CFD Analysis Of Elliptical Pin Fin Heat Sink

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ABSTRACT : The abstract should summarize the content of the paper. Try to keep the abstract below 200 words. Do not make references nor display equations in the abstract. The journal will be printed from the same-sized copy prepared The effective use of an electrical component is limited at its maximum operational junction temperature. The study was conducted by using the Computational Fluid Dynamics (CFD) method. The heat sinks are used with high power semiconductor devices such as power transistors, electronic devices lasers and light emitting diodes (LED'S). The major study was done on elliptical pin fin heat sink, the minor axis is taken as parameter. The heat transfer media was taken as an air & Aluminum (Al) as pin fin material.

In our analysis, CFD was used and the model was developed on NX-5. 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 Elliptical Pin fin heat sink (EPFHS) having minor axis is 1.5mm, 2.0mm and 2.5mm. In this study, the simulations of EPFHS at various wind velocity i.e., 6.5, 9.5 & 12.5 m/s and the configurations of pin-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 EPFHS is lower than that of the plate-circular pin-fin heat sink (PCPFHS) at the same wind velocity and the pressure drop of the EPFHS is much higher than that of the PCPFHS.*

Keywords –Plane pin fin heat sink ,Electronics cooling simulation ,Pressure Drop, Thermal Resistance, Nusslet Number

I. INTRODUCTION

The effective use of an electrical component is limited by its maximum operational junction temperature. To achieve a desired component temperature, excess heat dissipated by the device must be transferred to the environment [19]. The most common method for transferring heat from the component to the environment is to use a heat sink.

To estimate a component's junction temperature, a required value is the heat sink's thermal resistance. The thermal resistance of heat sink can be determined analytically or experimentally.

In electronic systems, a heat sink is a passive component that cools a device by dissipating heat into the surrounding air. In computers, heat sinks are used to cool electronic components. Heat sinks are used with high-power semiconductor devices such as power transistors and optoelectronic devices such as lasers and light emitting diodes (LEDs), wherever the heat dissipation ability of the basic device package is insufficient to control its temperature.

II OBJECTIVE OF WORK

The main objective of the current work is

1. Validation of the CFD models by comparing the present simulated results with the Experimental result by Yue-Tzu Yang & Huan-Sen Peng [7].
2. To predict velocity profiles, and temperature for different wind velocity (6.5, 9.5 & 12.5m/s) on the heat sink.
3. To simulate the heat sink of the elliptical pin fin having different minor axis and different velocity (6.5, 9.5 & 12.5m/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 elliptical pin fin profile and different velocity and constant heat input 10w.
6. To predict temperature distribution along the channel.

IV.PROBLEM FORMATION

The study of various literatures we find the thermal resistance and pressure drop is higher as compaired to present study. The purposes of this study reduce the thermal resistance and increase the pressure drop at various wind velocity. Thus chosen elliptical pin fin in place of circular pin fin

V. RESULT AND ANALYSIS

A three-dimension al model is developed to investigate flow and conjugate heat transfer in the heat sink for electronic applications. A series of numerical calculations have been conducted by FLUENT and the results are presented in order to show the effects of temperature distribution, overall heat transfer coefficient, Thermal Resistance, Surface Nusselt number in the heat sinks.

VALIDATION OF THE EXPERIMENTAL RESULT

The validation of the Experimental result is done by carrying out the simulation work on the Ansys Fluent 14.0 Work bench.

EXPERIMENTAL AND SIMULATION RESULT-

The thermal resistance of the heat sink, R_{th}, can be defined by-

$$R_{th} = \frac{\Delta T}{Q} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (1)$$

Where ΔT is temperature difference between the highest temperature on the fin base and the ambient air temperature, and Q is heat dissipation power applied on the fin base. Properties of the working fluid are the same as those of ambient air at 294 K, and the material of heat sinks is aluminum with thermal conductivity of 202 W/(m-K).

The pressure drop (Δp) from the inlet to the outlet of the flow passage, which reflects the hydraulic performance of the heat sink, is calculated by

$$\Delta p = p_{in} - p_{out} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (2)$$

Both simulation results and Yue-Tzu Yang, Huan-Sen Peng experiment results [7] for thermal resistances and pressure drops of the PFHS are plotted in Fig.1 and 2 respectively. As can be seen in these figures.

Observation Table-

(a) Thermal Resistance :

ISSN: 2278-0181
Vol. 2 Issue 3, March - 2013

Wind Velocity (m/s)	Experimental Result	Simulation Results
6.5	1.35	1.79
9.5	1.15	1.47
12.5	0.925	1.22

Table-(1) Experimental and Simulation Result for the Plate fin Heat Sink

b)Pressure Drop:

Wind Velocity (m/s)	Experimental Result	Simulation Results
6.5	20	23.3
9.5	37.5	40.6
12.5	56	59.5

Table-(2) Experimental and Simulation Result for the Plate fin Heat Sink

(c) Nusselt Number:

Wind Velocity (m/s)	Experimental Result	Simulation Results
6.5	570	888.78
9.5	680	1026.95
12.5	750	1170.47

Table-(3) Experimental and Simulation Result for the Plate fin Heat Sink

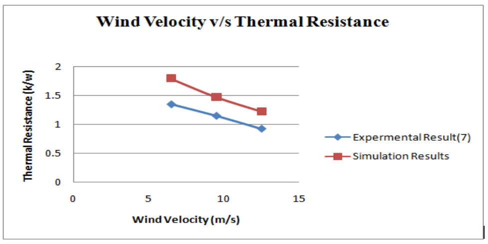


Figure: 1 Experimental and Simulation results for the PFHS: Thermal resistance vs. wind velocities

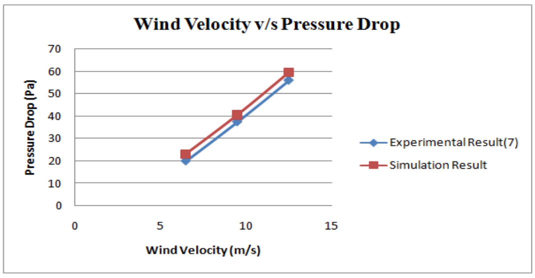


Figure: 2 Experimental and Simulation results for the PFHS: Pressure Drop vs. wind velocities.

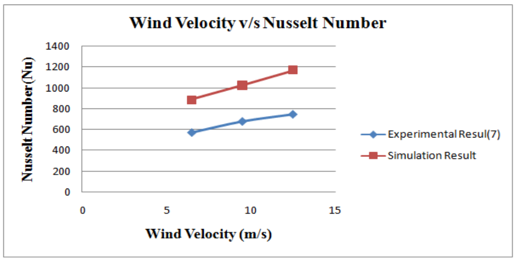


Figure: 3 Experimental and Simulation results for the PFHS : Nusselt Number vs. wind velocities.

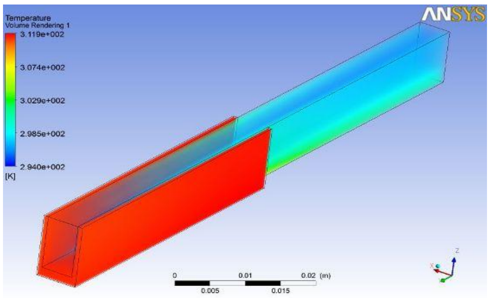


Figure 4: Temperature distribution in Plane fin heat sink with 6.5m/s velocity

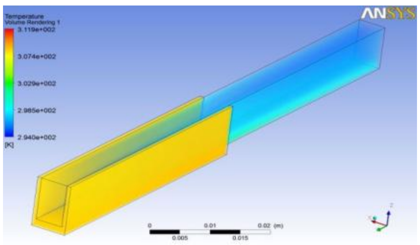


Figure 5: Temperature distribution in Plane fin heat sink with 9.5m/s velocity

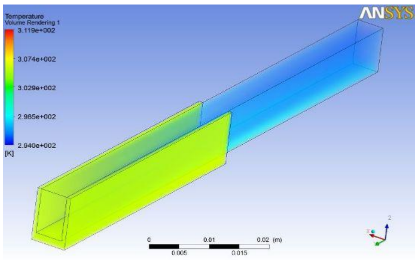


Figure 6 Temperature distribution in Plane fin heat sink with 12.5m/s velocity

Simulation of various Heats sinks Pin Model

Pin Model	Wind Velocity (m/s)	Pressure Drop (Pa)	Heating Power (w)	Fin base Temp. (k)	Temp. Difference (k)	Thermal Resistance (k/w)	Heat Transfer Coefficient (w/m²k)	Nusselt Number (Nu)
Plane Model	6.5	21.33	10	311.87	17.87	1.7969	21.5	888.7779
	9.5	37.58	10	308.72	14.72	1.4721	24.85	1026.947
	12.5	59.47	10	306.23	12.23	1.2227	28.32	1170.474
1.5 Pin Model	6.5	52.05	10	313.07	19.07	1.9078	48.31	1967.306
	9.5	96.14	10	312.34	18.34	1.8345	52.31	2133.679
	12.5	139.26	10	310.88	16.88	1.6881	56.43	2331.903
2 Pin Model	6.5	68.51	10	305.93	11.93	1.1933	48.64	2042.314
	9.5	122.89	10	304.32	10.32	1.0322	53.49	2219.739
	12.5	191.12	10	302.78	8.78	0.8659	58.63	2422.812
2.5 Pin Model	6.5	97.15	10	304.71	10.71	1.0715	52.62	2155.061
	9.5	165.44	10	303.08	9.084	0.9184	59.15	2339.574
	12.5	277.62	10	302.23	8.236	0.7936	61.08	2537.014

Table 4: Simulation of various Heat sinks Pin Model

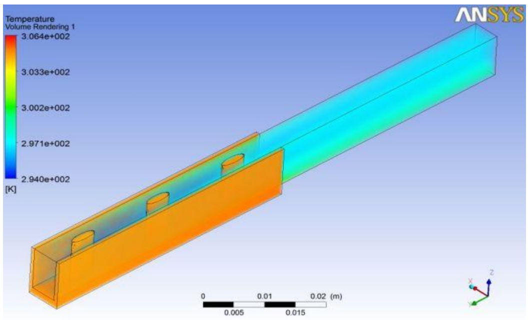


Figure 7 Temperature distribution in1.5 Elliptical pin fin heat sink with 6.5m/s velocity

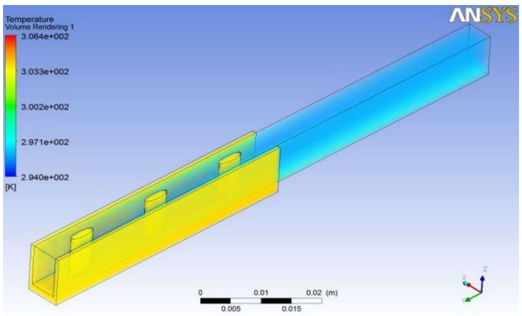


Figure 8 Temperature distribution in 1.5 Elliptical pin fin heat sink with 9.5m/s velocity

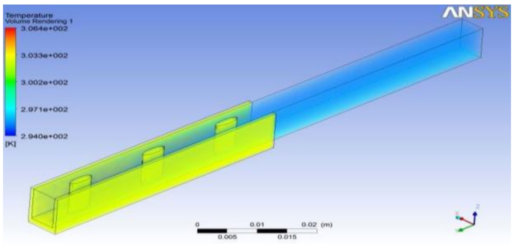


Figure 9 Temperature distribution in1.5 Elliptical pin fin heat sink with 12.5m/s velocity

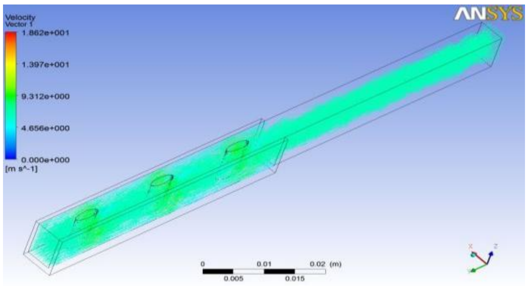


Figure 4 Velocity distribution in1.5 Elliptical pin fin heat sink with 6.5m/s velocity

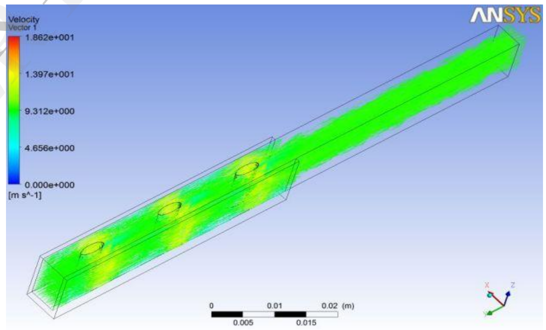


Figure 5 Velocity distribution in 1.5 Elliptical pin fin heat sink with 9.5m/s velocity

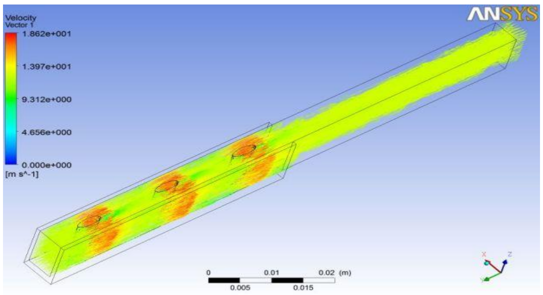


Figure 6 Velocity distribution in1.5 Elliptical pin fin heat sink with 12.5m/s velocity

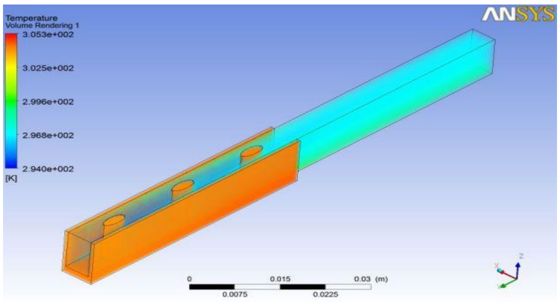


Figure 7 Temperature distribution in 2.0 Elliptical pin fin heat sink with 6.5m/s velocity

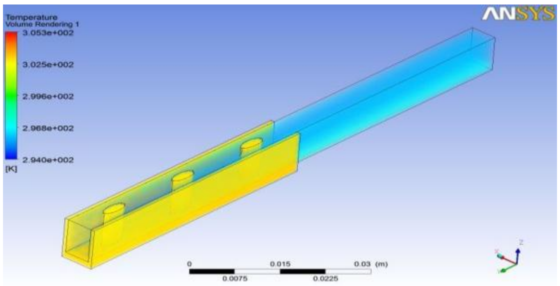


Figure 8 Temperature distribution in 2.0 Elliptical pin fin heat sink with 9.5m/s velocity

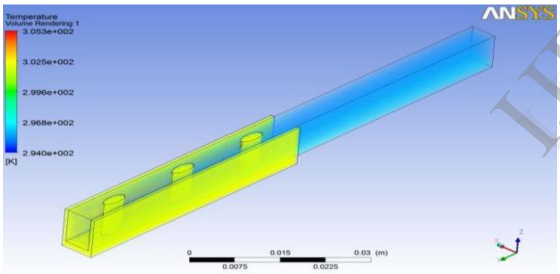


Figure 9 Temperature distribution in 2.0 Elliptical pin fin heat sink with 12.5m/s velocity

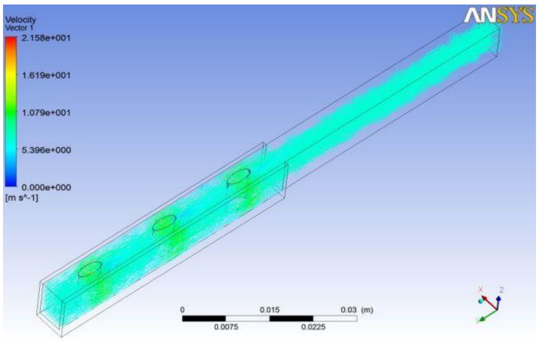


Figure 10 Velocity distribution in2.0 Elliptical pin fin heat sink with 6.5m/s velocity

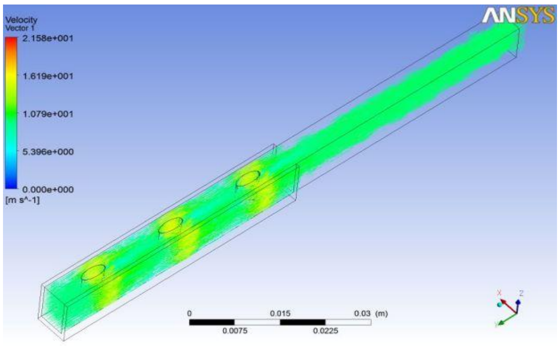


Figure 11 Velocity distributions in 2.0 Elliptical pin fin heat sink with 9.5m/s velocity

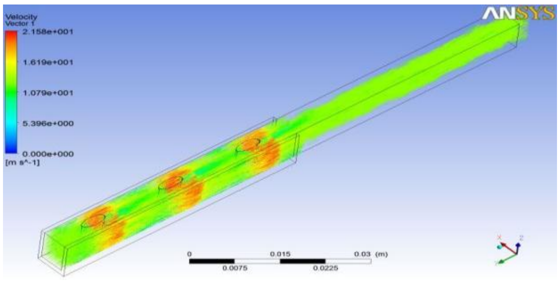


Figure 12 Velocity distribution in 2.0 Elliptical pin fin heat sink with 12.5m/s velocity

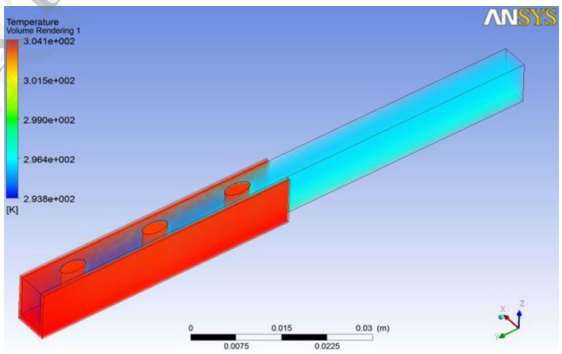


Figure 13 Temperature distribution in 2.5 Elliptical pin fin heat sink with 6.5m/s velocity

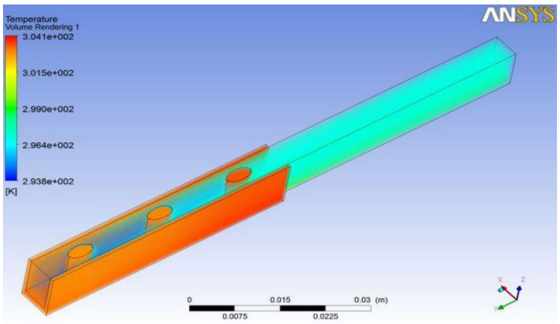


Figure 14 Temperature distribution in 2.5 Elliptical pin fin heat sink with 9.5m/s velocity

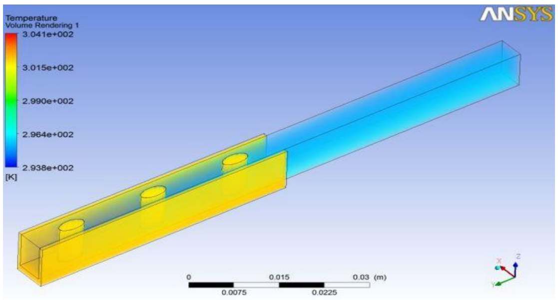


Figure 15 Temperature distribution in 2.5 Elliptical pin fin heat sink with 12.5m/s velocity

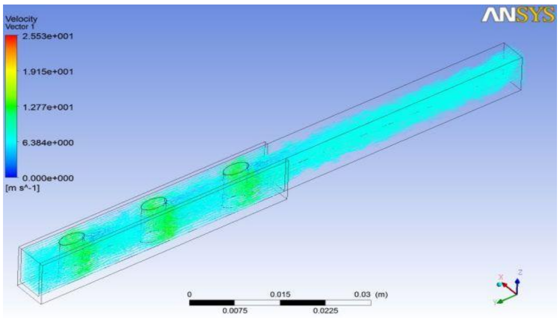


Figure 16 Velocity distribution in2.5 Elliptical pin fin heat sink with 6.5m/s velocity

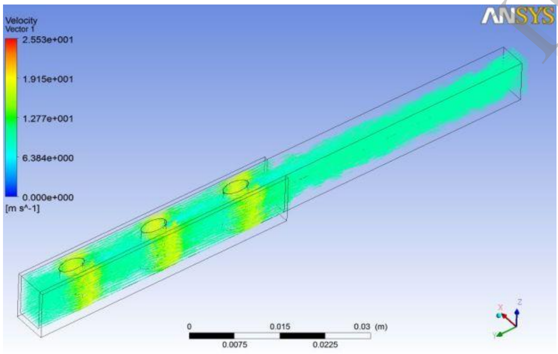


Figure 17 Velocity distribution in2.5 Elliptical pin fin heat sink with 9.5m/s velocity

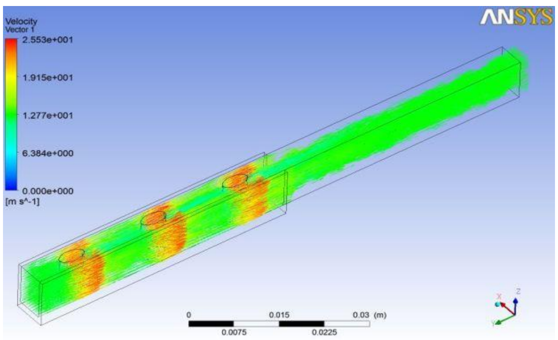
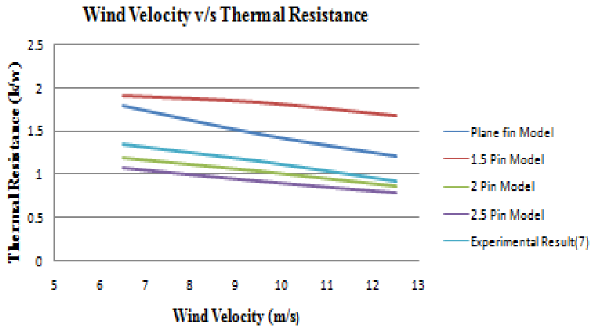
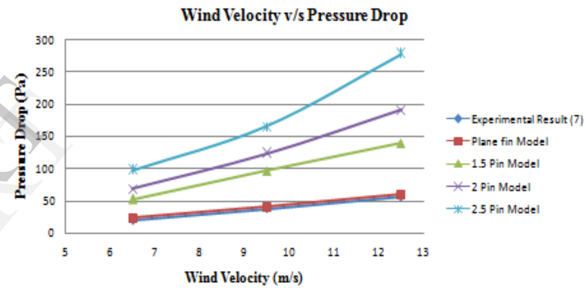


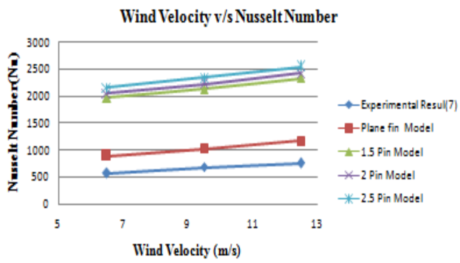
Figure 18 Velocity distribution in2.5 Elliptical pin fin heat sink with 12.5m/s velocity



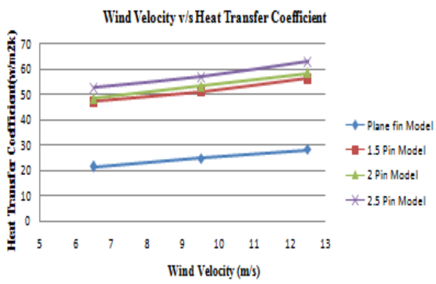
Thermal Resistance Variations for Different Fin Profile of Elliptical Pin



Pressure Drop Variations for Different Fin Profile of Elliptical Pin



Nusselt Number Variations for Different Fin Profile of Elliptical Pin



Heat Transfer Coefficient Variations for Different Fin Profile of Elliptical Pin

IV. Conclusion

I. The CFD model was developed on NX-5 and analysis was done by Fluent 14.0.

II. The prediction of CFD model show good relation with experimental result present in literature [7].

III. The internal consistency of the results confirms the validity of the CFD model.

IV. Simulated the heat sink of elliptical pin fin having different minor axis (i.e. 1.5mm, 2.0mm & 2.5mm) and different velocities (i.e. 6.5, 9.5, & 12.5m/s) for constant heat input.

V. From the above result we have least thermal resistance in elliptical pin fin with minor axis 2.5mm i.e. 0.7 K/W, after that 2mm minor axis i.e. 0.76K/W, subsequently with 1.5mm minor axis i.e. 1.7K/W.

VI. From the above result we have least pressure drop in elliptical pin fin with minor axis 1.5mm i.e. 145Pa, after that 2mm minor axis i.e. 180Pa, subsequently with 2.5mm minor axis i.e. 280Pa.

VII. So, from the above we can conclude that the 2mm minor axis elliptical pin fin at all velocity having better thermal resistance and pressure drop compared to 2.5mm and 1.5mm thermal resistance and pressure drop.

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