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Optimization of Heat Transfer Process Parameters for Heat Sink using CFD

Yogesh Kumar[1], N. V. Saxena[2]

[1]Research Scholar, [2]Assistant Professor,

[1,2]Department of Mechanical Engineering, Millennium Institute of Technology, Bhopal, Madhya Pradesh, India

ABSTRACT

As secondary source of heat transfer, heat sinks are primarily used. Heat generated by various equipments is first transferred to heat sink via conduction, after that heat is transferred to the environment. Heat sinks are thus used to maintain temperature of equipments under desirable range. CFD has recently emerged as an effective tool to judge performance of any equipment in design phase. CFD can also be used for design optimisation of heat sink also. In the present work, CFD analysis of heat sink has been carried out to find out the effect of change in air velocity. Effect of different materials used for the construction of heat sink on heat transfer (aluminium alloys that is AA-6063, AA-6061, AA-6060 and AA-1050) has been carried out. It has been found that material AA-1050 shows the maximum heat transfer as compared to other materials. The work has also been carried out for various thicknesses of base metals. It has been found that heat sink having 10 mm base thickness has maximum heat transfer.

KEYWORDS: *Heat sink, Velocity, Heat transfer, Computational fluid dynamics, Base thickness*

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INTRODUCTION

In electrical and electronic gadgets, heat is additionally produced which needs to be rejected to keep the gadget safe and in proper working condition. This work can easily be done by the use of heat sinks. Heat is absorbed by the heat sinks and then rejected to the atmosphere leading to proper functioning of the equipments and increasing their life.

With time Computational Fluid Dynamics (CFD) has emerged as a powerful tool to predict the performance of any equipment in design phase. CFD can also be used for performance prediction of heat sinks. CFD uses the basic principles of fluid flow and solves the equations to get the approximate solution to a problem.

A lot of work has been done in recent past. And there is further scope of research.

LITERATURE REVIEW

K. J. Craig, et al. [1] described the use of CFD and numerical optimization techniques to reduce heat sink mass. D. R. S. Raghuraman et al. [2] carried out a numerical study to investigate increase in the heat transfer process and fluid flow characteristics for heat sinks. Jiandong Zhou et al. [3] designed a sinusoidal wavy structure of micro-channel heat sink for cooling of compact electronic devices. Kyoungwoo Park et al., [4] numerically tried to reduce the pressure loss because of maximum temperature and geometric constraints. ZhouJian-hui et al., [5] found out a multi-parameter constrained optimization procedure to design the plate finned heat sinks. Shao Baodong et a;, [6] showed the shortcomings of traditional optimization methods. J. A. Visser et al. [7] have stressed that Computational Fluid Dynamics (CFD) approach is based on trial and error for designing heat sink. R. Arularasan and Velraj [8] have discussed about the heat dissipation in desktop computers. S. Manivannan et al. [9], presented an approach for the multi-objective optimization of the flat plate heat sink. Ranjan et al., [10] discussed the usage of heat sinks with different shapes to find out their effectiveness. Ranjan et al. [11] has also worked for perforated heat sink using CFD.

Heat sink is one of the important device for rejection of heat and CFD can be very effective for its performance prediction in design phase only.

GEOMETRIC MODELING

The geometry of heat sink was modelled in ANSYS Design Modeler with dimensions given in Table 1.

Table 1: Geometric parameters of heat sink

Parameters	values
Length of complete channel	450 mm
Base thickness (t_b)	8 mm
Heat sink fin thickness	3 mm
Total height of heat sink	50 mm
Length and width of heat sink	150 mm
Width of heat source	60 mm

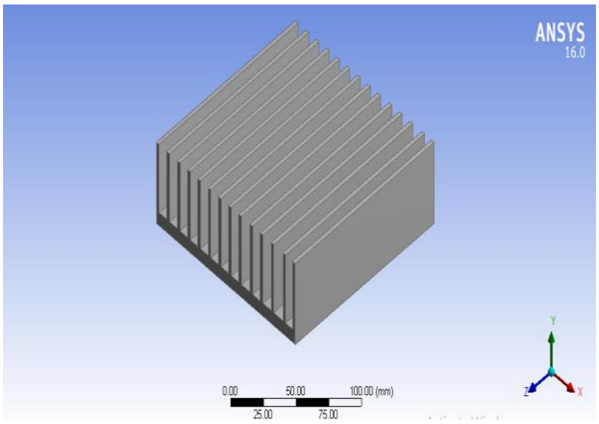

Fig 1: Solid model of heat sink

MESHING

For getting good results, refined mesh needs to be used. In this work the solid model of heat sink is discretized into 162699 number of element.

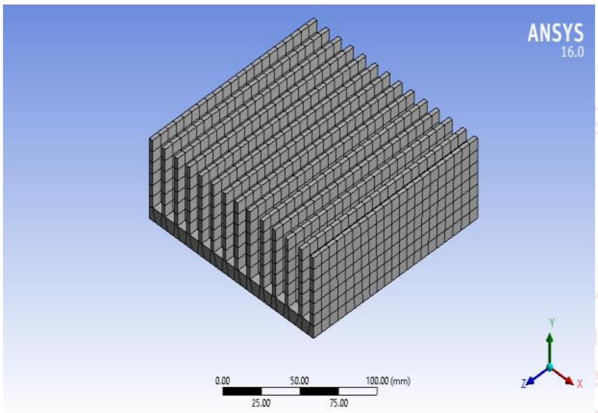

Fig 2: Meshing of heat sink

INPUT PARAMETERS AND BOUNDARY CONDITIONS

In order to validate the CFD model of heat sink, aluminium alloy AA-6063 has been considered. Other boundary conditions such as velocity of air was veried to check its effect, temperature of air at the inlet of domain is kept as 25^0 C. heat flux of 100 W was considered. For analysing the effect of different velocity of air, three different velocity of air that is 2, 4 and 6 m/s have been considered.

RESULTS AND DISCUSSIONS

ANSYS Fluent was used for analysis. Following temperature contours were obtained.

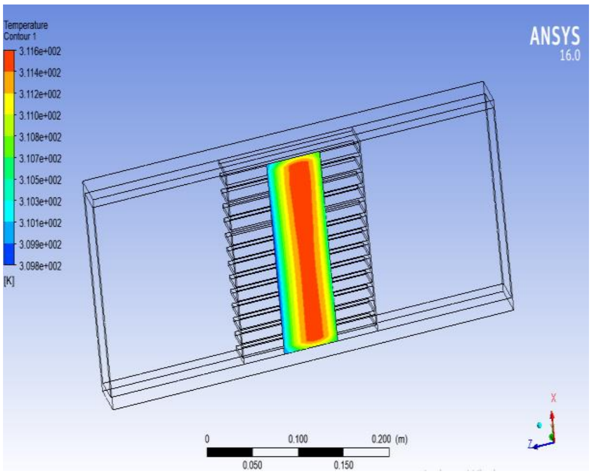

Fig 3: Temperature contours at the horizontal plane at the middle of heat sink for 2 m/sec air velocity

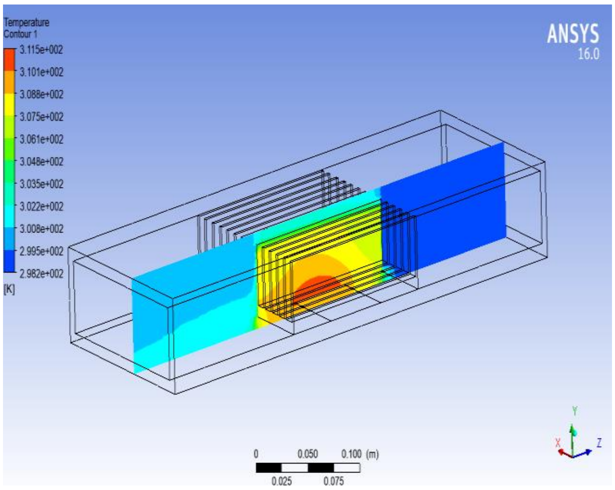

Fig 4: Temperature contours at the horizontal plane at the middle of heat sink for 4 m/sec air velocity

Through CFD analysis, it is found that the value of thermal resistance and nusselt number measured were near to the values obtained from the base paper. After validating the CFD model of heat sink here it analysed the effect of different materials used to manufacture heat sink and find the optimum material for the manufacturing of heat sink. It also calculates the effect of different base thickness of material, base thickness of heat sink also responsible for heat transfer. So in order to optimize the base thickness of heat sink here in this work it considered six different base thickness of heat sink.

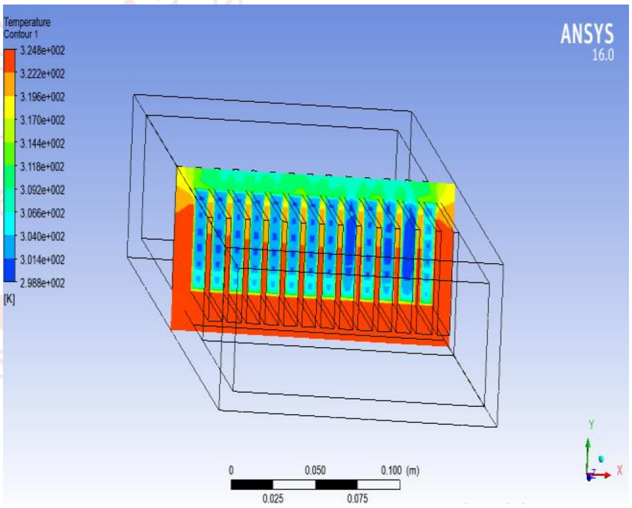

Fig. 5: Temperature contours of heat sink at the plane for AA-6060 material at 2 m/s velocity of air

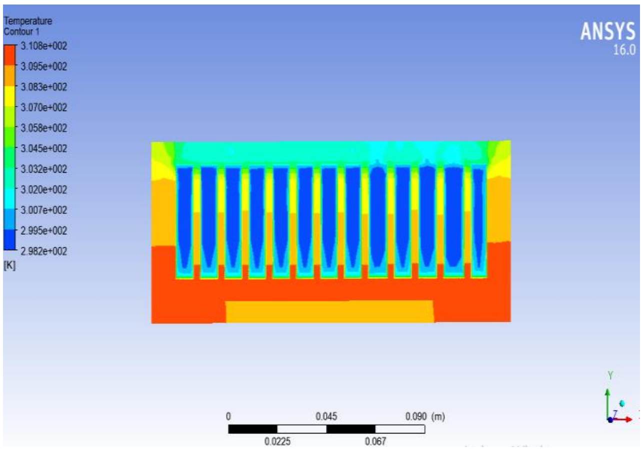

Fig. 6: Temperature contours of heat sink at the plane for AA-1050 material at 2 m/s velocity of air

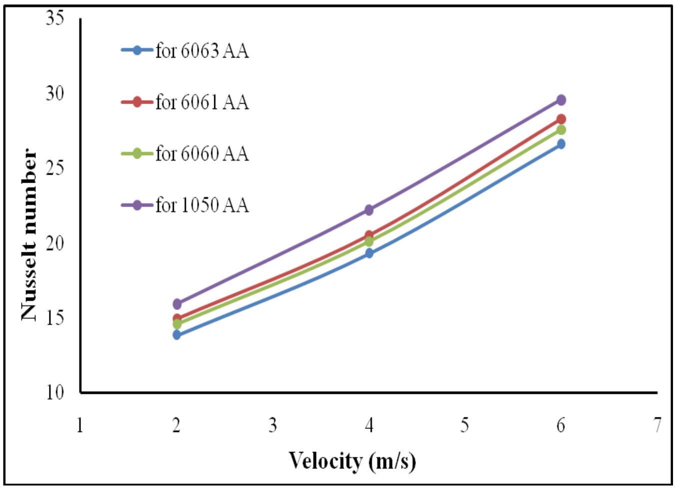

Fig 7: Nusselt number for different materials of heat sink

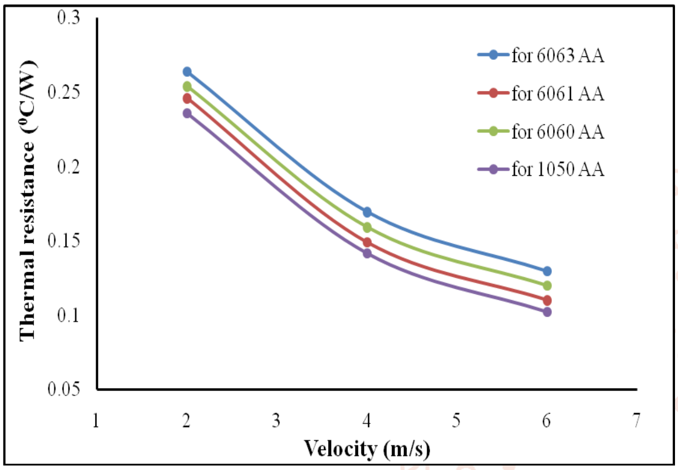

Fig. 8: Thermal resistance developed inside the heat sink

Nusselt number of AA-1050 material heat sink is higher, the value of thermal resistance for this material lower than the other materials. Through analysis it is found that change in thermal resistance of heat sink with respect to velocity of air flowing inside the channel follow same nature of variation.

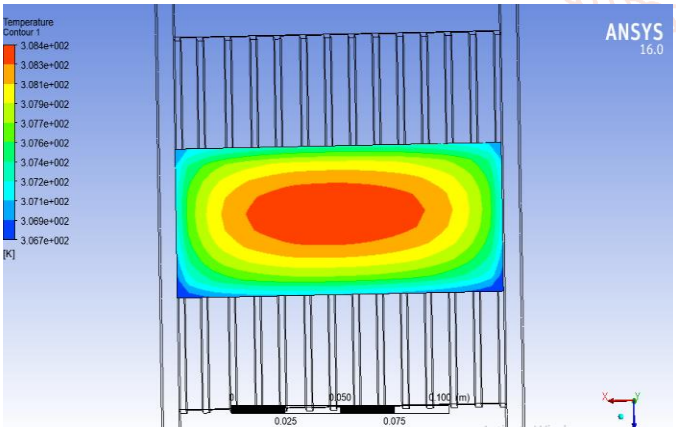

Fig 9: Temperature contour at the base of heat sink for 4 mm base thickness

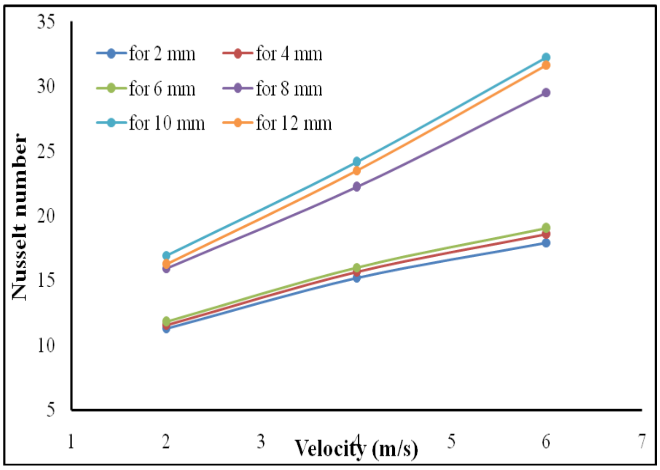

Fig 10: Nusslet number for different base thickness heat sink

It is found that the value of Nusselt number is higher in case of heat sink having 10 mm base thickness. Heat transfer is highest for 10 mm base thickness heat sink. So heat sink having 10 mm base thickness is most efficient for heat transfer.

CONCLUSIONS

Through CFD analysis, temperature distribution inside the heat sink has been found out. Through analysis it is found that as the Nusselt number of AA-1050 material heat sink is higher as compared to other aluminium alloys. The value of thermal resistance for AA-1050 material is lower than the other materials used for heat sink. Thermal conductivity of AA-1050 material is higher than the other materials so heat transfer is highest for it. It has been found that change in thermal resistance of heat sink with variation in velocity of air follows same nature of variation for all materials. As the velocity of air increases, the value of thermal resistance of heat sink decreases. Heat sink having 10 mm base thickness shows the maximum heat transfer as compared to other base thickness.

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