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Comparative study of heat sink without shield and heat sink with shield using CFD analysis

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Abstract: *The whole idea of this study is to compare heat sink without shield and heat sink with shield used in electronic cooling system. The study is based on the principle of Computational fluid dynamics (CFD) in which the flow of fluid is taken into consideration for study. For the purpose of study heat sink with optimal geometric parameter such as fin height, fin thickness, base height, fin pitch as 48 mm, 1.6 mm, 8mm, 4mm are modeled and also the shield is provided to this heat sink with trapezoidal shape. The simulation is done on models with the parameters like heat load of 75W and with air velocity of 4.717 m/s and inlet temperature is taken as 295 K etc. The simulation is carried out with a commercial package provided by fluent incorporation. The thermal performances of the heat sinks are only considered in the study. Nowadays technological development is done considering the performance of device; whether it is a normal computer or laptop or the rack server we need everything that can be work at its best, so here the thermal equivalency plays major role as you cannot allows overheating of device. So in this paper the effort are taken to enhance the heat dissipation efficiently.*

Keywords: *Heat Sink, Pressure Drop, Shield, Surface Nusselt Number, Temperature.*

I. Introduction

In general heat sink is the component which is used in cooling system of electronic devices. The proper functioning of any electronic device is basically depends on how effectively it handle the heat produced within its self. Thus the extended surfaces or fin are playing a major role to dissipate the heat and allow working the device for more time. Also the effective heat dissipation gives better life to device and hence designing of heat is crucial subject in matters to develop any electronic device.

In order to design an effective heat sink, some criterions such as a large heat transfer rate, a low pressure drop, high heat transfer coefficient, lowest maximum temperature attained, high surface Nusselt number, an easier manufacturing, a simpler structure, a reasonable cost and so on should be considered. The optimal geometric parameter is as per [3]. And the material of the construction is taken aluminum as Aluminum has a thermal conductivity of 235 watts per Kelvin per meter (W/MK). Aluminum is also cheap to produce and is lightweight. When a heat sink is attached, its weight puts a certain level of stress on the motherboard, which the motherboard is designed to accommodate. Yet the lightweight make up of aluminum is beneficial because it adds little weight and stress to the motherboard.

Also in general it has been proved that the shield provided to general components gives better performance than without shield components. Thus the efforts are taken in this study to find whether shielding provide better heat dissipation or not in case of heat sink used in electronic cooling system.

II. Objective Of Work

1) The main objective of work is:-
2) To evaluate the shielding effect holds for heat sink.
3) To predict temperature distribution along the channel.
4) To predict temperature profiles for heat input of 75w applied to heat sink.
5) To compare the result between the heat sink having shield and heat sink without shield.

1. Procedure for CFD Calculation

CFD codes are structured around the numerical algorithms that can be tackle fluid problems. In order to provide easy access to their solving power all commercial CFD packages include sophisticated user interfaces input problem parameters and to examine the results. Hence all Codes contain three main elements: In CFD calculations, there are three main steps

1. Pre-processing.
2. Solver
3. Post processing.

1.1 CFD Governing Equations Solve By Fluent

This section is a summary of the governing equations used in CFD to mathematically solve for fluid flow and heat transfer, based on the principles of conservation of mass, momentum, and energy. These equations solve by the fluent software. The conservation laws of physics form the basis for fluid flow governing equations[9].

Law of Conservation of Mass

$$\frac{\partial \rho}{\partial t} + \nabla.(\rho \vec{V}) = 0 \quad \text{…. (1)}$$

Momentum Equations

X-Momentum:-

$$\frac{\partial(\rho u)}{\partial t} + \nabla.(\rho u \vec{V}) = -\frac{\partial p}{\partial x} + \frac{\partial \tau_{xx}}{\partial x} + \frac{\partial \tau_{yx}}{\partial y} + \frac{\partial \tau_{zx}}{\partial z} + S_{Mx} \quad \text{…. (2)}$$

Y-Momentum:-

$$\frac{\partial(\rho v)}{\partial t} + \nabla.(\rho v \vec{V}) = -\frac{\partial p}{\partial y} + \frac{\partial \tau_{xy}}{\partial x} + \frac{\partial \tau_{yy}}{\partial y} + \frac{\partial \tau_{zy}}{\partial z} + S_{My} \quad \text{…. (3)}$$

Z-Momentum:-

$$\frac{\partial(\rho w)}{\partial t} + \nabla.(\rho w \vec{V}) = -\frac{\partial p}{\partial z} + \frac{\partial \tau_{xz}}{\partial x} + \frac{\partial \tau_{yz}}{\partial y} + \frac{\partial \tau_{zz}}{\partial z} + S_{Mz} \quad \text{…. (4)}$$

Energy Equation:-

$$\frac{\partial(\rho h_0)}{\partial t} + \nabla.(\rho h_0 \vec{V}) = -p \nabla.\vec{V} + \nabla.(k \nabla T) + \Phi + S_h \quad \text{…. (5)}$$

Equations of State:

$$p = \rho R T \quad \text{…. (6)}$$

Where ρ is the density, *u, v* and *w* are velocity components, *V* is the velocity vector, *p* is the pressure, *S* terms are the source terms and terms are the viscous stress components which are defined for a Newtonian fluid as.

$$\tau_{xx} = \lambda\left(\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z}\right) + 2\mu \frac{\partial u}{\partial x} \quad \text{…. (7)}$$

$$\tau_{yy} = \lambda\left(\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z}\right) + 2\mu \frac{\partial v}{\partial y} \quad \text{…. (8)}$$

$$\tau_{zz} = \lambda\left(\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z}\right) + 2\mu \frac{\partial w}{\partial z} \quad \text{…. (9)}$$

$$\tau_{xy} = \tau_{yx} = \mu\left(\frac{\partial u}{\partial y} + \frac{\partial v}{\partial x}\right) \quad \text{…. (10)}$$

$$\tau_{xz} = \tau_{zx} = \mu\left(\frac{\partial u}{\partial z} + \frac{\partial w}{\partial x}\right) \quad \text{.... (11)}$$

$$\tau_{yz} = \tau_{zy} = \mu\left(\frac{\partial v}{\partial z} + \frac{\partial w}{\partial y}\right) \quad \text{.... (12)}$$

III. Modeling And Analysis

The procedure for solving the problem is:

- Create the geometry.
- Mesh the domain.
- Set the material properties and boundary conditions.
- Obtaining the solution

Modeling software CATIA V5 R19 creates the geometry and the geometry is imported to the ANSYS workbench 14.0 where meshing is done, and exports the mesh to FLUENT. The boundary conditions, material properties, and surrounding properties are set through parameterized case files. FLUENT solves the problem until either the convergence limit is met, or the number of iterations specified by the user is achieved.

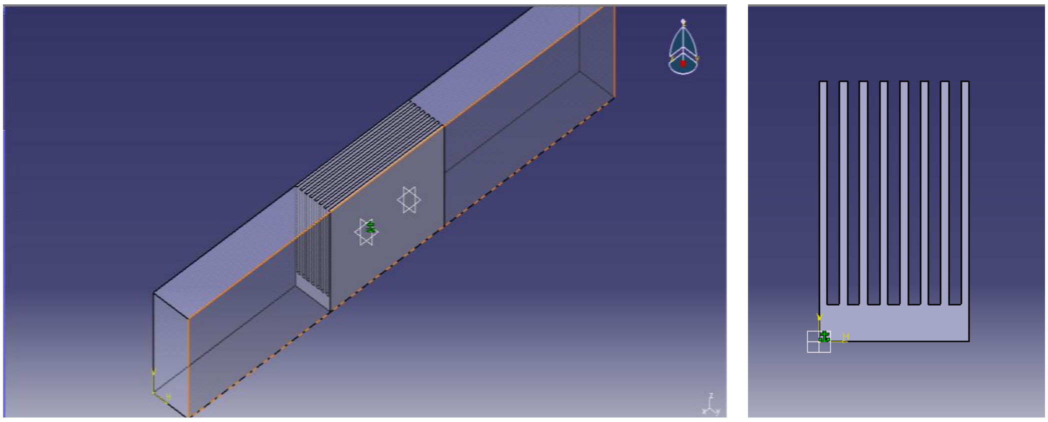

Fig. 1- Model of heat sink with air domain.

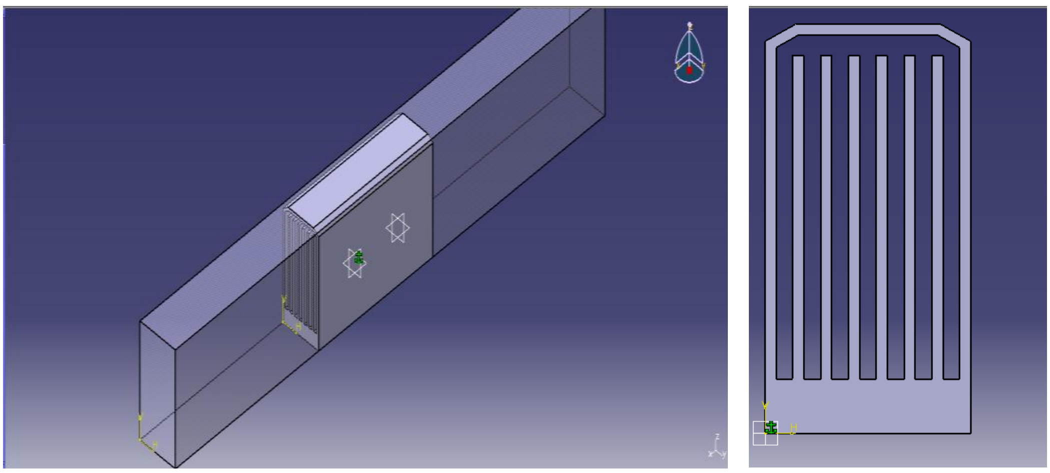

Fig. 2- Heat sink with trapezoidal shield.

IV. Results and Discussions

Table -1 Results

Parameter Considered	Heat sink without shield.		Heat sink with trapezoidal shield.	
Heat Input	75w	100w	75w	100w
Lowest Maximum Temperature (k)	334.054	345.380	331.53	343.383
Pressure Drop (pa)	25.56	17.921	28.831	24.601
Surface Heat Transfer Coefficient	24.533	19.879	25.425	26.088
Surface Nusselt Number	1013.76	821.448	1050.565	1078.488
Thermal Resistance (k/w)	0.520	0.503	0.48	0.488

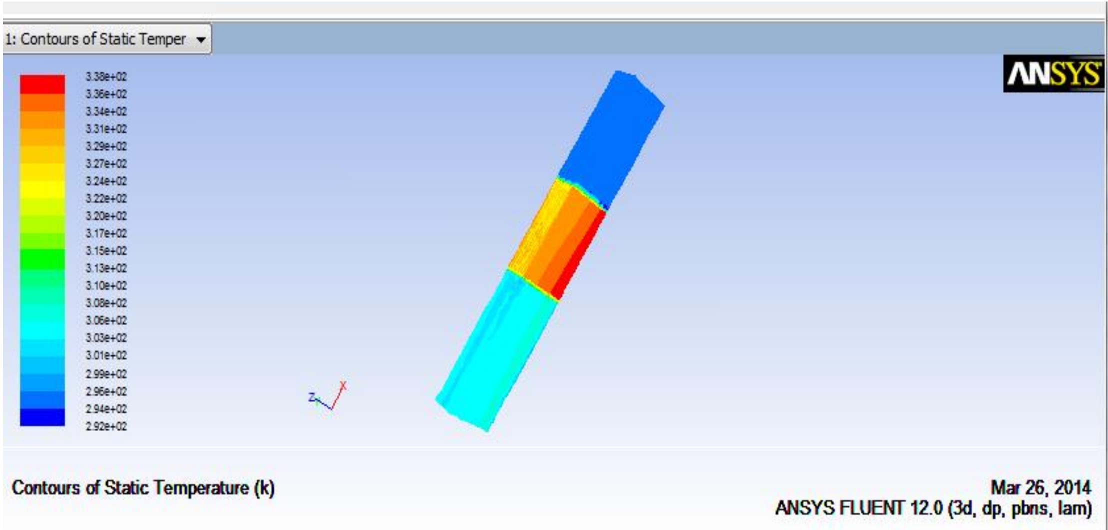

Fig. 3- Contour plot of temperature of heat sink without shield.

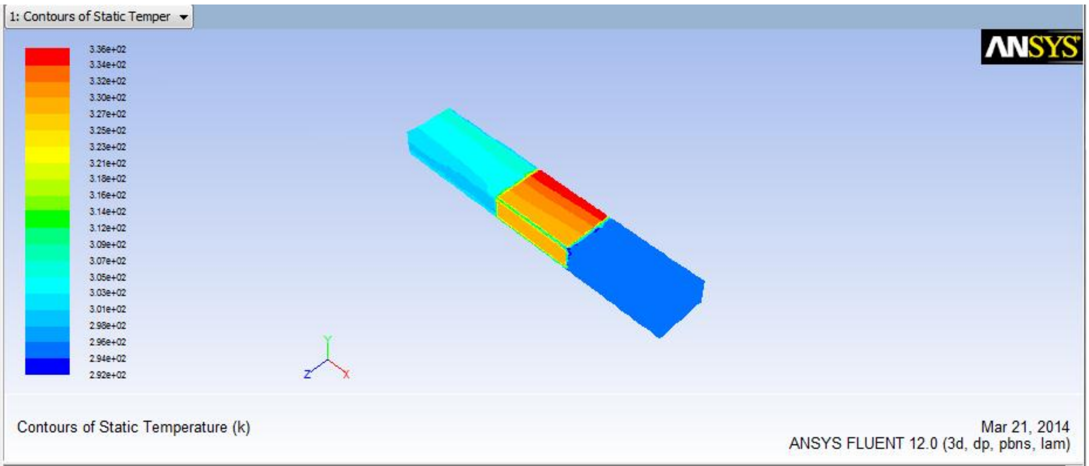

Fig. 3-Contour plot of temperature of heat sink with trapezoidal shield model.

V. Conclusion

From the study of the model and simulation it is concluded that by considering the maximum lowest temperature of the heat sink with trapezoidal shield is lower than that of the heat sink without shield by certain Kelvin. Thus the main objective of this study is satisfied. Also it proves that the shielding gives better result for heat sink used in electronic cooling.

Heat transfer coefficient and surface Nusselt number is Maximum in “Trapezoidal shielded heat sink” than that of without shield heat sink for heat loads of 75W, 100W. As per the criterion for the selection of heat sink, the heat sink should have maximum heat transfer coefficient, lowest thermal resistance. The “Trapezoidal shielded heat sink” shows the better heat transfer coefficient and lowest thermal resistance k/w. From the calculated values we can find that the best configuration for this type of convective heat transfer of a heat sink is a heat sink with TRAPEZOIDAL SHIELDED HEAT SINK as they have the highest total heat transfer rate and it has the lowest maximum temperature attained compared to without shield heat sink. Also improved surface Nusselt number along with highest surface heat transfer coefficient for a given heat load of 75w, 100W. The Trapezoidal Shape shield gives better result for heat transfer as earlier shown by [8] [9].

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