CFD Analysis of Enhancement of the Forced Convection Heat Transfer over The Pin Fin with Trapezoidal Fin And Flow Structure Analysis , using "ANYSIS" Fluent 15.0

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Abstract— The proposed work is concerned with the analysis of the improved heat transfer by forced convection on the pin fin with trapezoidal fin and analysis of the structure of flows in a CFD. This working research thermal performance of the circular pin fin. The value of heat transfer coefficient obtained for the surface of Nusselt number of the pressure drop of the study, the heat resistance and the pressure drop of the heat to the circular pin fin heat dissipating fins trapezoidal fin information at different velocityes in different heights is to examine the effect of a pin fin design .thermal resistance, pressure drop , and structure of the Nusselt number are compared with experimental results and the simulation results .Parameters such as the geometry of the fin plate and the pin height and number of the fin of the fins of the fin base height is regarded , in particular, the shape of the heat sink. the thermal model of the computer system with various fin heat sink design of the geometry has been selected and the characteristics of the heat sink thermal fluid flow stream were studied. The pin fin plate and trapezoidal heat sinks of the fin geometry were used with base plate to improve heat dissipation. Some features formed in an infinite variety of geometries resulting in different heat transfer characteristics. The objective of the present work is to find the heat transfer rate and distribution of the airflow on surfaces installed pin fins with different parameters (height, speed) and all results will be compared with each other.

Key words: microchip Electronics, Computational Fluid Dynamics, Pin-end heat sink, trapezoidal fin

I. INTRODUCTION

The most common method for the transfer of heat from the environment is to use a heat sink member. Estimate the junction temperature of a component, is the value of the desired heat sink thermal resistance. The thermal resistance of the heat sink can be determined by analysis or experiment. In electronic systems, a heat sink is a passive element. In the computer, the heat sink for cooling the electronic components. Heat Sinks for high-performance semi-conductors, such as power transistors and optoelectronic devices such as lasers and light emitting diodes (LED), wherein the heat capacity of the entire device base insufficient to regulate the temperature.

Heat sink is cooling system. it is always looking for new technologies that improve the thermal performance without cost penalties. Heat dissipation characteristics that incorporate the results of breakthroughs thermal re-research and manufacturing are sought as new product offerings. pin fin heat sink is of interest and should be investigated. An isometric model is developed to investigate the heat transfer rate and the combined heat sink for any item as electronic device. A series of numerical calculations have been carried out in common and the results are shown in order to represent the effects of the temperature distribution, overall coefficient of heat transfer, and thermal resistance surface Nusselt number in the heat sinks.

II. OBJECTIVES OF THE WORK

In this study, the fin pin arrangement is made to analyze the effect on the transfer of heat from outer surface without pin and pin with circular fins with trapezoidal fin at different velocity with different dimensions of the pin fin is considered with the following objectives.

- to obtain the understanding the flow structure. heat transfer met in a heat sink pin-fin of a circular pin fins mounted on the trapezoidal surface fins.
- To study the performance of pin fins at different air velocities.
- In order to study the performance of the circular pin-finned by varying the geometric size (diameter and height) and position of pin fins.
- To reduce the material used to optimize the structure to dissipate heat maximum.

To compare the potential of enhancing a circular pin fins with and without Pin fins and finding the reduced heat transfer rates to different air velocities.

III. CONDUCTION IN THE PLANE WALL

The heat transfers through a wall of a conduction problem a dimension where the temperature is a function of the distance from one of the wall surfaces. It is assumed that the rest of the wall surfaces are at a constant temperature. The heat transfer from the surfaces of the wall is effected by convection with ambient air, causing them to have regular state of the temperatures of T_1 and T_2 on their surfaces. Let assume that the fluid side of the wall with temperature T_1 is at $T1\infty$ and has a heat transfer coefficient h_1, and that on the side of the wall with temperature T_2 is at $T2\infty$ with heat transfer coefficient h_2, and that $T1\infty \geq t2\infty$. The hypothesis implies that $h1 \geq h2$. Since the surface does not store any heat energy, all the energy of heat, all the heat of the hot surface is formed to the cooling surface. energy conservation requires.

$$\nabla^2 T = 0$$

for a body that generates no heat or no heat stores. By applying the same to the case 1 -D with the direction of the x axis perpendicular to the surface of the wall is obtained

$$-k\frac{d^2T}{dx^2} = 0$$

On solving and putting the appropriate boundary conditions, (At x=0, $T = T_1$ and at x=L, $T = T_2$) we get a linear variation for T within the wall thickness.

$$T(x) = (T_2 - T_1)\frac{X}{L} + T_1$$

It is distributed within the wall and the temperature of varies linearly that the distance of the surface of a linear equation changes significantly. Since we have a change of temperature, the thermal conductivity can be calculated from the Fourier method.

$$q''_s = -k\,A\frac{dT}{dx} = \frac{k}{L}(T_1 - T_2)$$

it can be seen from the above equation , the heat flus is independent X is a constant. This example illustrates the standard method of solving a problem of conduction. First, the temperature profile with in the body is by using the energy conservation equation and the temperature equation is used to solve for the heat flux by plugging it into the right of the Fourier equation

IV. GOVERNING EQUATION

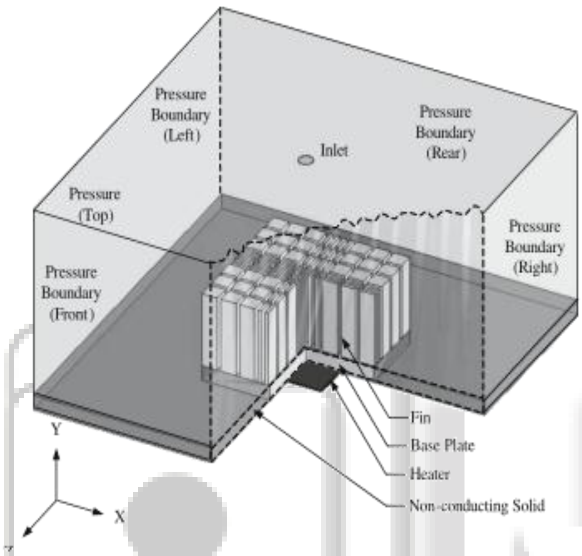

Fig. 1: Governing Equation

Time-Independent flow equation of with the turbulence is resolved. the equations governing CFD used to mathematically solve for fluid flow and heat transfer therefore, the equation governing the flow of fluid and heat transfer are the following form of the incompressible continuity equation, the three-dimensional Navier-Stokes turbulence and energy equation are solved numerically (using a scheme of finite-differences) combined with the continuity equation to simulate the flow field eddy viscosity model .A heat and turbulent is used to account for turbulence effects of .the flow is assumed to be stable. Incompressible, and in three dimensions. The heat transfer effect and buoyancy radiation are neglected. The schematic diagram of the geometry and of the computational domain is show in Fig. And these equations to be solved through software fluent. The equation governing three-dimensional mass momentum of the turbulent kinetic energy.

A. *Law Of Conservation Of Mass*

$$\frac{\partial \rho}{\partial t} + \nabla.(\rho\tilde{v}) = 0$$

B. *Momentum equation*

1) *X-momentum*

$$\frac{\partial(\rho u)}{\partial t} + \nabla.(\rho u v) = -\frac{\partial \rho}{\partial x} + \frac{\partial \tau_{xx}}{\partial x} + \frac{\partial \tau_{yx}}{\partial y} + \frac{\partial \tau_{zx}}{\partial z} + S_{Mx}$$

2) *Y-momentum*

$$\frac{\partial(\rho v)}{\partial t} + \nabla.(\rho v V) = -\frac{\partial \rho}{\partial y} + \frac{\partial \tau_{xy}}{\partial x} + \frac{\partial \tau_{yy}}{\partial y} + \frac{\partial \tau_{zy}}{\partial z} + S_{My}$$

3) *Z-Momentum*

$$\frac{\partial(\rho w)}{\partial t} + \nabla.(\rho w V) = -\frac{\partial \rho}{\partial z} + \frac{\partial \tau_{xz}}{\partial x} + \frac{\partial \tau_{yz}}{\partial y} + \frac{\partial \tau_{zz}}{\partial z} + S_{Mz}$$

4) *Energy Equation*

$$\frac{\partial(\rho h_0)}{\partial t} + \nabla.(\rho h_0 V) = -\rho\nabla.V + \nabla.(k\nabla T) + \emptyset + S_h$$

5) *Equation Of state*

$$P=\rho RT$$

C. *Computational Domain and Boundary Conditions For The System*

The mathematical simulation of the finned heat transfer pin system and the numerical simulation of the undersized pin fin system, depending on the dimensions of the pin fin heat sink, is studied using a (CFD) computational fluid dynamics technique. Analysis of the circular pin fin CFD analysis based on the maximum rate of heat transfer.

V. MODELING AND ANALYSIS

Modeling software Creo Parametric 1.0 creates geometry and the geometry is imported to the established Ansys 15.0, where the mesh is made and exports Fluent mesh. The Boundary conditions, material properties, and surrounding property is defined by the fluent file . Fixed a problem with the software to achieve the convergence limit is the number specified by the user to be implemented to achieve the iterations

The procedure to solve the problem is:

1) Create geometry.
2) Mesh the domain.
3) Define the material properties and boundary conditions.
4) Obtaining the solution

A. *Geometry Parameters of Heat Sink*

Fin No. N	Fin height. H(mm)	Fin Length L. (mm)	Fin thickness t. (mm)	Fin-to-fin distance ,ξ(mm)
3	10	50	1 to 0.8 as described in following cases	12.5

Table 1: Geometry Parameters of Heat Sink

Case	Height of pin fin (10 mm)	Velocity in (m/s)	Simulation Velocity	Base Temp. (K)	Temp Difference. (k)	Thermal Resistivity (K/W)	Pressure Difference(pa)	U	Nu
Case1	1 by 3	6.5	9.581057	311.368	11.368	1.1368	51.8	40.06301	1655.496
Cas	1 by 3	9.5	14.03369	308.9937	8.9937	0.89937	97.57922	44.56	1841.

e2									811	657
Case3	1 by 3	12.5	18.32926	307.606	7.606	0.7606	152.4734	47.66929	1969.805
Case4	1 by 2	6.5	10.28064	310.3106	10.3106	1.03106	60.39196	40.43726	1670.961
Case5	1 by 2	9.5	14.87422	307.4274	7.4274	0.7274	113.7211	44.46535	1887.411
Case6	1 by 2	12.5	19.41301	307.0139	7.0139	0.70139	176.0591	47.24597	1952.313
Case7	2 by 3	6.5	10.977785	309.353	9.353	0.9353	70.9341	40.67263	1680.687
Case8	2 by 3	9.5	15.61528	307.5157	7.5157	0.75157	131.1935	44.49615	1838.684
Case9	2 by 3	12.5	20.4019	306.46	6.46	0.646	201.5175	47.03553	1943.617

Table. 2: Dimensions of Circular Pin Fin

Case	**Height of pin fin(10 mm)**	**Velocity in (m/s)**	**Initial Temp.(K)**	**Base Temp.(K)**	**Temp Difference.(k)**	**Thermal Resistivity(K/W)**	**Pressure Difference (pa)**	**U**	**Nu**
3 cases	1to 3	6.5,9.5 and 12.5	T_1	T_2	$\Delta T = T_2 - T_1$	R=$\frac{\Delta T}{Q}$	ΔP= $P_{in} - P_{out}$	H=$\frac{q}{\Delta T}$	Nu=$\frac{hd}{ka}$
			300						

Table 3: Theoretical Analysis Table

VI. MODELLING AND ANALYSIS

We have take 9 cases to show vary with height of pin fin. And find out results from ansys software R 15.0 . like Thermal Resistivity, Nusselt Number , Pressure drop with respect to air Velocity.

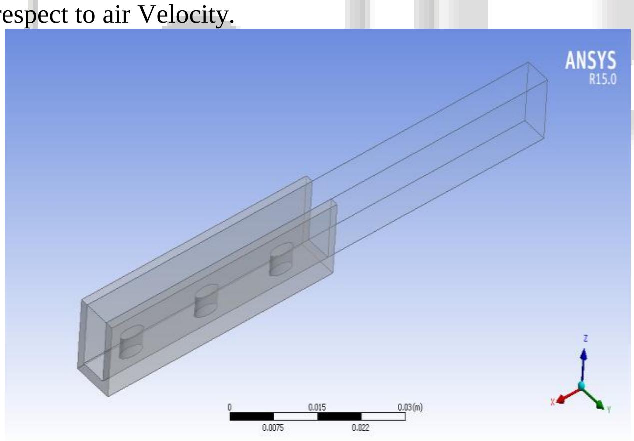

Fig. 2: (Case 1) 3D Model Of Circular Pin Of 4mm Dia Trapezoidal Fin Of Height 1 By 3 (10 Mm) Heat Sink

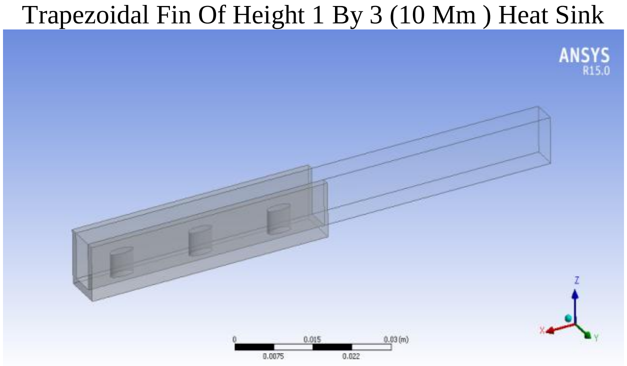

Fig. 3: (Case 2) 3D Model Of Circular Pin Of 4mm Dia Trapezoidal Fin Of Height 1 By 2 (10 Mm) Heat Sink

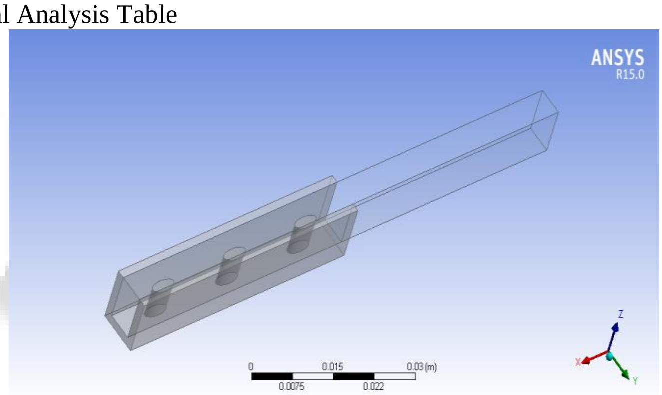

Fig. 4: (Case 3) 3D Model Of Circular Pin Of 4mm Dia Trapezoidal Fin Of Height 2 By 3 (10 Mm) Heat Sink

VII. MESHING OF THE DOMAIN

Experimental in the solid Para size (: .x-t) to the ANSYS 15.0 Workbench modular design. Then, define the field of air and the solid area . It for further processing . Definition of the mesh to the domain.

The second part of pre-processing is the mesh generation . After the model is imported to Ansys Workbench 15.0 R , then it is launched in the mesh module for the bulk of the mesh generation , medium, and fine mesh types are available. Here, we chose the relevant center and high fine mesh smoothing. CFD and physical preference . Mesh is the key element of a high quality solution. There are three types of mesh algorithms. These are.

1) Hexahedral Cartesian
2) Hexahedral Unstructured
3) Tetrahedral mashers.

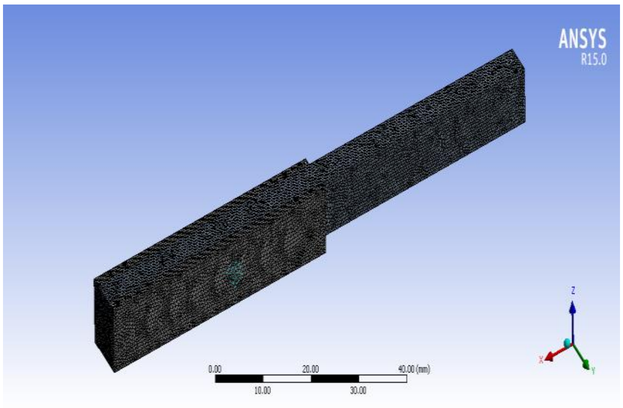

Fig. 5: (Case 1) Mesh Of Circular Fin Pin Heat Sink Model

A. *Steps in CFD Calculation*

CFD numerical algorithms can solve the problem code in the fluid. To facilitate access to their own power to solve all the commercial CFD software, including the input parameters of the problem, the complexity of the user interface and check the results. Therefore, all the code is composed of three main factors: the CFD calculations , there are three main steps

1) Pre- treatment
2) Resolution
3) The post-processing.

B. *Solving the CFD Problem*

The component that analysis and work the problem is called the CFD solver. It produces the required results in a non-interactive / batch process. A CFD problem is solved as follows.

1) The partial differential equations are integrated over all control volumes in the region of interest. This is equivalent to applying a fundamental law of conservation (for example, for mass or momentum) for each control volume.
2) These integral equations are converted into a system of algebraic equations by generating a set of approximations for the terms in the integral equations.
3) The algebraic equations are solved iteratively.

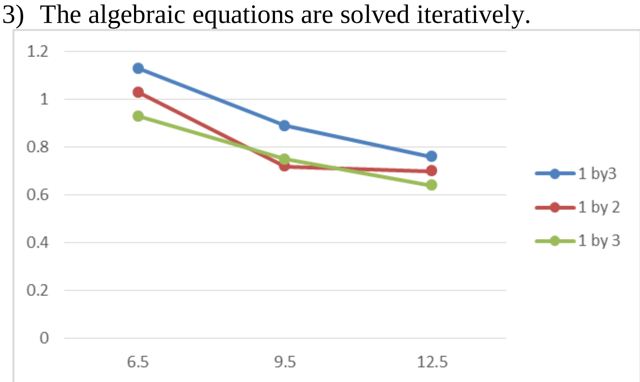

Fig. 6: Graph.1: Air Velocity-Thermal Resistance

	Pin fin height 10 mm		
Air velocity	1 by 3	1 by 2	2 by 3
6.5	1.13	1.03	0.93
9.5	0.89	0.72	0.75
12.5	0.76	0.70	0.64

Table 4: Thermal Resistance

The graph represents the relation between the thermal resistance and velocity of nine the cases, the lines shows the geometrical variation we have taken for the study. Series 1 is the validation case it is plane fin, All the above geometrical variation are compared the experimental data. The minimum value of the Thermal resistance is 0.64 .and pin height 2 by 3 and air velocity is 12.5 .

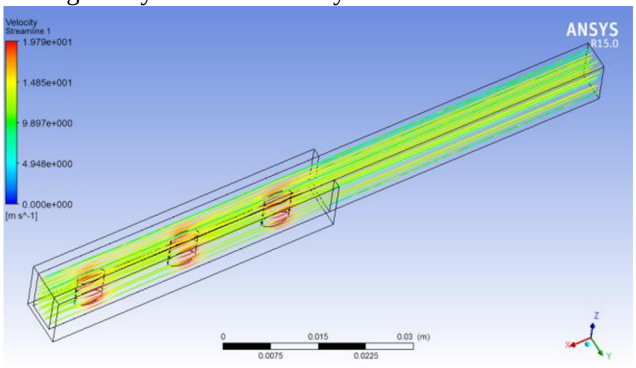

Fig. 6: Solving The CFD Problem

VIII. OBSERVATION TABLE

A. *Thermal Resistance*

Wind Velocity (m/s)	Experimental Result(1)	Simulation Results(2)	Simulation Results(3)	Simulation Results
6.5	1.35	1.79	1.82	1.13
9.5	1.15	1.47	1.46	0.89
12.5	0.925	1.22	1.24	0.76

Table 4: Experimental (1), Simulation (2) And (3), Simulation Result For The Plate Fin Heat Sink

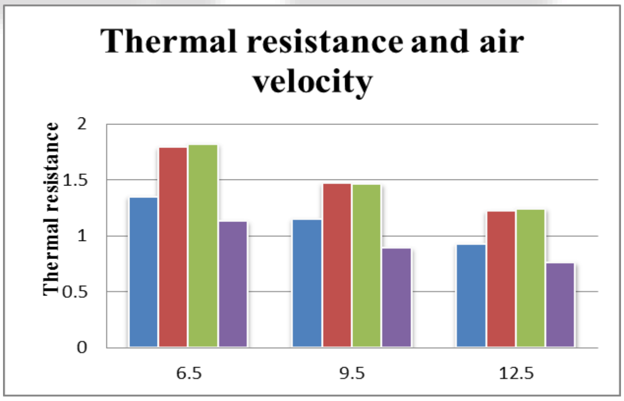

Fig. 7: Graph.2: Thermal Resistance and Air Velocity

B. *Pressure Drop*

Wind Velocity (m/s)	**Experimental Result(1)**	**Simulation Results(2)**	**Simulation Results(3)**	**Simulation Results**
6.5	20	23.3	20.80	27.546
9.5	37.5	40.6	37.22	41.08
12.5	56	59.5	57.37	76.845

Table 5: Experimental (1), Simulation (2) And (3), Simulation Result For The Plate Fin Heat Sink

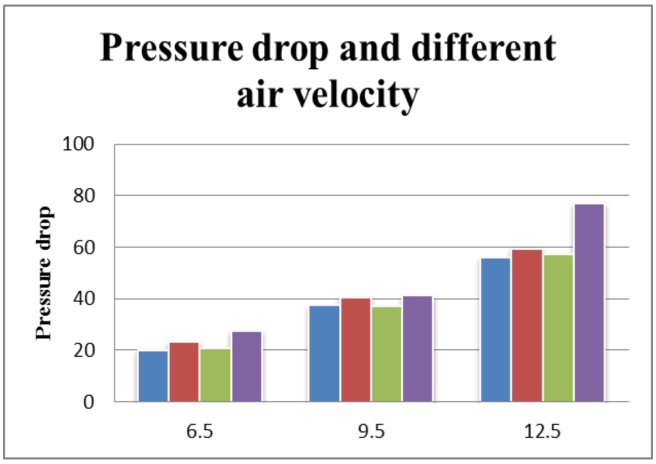

Fig. 8: Graph.3: Pressure drop and different air velocity

C. Nusselt Number

Wind Velocity (m/s)	Experimental Result(1)	Simulation Results(2)	Simulation Results(3)	Simulation Results
6.5	570	888.78	1397.38	1655.496
9.5	680	1026.95	1585.04	1841.657
12.5	750	1170.47	1730.00	1969.805

Table. 6: Experimental (1), Simulation (2) And (3), Simulation Result For The Plate Fin Heat Sink

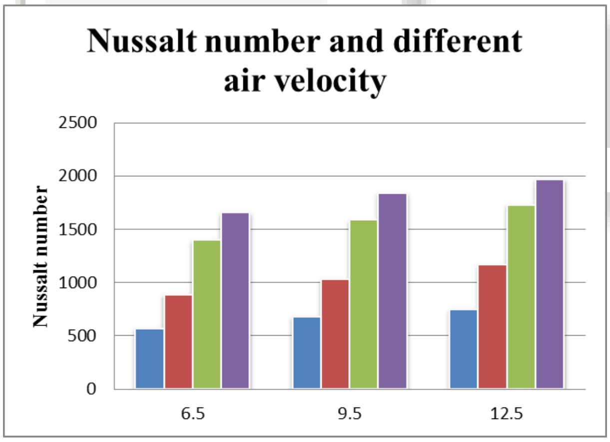

Fig. 9: Graph.4: Nussail number and different air velocity

IX. CONCLUSION

As we have realized in the results above thermal resistivity, Nusselts number, the heat transfer coefficient, pressure drop, we are here to conclude that the maximum pressure drop is (Case No. 9) 201.517 Pascal and the minimum pressure drop that is 51.80 Pascal (case 1), and as we saw with the maximum thermal resistance is 1.136 in (case no 1) and the minimum thermal resistance of to 0.646 (Case No. 9). Also one of our concentration by Nusselt number, the maximum value of Nusselt number in 1969.805 (case 3) .and Nusselt Min value not in 1,655,456 (case no 1) .Similarly Max. value of the heat transfer coefficient is 47.66 (case no 3) and a minimum heat transfer coefficient in 40.06301 (Case no 1). This discussion will lead us to understand the best combination of fin arrangement. Most values in our favor arrives (case 3). That is Pin height 1 by 3 at 12.5 m/s velocity with small consideration of Pressure drop 50 Pascal higher than (case no 9) but thermal resistance is 0.76 in place of 0.646.

X. REFERENCES

[1] http://www.techterms.com/defination

[2] http://en.wikipedia.org//wiki/heatsink

[3] mr. Yue-Tzu Yang-2009 " INVESTIGATION OF PLANTED PIN FINS FOR HEAT TRANSFER ENHANCEMENT IN PLATE FIN HEAT SINK" Elsevier Ltd, (2009) 163–169 Elsevier Ltd

[4] mr. Irfan Vohra1, Mohammad Azim Aijaz, Dr. B. B. Saxena -2014" CFD ANALYSIS OF CYLINDRICAL PIN WITH TRAPEZOIDAL FIN HEAT SINK USING ANSYS FLUENT 14.0" International Journal of Emerging Technology and Advanced Engineering Volume 4, Issue 5, May 2014

[5] yue-Tzu yang, Haun-sen peng-2009"NUMERICAL STUDY OF THE HEAT SINK WITH UN-UNIFORM FIN WIDTH DESIGN" Elsevier Ltd, (2009)3473-3480 Elsevier Ltd

[6] R.Mohan and Dr. P. Govindarajan-2010 "THERMAL ANALYSIS OF CPU WITH COMPOSITE PIN FIN HEAT SINKS" International Journal of Engineering Science and Technology Vol. 2(9), 2010, 4051-4062

[7] Amol B. Dhumne, Hemant S. Farkade-2013 "HEAT TRANSFER ANALYSIS OF CYLINDRICAL PERFORATED FINS IN STAGGERED ARRANGEMENT" International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN: 2278-3075, Volume-2, Issue-5, April 2013 225

[8] B.Sri Aravindh Dr.T.R.Gopalakrishnan Nair-2008 " HEAT SINK PERFORMANCE ANALYSIS THROUGH NUMERICAL TECHNIQUE" IEEE Symposium (NSSP08), Bangalore, 2008

[9] Bill L. Schmidt Christopher L. Chapman, and Seri Lee-"Thermal Performance Of An Elliptical Pin Fin Heat Sink"

[10] Sukhvinder Kang Aavid Thermalloy NH Maurice Holahan-2003 "THE THERMAL RESISTANCE OF PIN FIN HEAT SINKS IN TRANSVERSE FLOW" International Electronic Packaging Technical Conference and Exhibition, inter Pack2003-35104

[11] W. A. Khan, J. R. Culham, and M. M. Yovanovich-2001 "OPTIMIZATION OF PIN-FIN HEAT SINKS USING ENTROPY GENERATION MINIMIZATION" Microelectronics Heat Transfer Laboratory Department of Mechanical Engineering.

[12] Yoav Peles, Ali Kos_ar, Chandan Mishra, Chih-Jung Kuo, Brandon Schneider-2005 "FORCED CONVECTIVE HEAT TRANSFER ACROSS A PIN FIN MICRO HEAT SINK" Elsevier Ltd ,International Journal of Heat and Mass Transfer 48 (2005) 3615–3627.

[13] A Diani, S Mancin, C Zilio1 and L Rossetto" EXPERIMENTAL AND NUMERICAL ANALYSES OF DIFFERENT EXTENDED SURFACES" department of Ingegneria Industriale, university of Padova, via Venezia 1, 35131

[14] Michael E. Lyall-2006 "HEAT TRANSFER FROM LOW ASPECT RATIO PIN FINS"

[15] Abel M. Siu-Ho, Weilin Qu-2006 "PRESSURE DROP AND HEAT TRANSFER IN A SINGLE-PHASE MICRO-PIN-FIN HEAT SINK" 2006 ASME International Mechanical Engineering Congress and Exposition, IMECE2006-14777.
[16] Seri Lee 1995"OPTIMUM DESIGN AND SELECTION OF HEAT SINKS" 03247-ieee-1995
[17] S. Rangadinesh, M. Rajasekar, S. Arunkumar and M. Venkatesan,-2014 "EXPERIMENTAL AND NUMERICAL ANALYSIS ON HEAT TRANSFER CHARACTERISTICS OF SHOE BRUSH-SHAPED FINS" SCIENCE, VOL. 106, NO. 1414 10, 25 MAY 2014