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Forced Convection upon Heat Sink of AL-Cu for Design Optimization by Experimental and CFD Analysis for cooling of ICs in CPU.

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Abstract: *A heat sink device is used with specific power input at 100V and 20W by the heater attached at the base plate of copper and then obtaining the average temperature of Heat sink by the help of 10 thermocouples .Two specimens of heat sinks were designed and were tested for mass flow rate and heat transfer coefficient. With base of 1.5mm&2.5mmtip thickness and another specimen with dimensions as tip0.5mm and1.00mmbase thickness are used By experimenting and CFD simulations,optimization of heat sink design was done.Then correlation and Validation foe both the specimen was done and were found satisfactory results.*

Keywords-*Base plate,Cooling fan, CFD simulation, Heat sink, Heat dissipation, IC's ,Fin configuration, Thermocouples.*

I. INTRODUCTION:

In modern and recent advances in the science & technology, especially in the electronics and computer application area a lot of advancements has taken place in Electronic cooling in CPU. Also with advent, few drawbacks are also seen in operations & application of electronic cooling in CPU. Recent advances using with compact space for computers, heat dissipation from IC's has been a complex phenomenon.Hence by using easy design & fabrication ,experimental calculations and by simulation we can overcome the problems.Software simulations correlation was done for better design and performance of the heat sinks. Composite materials in Metal-foam heat sinks have received considerable attention, Lee et al., [1] Antohe et al., [2]; Camidi and Mahajan, [3]; Kim et al, [4] and these composite materials have good physical and chemical properties,also its good in high thermal conductivity and electrical activity.metal foams have less density,high strength ,porous,large surface area to volume . M. Shimada et al.: [5]El-Sayed et al.[6], Yazawa et all[7]. The materials of heat sink differ in many ways for design and fins are concerned .According to requirements the heat sinks are sequenced for applications in the system.. Dempsey et al. [8]Theoretically heat sink are made known by the difference of transfer performance of a stochastic cellular metal heat sink to a square-celled LCA, Bhattacharya and Mahajan [9]founded heat sink as heat exchanger in the composite materials with fins on it. Composite materials fins fixed side by side joined in between are used in free convection conditions, plate fins characteristics was investigated
by theoretically the heat sinks by Duan and Muzychka [10]. Geometric parameters of fins are assumed as 1-D, transfer of heat in clockwise directions in 360^0. Also distance between fins heights differently to know the characteristics of single fin. Banerjee et al[11]; Geisler, [11], Cooling is important to dissipate heat from the ICs to the surroundings ,so that the performance of ICs are improved considerably,passive cooling is not the best practices.Sultan, [12], investigated there are alternate methods to cool the electronc devices by pin-fin,use of fluids ,hot pipes,miniature heat sink Wirtz et al. (1994) [13].Theoretically studied the bypass affect on fins placed inline on heat sink. Later they found the velocities and heat transfer coefficients relations by using the dimensional analysis equations under free convections. Yuan et al. (1996)[14] investigated the effect of fins in a particular crossection passage using the CFD analysis.The values when compared with experimental and CFD Analysis were in close agreement. Simons and Schmidt (1997) [15] Innovated by using fluid dynamics by applying mass and momentum ,between fins and bypass area by neglecting the pressure drop..Heat sinks of varied dimensions, size,shapes,materials fins are used.According to our requirements fins are chosen.Commonly used forced flow convection.
.R.Mohanand.P.Govindarajan,[16],springer,journal of mechanical science and technology,&KSME.

II. EXPERIMENTAL SETUP AND PROCEDURE

The material for fins orExtended surfaces used are a combinationof Aluminium as fins and Copper as base plate material.Two specimens were prepared with tapered fins of Aluminum & base plate material of copper. One specimen ofdimensions 40mmx50mm x5mm and second specimen with dimension of40x50x2.0mm is prepared. A small heater is attached at the base of copper plate . Both the materials have been machined carefully for the required dimensions.Silicon compound and adhesivegel are used to attach the fins to the base plate. Aluminum tapered fins in 4 numbers are fixed to the copper plate.The two specimens with fins of base thickness 2.5mm & tip thickness 1.5mm.and 1mm base and 05mm tip thickness of fins respectively fixed.

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To regulate the heat a centrifugal blower is fixed above the fins horizontally with flow rate of 90 CFM, withradius of fan diameter 90mm.The temperatures are measured on heat sink by ten(10) J type of thermocouples.

The position of thermocouples are at 10mm from thebaseoffinonheatsink,Eachfinconsistoftwothermocouples, overall thermocouples are 08 on fins.The copper base plate is fixed with 02 thermocouples at centre to measure the base plate temperature. Hence, a total of 10 thermocouples are fixed on the heat sink.

Heat is supplied to the heat sink heater with constant power of 20W, with steady state and even assumed that the change in maximum temperature was minimum than ±10°C for a time span of 4minutes.A voltmeter, wattmeter & temperature indicator were connected to measure the required parameters. Steady temperature of 50°C for heat sink is obtained with surrounding temperature as38°C. Both the specimen are as shown below in figure-1a&b.and the dimensions used are given in table 1 &2.

Experimental setup photograph.

Figure 1: Heat sink specimen (a) Without holes (b) With holes

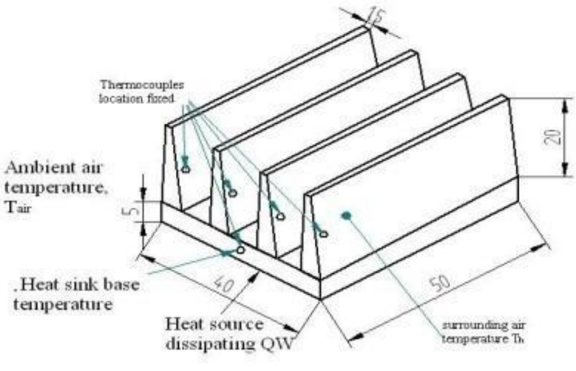


fig:1

fig1(a)

Table1:Dimensions of the heat sink with holes.

Fin Length, Lf (mm)	Fin Height Hf (mm)	Fin Width Wf mm	Fin Number N	Thickness,of fin at tip tft (mm)	Fin –to- Fin distance ξ (mm)	Base thickness tb (mm)	Base Fin Thickness tfb (mm)
50	20	40	04	1.5	7	5	2.5

Table2:Dimensions of the heat sink with holes.

Fin Length, Lf (mm)	**Fin Height Hf (mm)**	**Fin Width Wf mm**
50	20	40
Fin Number N	**Thickness of fin at tip tft (mm)**	**Fin –to- Fin distance ξ (mm)**
04	0.5	15
Base thickness tb (mm)	**Base Fin Thickness tfb (mm)**	**Holes On Sinks mm** of 2mm diameter
2.0		1

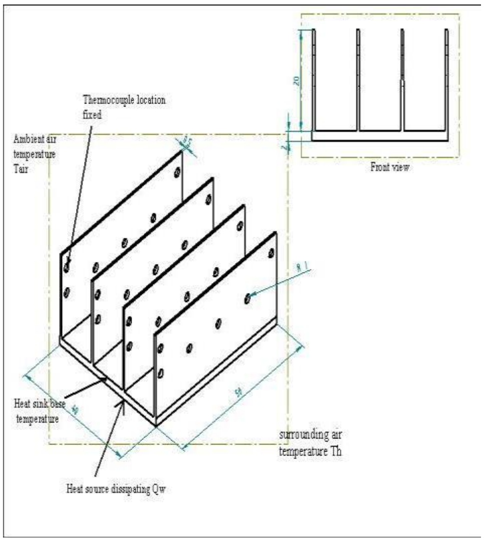


fig1(b)

4.1 CFD ANALYSIS:

CFD analysis of the experimental setup was conducted as per the conditions used in the experimentation. The heat sink model and the fluid domain was generated using CATIA V5 which was exported to the Fluent component in the ANSYS solver. The inlet velocity was calculated from the fan flow rate and the temperature of the heat sink was kept at a steady 50°C. The analysis was performed for four models as given below.

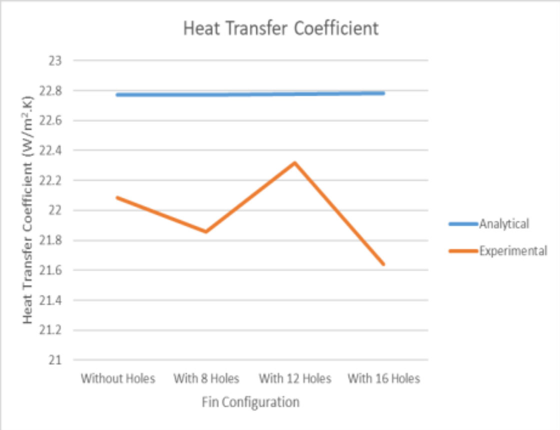
a) Heat sink without holes
b) Heat sink with 8 holes
c) Heat sink with 12 holes
d) Heat sink with 16 holes

After the analysis, the three models with holes were compared to get one with the best performance. The velocity profile obtained from CFD analysis of the specimen are as shown in Figure 2.

Table-3: comparison of experimental and analytical values obtained during this research work.

Graphs below showing comparison of mass flow rate and heat transfer rate for both experimental and analytical values.

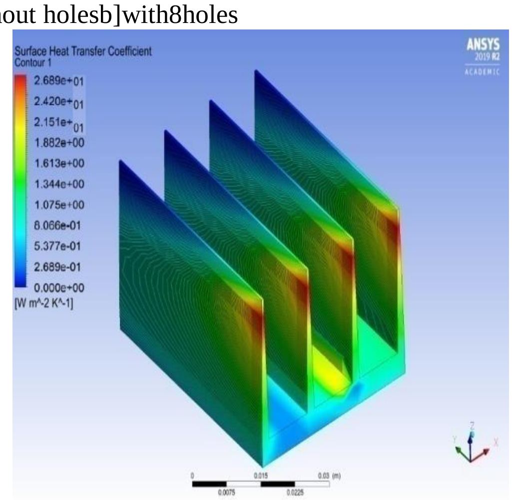
Fin Configuration	Mass flow rate (kg/s)		Heat transfer co-efficient (W/m2K)	
	Experimental	Analytical	Experimental	Analyti cal
Without Holes	0.0495	0.0492	22.7698	22.086
With 8 Holes	0.0495	0.0493	22.7702	21.859
With 12 Holes	**0.0495**	**0.04926**	**22.7745**	**22.319**
With 16 Holes	0.0495	0.04917	22.7812	21.642



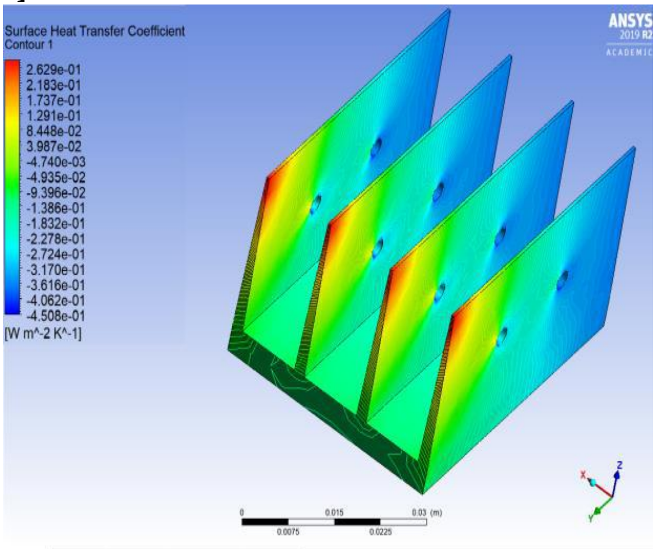
Experimental line is straight and analytical is fluctuating.

CFDANALYSIS OF ALLFOURSPECIMENS SHOWINGHEATTRANSFERCOEFFICENT.

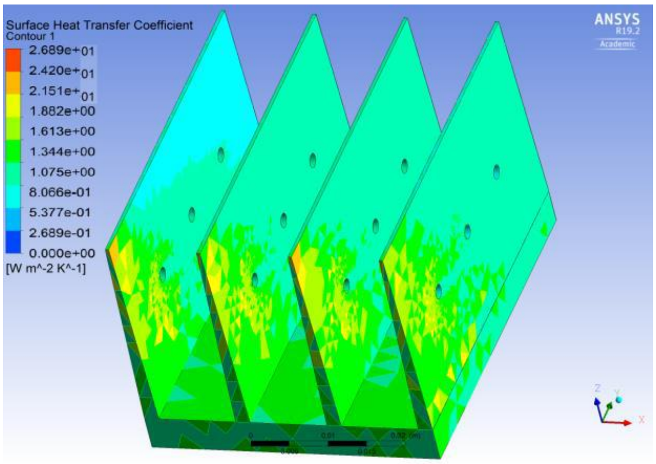
a]without holesb]with8holes



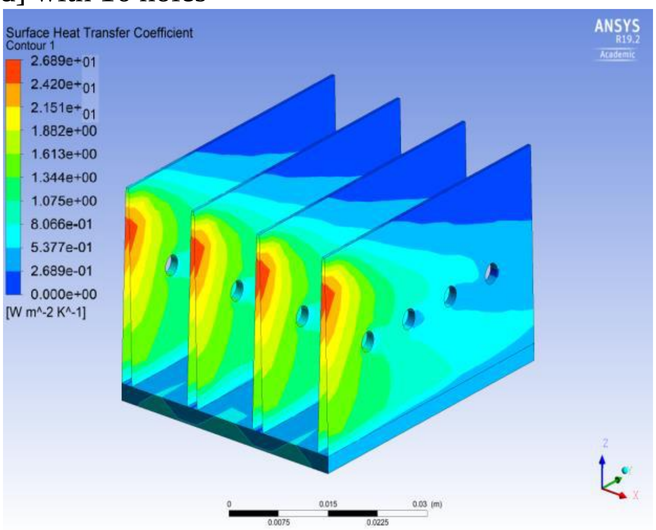
b] with8holes



c] with 12 holes

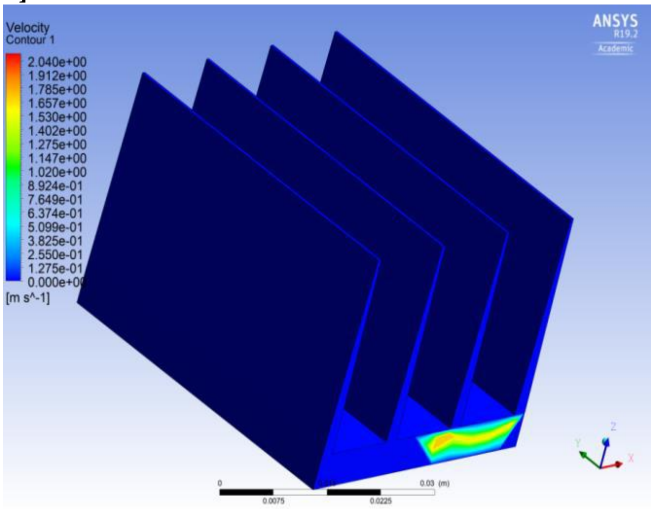


d] with 16 holes

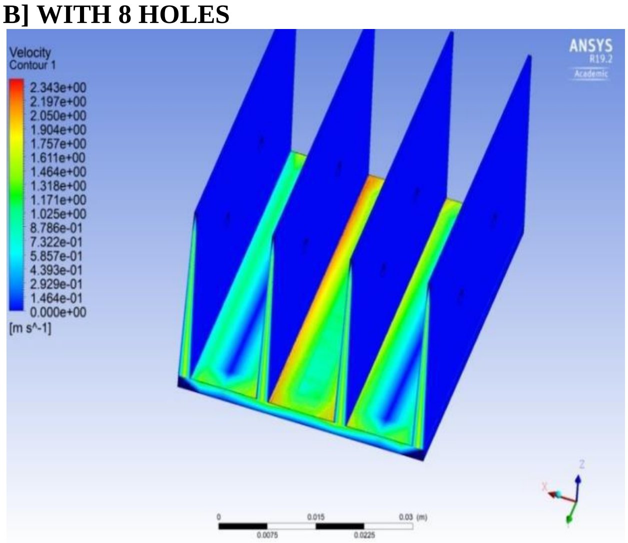


CFD VELOCITY PROFILES OF ALL HEAT SINKS

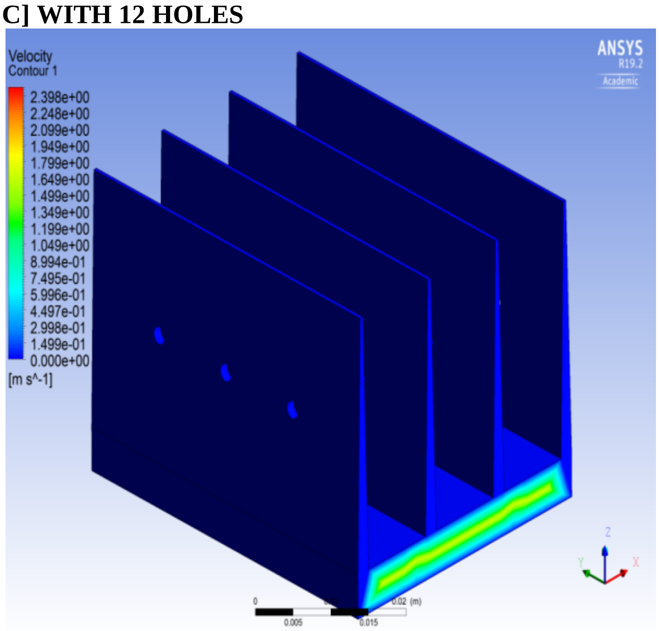
A] WITHOUT HOLES.



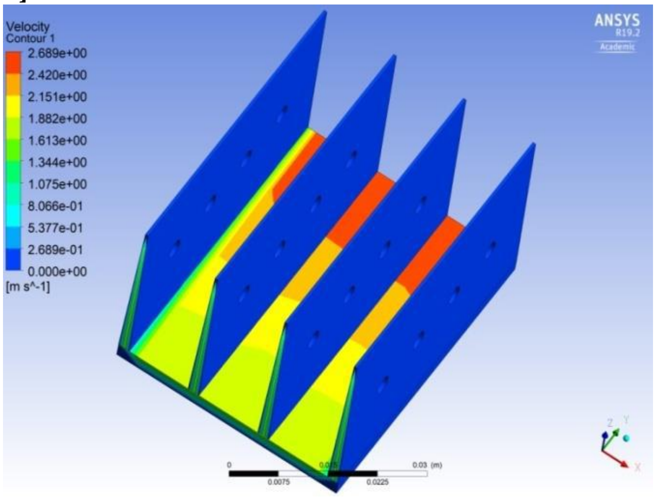
B] WITH 8 HOLES



C] WITH 12 HOLES

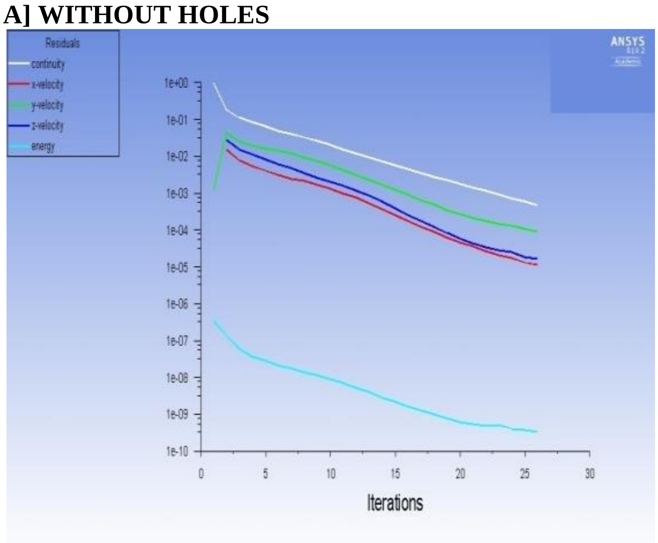


D] WITH 16 HOLES

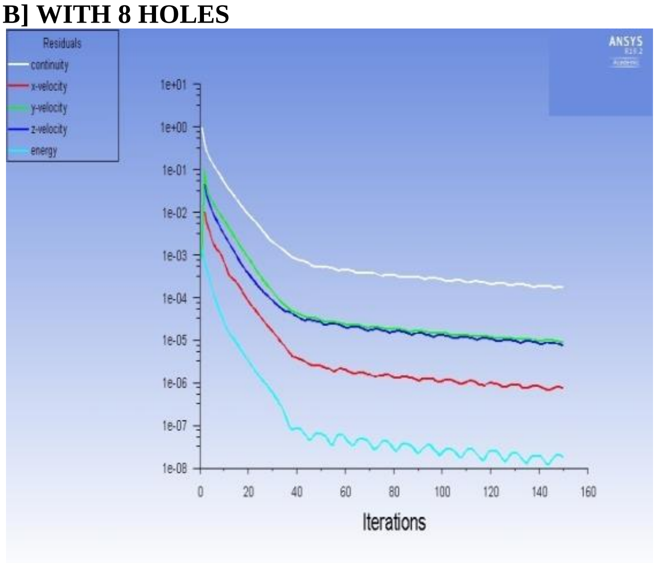


VELOCITY PROFILES CURVES OF ALL HEAT SINKS.

A] WITHOUT HOLES



B] WITH 8 HOLES



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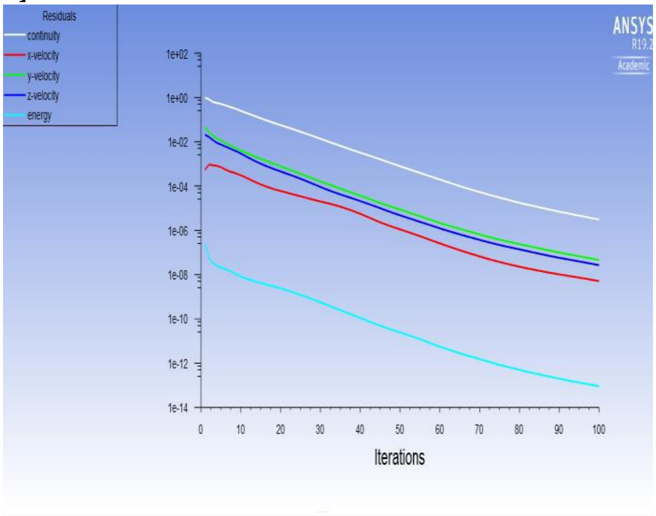
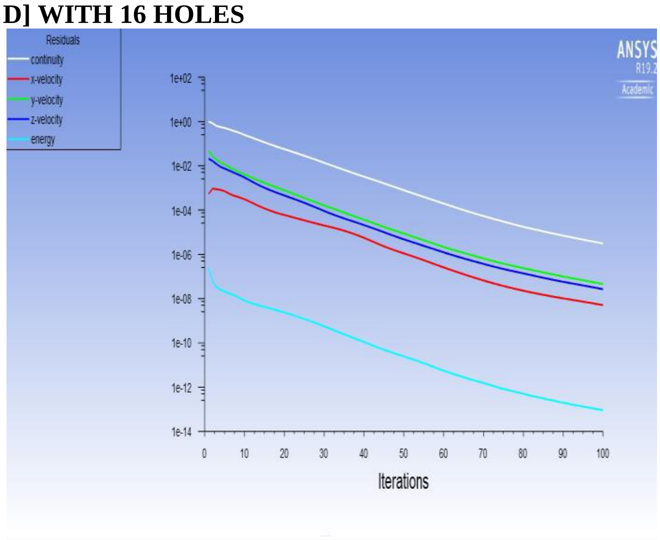
C] WITH 12 HOLES



D] WITH 16 HOLES



III. CONCLUSIONS

The main focus of this research work is to compare the heat transfer between heat sinks of different configurations. This was achieved by comparing four different configurations i.e., Heat sinks without holes, with 8 holes, with 12 holes and with 16 holes. The heat transfer co-efficient obtained through experimentation and CFD analysis indicated that the theoretical model selected for analysis was similar to the experimental model and the values are in close agreement with each other with a very small difference between 1-1.5%.FINALLY HEAT SINK WITH 12 HOLES WAS SEEN AS OPTIMUM VALUE.

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