

## Modelling And Analysis Of Heat Sink With Rectangular Fins Having Through Holes

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### ABSTRACT

Heat indulgence techniques are the prime concern to remove the waste heat produced by Electronic Devices, to keep them within permitted operating temperature limits. Heat indulgence techniques include heat sinks, fans for air cooling, and other forms of cooling such as liquid cooling. Heat produced by electronic devices and circuitry must be self-indulgent to improve reliability and prevent premature failure. Integrated circuits such as CPUs, chipset, graphic cards, and hard disk drives are susceptible to temporary malfunction or permanent failure if overheated. As a result, efficient cooling of electronic devices remains a challenge in thermal engineering.

The objective of this paper is to present a best possible Heat Sink for efficient cooling of electronic devices. The choice of an optimal heat sink depends on a number of geometric parameters such as fin height, fin length, fin thickness, number of fins, base plate thickness, space between fins, fin shape or profile, material etc. Therefore for an optimal heat sink design, initial studies on the fluid flow and heat transfer characteristics of standard continuous heat sinks of different designs have been carried through CFD simulations. It is observed from the results that optimum cooling is achieved by the heat sink design which contains interrupted fins with holes. These heat sink designs promises to keep electronic circuits cooler than standard heat sinks and reduction in cost due to reduction in material.

**Key words:** Continuous fins, Electronics cooling, Heat sink, Interrupted fin, through holes.

### 1. INTRODUCTION

According to Moore's law the number of transistors mounted on a chip gets doubled for every two years. As the number of transistors increase with development of chip integration technology increases the power draw and heat load to disperse during operation increases. With the development of chip integrated circuits gradual decrease in size of the components has resulted severe increase in the

amount of heat generation per unit volume. Unless they are properly designed and controlled high rates of heat generation result in the failure of electronic component due to high operating temperature.

Heat sinks are the most common thermal management hardware used in electronics. They improve the thermal control of electronic components, assemblies, and modules by enhancing their surface area through the use of fins. Applications utilizing fin heat sinks for cooling of electronics have increased significantly during the last few decades due to an increase in heat flux densities and product miniaturization. Today's advanced electronic circuits disperse substantially heavier loads of heat than ever before. At the same time, the premium associated with miniaturized applications has never been greater, and space allocated for cooling purposes is on the decline. These factors have forced design engineers to seek more efficient heat sink technologies.

Air-cooling also is accepted as an important technique in the thermal design of electronic packages, because besides its availability, it is safe, does not contaminate the air and does not add Vibrations, noise and humidity to the system in which it is used. Such features of Forced convection stimulated considerable research on the development of optimized finned heat sinks and enclosures. Using fins is one of the most inexpensive and common ways to dissipate unwanted heat and it has been successfully used for many engineering applications.

Rectangular fins are the most popular fin type because of their low production costs and high thermal effectiveness.

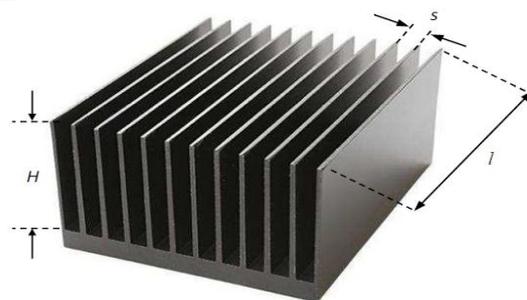


Fig: 1 Continuous rectangular fin heat sink

Even though standard continuous fin heat sinks as shown in Fig.1 provide major levels of cooling, there are applications in which even greater cooling power is required. So Interrupted fins are designed as shown in Fig.2 proper selection of fin spacing and interruption sizes can lead to higher thermal performance and adding interruptions leads to a heat transfer surface area reduction. Fin interruption leads to significant less in weight due to reduction in material and thus low manufacturing cost results in heat sinks.

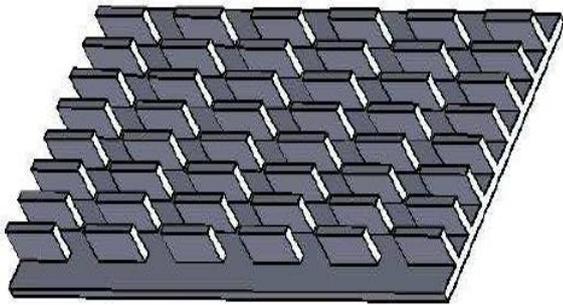


Fig: 2 rectangular interrupted fins

In the most challenging cooling applications, designers can install interrupted heat sinks and continuous heat sinks with further design like through holes to achieve the required cooling without making excessive tradeoffs in heat sink size or weight.

## 2. STATE OF THE ART

Majid Bahrami reported experimental results on vertically-mounted rectangular interrupted fins. A proper selection of fin spacing and interruption sizes leading to high thermal boundary performance. Fin interruption leads to significant weight and thus cost reduction in heat sinks. [1]

Golnoosh Mostafavi analyzed about steady-state external natural convection heat transfer from vertically-mounted rectangular interrupted finned heat sinks is investigated The optimum interruption length for maximum fin array thermal performance is found and a compact relationship for the Nusselt number based on geometrical parameters for interrupted walls is presented using a blending technical for two asymptotes of interruption length. Additionally, fin interruption results in a considerable weight reduction and that can lead into lower manufacturing costs. [2]

## 3. MODELLING

The modeling of continuous rectangular fin heat sink, rectangular interrupted fins heat sink and further designs of through holes to the above models are designed in 'PRO-E WILDFIRE 5'.

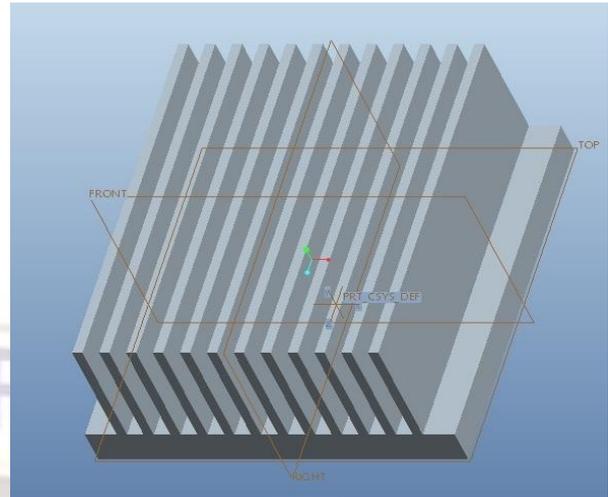


Fig: 3 continuous rectangular fins heat sink.

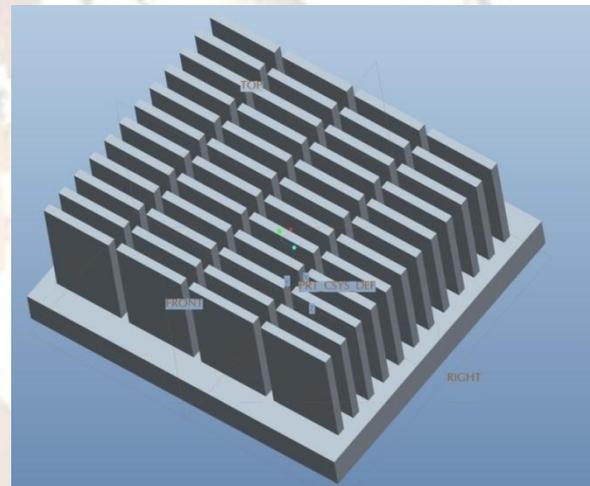


Fig: 4 interrupted rectangular fins heat sink.

Fig 4 is advancement to Fig 3 in following parameters like reduction in thermal boundary, increase in heat transfer rate and reduction in weight due to less material.

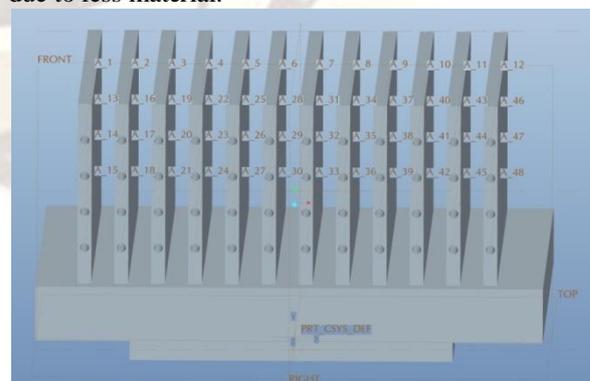


Fig: 5 continuous rectangular fins with through holes.

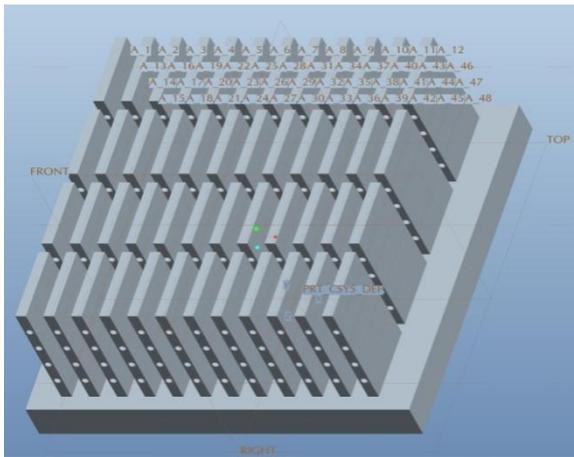


Fig: 6 interrupted rectangular fins with through holes.

Fig 5 and fig 6 are the advancement in design to the fig 3 and fig 4 respectively. By giving through holes to the previous designs air passes into the fins may give better heat transfer rate.

## 4. MODELLING ANALYSIS

### 4.1. GEOMETRY

Heat sinks, used in electronic devices, usually consist of arrays of fins arranged in an in-line manner as shown in Fig 7. The fins are attached to a common base and the geometry of the array is determined by the fin dimensions, number of fin arrangement.

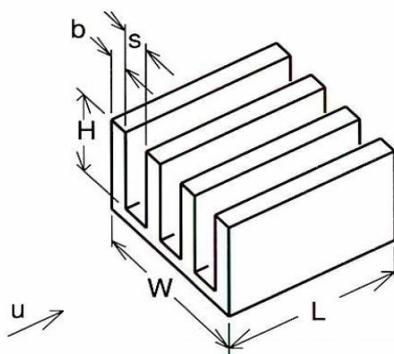


Fig: 7 Geometry of in-line continuous rectangular fins heat sink.

The geometry of an in-line continuous rectangular fin heat sink is shown in Fig 7. The dimensions of the base plate are  $L \times W \times H$ , where  $L$  is the length in the stream wise direction,  $W$  is the width, and  $H$  is the height. The approach velocity of the air is  $U$ . The direction of the flow is parallel to the  $x$ -axis. The base plate is kept at constant heat flux and the top surface of the fins is adiabatic. The heat source is idealized as a constant heat flux boundary condition at the bottom surface of the base plate. It is assumed that the heat sink is fully shrouded and the heat source is situated at the centre of the base plate. It is assumed that the fluid temperature is averaged over the height of the heat sink, so the fluid temperature  $T$  is the bulk mean

fluid temperature. Fully developed heat and fluid flow are assumed in the analysis, and the thermo physical properties are taken to be temperature independent. The overall mesh of the geometry shown in Fig.8.

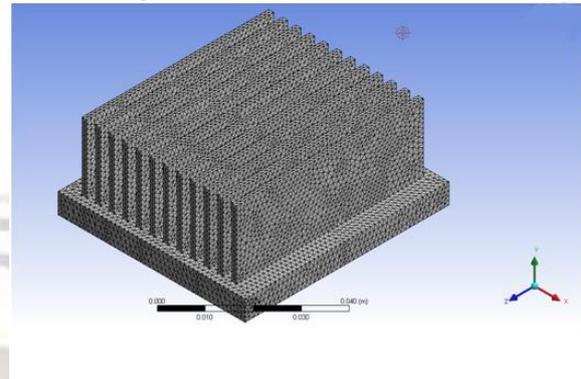


Fig: 8 meshing of continuous rectangular fins heat sink.

### 4.2 Calculations

To form an appropriate model for calculations, the following assumptions are made.

1. The contact resistance between the heat sink and processor would be negligible when using a high quality thermal paste.
2. The average temperature of the air flowing through the heat sink would be 297 K.

#### 4.2.1 Heat transfer coefficient over flat plate

$$\text{Reynolds's number (ReL)} = (\rho v L) / \mu \quad (1)$$

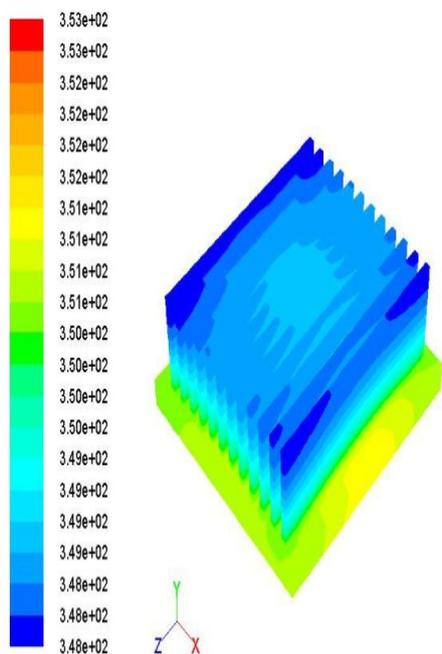
$$\text{Nu} = 0.332 \text{ReL}^{0.5} \text{Pr}^{0.333} \quad (2)$$

$$\text{Nu} = hL/k \quad (3)$$

$$hL = \text{Nu} k/L \quad (4)$$

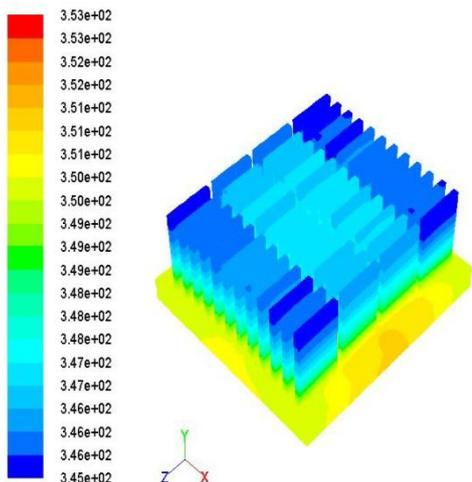
## 5. CFD simulation approach

The ANSYS FLUENT CFD code was used for the simulations. The simulation procedure was started with pre-processing. The computational mesh was generated using tetrahedral elements. In order to accurately resolve the solution fields in the high gradient regions, the grid was stretched. The discretization scheme was first order upwind scheme. A SIMPLE algorithm was used. For the simulations presented here, depending on the geometry used, fine meshing was used. The flow field and heat transfer were determined by iteratively solving the governing momentum and energy equations. The under-relaxation factors were first set at low values to stabilize the calculation process, and were increased to speed up the convergence.



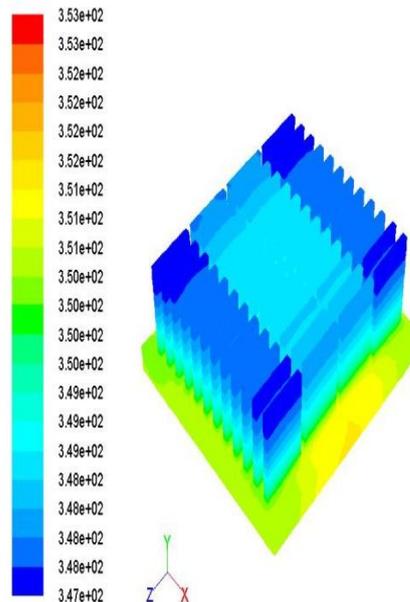
Contours of Static Temperature (k)

Fig: 9 Temperature Contours of continuous rectangular fins with 2 m/s velocity



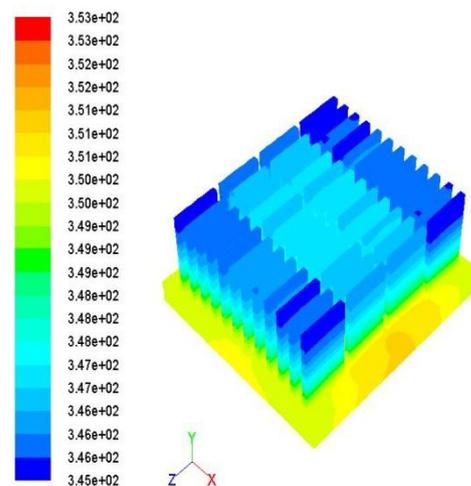
Contours of Static Temperature (k)

Fig: 10 Temperatures contours of interrupted rectangular fins with 2 m/s velocity.



Contours of Static Temperature (k)

Fig: 11 Temperature contours of continuous rectangular fins with through holes of 2m/s velocity



Contours of Static Temperature (k)

Fig: 12 Temperature contours of interrupted rectangular fins with through holes of 2m/s velocity

## 6. RESULTS AND DISCUSSION

The results obtained from CFD simulation approach shown in figures 9 to 12 illustrates that heat transfer rate is increasing in interrupted rectangular fins with holes comparative to continuous rectangular fins heat sink. Reduction in material also results in reduction of weight.

## 7. CONCLUSION

In this present paper CFD analysis of heat sinks which contain continuous rectangular fins, interrupted rectangular fins and above models with through holes for electronic cooling is investigated. Based on the result obtained it can conclude that in the sense of junction temperature interrupted fins are efficient than continuous. It also found that through holes for the interrupted fins has better performance than interrupted rectangular fins of heat sinks and reduction in weight due to more material removal from the standard.

## 8. NOMENCLATURE

- b – Thickness of a fin
- L – Length of a fin
- w – Width of a fin
- H – Height of a fin
- u- Velocity of air
- ReL – Reynolds number (laminar)
- $\mu$  = absolute viscosity of fluid [kg/ms]
- $\nu$  = kinematic viscosity of fluid [m<sup>2</sup>/s]
- $\rho$  = fluid density [kg/m<sup>3</sup>]
- Pr – Prandtl number
- h- Heat transfer rate
- K – Thermal conductivity

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