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Analysis of Hyoid Structured And Perforated Pinfin Heat Sink In Inline And Staggered Flow

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ABSTRACT

The usage of the electronic goods has been increased tremendously; hence it is the challenging task to improve the cooling for such devices. The heat dissipation rate should be maximized in the electronic devices like integrated CPUs, chipset and hard disk drives with the help of heat sinks, fans and other forms like liquid cooling in order to protect the device due to overheating,as overheating results in reducing the life or damaging the device, hence it is necessary to modify the heat sink design in various vital parameters like fin height, fin length, fin thickness, number of fins, number of perforations, base plate thickness, fin spacing, material etc.

The main objective of this present paper is to present the modified model of the heat sink with above mentioned geometrical parameters, and both flow types of inline and staggered with and without perforations of C/H=0, C/H=0.333, and C/H=1; =1.308, 500 < Re < 42,000; 1.208 < Sy/D < 3.417, 0 < C/H < 1 and observing the heat flow rate in the Hyoid (U-shaped) pin fin heat sink.
The results revealed improved heat dissipation characteristics

KEYWORDS:
Heat transfer, perforated fins, Hyoid pin fin heat sink, Base plate, inline and staggered.

I.INTRODUCTION

The most essential part of the low velocity devices that is for electronic devices is the heat sinks where complete better functioning of the of the CPUs is only possible with better heat sink.An enormous amount of heat is produced in the device, when it is operated for a long time hence the waste heat should be removed properly in order to avoid the malfunctioning. Therefore heat sinks are assembled as essential component for cooling.A number of heat sinks were designed so far to improve the cooling rate and here the inline and staggered pin fin heat sinks with and without perforations cooling rates are compared also a new model of hyoid structured pin fin heat sink is designed to improve heat transfer rates.

Hyoid pin fin heat sink is the advanced model to improve the heat transfer rate. The base plates is fixed with array of pin fins with decreasing heights from left corner to centre and from the centre of the heights of the pins are increased consecutively and it appears as a U-shaped arrangement as in fig.1 hence named as Hyoid structure. As the arrangement in pin fins results in the decreasing of its weight and material required also reduces and allows air to be flow in all directions to the centre where exactly the chip is placed and hence rapid cooling is possible with this arrangement.

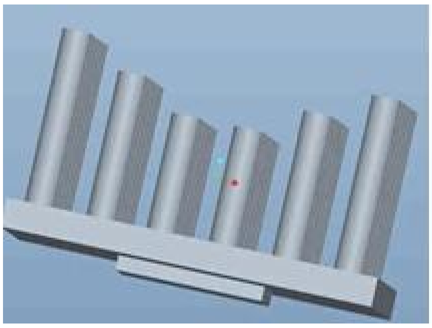

Fig.1:Hyoid pin fin heat sink

As in the low air speeds the thermal performance increasesin the staggered arrangement of pin finf with and without perforations ,similarly in the hyoid pinfin arrangement also better thermal performnce is observed.

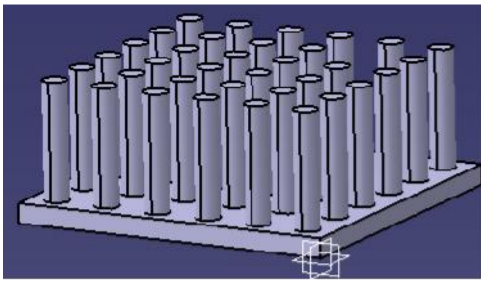

Fig2.inline arrangement

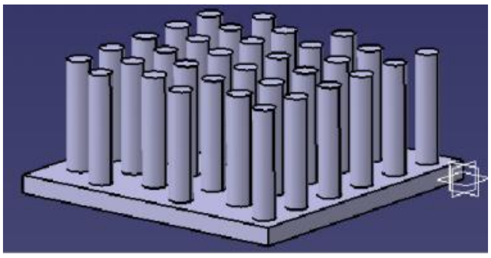

Fig3.staggered arrangement

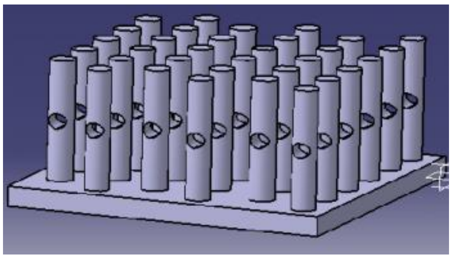

fig.4.staggered with perforations

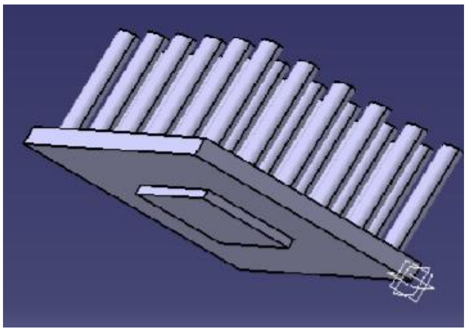

Fig5.pinfin heatsink with chip attached at the base

It is clearly observed that the heat transfer rate is very better in the staggered arrangement of pinfins with perforations than the inline arrangement. perforations are done by driiling with the required diameter at the center.

The inline fig.2 and staggerd fig.3 arrangements were popularly researched arrangement out of both the staggerd arrangement with cylindrical pin fins are gives high performance.with the comparisons made as above the hyoid pin fin heat sink is present researching area to improve the performance due to various advantages like reduced weight and less material is uesd to manufacture also as copper is approx 3.2 times the weight of the aluminium hence this structure is very much prefferable.Another additional advantage with the perforations are it will reduces the weight of the heat sink with less material usage.

Bayram sahin,Alparslan Demir studied the heat transfer enhancement and pressure drop over a flat square surface with perforated pin fins rectangular channel and the reynolds number is 13,500 - 42000,and develops a correlations for heat transfer,friction factor and enhancement efficiency.

O.A.Sarma, observed from the results that optimum cooling is achieved by splayed & hybrid pin fin heat sinks. These heat sink designs promises to keep electronic circuits 20 to 40% cooler than standard pin-fin heat sinks. Either pressure rise or fan power and fin height [1].

R.karthikeyan and R.Rathanasamy studied and showed the result of heat transfer enhancement is better and for high thermal performance low friction factor, low clearance ratio and low inter fin distance are preferred with low Reynolds number.

Mr. Amol B. Dhumne showed the result that by decreasing the diameter of the pin fin heat transfer rate can be increased in both inline and staggered flow with the perforations. And also observed that by increasing the velocity high heat transfer rate is achieved.

Jonson and Bjorn studied on various pin fins shapes and prefers elliptical pin fins at high velocities and circular pin fins at mid range velocities. They evaluate the thermal performance by comparing thermal resistance of heat sink at average velocities and equal pressure drop.

Hence I compared the inline with staggered arrangement to improve the performance of heat transfer with small number of pin fins with and without perforations also work carried on Hyoid pin fin heat sink.

II MODEL ANALYSIS:

The analysis of the pinfin heat sinks are by the Pro-e extension software called FLOW-EFD.The heat and temperature distribution is observed both thereotically and analytically.The following are the assumptions done for the analysis:

1.The cooling medium that is air is incompressible throuhout the process.
2.The flow of air is laminar,steady and two dimensional.
3.In the pinfins there are no heat sources.
4.Uniform temperature at the base of the fin .
5.Temperature and the heat flow in pin fins are constant, and tip of the fins are adiabatic.
6.Perforations are uniform for all the pinfins

2.1Calculations:

2.1.1 Heat transfer coefficient over flate plate

Reynolds's number (ReL) = (ρ v L)/μ (1)
Nu = 0.332 ReL0.5 Pr 0.333 (2)
Nu= h1L/k (3)
h1 = Nu k/L (4)

2.1.2 Heat transfer coefficient across bank of tubes

Reference Velocity in inline arrangement:

The mean velocity in the minimum free cross section between two rows, Vmax, is used in Re.

Reference velocity in the calculations of fluid flow and heat transfer for inline arrangement, and is given by

Vmax= [ST/(ST-D)] Uapp (5)

where Uapp is the approach velocity, SL, and ST are the dimensionless longitudinal and transverse pitches,

ReDmax= ρ vmax D (6)
Nu= C (ReDmax) n (7)
For the values of C and n from data book
Nu= h2D/k (8)
h2 = Nu k/D

2.1.3 Heat transfer coefficient across bank of tubes

Reference Velocity in staggered arrangement:

The mean velocity in the minimum free cross section between two rows, V_{max}, is used as a reference velocity in the

Calculations of fluid flow and heat transfer for staggered arrangement, and is given by

V_{max}= [SL/2(SD-D)] U_{app} (5)

where U_{app} is the approach velocity, SL, and ST are the dimensionless longitudinal and transverse pitches,

ReD_{max}= ρ V_{max} D (6)
Nu= C1(C (ReD_{max}) n)(7)
For the values of C and n from data book
Nu= h2D/k (8)
h2 = Nu k/D

Table.1 Dimensions of Heat sink model

Sl. NO	Name of the part	Dimensions and quantity
1.	Footprint (mm2)	25.4×25.4
2	Base plate thickness (mm)	2
3	Overall height of fin(mm)	12
4	No. of perforations in inline flow	36
5	No. of perforations in staggered flow	33
6	Diameter of perforation (mm)	1.5

Table.2 Properties of material

s.no	Property	Value
1.	Overall height of fin(mm)	12
2.	Approach velocity (m/s)	3
3.	Thermal conductivity of solid aluminum(W/m•K) for aluminum	237
4.	Thermal conductivity of solid copper(W/m•K)	401
5.	Thermal conductivity of air (W/m•K)	0.0284
6.	Density of air (kg/m3)	1.086
7.	Specific heat of air (J/kg•K)	1007
8.	Kinematic viscosity (m2/s)	18.15×10−6
9.	Absolute viscosity (Ns/m2)	19.70×10−6
10.	Prandtl number (Air)	0.6976
11.	Heat load (W)	130
12.	Ambient temperature (K)	297
13.	Base plate temperature (K)	353

III EVALUATION OF HEAT TRANSFER:

To find out the average Nusselt Number of smooth surface without perforations is correlated with the function of Reynolds and prandtl number is given as,

N=0.007RP

The Nusselt number based on C/H and /D ratios are correlated as:

Nup=45.99R(1+C/H(/Dr$^{1/3}$

N6.67R(1+C/H(/DPr

The above equations can be used in the range of 13,500 ≤ Re ≥ 6 42,000,

1.208 <Sy/D < 3.417,

0 ≤C/H ≤ 1 and Pr = 0.7

By using these equations the nusselt number for perforated fins can be determined.

3. Evaluation of output parameters

3.1 Evaluation of Friction Factor

The experimental pressure drops can be represented as a Friction Factor “F” theoretically, and it is correlated with the following relation as:

F=2.4R(1+C/H) (/D

Within the range of 13,500 < Re < 42,000; 1.208 < Sy/D < 3.417, 0 < C/H < 1 By using the above Equation the variations in the friction factor ‘f’ for different clearance ratios (C/H) i.e. C/H=0, C/H=0.333,C/H=1 at constant Sy/D = 1.308 will be determine.

IV RESULT AND DISCUSSION:

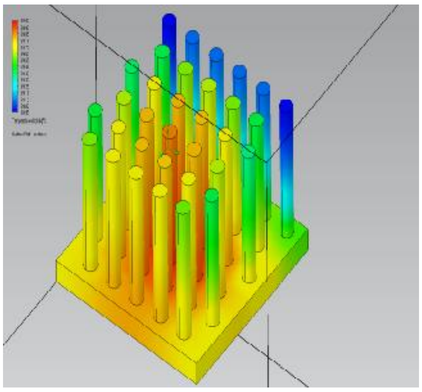

Fig6.temperature contours in the cu heatsinkUnder staggered flow without perforations

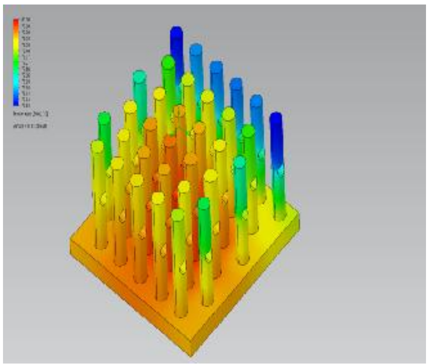

Fig7.temperature contours in the Cu heatsink understaggered with perforations

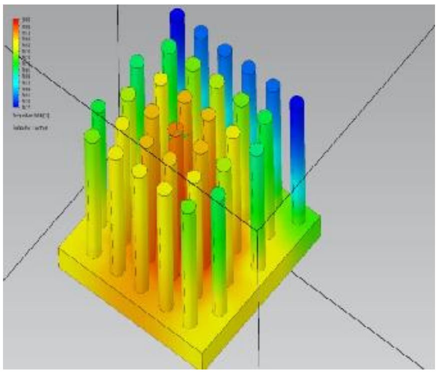

Fig8 .temperature contours in the Al heatsinkUnder staggered arrangement

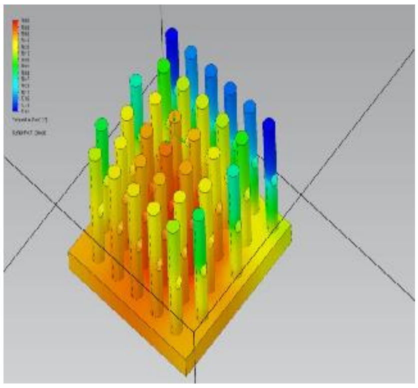

Fig9.temperature contours in the Al heatsink Under staggered arrangement with perforations

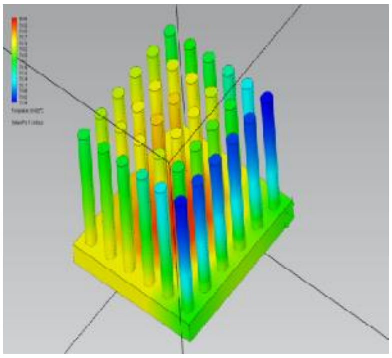

Fig10. Under inline arrangement without perforations

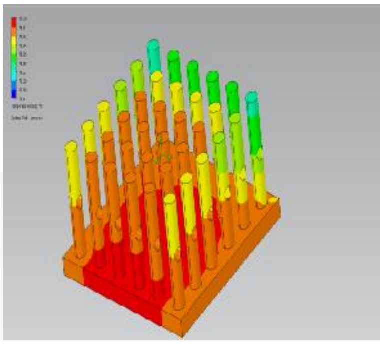

Fig11.temperature contours in the Cu heatsink Under inline arrangement with perforations

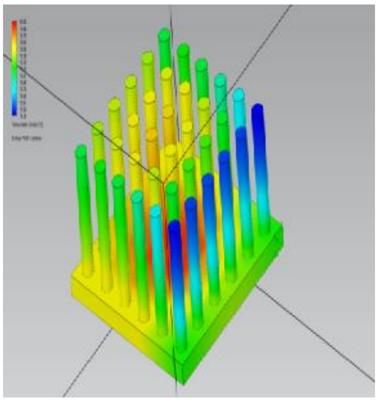

Fig12.temperature contours in the Al heatsinkUnder inline arrangement without perforations

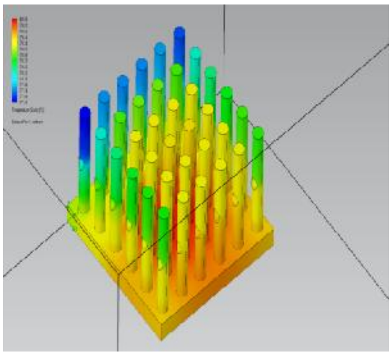

Fig13.temperature contours in the Al heatsink Under inline arrangementwith perforations

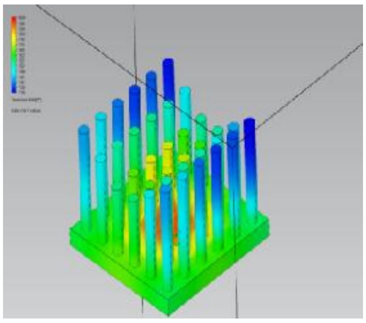

Fig14.temperature contours in hyoid Cupinfin Heatsink

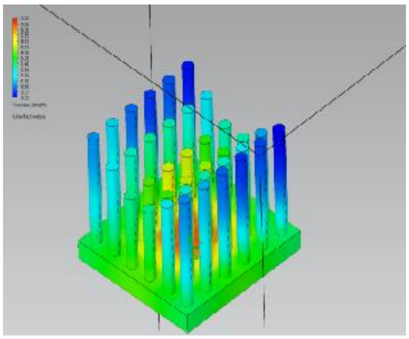

Fig15.temperature contours in hyoid Al pinfin Heatsink

The temperatures of inline, staggered with and without perforations and hyoid pinfin heatsink is compared and tabulated as follows:

Table.3

Arrangement	Cu(k)	Al(k)
Inline without perforations	352.85	352.75
Inline with perforations	353	352.81
Staggered without perforations	352.92	352.88
Staggered with perforations	352.9	352.83
Hyoid pinfin heatsink	352.47	352.18

It is clear with the simulation done in FloEFD for Creo software, CFD ANALYSIS it is observed from the fig 6to fig 15, the heat spreading capability is more with less thermal resistance in the copper pin fin heat sink in the inline arrangement with perforations than any other. Also copper pin fin heat sink with staggered arrangement with out perforations are yielding better heat spreading capacity. The maximum base plate area is exposed to the heat dissipating in the case of cu staggered arrangement of pin fin heat sink with perforations; hence copper is used for extreme cooling conditions. But due to the drawback of high cost and more weight of copper the hyoid pin fin heat sink is preferred.

V CONCLUSION

From the present investigation it can be concluded that the hyoid pin fin heat sink is giving better performance compared to the standard pin fin heat sink. Hence the pin fin heat sink can be modified as hyoid pin fin heat sink. Also the heat transfer rate is increased by decreasing the Reynolds number. By decreasing the clearance ratio and inter fin distance ratio, the friction factor is increased.

VI FUTURE SCOPE:

The experiment can be carried out with perforated Hyoid pin fins and also the experiment can be carried out at different temperatures.

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