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Review Article

Study on Thermal Performance of Micro Fin Heat Sink under Natural Convection–A Review

Shashikant.V. Raut* **and Basavraj.S.Kothavale**

Mechanical Department, MIT Collage of Engg, SSPU Pune, India

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Abstract

The present study of heat transfer micro fin under natural convection. The heat transfer of fin array is depends on various parameter of fin or fin array like fin thickness, fin spacing and fin height. By varying this parameters what is the effect on heat transfer studied. In that the micro fin array are micro scale dimension are 5× 5 cm. this is the very small fin array use in electronic cooling applications where no space for the fan or blower. The fin parameter varies in also micro scale fin thickness varies between 0.2-0.8 mm, fin spacing 0.2-0.8 mm, and fin height 0.6-0.8 mm. by using this parameter variation develop the 10 no of geometry and checking the mass specific heat transfer coefficient for each geometry. During this heat input also varies i.e. Also check the performance for various electrical loads. It is found that the specific mass heat transfer increases when increasing the spacing of the fins.The performance of micro fin array maximum at maximum spacing and minimum thickness of fin like 0.8mm spacing and 0.2mm fin thickness.

Keywords: *Micro fin, Natural Convection, Plate fin.*

1. Introduction

Extended surface or fins are commonly used to enhancement of heat transfer from a system to surrounding any fluid. The fins are improving the heat transfer from system to surrounding fluid. The application of fins has been investigated for different purpose such as electronics cooling, industrial process and energy generation process. In a convective heat transfer there are two ways such as increasing area or increase the heat transfer coefficient. For increase heat transfer coefficient there is need of fan or blower.

It is more cost than natural convection. Natural convection is done by using the increase the surface area and also the there is no space for the fan or blower. The micro fins are having with micro scale with very small dimension. Also the fin having various types like straight fin of uniform cross section, straight fin of non-uniform cross section, annular fin and pin fin. There are used by depending on application or special purpose.

The material selection for fin is very important depending on the application and also depends on material properties. Fin material having with the high thermal conductivity and also other thermal properties. According to high thermal conductivity Diamond having very high thermal conductivity due to lattice vibration but it is lot expensive than the other material. Also the copper having with high thermal conductivity (420 W/mK) is best but copper is expensive. It is used for special purpose application. The aluminum and its alloy is the best material for the fin with having high thermal conductivity (219 W/mK). It is most commonly used for fin material.

The experimental comparison of micro scaled plate fin and pin fins under the natural convection. In that case they comprised thermal performance of plate fins to the pin fins. The geometry of plate fins and pin fin are having various electrical load with investigating the thermal performance or parameters under the natural convection. In that investigating the thermal performance of micro pin fin improve the thermal performance than the plate micro fins. (Leonardo Micheli *et al*. 2016)

Thermal effectiveness and mass usage of horizontal micro fins under natural convection investigation gives an overview or thermal performance of micro find behavior taking into account. There are the different sink matrix are used and the fin effectiveness and mass specific heat transfer coefficient taking into in account. The micro fins are able to achieve higher heat transfer coefficient. The micro always used at the considered at advantageous in those applications that required the minimized weight of the heat sink. (K.S. Reddy *et al*. 2016).

Study on General correlation among geometry, orientations and thermal performance of natural convection micro fin heat sink. In this case the micro fins heat sink having with small dimension also in that case varying the various fin parameter like fin spacing, fin height and fin thickness. All the parameter study on

*Corresponding author: **Shashikant.V. Raut**

the various load and find which combination is optimization for the applications. In that the parameter varying parameter three times and formation of various geometry and find which geometry is optimum for given applications. Also the plate micro fin in natural convection is an opportunity for the passive concentrating photoelectric cooling also applicable for CPV applications.(Junye Hua *et al*.2016)

2. Application

Fins are most commonly used in heat exchanging devices also in electronic equipments and in cars cooling system, in computer heat sinks, and heat exchangers in power plants. They are also used in newer technology such fuel cells. Nature has also taken advantage of the phenomena of fins. The ears of jackrabbits and fennec foxes act as fins to release heat from the blood that flows through them. The applications of micro fin in electronic equipment areRadiators (Cars), Heat Sink (CPU), Heat Exchangers (Power plant), Electronic Equipment.

3. Experimental setup

In this study, two rectangular plate-fins geometries have been studied. Square, 5 cm × 5 cm wide, 1.4 mm-thick silicon flat wafers have been used as base plate. The fin array is as shown **in fig.3.** With varying the various parameters like fin spacing, fin height and fin thickness.

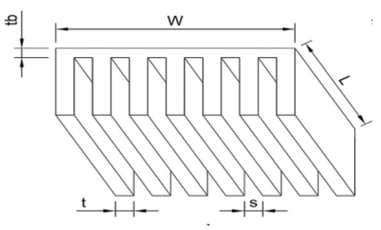

Fig.1. Plate fin array (Source: Leonardo Micheli *et al.* 2016)

The according to combination fins parameter create 10 geometry. The fins have been obtained through a dicing machine, able to produce 2D profiles. All the dimensions are reported in Table

Table1. Fin dimensions. Geometry has been used to produce a plate fin array

Sr.No		W&L [*mm*]	t[*mm*]	s[*mm*]	H[*mm*]
1	Geometry 1	50	0.2	0.2	0.6
2	Geometry 2	50	0.4	0.8	0.6
3	Geometry 3	50	0.4	0.2	0.6
4	Geometry 4	50	0.4	0.8	0.6
5	Geometry 5	50	0.2	0.2	0.6
6	Geometry 6	50	0.2	0.2	0.8
7	Geometry 7	50	0.4	0.4	0.6
8	Geometry 8	50	0.4	0.4	0.8
9	Geometry 9	50	0.2	0.8	0.6
10	Geometry 10	50	0.8	0.8	0.6

In that the micro fin array are micro scale dimension are 5× 5 cm. this is the very small fin array use in electronic cooling applications where no space for the fan or blower. The fin parameter varies in also micro scale fin thickness varies between 0.2-0.8 mm, fin spacing 0.2-0.8 mm, and fin height 0.6-0.8 mm. by using this parameter variation develop the 10 no of geometry and checking the mass specific heat transfer coefficient for each geometry.
The check the thermal performance for all 10 geometry for the various load also the this fin array placed on spores block .also this fin array is specially for the upward facing condition not for the downward facing conditions. The facing is very important for the air flow patterns for downward facing fin array the air flow patterns is blocked because of it's the against the gravity but in case of the upward facing the air flow with the gravity so the air circulation is continuous flow.

In geometry the fin thickness is equal to the fin spacing. The experimental setup used for this investigation in shown in fig.

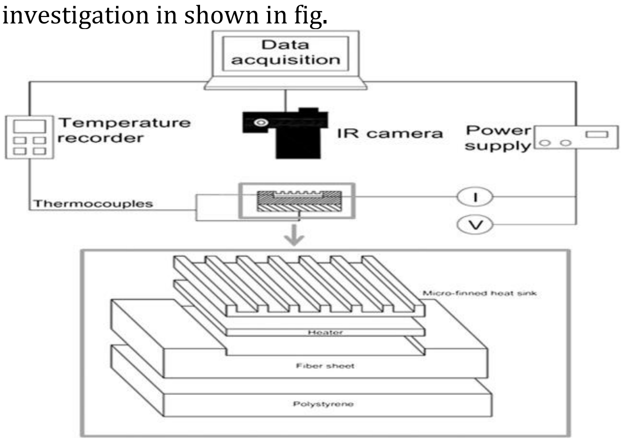

Fig.2. Experimental setup for plate fin array.(Leonardo Micheli *et al*. 2016).

On an insulating box of a 1-cm thick having fibre material arrays of fin have been placed. The box is also covered by polystyrene layer of 1 cm thick. On back surface of each fin electrical heater (Omega KHLV-202/2.5) is placed. Which is operated on a dc power supply and used as heat source. By using millimetre the current and voltage is measured which is used to calculate the heat produced. Box which is open on top fin array is placed inside it having size of 25 cm X 25 cm X 25 cm. for the measurement of temp of fins thermal imaging camera is used. Assuming the constant temp and constant height across fin and fin resp. k- type thermocouple is used to measure the temp at insulating case walls, and 3 more k-type thermocouple are used to measure the temp of fin array. The experiment conducted at steady state and the environmental temp is 25 ^{0}c. Readings are taken for 3 times for fin arrays in horizontal position, in upward direction and under the natural convection current. 5W, 7.5 W, 10W power inputs given to heater.

So the power density is calculated as of 2.0 KW/m2, 3.0 KW/m2 and 4.0KW/m2.Validation description and uncertainty is alreadythe description of the validation and the calculation of the experimental uncertainties is already reported in this. 8.25% of uncertainty is reported in experimental measurement of heat transfer coefficient, 6.07 % of discrepancy is found between the experimental and numerical results.

4. Data analysis

Heat dissipation done in 3 ways such as convection Qc , radiation Qr& combined convective/radiative losses Qloss from the insulating case.

Qin=Qc+Qr+Qloss. (1)

Value for Qloss is determined in each test rep. From test it has been observed that about 26% of heat is lost through the insulation case.

Same assumptions like for isothermal fins & not-radiating surrounding is considered for calculation of radioactive heat transfer. The surrounding conditions assumed to be large and black body, so temp of that is equal to ambient temp.by using Stefan-Boltzmann:-

$$Qr = \sum \epsilon\, \sigma AiFi(\Delta T)^4 \quad (2)$$

where ε is the experimentally determined emissivity of silicon, σ is the Stefan–Boltzmann constant (5.67·10−8Wm−2 K−4), Ai is the area of each i-surface of the fins, Fi,amb is the view factor between the i-surface and the ambient and Tfins and Tamb are the temperatures of the fins and the ambient respectively.The view factors rely is depends on the geometry of the fins and vary for each surface. The method to determine the view factors of the plate fins has been described as flows; a simplified method to calculate the view factors of the pin fin has been introduced. The fin base is not considered uniform because of the plate fins is the view factor. For this condition in present study fin base classified in 2 ways

- Enclosed fin base: this is the portion of base which is limited on two sides by the fin walls.
- Open fin base: this is the portion which is placed in space between among four adjacent pin fins.

View factor for enclosed fin base can be calculated using equation for enclosure of four surfaces. A new way of finding the view factor for open fin base has been found. By assuming view factor for open fin base to be 1it can see that all the surfaces of the enclosure other than the open fin base consist of air.

The heat exchange coefficient can be obtained by giving input power, the losses and the radioactive contribution. The average convective heat transfer coefficient for a fin array can be calculated as:

$$\text{hfins} = \frac{Q_c}{A_{fins}\ (\Delta T)} \quad (3)$$

Where, Afins is the area of the finned surface.

The heat sink is categorized by into two or three categorized. the thermal resistance and analog to Electrical resistance and also the heat dissipate form the heat sink and also the temperature difference between them .

$$R_{fin} = \frac{(T_{fins} - T_{amb})}{Q_c} \quad (4)$$

The thermal resistance is most important in thermal analysis. But in case the thermal resistance is not to be consider because of the extension of the thermal exchanging surface. The consideration of heat transfer of overall performance of hest sink in the presence of performance per unit heat sink per unit surface area. For finding effectiveness of various matrixes are used for that. The mass specific heat coefficient depends on the fin effectiveness and the fin materials.

$$h_m = \frac{Q_c}{A_{fins} \times \rho_{fins} \times (T_{fins} - T_{amb})} \quad (5)$$

Where, Vfins and ρfins are respectively the volume and the density of the finned array.

In order to measure the enhancement in performance due to the micro-fin arrays, the overall fin effectiveness (ε fins) is considered as well. This parameter cleared the ratio between the heat transferred by the fins and that transferred without fins of a flat surface of length L and width W. The fin effectiveness has been calculated as follow:

$$\in_{fins} = \frac{Q_c}{Q_{flat}} \quad (6)$$

Where Qflat is the heat transferred by convection from the unfinned flat surface.

5. Heat transfer coefficient

The coefficient of proportionality of a difference of temperature between a surface and a fluid and the heat flux is known as heat transfer coefficient. The heat transfer coefficient mainly depends upon the geometry of fluid also in air velocity and some various factors. It is not the property of fluid. In the current experimentation, the heat transfer coefficient of the plate fins under natural convection lower than that of pin fins. Considering the similar power input. It means that the greater volumes which are available for air, provides facilitation of the dissipation of heat. There is limitation to enhancement by the constraint air volumes between the fins, where there is increase in viscous force effects.

In a porous system, for calculation of the heat flow values many factors should be considered. The combination of conduction through the enclosed gas, conduction through the solid phase usually gives a complex heat flow, whose description is given by an effective thermal conductivity.

6. Mass specific heat transfer coefficient

In literature it already given that by using the micro fins leads to two main application: increase in thermal performance and decrease in mass of surface compared with the flat surface. This is happed because of the subtractive methods that are used to create micro fins, by removing part of material from main surface.it was showed that the by suing the mass specific heat transfer coefficient the array of plate micro fins could enhance the effeteness of fin material. Plate fin array is investigated with the mass heat transfer coefficient. Both are in upward direction.so plate fin are having surface extension in it.so pin fin array becomes an interesting topic for use in light weight application.so because of the enhancement in heat transfer from pin fin. Pin fin becomes a most efficient choice for the heat transfer application compared to plate fin for natural convection application.

Effect of fin with different parameter like spacing (s=0.2mm & 0.8mm),fin thickness 0.2mm,fin height 0.6mm on mass heat transfer coefficient presented.

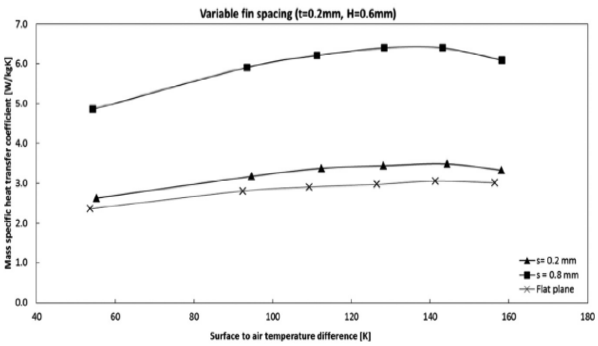

Fig.3. The effects of fin spacing for upward-facing fin arrays on the mass specific heat transfer coefficient: t = 0.2 mm and H = 0.6 mm.(Source K.S. Reddy *et al*. 2016)

Effect of fin with different parameter like spacing (s=0.2mm & 0.8mm),fin thickness 0.4mm,fin height 0.6mm on mass heat transfer coefficient presented.

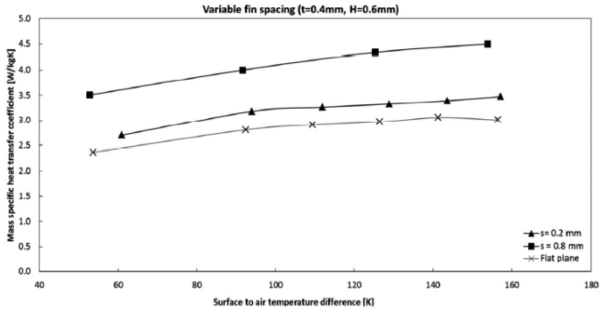

Fig.4. The effects of fin spacing for upward-facing fin arrays on the mass specific heat transfer coefficient t = 0.4 mm and H = 0.6 mm. (Source: K.S. Reddy *et al*. 2016)

Effect of fin with different parameter like spacing 0.2 mm, fin thickness 0.2 mm, fin height (0.6mm-0.8mm) on mass heat transfer coefficient presented.

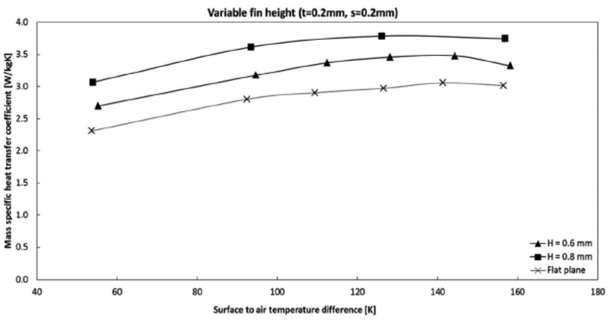

Fig.5. The effects of fin height for upward-facing fin arrays on the mass specific heat transfer coefficient: t = 0.2 mm and s = 0.2 mm.(Source: K.S. Reddy *et al*. 2016)

Effect of fin with different parameter like spacing 0.4 mm ,fin thickness 0.4 mm, fin height (H=0.6mm & 0.8 mm) on mass heat transfer coefficient presented.

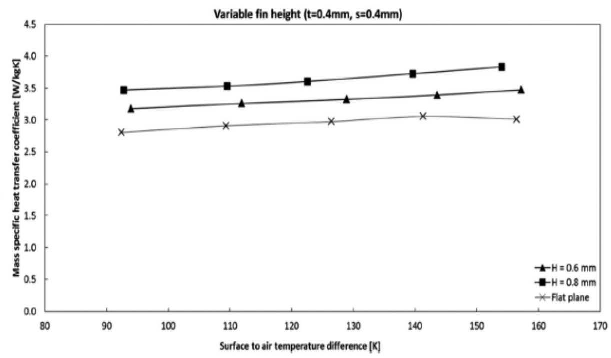

Fig.6. The effects of fin height for upward-facing fin arrays on the mass specific heat transfer coefficient: t = 0.4 mm and s = 0.4 mm.(Source K.S. Reddy *et al*. 2016)

Effect of fin with different parameter like spacing 0.8 mm, fin thickness (t=0.2 mm & 0.8 mm), fin height 0.8 mm on mass heat transfer coefficient presented.

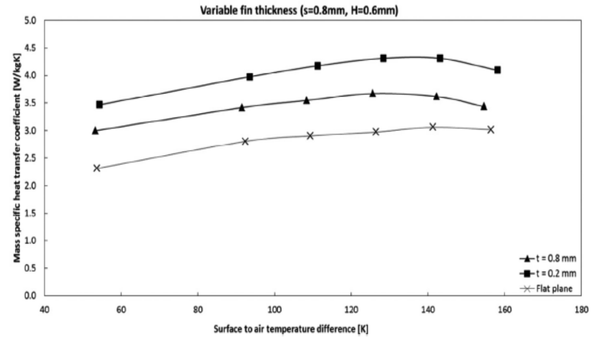

Fig.7. The effects of fin thickness for upward-facing fin arrays on the mass specific heat transfer coefficient: s = 0.8 mm and H = 0.6 mm.(Source: K.S. Reddy *et al*. 2016)

Conclusion

There is an improvement of 50% in mass heat transfer coefficient compared with flat plate by using micro fins. With increasing the spacing of fins there is an increment in specific heat and mass transfer coefficient. Also increases with the increasing height as expected. The maximum increment found at a 0.8 spacing & 0.2 mm thickness.

References

Leonardo Micheli, K.S. Reddy, Tapas K. Mallick,(2016) Thermal effectiveness and mass usage of horizontal micro-fins under Natural convection *Applied thermal engg* 9739-47.

Junye Hua, Gui Li, Xiaobao Zhao, Qihe Li, Jiao Hu(2016), Study on the flow resistance performance of fluid cross various shapes of micro-scale pin fin, Applied Thermal
Engineering 107, 768–775

Leonardo Micheli, K.S. Reddy, Tapas K. Mallick,(2016) Experimental comparison of micro-scaled plate-fins and pin-fins under natural convection. *International Communications in Heat and Mass Transfer* 75, 59–66.

Leonardo Micheli a,⇑, K.S. Reddy b, Tapas K. Mallick, (2015) General correlations among geometry, orientation and thermal performance of natural convective micro-finned heat sinks *International Journal of Heat and Mass Transfer* 91, 711–724.

Leonardo Michelia,, K. S. Reddy, Tapas K. Mallick, (2015) Plate micro-fins in natural convection: an opportunity for passive concentrating photovoltaic cooling Energy Procedia 82, 301 – 308

Guei-jang Huang, Shwin-Chung Wong, Chun-Pei Lin(2014), Enhancement of natural convection heat transfer from horizontal Rectangular fin arrays with perforations in fin base *International Journal of Thermal Sciences* 84, 164-174.

Pankaj Singh, Anil K. Patil,(2014) Experimental Investigation of Heat Transfer Enhancement through Embossed Fin Heat sink under Natural Convection *Experimental Thermal and Fluid Science* 1777,00253-2.

Li-Hao, Tai-Her yang, Sih-Li chen,(2014) Influence of inter-fin base length on thermal performance of free hanging horizontal Base heat sinks. *International Journal of Thermal Sciences*84 164-174.

R.A. Pulavarthy, M.T. Alam, M.A. Haque(2014), Effect of heated zone size on micro and nanoscale convective heat transfer,*International Communications in Heat and Mass Transfer* 52 56–60.

L. Micheli, N. Sarmah, X. Luo, K.S. Reddy, T.K. Mallick,(2013) Opportunities and challenges in micro- and nano-technologies for concentrating photovoltaic cooling: a review, *Renew. Sustain. Energy Rev.* 20 595–610,