Thermal Performance Various Square Pin-Fin Heat Sinks using Ansys

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Abstract— This paper gives the research on Steady state thermal analysis of four type of square pin-fin heat sinks using the analysis and simulation software called Ansys. The three-dimensional solid model of the square pin-fin heat sinks were created by using the one of the 3D solid modelling software called "Creo". Among the all thermal materials, Aluminium material was chosen and the steady state thermal project was selected for the heat transfer enhancement of the pin-fin heat sinks. From the various researches, it was found that the heat transfer rate increases with increasing the surface area. In this research it was found that the surface area of the square pin-fin heat sinks which having the projection plate along its length and also having the centre hole has the maximum heat transfer rate.

Key words: Fins, Steady State Thermal, Pin-Fin Heat Sinks, Thermal Performance of Fins, Fins using Ansys

I. INTRODUCTION

Fins are one of the heat exchangers which are extended from a surface. Fins are used to increase the heat transfer rate wherever the heat exchanging is needed. These are used in several places such as IC engines, computer CPU heat sinks, radiators and etc. This is an efficient and passive cooling technique. In this research, the various square pin-fin heat sinks were analysed for its thermal performance using the steady state thermal project of ansys. The various pin-fin configurations were done by using creo software which is one of the best solid modelling software of parametric technology corporations. The modelling was done for the square pin-fin heat sinks with and without plates and holes were created as shown in figures.

II. MATERIAL PROPERTIES

Aluminium is one of the metals in which having high thermal conductivity and hardness. It can withstand high temperature. Mostly Aluminium fins and aluminium alloys were used in fins. This is because of the thermal properties of the aluminium material. In this project Aluminium material was chosen under the thermal materials of engineering data having the following specifications such as thermal conductivity, density and specific heat.

Thermal Conductivity, K - 237.5 W / m ºC
Density, ρ - 2689 kg / m^3
Specific Heat, C_p - 951 J / kg ºC

III. CAD MODELLING

The three dimensional was done by using the Creo software in which the dimensions are shown in table. The base plate was designed for (580 x 410 x 50) mm.

The total number of fins in horizontal direction is 7 with the spacing distance of 30 mm. And the number of fins in vertical direction is 5 with the spacing distance of 30mm.

Type	Parameters (mm)	
I. Square pin-fins (no perforations)	Size	30
	lengh	200
II. Square pin-fins with plate projections	Size	30
	Lengh	200
	Disc thickness	5
III. Square pin-fins with plates and holes	Size	30
	Lengh	200
	Disc thickness	5
	Plate hole dia.	3
IV. Square pin-fins with center holes	Size	30
	Length	200
	Disc thickness	5
	Plate hole dia.	3
	Centre Hole dia.	20

TABLE I DESIGN PARAMETERS

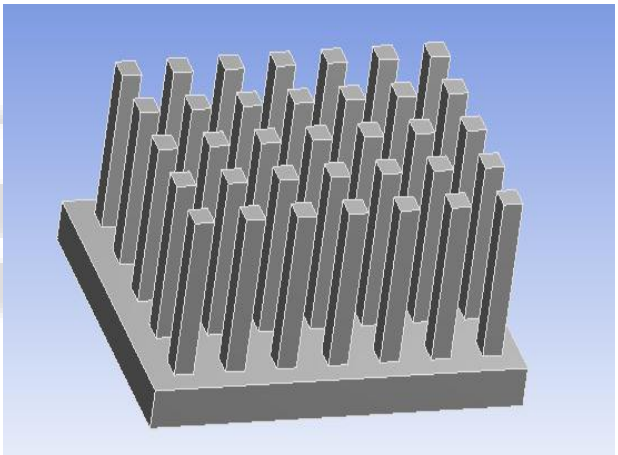


Fig (a): Type I : Normal Square Pin-fin (without plates and holes)

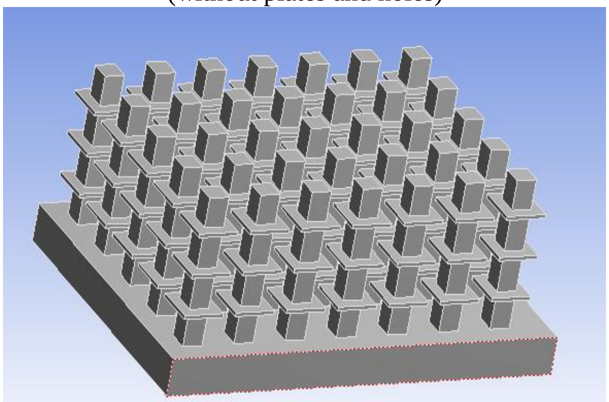


Fig (b): Type II: Square pin-fins with plate projections

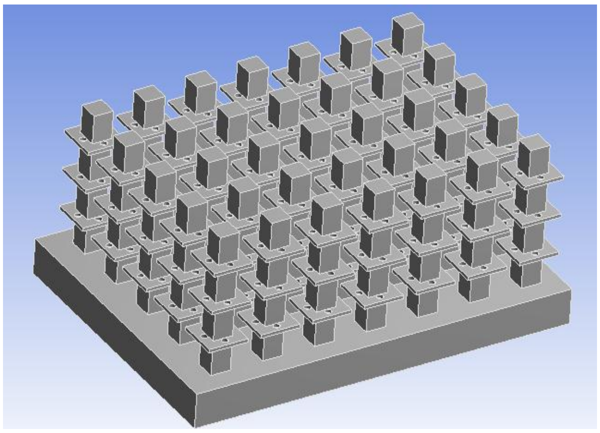


Fig (c): Type III: Square pin-fins with plates and holes

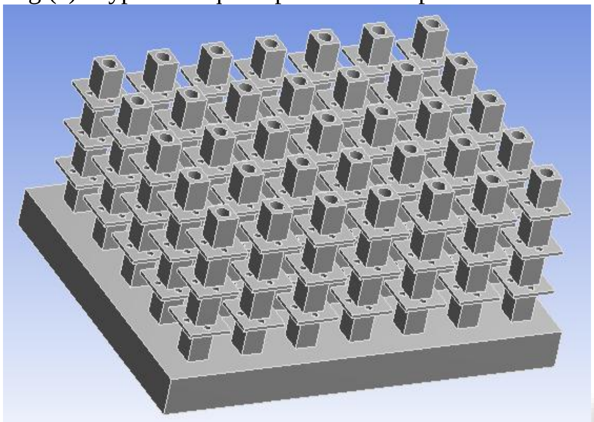


Fig (d): Type IV: Square pin-fins with center holes

IV. MESHING MODEL

Meshing is the main function of Ansys. In this project, the numerical meshing was done and for this meshing, the accuracy of the space angle and the relevant centre is increased. From meshing of various modelling, it was found that when number of edges increases, the number nodes and elements were increased. According to this, the modelling type IV has the higher elements and nodes. Hence it takes larger time when comparing to the other three modelling types.

Thus, the following figures illustrates the meshing of the four types of modelling in Ansys.

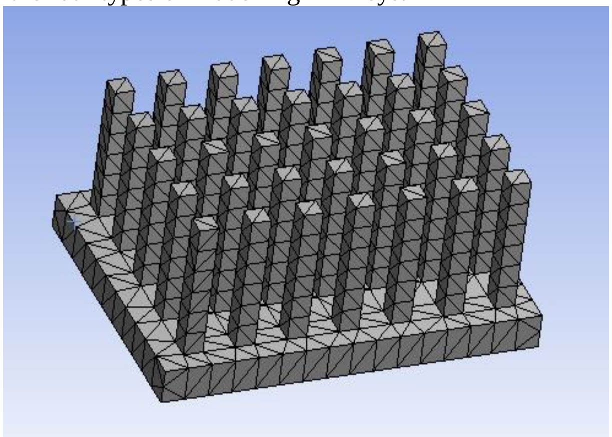


Fig (e): Numerical Meshing of
Type I : Normal Square Pin-fin

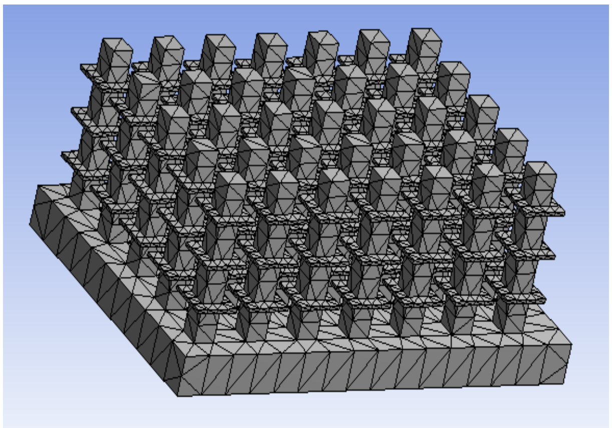


Fig (f): Numerical Meshing of
Type II: Square pin-fins with plate projections

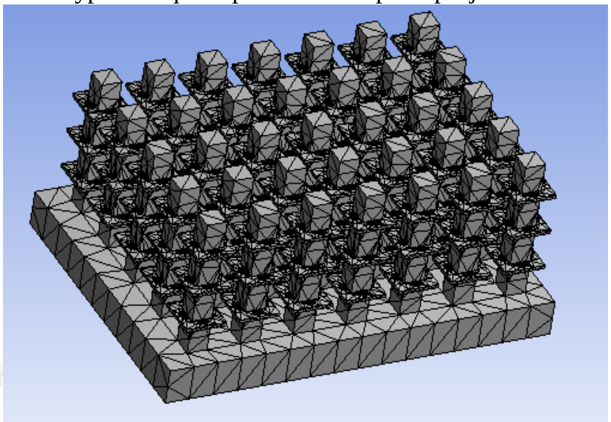


Fig (g): Numerical Meshing of
Type III: Square pin-fins with plates and holes

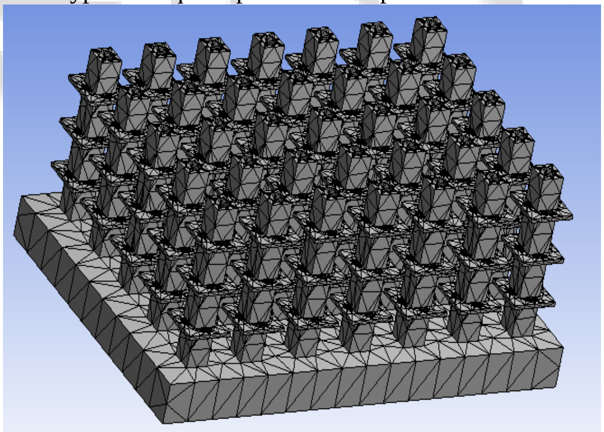


Fig (h): Numerical Meshing of
Type IV: Square pin-fins with center holes

V. STEADY STATE ANALYSIS

In Ansys workbench, among the steady state and transient analysis, steady state thermal analysis was chosen to run the analysis. In this analysis the workbench uses the APDL numerical analysis method. The all modelling consists of 6 faces and 1 body. The average inlet temperature magnitude for the fin base is 600 ºC. And the performance analysis was undertaken for the average convection heat transfer coefficient at 20 W/m ºC. It was taken that the ambient temperature is at 22ºC. The following table illustrates the input conditions and parameters of the steady state analysis in Ansys workbench.

Scoping Method	Geometry Selection	
Geometry	6 Faces	1 Body
Definition		
Type	Temperature	Convection
Magnitude	600. °C (ramped)	-
Suppressed	No	
Film Coefficient	-	22. W/m²·°C (step applied)
Ambient Temperature	-	22. °C (ramped)
Convection Matrix	-	Program Controlled

TABLE II STEADY STATE ANALYSIS INPUT DATA

VI. RESULTS

From the steady state analysis of various square pin-fin configurations, the following temperature difference figures and the heat flux difference were found. The convection heat transfer rate is assumed to be in all over the surface. Then the input temperature is supplied only for the base plate of the pin-fin heat sink.

Note: Type I : Normal Square Pin-fin
Type II: Square pin-fins with plate projections
Type III: Square pin-fins with plates and holes
Type IV: Square pin-fins with center holes

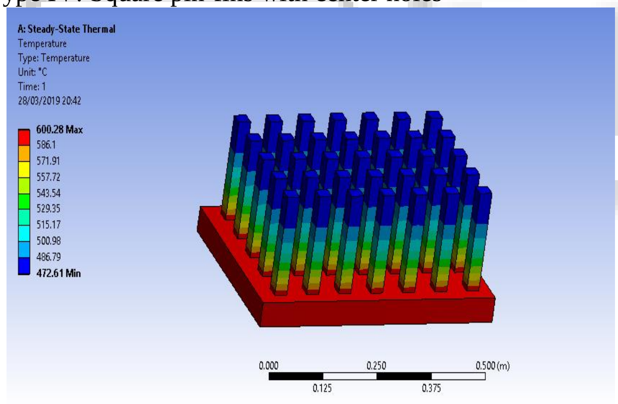


Fig (i): Temperature difference of Type I

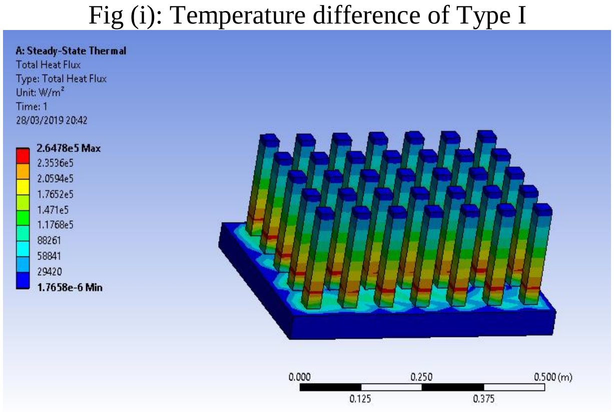


Fig (j): Heat flux difference of Type I

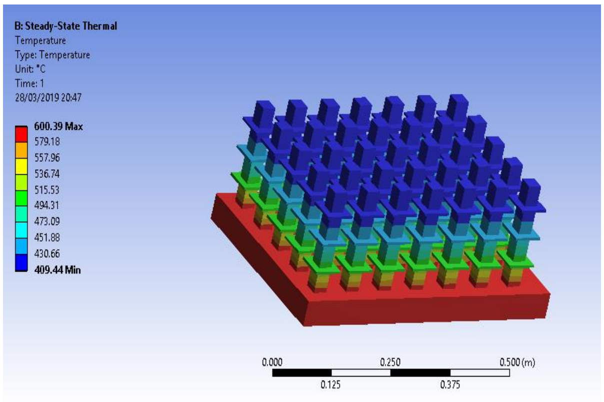


Fig (k): Temperature difference of Type I

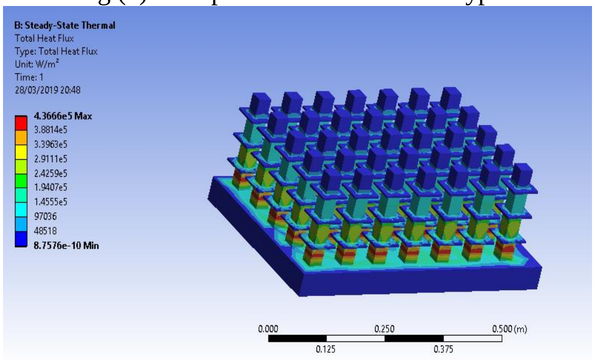


Fig (l): Heat flux difference of Type I

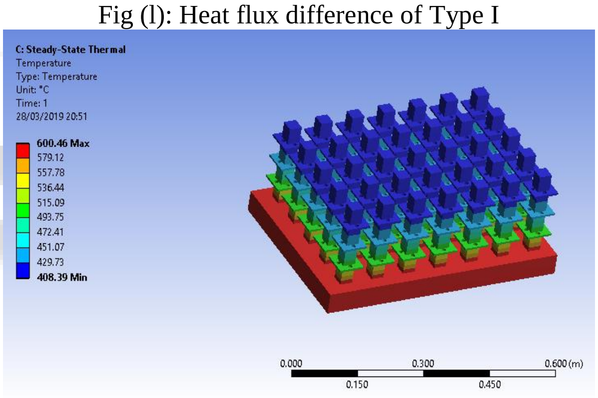


Fig (m): Temperature difference of Type I

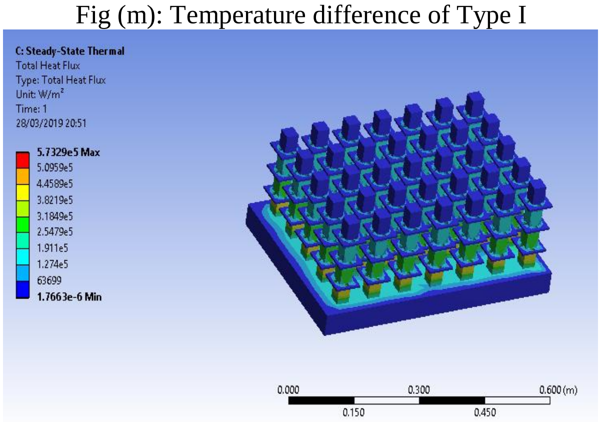


Fig (n): Heat flux difference of Type I

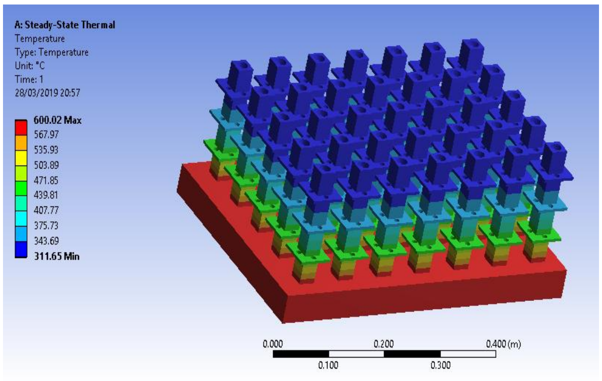


Fig (o): Temperature difference of Type I

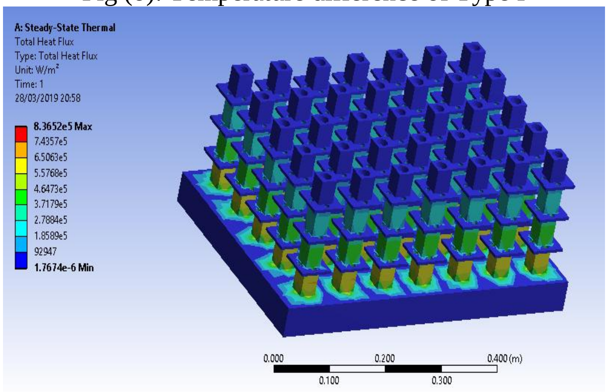


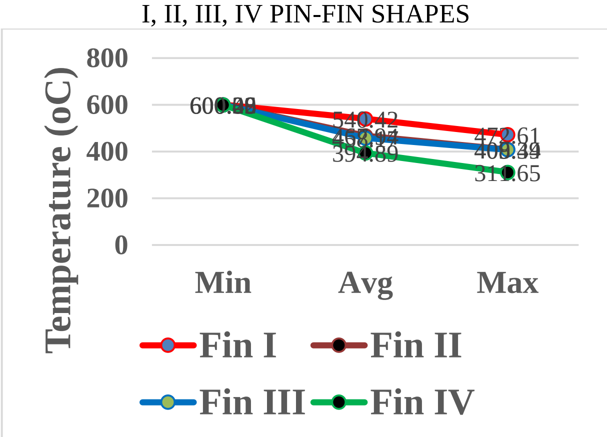
Fig (p): Heat Flux difference of Type I

Pin-fin Types	Min.Temp.	Max.Temp.	Avg.Temp.
	($^{\circ}$C)		
I	472.61	600.28	540.42
II	409.44	600.39	467.94
III	408.39	600.46	458.17
IV	311.65	600.02	394.89

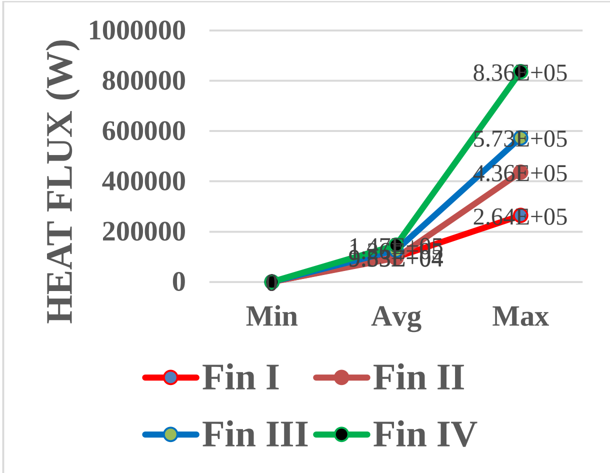
TABLE III TEMPERATURE COMPARISON BETWEEN THE I, II, III, IV PIN-FIN SHAPES

Pin-fin Type	Min.Heat Flux	Max. Heat Flux	Avg. Heat Flux
	(W/m^2)		
I	1.765 e-6	2.647 e5	0.931 e5
II	1.766 e-6	4.366 e5	0.953 e5
III	1.766 e-6	5.732 e5	1.262 e5
IV	1.767 e-6	8.365 e5	1.465 e5

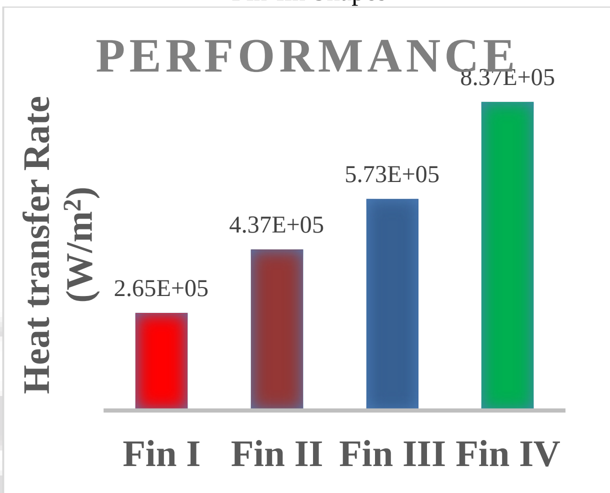
TABLE IV HEAT FLUX COMPARISON BETWEEN THE I, II, III, IV PIN-FIN SHAPES



Graph (a): Temperature Comparison between the I, II, III, IV Pin-fin Shapes



Graph (b): Heat Flux Comparison between the I, II, III, IV Pin-fin Shapes



Graph (c): Performance Comparison between the I, II, III, IV Pin-fin Shapes

VII. Conclusion

From the graphical results a, b and c, It was found that no longer difference between the pin-fin configurations type II and type III. It is due to smaller increases in plate hole area. But these are slightly higher than the pin-fin type I. Among the four configurations the heat transfer rate of pin-fin type IV is having the maximum performance. It reduces more temperature and increases heat transfer rate. It is because of adding perforation on the centre of the square pin-fin along its length. Thus, the fourth configuration is better than the other three.

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