Enhancement of Thermal Performance of Microchannel Heat Sink Used in Computer SMPS Fins by using CFD

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Abstract— In this research article various types of fin geometry were analyzed numerically to improve the heat transfer performance of microchannel heat sink of a computer SMPS fins. For numerical analysis a parallel plate fins portion of SMPS fins were taken with standard size. The geometry was modeled in Ansys fluent 14.0 and heat transfer rate evaluation were done with using steady state pressure based fluent solver. Some standard boundary and flow conditions were given for analysis. Then comparative analyses were done using square and circular pin fins. Aluminum, copper and nickel were used as materials. It was fond that replacing parallel plate fins with square and circular cross section fins with aluminum, copper and nickel material gives appreciable increase in thermal performance within appreciable volume of material. It was deduced that use of square and circular pin fins enhances heat transfer performance of heat sink.

Key words: CFD, Microchannel Heat Sink, SMPS Fins

I. INTRODUCTION

Now a day's its becoming more and more important to make electronic devices slim and compact with no compromise in its operational and thermal performance. Since there is a limited quantity of space available for heat transfer its quite challenging for manufacturer to maintain thermal performance of the integrated system within certain acceptable standards. It's a quite challenging task for manufacturer to utilize available space or surface area to produce proper amount of heat transfer by heat sink installed in it. For this purpose manufacturer uses different kind of fin geometries available such as rectangular, square, circular, trapezoidal, hexagonal etc to maintain the proper amount of heat transfer. Sometimes they made changes in the material configuration also to get proper heat transfer performance. Various kinds of technologies are now a day's available that can be used to enhance the thermal performance of heat sink such as layer and double layer heat sink. Use of nano fluids for heat dissipation is quite popular now days. They can absorb an appreciable amount of heat from the required space. Sometimes flow conditions can be changed such as straight flow, cross flow to get the high thermal performance. Specific entropy generation minimization, pressure drop, thermal resistances are other parameters to get the desired thermal performance. It's a very necessary aspect of electronic industry to design their products with certain desirable thermal performance of the equipment since it will have to survive in the changeable atmospheric conditions. It becomes more necessary to design the electronic component with standard thermal performance since its related with human life. If it's warming up to much, it may burst and cause a serious injury to human being around it. So it's related with human safety that enforces manufacturers to not compromising from its thermal performance.

II. METHODOLOGY

A. *Geometry parameters of parallel plate fins in mm:*

Its parameters are as follows

1) Base plate (its dimension will be same for square and circular pin fins)
   Material –aluminum, copper and nickel in case 1, 2 & 3 respectively
   Origin – (1, 0, 1)
   Dimension – (60, 1, 13)
2) Parallel plate straight Fins
   Material –aluminum, copper and nickel in case 1, 2 & 3 respectively
   Origin- (1, 1, 1)
   Dimension – (60, 10, 1), Offset - 3 mm.

The figure shown below is the geometry of parallel plate fins of computer SMPS modeled in Ansys fluent 14.0

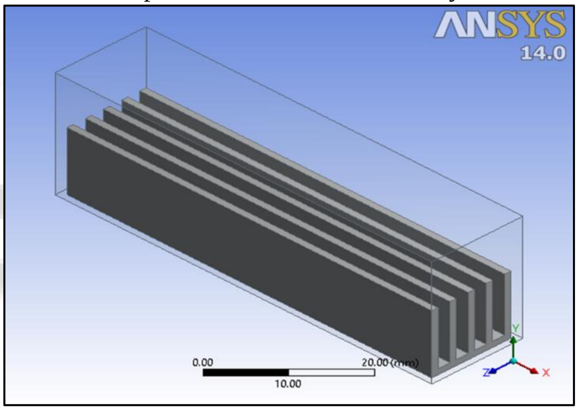

Fig. 2.1.1: Parallel plate fins of CPU SMPS

B. *Geometry parameters of square pin fins in mm:*

Its parameters are as follows

1) Square pin fins
   Material –aluminum, copper and nickel in case 1, 2 & 3 respectively
   Origin- (1.25, 1, 2)
   Dimension – (1.25, 10, and 1.25), Offset – 2.3 & 2 mm in x & z direction

The figure shown below is the geometry of square pin fins of computer SMPS modeled in Ansys fluent 14.0

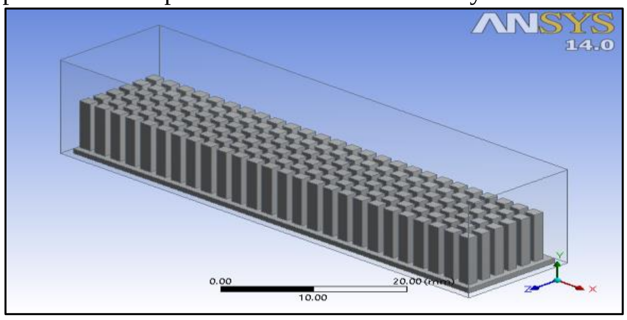

Fig. 2.1.2: geometry of square pin fins

C. Geometry parameters of circular pin fins in mm:

Its parameters are as follows

1) Circular pin fins

Material –aluminum, copper and nickel in case 1, 2 & 3 respectively

Origin- (2, 2, 1), base plane -zx

Dimension – height of fin =10mm & radius=1 mm.

The figure shown below is the geometry of circular pin fins of computer SMPS modeled in Ansys fluent 14.0

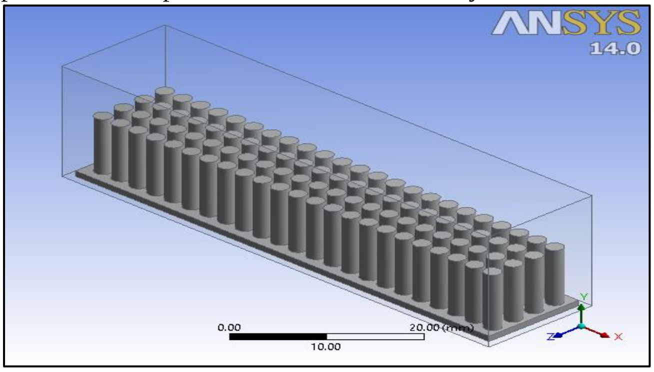

Fig. 2.1.3: Geometry of circular pin fins

D. Meshing:

The below Figure is showing the meshing of the fin arrangement of square fins with base plate. Meshing is done on fluent using following meshing conditions.

– Advanced size function – on: curvature
– Relevance center – coarse
– Initial size feed – active assembly
– Transition – slow
– Smoothing – medium

The figure shown below is the meshing of parallel plate fins of computer SMPS modeled in Ansys fluent 14.0

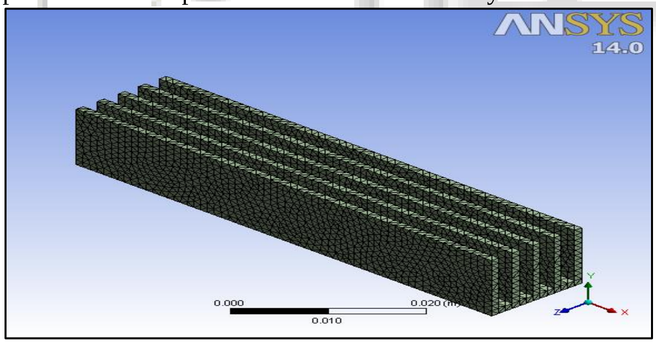

Fig. 2.2.1: meshing of parallel plate fins of SMPS

The figure shown below is the meshing of square pin fins modeled in Ansys fluent 14.0

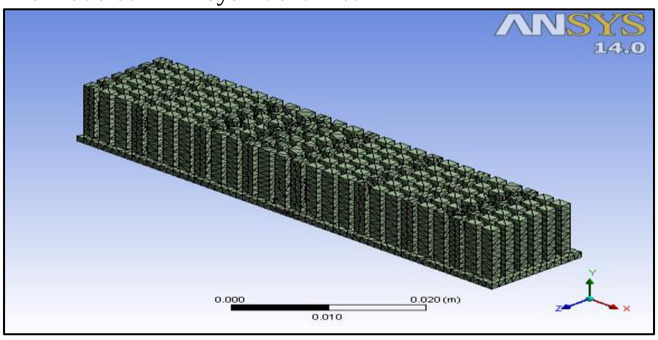

Fig. 2.2.2: meshing of square pin fins

The figure shown below is the meshing of circular pin fins modeled in Ansys fluent 14.0

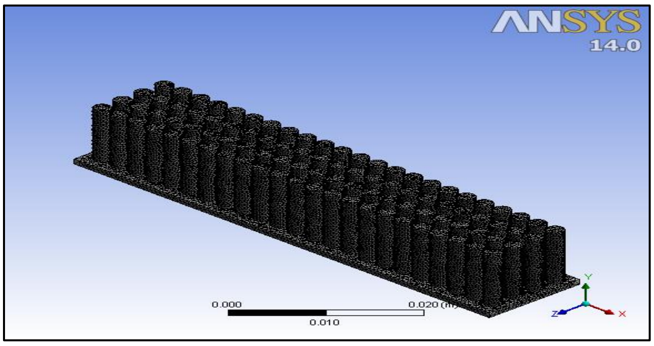

Fig. 2.2.3; meshing of circular pin fins

E. Solution Setup:

The below table is showing the boundary conditions and details of thermal model, which will be used in the fluid flow analysis .The solution is analyzed in Ansys fluent 14.0.

Table 2.3 showing solution setup for Aluminum, Copper & Nickel respectively.

Boundary Conditions	velocity at inlet = 10 m/s Pressure outlet (gauge pressure) = 0 Temperature at the fin base =358 k Temperature at the air outlet = 330 k Atmospheric temperature = 303 k
General	Solver – pressure based Time – steady Velocity formulation – absolute Gravity – 9.81m/s^2
Models	Energy Equation – on Standard K- epsilon model

Table 2.3: solution setup for Aluminum, Copper & Nickel respectively.

III. Results

A. Results of parallel plate fins:

1) The figure shown below shows the variation of temperature from the parallel plate fins .it is visible that temperature decreases from fin base plate to the top of fins with materials aluminum, copper and nickel respectively:

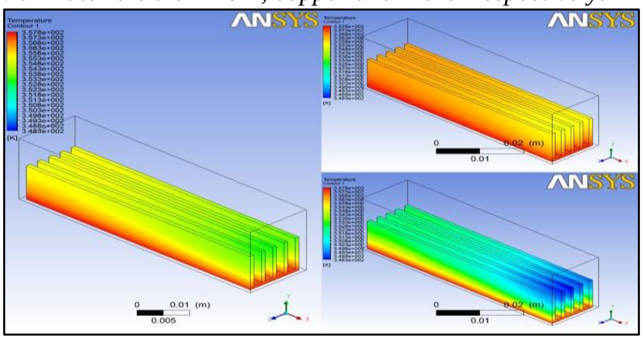

Fig. 3.1.1: temperature variation in parallel plate fins

2) The figure shown below shows the variation of total pressure from the parallel plate fins. It is visible that how *total pressure varies along fins with materials aluminum, copper and nickel respectively:*

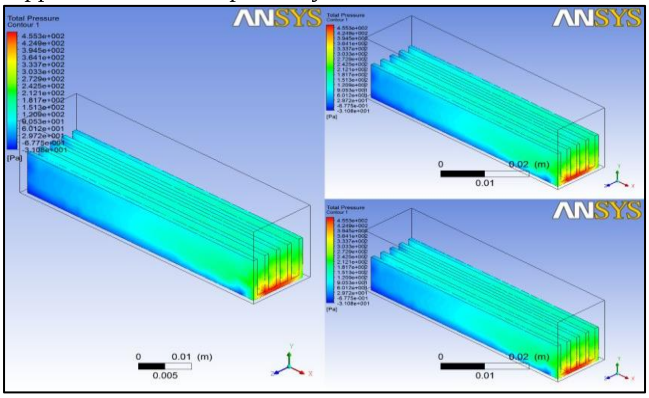

Fig. 3.1.2: variation of total pressure in parallel plate fi

B. Results of square pin fins:

***1)** The figure shown below shows the variation of temperature from the square pin fins .it is visible that temperature decreases from fin base plate to the top of fins with materials aluminum, copper and nickel respectively.*

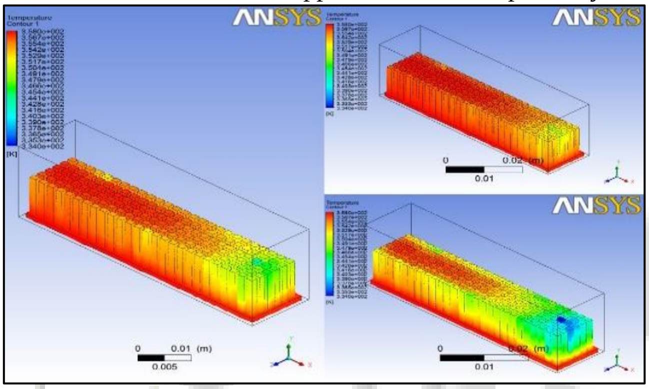

Fig. 3.2.1: temperature variation in square pin fins

2) The figure shown below shows the variation of total pressure from the square pin fins. It is visible that how total pressure varies along fins with materials aluminum, copper and nickel respectively.

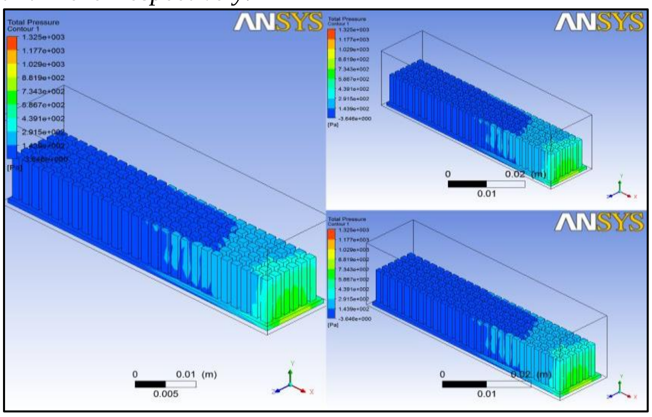

Fig. 3.2.2: variation of total pressure in square pin fins

C. Results of circular pin fins:

***1)** The figure shown below shows the variation of temperature from the circular pin fins .it is visible that temperature decreases from fin base plate to the top of fins with materials aluminum, copper and nickel respectively.*

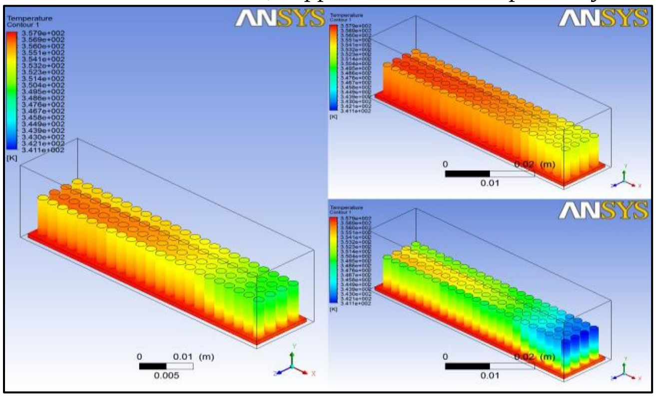

Fig. 3.3.1: temperature variation in circular pin fins

2) The figure shown below shows the variation of total pressure from the circular pin fins. It is visible that how total pressure varies along fins with materials aluminum, copper and nickel respectively.

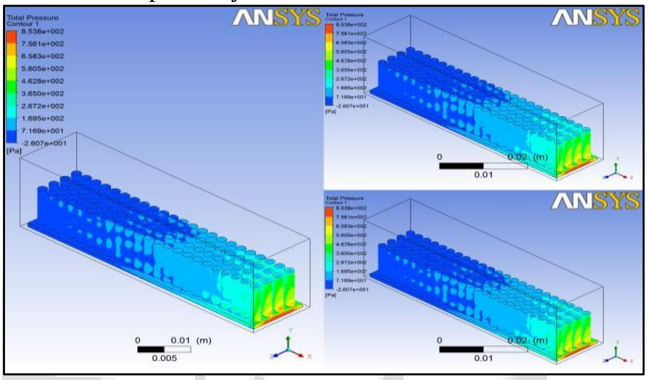

Fig. 3.3.2: variation of total pressure in circular pin fins

IV. HEAT TRANSFER RATE (WATTS) AND MATERIAL VOLUME (MM^3)

material	Parallel plate fins	Square pin fins	Circular pin fins
Volume (mm^3)	3780	3705	3670
aluminum	37.515202	38.014256	41.965469
copper	38.272701	39.258144	43.154442
nickel	35.764442	35.354595	39.295315

Table 1:

V. CONCLUSION

In this research article we have done numerical solution for heat transfer rate enhancement of parallel plate fins used in SMPS of CPU using Ansys Fluent 14.0. Parallel plate fins were replaced by square and circular pin fins with less volume as compared to parallel plate fins. It was found that both square and circular pin fins gives appreciable increase in heat transfer rate with aluminum and copper materials. Nickel is also very near around the desired results that can be achieved with some geometrical and flow modifications in the analysis. So square and circular pin fins with aluminum and copper can be surely used in CPU SMPS fins to increase the thermal performance of the microchannel heat sink of CPU SMPS.

References

[1] Ravi Mahajan, "Cooling a Microprocessor Chip", *Proceedings of the IEEE* , Vol. 94, No. 8, August 2006.
[2] Jason D. Carr, "An Examination of CPU Cooling Technologies", *Thermal Management Options for Engineers*, 2013.
[3] Jin Zhao , Shanbo Huang , Liang Gong and Zhaoqin Huang , "Numerical study and optimizing on micro square pin-fin heat sink forelectronic cooling ", *Applied Thermal Engineering* (2015),1-13.
[4] Shadlaghani, M. R. Tavakoli, M. Farzaneh and M. R. Salimpour , "Optimization of triangular fins with/without longitudinal perforate for thermal performance enhancement", Journal of Mechanical Science and Technology ,30 (4) (2016) 1903-1910.
[5] Manish Belwanshi, N.D. Pal and Jitendra Pandey , "Thermal Performance Analysis of Square Crossection Aluminum Fins for using in Microchannel Heat Sink via CFD", *international journal of research in aeronautical and mechanical engineering*, volume 4, issue 4, pages 98-107, april 2016.
[6] Guilian Wang, Di Niu, Fuqiang Xie, Yan Wang, Xiaolin Zhao and Guifu Ding, "Experimental and numerical investigation of a microchannel heat sink (MCHS) with micro-scale ribs and grooves for chip cooling", *Applied Thermal Engineering* , 85 (2015) 61-70.
[7] *Abhishek Tripathi and Ajay Kumar Singh, "*CFD prediction of pressure drop & thermal performance in 36 solid circular finned tube bundles positioned at inline arrangement, staggered arrangement & crinkled 45° arrangement*" International Journal of Innovation and Scientific Research,* Vol. 16 ,1 Jun. 2015, pp. 225-238.
[8] S. Rangadinesh, M. Rajasekar, S. Arunkumar and M. Venkatesan, "Experimental and numerical analysis on heat transfer characteristics of shoe brush-shaped fins" ,*current science*, vol. 106, no. 1414 10, 25 may 2014.
[9] Dr. Ali A. F. Al Hamadani and Dr. Abbas Jassim Jubear, "Numerical Simulation of Natural Convection Heat Transfer from Interrupted Rectangular Fins", *Journal of Engineering*, Volume 21 ,October 2015.
[10] Guodong Xia , Dandan Ma, Yuling Zhai, Yunfei Li, Ran Liu and Mo Du, "Experimental and numerical study of fluid flow and heat transfer characteristics in microchannel heat sink with complex structure", *Energy Conversion and Management* ,105 (2015) 848–857.
[11] Anant Joshi and D GKumbhar, "Analysis of Heat Transfer From Horizontal Rectangular (Square Notched) Fin Arrays by Natural Convection", *International Journal of Engineering Innovation & Research*,Volume 4, Issue 1, ISSN: 2277 – 5668, 2014.
[12] Kavita H. Dhanawade, Vivek K. Sunnapwar and Hanamant S. Dhanawade, " Thermal Analysis of Square and Circular Perforated Fin Arrays by Forced Convection" , *International Journal of Current Engineering and Technology*, 2014.
[13] Mahdi Tavana, Oveis Pourmehran, Akbar Aghaei khasraghei, Mofid Gorji Bandpy and Jafar Alipour Sangarab, "Numerical Analysis of Fluid Flow and Heat Transfer in Microchannels with Various Internal Fins", *International Journal of Artificial Intelligence and Mechatronics*,Volume 3, Issue 4, ISSN 2320 – 5121, 2015.
[14] Qie Shen, Daming Sun , Ya Xu, Tao Jin and Xu Zhao, "Orientation effects on natural convection heat dissipation of rectangular fin heat sinks mounted on LEDs", *International Journal of Heat and Mass Transfer*, 75 , 462–469, 2014.
[15] Yen-Tso Chang, Han-Ching Lin, Chi-Jui Huang, Chun-Hsien Chen, Chien-Jen Lin and Go Long Tsai, " Heat Transfer Analysis of Plate-fin Heat Sink with Piezoelectric Fan" *Universal Journal of Mechanical Engineering* ,3(1), 12-20, 2015.
[16] Jae-Mo Koo, Sungjun Im & Linan Jiang, "Integrated Microchannel Cooling for Three-Dimensional Electronic Circuit Architectures", *Journal of Heat Transfer*, january 2005, Vol. 127 .