Analysis of Heat Transfer Effect in Slotted Fin Heat Sink with different Slotted Width

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Abstract — In our analysis, CFD was used and the model was developed on NX-8. In order to verify the present CFD model, the thermal resistance and the pressure drop are compared with the available experimental results present in the literature and the design of slotted fin heat sink (SFHS) having Pitch is 5, 10 and 15. In this study, the simulations of SFHS at various wind velocity i.e., 6.5, 9.5 & 12.0m/s and the configurations of Pitch fins design are proposed.

The results show that increasing wind velocity could reduce the thermal resistance and increase the pressure drop simultaneously. The thermal resistance of the SFHS is lower than that of the Flat Plate fin heat sink (FPFHS) at the same wind velocity and the pressure drop of the SFHS is much higher than that of the FPFHS.

Keywords— *Plate fin heat sink, Slotted fin heat sink, Temperature distribution, Thermal resistance.*

I INTRODUCTION

A heat sink is a passive heat exchanger part used in electrical systems that cools a device by dispersing heat into the ambient air. Heat sinks are used to cool the central processor units or the graphics processing in computers. When the basic device package's capacity for heat dissipation is insufficient to regulate the temperature of a high-power semiconductor device, such as a power transistor or an optoelectronic component like a laser or light emitting diode (LED), a heat sink is needed.

A heat sink is made to have more surface area in contact with the air or other nearby cooling medium. The approach air velocity, material selection, design of the fins (or other protrusions), and surface treatment are a few of the variables that determine a heat sink's thermal performance. The final die temperature of the integrated circuit is also influenced by heat sink attachment techniques and thermal interface materials. The air space between the heat sink and the device is filled with thermal glue or thermal grease to enhance thermal performance. The thermal performance of a heat sink may be assessed using theoretical, experimental, and computational approaches.

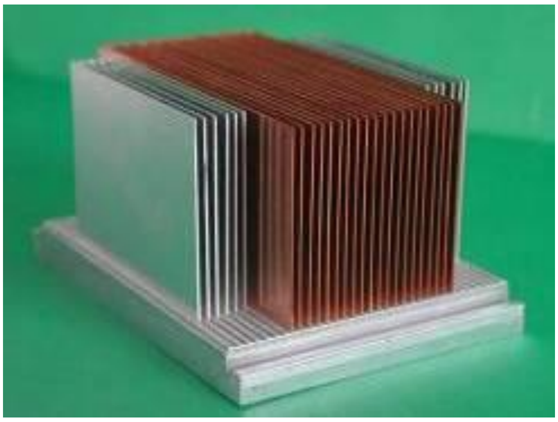

Fig.1 Crimped fin heat sink

- **New Thermal Design Requirements.**

1. Design for improved cool ability at the package level via optimized internal thermal conduction paths.
2. Design for direct air cooling at the product level via enhanced convection process over the packages.
3. Design for special cooling needs at the module level via spot cooling devices attached to the packages.
4. Design for low temperature applications-Sub ambient to cryogenic
5. Design for low cost via CATE and improved manufacturability.

- **Internal Module Cooling**

Conduction is the main method of internal heat transmission in the module. Therefore, the physical design and material characteristics of the module control the internal heat resistance. The goal is to efficiently transmit heat from the electronics circuits to the module's exterior surface, where it will be expelled using methods covered in the next section.

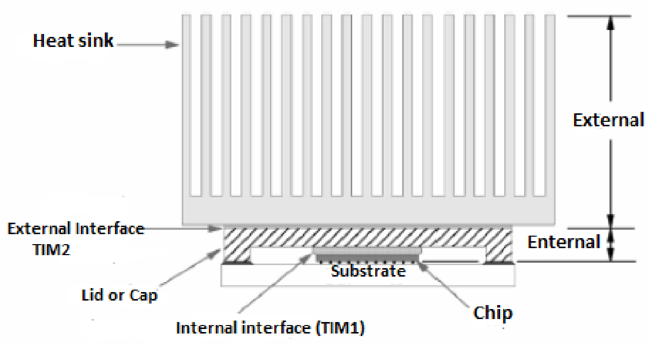

Fig.2. Cross-section of a typical module denoting internal cooling region and external cooling region.

- **External Module Cooling**

The principal method for efficiently transferring the heat produced inside the module to the system environment is external cooling. In order to do this, the module is primarily fitted with a heat sink. Because it is simple to deploy, inexpensive, and transparent to the end user or customer, air has historically been used as the system environment.

II OBJECTIVES

1. Validation of the CFD models by comparing the present simulated results with the experimental result present in literature.
2. To predict velocity profiles, and temperature for different wind velocity (6.5, 9.5 & 12.0 m/s) on the heat sink.
3. To simulate the heat sink of the slotted fin having different Pitch (5, 10 &15mm) and different velocity (6.5, 9.5 & 12.0m/s) for constant heat input.
4. Parameter sensitivity study of micro channel.
5. To define average heat transfer coefficient, surface Nusselt number, thermal resistance
and pressure drop for the heat sink of the different slotted fin profile and different velocity and constant heat input 18W.
6. To predict temperature distribution along the channel.

- DESIGN PARAMETERS OF HEAT SINK MODELS

Table 5.1: Basic geometric parameters of plate fin heat sink

Fin Length L(mm)	Fin Height L(mm)	Fin Thickness (L)mm	Fin Number (N)	Fin to Fin Distance (mm)
51	10	1.5	3	5

Table (4.2) Pitch of Slotted fin

Model	5-Pitch
	10-Pitch
	15-Pitch

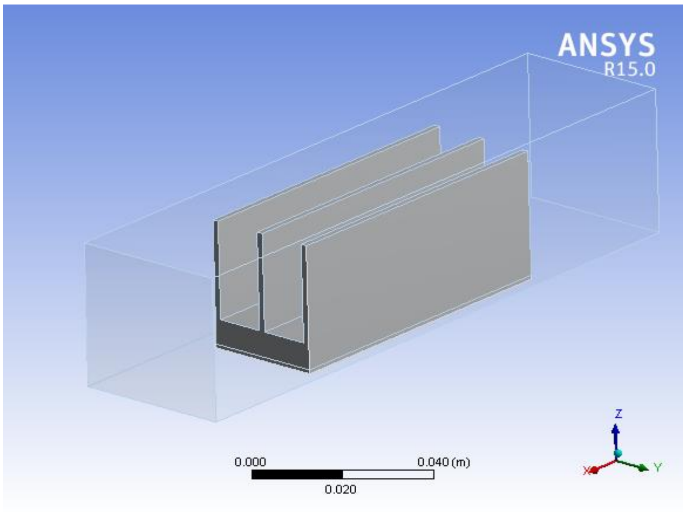

Figure 3: 3D Model of plate fin heat sink (PFHS).

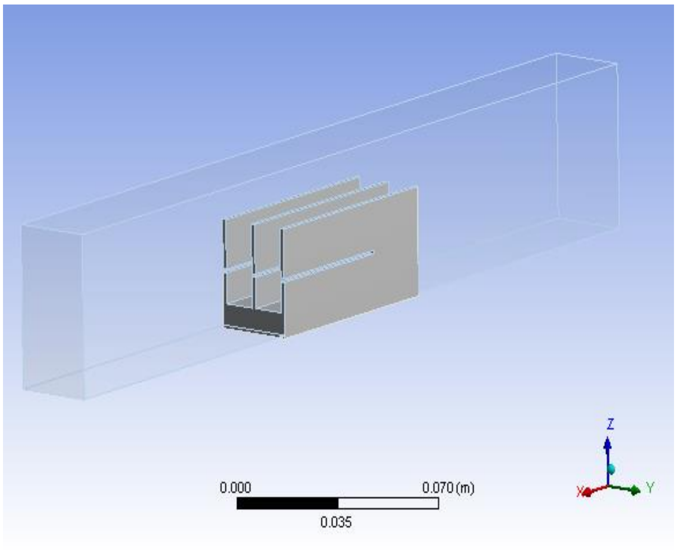

Figure: 4, 3-D model of 5-pitch horizontal slotted fin heat sink

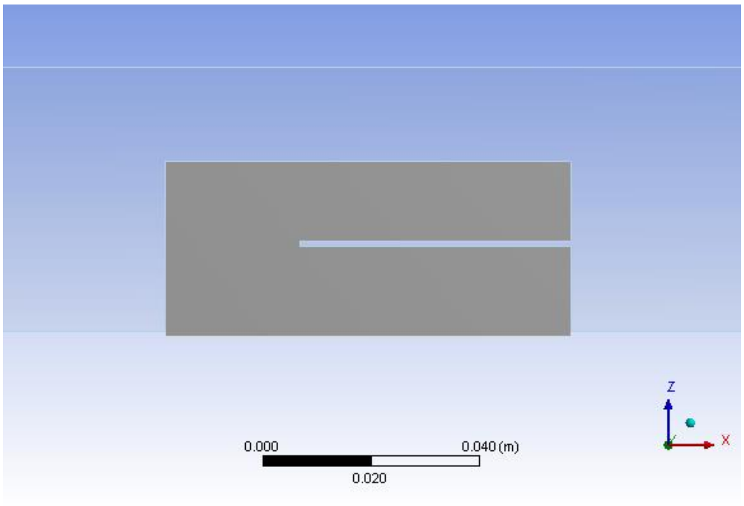

Figure: 5, 3-D model of 10-pitch horizontal slotted fin heat sink

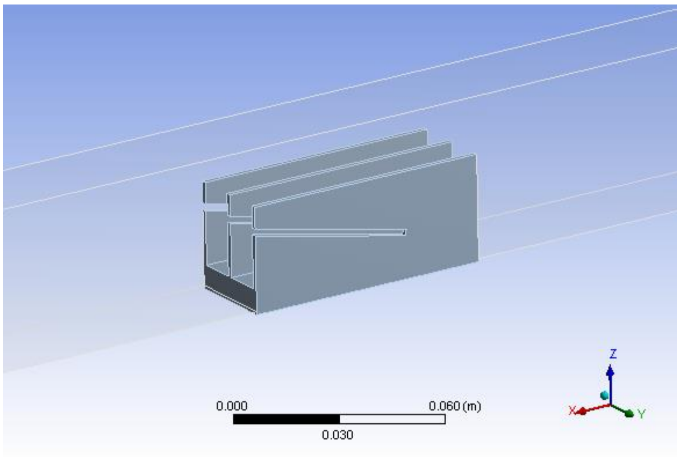

Figure: 6, 3-D model of 5-pitch inclined slotted fin heat sink

Boundary conditions

III RESULTS

The Existing simulation results are obtained for pressure drops (ΔP) and thermal resistances (Rth) w.r.t. Reynolds number (Re) ranging from 3450 to 7970. The results are in graphs show less than 5% deviations between existing simulation results and experimental results. But the deviations are not so large, and thus the existing simulation results of different configurations of plate pin fin heat sink models in the research work can be regarded as reasonable.

Table 5.5: Boundary conditions

Fin Profile	Fin type	Velocity(m/s)			Heating Value(Q)	Periodic Boundary condition
	Plane Fin	6.5	9.5	12.0	18.2	Translate in Y- Direction
	05-pitch	6.5	9.5	12.0	18.2	Translate in Y- Direction
	10-pitch	6.5	9.5	12.0	18.2	Translate in Y- Direction
	15-pitch	6.5	9.5	12.0	18.2	Translate in Y- Direction

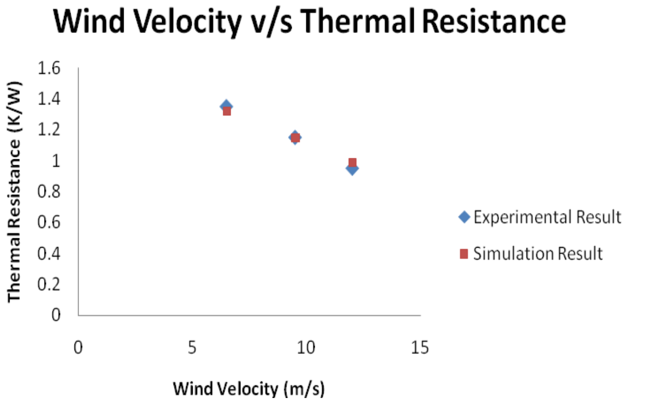

Figure 7: *Experimental and Simulation results for the PFHS: Thermal resistance vs. wind velocities.*

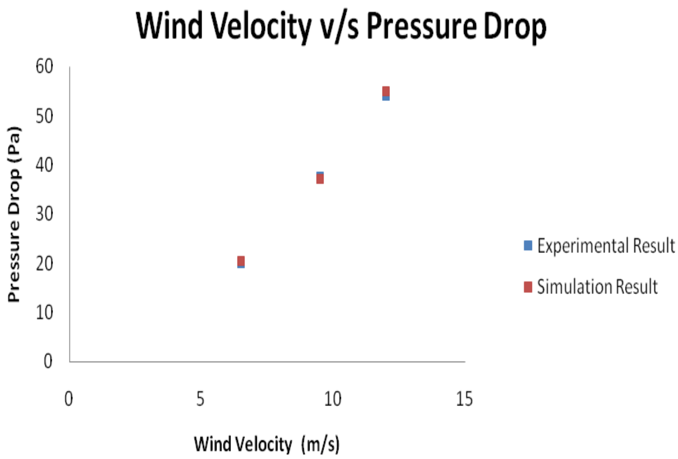

Figure 8: *Experimental and Simulation results for the PFHS: Pressure Drop vs. wind velocities.*

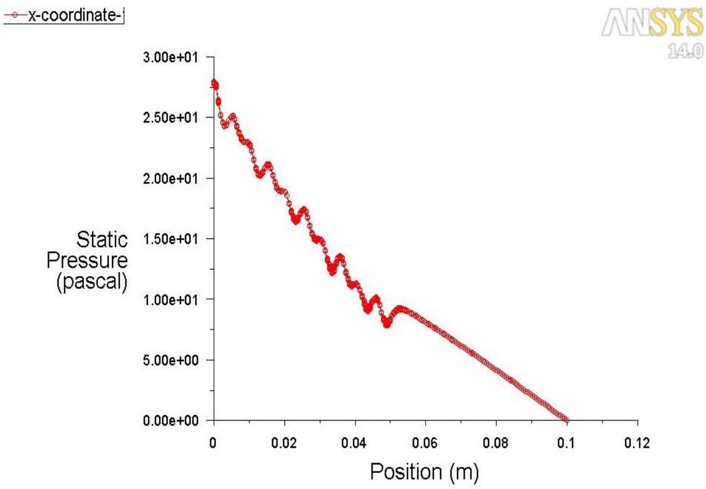

Figure 9: *Pressure Drop of 5 Pitch Slotted fins at velocity 6.5m/s*

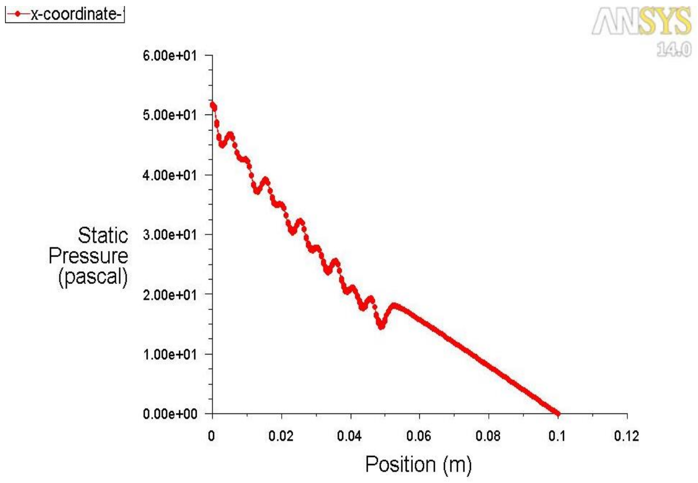

Figure 10: *Pressure Drop of 5 Pitch Slotted fins at velocity 9.5m/s*

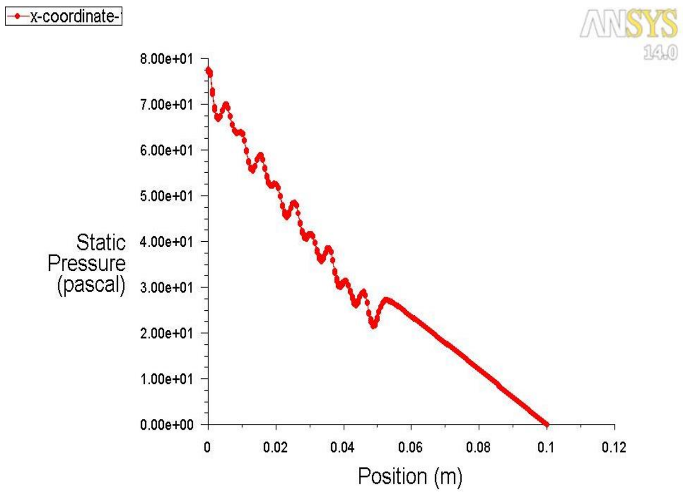

Figure 11*-Pressure Drop of 5 Pitch Slotted fins at velocity 12.0m/s*

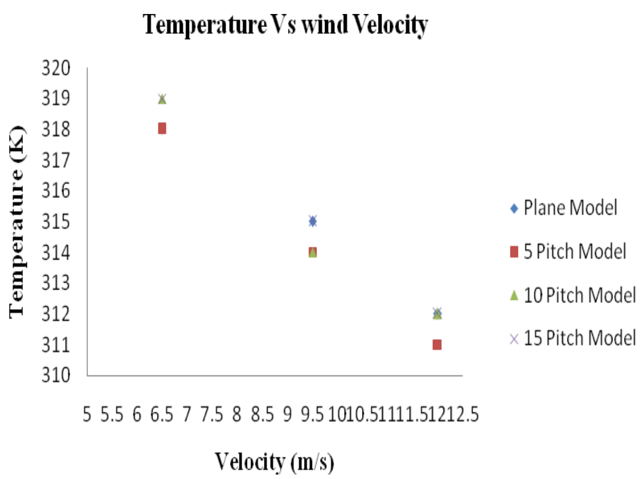

Fig.12 *Thermal Resistance Variations for Different Fin Profile of Slotted fin.*

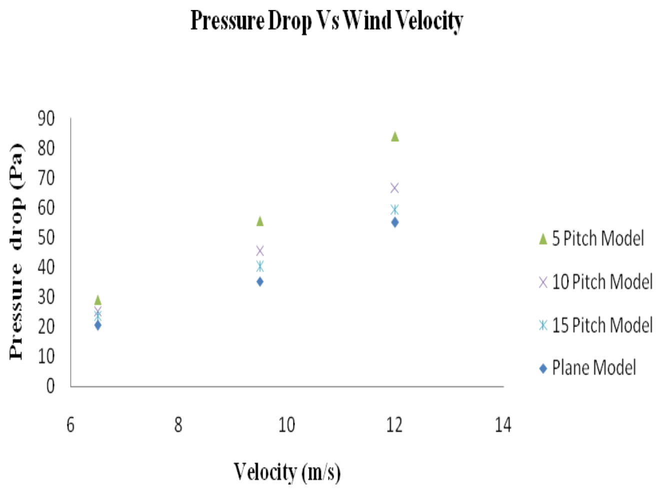

Fig.13 *Thermal Resistance Variations for Different Fin Profile of Slotted fin.*

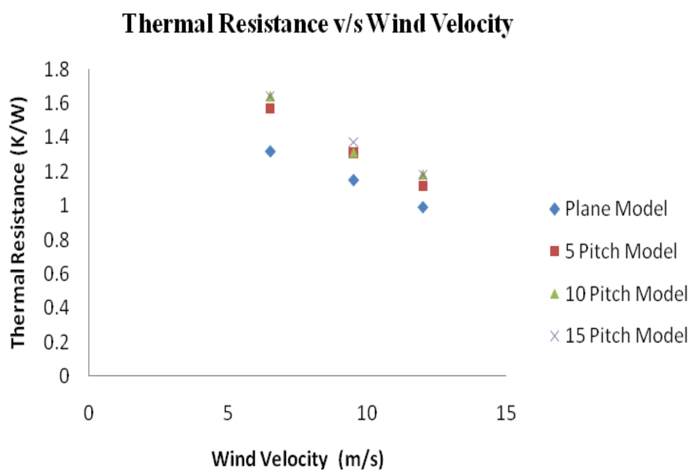

Fig.14 *Thermal Resistance Variations for Different Fin Profile of Slotted fin*

CONCLUSION

1. From the above result we have least thermal resistance in slotted fin with 5-Pitch i.e. 1.57K/W, after that 10-Pitch i.e. 1.64K/W, subsequently with 15Pitch i.e. 1.64K/W.
2. From the above result we have least pressure drop in inclined slotted fin with 5-Pitch i.e. 29.22

Pa, after that 10-Pitch i.e. 25.39 Pa, subsequently with 15-Pitch i.e. 23.83 Pa

3. So, from the above we can conclude that the 5-Pitch inclined slotted fin at all velocity having better thermal resistance and pressure drop compared to 10-Pitch and 15-Pitch thermal resistance and pressure drop as compared to horizontal slotted fin.

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