42.8	37.3	36
	48.8	43.1	43	39.8	39.2
	52.8	46.5	46.2	41	41.3
	54.5	47.3	48.5	43.3	44
	56.4	50.6	50.4	45.8	46.2
	59.7	53.7	52.8	48.9	48.3
	63.2	57.3	57.8	52	51.4
	64	59.3	59.7	55	56.1
	64.3	59.5	60	56.2	56.8

1) V=50V, I=0.75 amp

$$T_S = \frac{T2+T3+T4+T5}{4}$$

$$T_S = \frac{41+42.3+35+35.3}{4}$$

T_S=38.4°C

T_∞=21°C

Q = V✕I

Q =50✕0.75

Q =37.5 W

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Area of solid fin= $112000 \times 5 \times 10^{-6}$ mm^2

Q= h×A× (T_S-T_∞)

$37.5 = h \times 11200 \times 5 \times 10^{-6} \times (38.4-21)$

h=38.48 W/m$^{2°}$k

2) Voltage: 75 V, Current 1.3 A

$$T_S = \frac{T2+T3+T4+T5}{4}$$

$$T_S = \frac{59.5+60+56.2+56.8}{4}$$

T_S=58.125°C

T_∞=21°C

Q = V×I

Q=75× 1.3

Q=97.5 W

Area of solid fin= $11200 \times 5 \times 10^{-6}$ m^2

Q= h×A× (T_S-T_∞)

$97.5 = h \times 11200 \times 5 \times 10^{-6} \times (58.125-21)$

h=46.89 W/m$^{2°}$C

Table: Experimental data for fins with circular perforations (Radius of perforation=4 mm)

Thermo-couples	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8
1. Voltage: 50V, Current 0.75 A								
Temp.	28.6	26.7	25.9	24	23.5	23.5	23.8	18.2
	33	30.5	29	28.1	28.5	27.5	27.2	18
	35	33.5	32	30.8	30	29.5	29.6	18
	42.5	35.1	34.8	32	31.8	30	30	18.9
	43.5	36.5	35.9	33.5	32.8	31.5	31.3	18.6
	45.6	37.2	36.1	35	34.2	32.4	32.8	18.5
	45.2	36.9	36.2	33.1	34.5	33.5	34.4	18.3
Thermocouples	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8
2. Voltage: 75 V, Current 1.3 A								
Temp.	52	39.2	38.7	36.1	35.4	34.8	34.8	18
	63	45.3	44.7	40	41.3	36.6	38.6	18
	65.3	47.2	46.8	44.2	43.8	42	43.2	19.5
	72.2	54.5	53.5	45	44.5	45.3	46.3	18.1
	73.6	56.2	55	46.2	47.1	47	48.2	18.4
	74.2	59.5	60	48	49.3	48	48.3	18.6
	73	58.2	59.6	50.5	49	51.3	49.2	18.8

1) V=50V, I=0.75 amp

$$T_S = \frac{T2+T3+T4+T5+T6+T7}{6}$$

$$T_S = \frac{36.9+36.2+33.1+34.5+33.5+34.4}{6}$$

T_S=34.76°C

T_∞=21°C

Q = V×I

Q =50×0.75

Q =37.5 W

Area of solid fin= 47952.21×10^{-6} m^2

Q= h×A× (T_S-T_∞)

$37.5 = h \times 47952.21 \times 10^{-6} \times (34.76-21)$

h=56.83 W/m$^{2°}$C

2) Voltage: 75 V, Current 1.3 A

$$T_S = \frac{T2+T3+T4+T5+T6+T7}{6}$$

$$T_S = \frac{58.2+59.6+50.5+49+51.3+49.2}{6}$$

T_S=52.96°C

T_∞=21.3°C

Q = V×I

Q =75×1.3

Q =97.5 W

Area of solid fin= 47952.21×10^{-6} m^2

Q= h×A× (T_S-T_∞)

$97.5 = h \times 47952.21 \times 10^{-6} \times (52.96-21.3)$

h=64.22 W/m$^{2°}$C

VII. CONCLUSION

From experimental calculations it is found that convection heat transfer coefficient is more in a situation with perforations as compared to solid fins. Hence heat transfer rate increases with perforations.

Solid fins

Voltage (V)	50	75
Convective heat transfer coefficient (W/m^{2}k)	**38.48**	**46.89**

Perforated fins

Voltage (V)	50	75

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Convective heat transfer coefficient (W/m^2k)	**56.83**	**64.22**

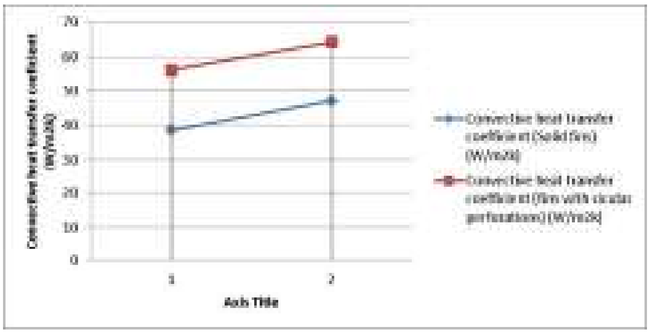
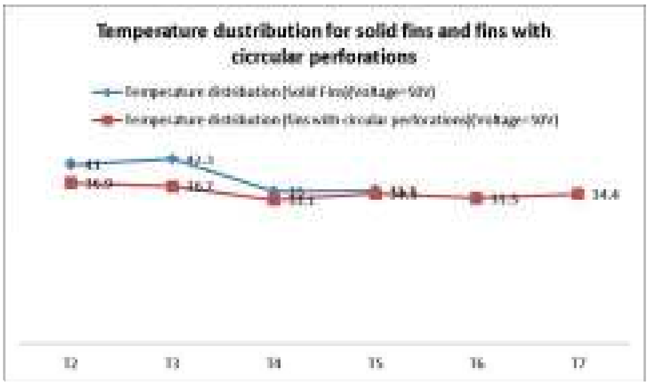
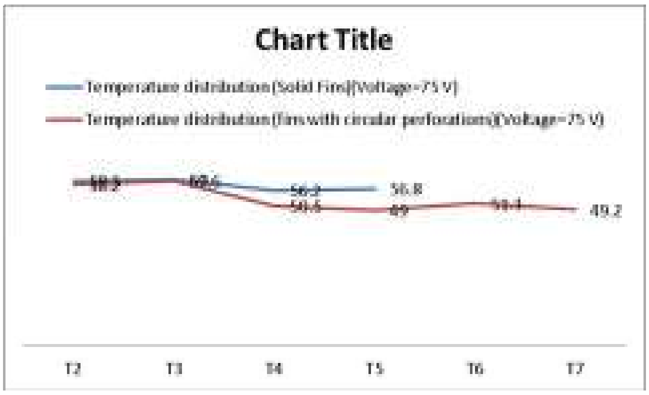


Fig: Heat transfer coefficient for solid fins and fins with circular perforations.

Temperature distribution is shown below for solid fins and fins with circular perforations, for 50 Volt and 75 Volt. It is found that for a given heat input to fin, surface temperature of fin is lower in case of perorated fins as compared to sold fin, which gives better heat transfer rate from fin surface as compared to solid fin.





REFERENCES

[1] Heat and mass transfer, fundamentals and applications, Ynunus A. Cengel, Afshin J. Ghajar, fifth Edition

[2] Fundamentals of heat and mass transfer, Theodore L. Bergman, Addrine S. Lavinne, Frank P. Incopera, Devid P. Dewitt, seventh Edition.

[3] ALHASSAM SALAMI TIJANI, NURSYAMEERA BINTI JAFREE, "THERMAL ANALYSIS OF PERFORATED PIN-FIN HEAT SINK" UNDER FORCED CONVECTION CONDITION, AVAILABLE ONLINE AT WWW.SCIENCEDIRECT.COM.

[4] SHITOLE PANKAJ, BHOSLE SANTOSH, KULKARNI KISHOR, JOSHI SARANG, "EXPERIMENTAL INVESTIGATION OF HEAT TRANSFER BY NATURAL CONVECTION WITH PERFORATED PIN FIN ARRAY", AVAILABLE ONLINE AT WWW.SCIENCEDIRECT.COM.

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[5] Md. Farhad Ismail, M.O. Reza, M.A. Zobaer, Mohammad Ali "Numerical investigation of turbulent heat convection from solid and longitudinally perforated rectangular fins and longitudinally perforated rectangular fins", available online at www.sciencedirect.com.

[6] Mehedi eheteshum, Md. Ali, Md. Quamrul Islam, Muhsia Tabassum, "Thermal and hydraulic performance analysis of rectangular fin arrays with perforation size and number", available online at www.sciencedirect.com.

[7] ASSEL SAKANOVA, *HEAT TRANSFER ENHANCEMENT OF PERFORATED PIN HEAT SINK IN FUTURE AIRCRAFT APPLICATIONS, APPLIED THERMAL ENGINEERING* (2017), DOI: HTTP://DX.DOI.ORG/10.1016/J.APPLTHERMALENG.2017.06.031.

[8] **M.R. Shaeri, R. Bonner,** *Laminar Forced Convection Heat Transfer from Laterally Perforated-Finned Heat Sinks*, Applied Thermal Engineering (2016), doi: http://dx.doi.org/10.1016/j.applthermaleng.2016.12.103.

[3] **Zan WU, Wei LI, Zhi-jian SUN**, *Rong-hua HONG, Modeling natural convection heat transfer from perforated plates*, Journal of Zhejiang University-SCIENCE A (Applied Physics & Engineering) ISSN 1673-565X (Print); ISSN 1862-1775 (Online).

[4] **A. Maji, D. Bhanja, P.K. Patowari**, *Numerical investigation on heat transfer enhancement of heat sink using perforated pin fins with inline and staggered arrangement,* Applied Thermal Engineering (2017), doi: http://dx.doi.org/10.1016/j.applthermaleng.2017.07.053.

[5] **Amir Abbas Rezaei and Masoud Ziabasharhagh**, *An Experimental Investigation on the Effect of a Perforated Fin on Free Convection Heat Transfer from a Confined Horizontal Cylinder*, Heat Transfer—Asian Research, 42 (3), 2013.