Heat transfer Analysis between Plate Fins and Pin Fins Using Ansys

Satyaprakash gaur[1], P. S. Dhakar[2]

[1]PG Scholar NITM Gwalior (M.P.) Madhya Pradesh, India
[2] Asst. Professor NITM Gwalior (M.P.) Madhya Pradesh, India

Abstract: The Engine chamber is one of the essential engine components, that is subjected to over the top temperature differences and thermal stresses. Fins are set on the surface of the cylinder to improve the quantity of heat exchange by convection. The present examination gives the heat exchange investigation between plate fins and pin fins. pins fins composed in two shapes (circular, rectangular) fitted with tube-shaped cross-sectional so as to decide better improvement in the heat exchange rate. we have optimized Heat exchange rate and optimized with all perspectives to get higher Heat exchange rate. In the present work, Experiments have been performed to discover the temperature variations inside the fins made in three kind geometries (plate Fins, Circular Pin fins, and Rectangular pin fins) and consistent state heat exchange examination has been studied utilizing a finite element software ANSYS to test and approve results. The temperature variations at various areas of pin fins are evaluated by FEM and compared plate fins result with the results of pin fins obtained by experimentally in Ansys. The principle implemented in this project is to expand the heat dissipation rate by utilizing the wind flow. The main aim of the study is to enhance the thermal properties by shifting geometry, material, and design of fins.

Keywords: heat transfer, Extended surfaces, Thermal analysis, FEM, Analysis and Heat transfer enhancement.

I. Introduction

Heating of a component under different working applications is a big problem for today's engineering applications therefore fast heat transfer from heated surfaces and reducing cost and material weight has turned into a major challenge for design of heat exchanger component. The expulsion of unnecessary heat from system parts is necessary to maintain a strategic distance from the damaging impacts of burning or overheating. In this way, the improvement of Heat exchange is a vital subject of thermal engineering. The heat exchange from surfaces may, in general, be enhanced by expanding the heat exchange coefficient between a surface and its environment, by expanding the heat exchange zone of the surface, or by both. In most cases, the region of Heat exchange is expanded by using Extended surfaces as balances the fins joined to walls and surfaces. Expanded surfaces (fins) are much of the time utilized in heat exchanging devices to increase the heat exchange between an essential surface and the surrounding liquid. Different types of fins, going from moderately simple geometries to complex geometries have been utilized. A shape of the regular fins geometries is rectangular, triangular, cylindrical, trapezoidal etc. For the guideline of conduction, convection, radiation of a fin arrangement optimized the quantity of heat it exchanges Increasing the temperature contrast between the fin setup and based upon surroundings, marginally expanding the convection heat transfer coefficient, or somewhat expanding the surface region of the fin design of the object enhance the heat exchange. Now and then it is not economical or it isn't achievable to change the initial two alternatives. Adding a fin design to the fins model, in any case, somewhat enhance the surface area and can now and again be the economical option for Heat exchange issues. Circumferential fins around the chamber, square and rectangular state of an engine of motorcycle and fins connected to condenser containers of a refrigerator are a few of familiar precedents just happen when there is a temperature distinction, flow quicker when this variation is higher, always move out of high to low temperature, Is greater with more prominent surface region.

II. Extended Surfaces (Fins)

In the Heat exchange study, the surface that extruded out from a base is known as a fin. fins are utilized to enhance the rate of heat dissipation from or to the environment by expanding the rate of convection. The all of convection, conduction, or radiation of an object chooses the rate of heat it transferred. It increments with the distinction of temperature between surroundings and the object, additionally expanding the convection coefficient of heat exchange, or expanding the surface region. But, increase of the area also causes increased resistance to the heat flow. Hence, coefficient of heat transfer is based on the total area (the base and fin surface area) which comes out to be less than that of the base. There are different types of shape and size fins used in engineering applications to increasing the heat transfer rate such as

- Rectangular fins
- Triangular fins
- Trapezium fins
- Circular segmental fins.

Different shape and designs of fins are used in different situations.

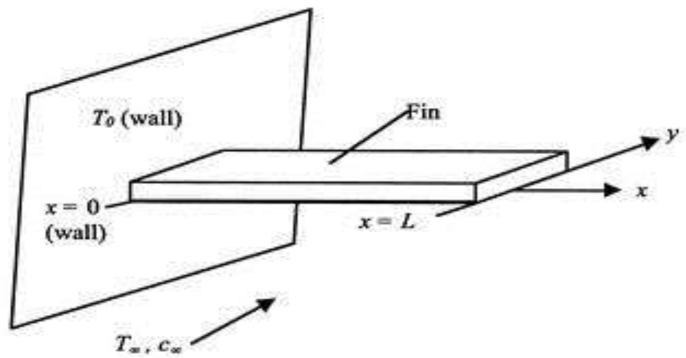

Figure 1: diagram of heat transfer fin
(Source: Heat and Mass Transfer. Revised edition, R. K. Rajput).

III. Material properties of Fins material

Thermal analysis of Fins performed by using Aluminum alloy of the Fins material. Composition of Aluminum alloy is shown in Table 1.

Table 1: Material properties of Fins Model

Parameters	Unit	Aluminum alloy (1060)
Density	(Kg/m^3)	2700
Young's Modulus	(MPa)	69000
Coefficient of thermal expansion	(1/K)	2.3×10^{-5}
Poisson's Ratio	-	0.33
Elastic modulus	(GPa)	70
Ultimate Tensile Strength	(MPa)	310
Thermal conductivity	$(W/m/^0C)$	200

IV. Design and Analysis of Fins

a. Modeling of Fins Model

Fins models designed with the material selection of aluminum alloy 1060 and three Fins model designed here i.e. plate Fins, Circular Pin fins and Rectangular pin fins. Fins model with plate fins and pin fins in type of circular and rectangular holes pin fins fins for passing air through fins. FEM analysis performed through Ansys. The practical use of finite element modeling is known as FEA which is best understood during the real problem solving. FEA has been broadly utilized by the automotive business. It is an extremely prominent instrument for configuration builds in the product development technique. It is imperative to comprehend the FEA basics and design technique, demonstrating systems, the inherent mistakes and their impacts on the nature of the outcomes to render FEA as an effective design tool. FEA is also used as a computational tool for carrying out engineering problem analyses.

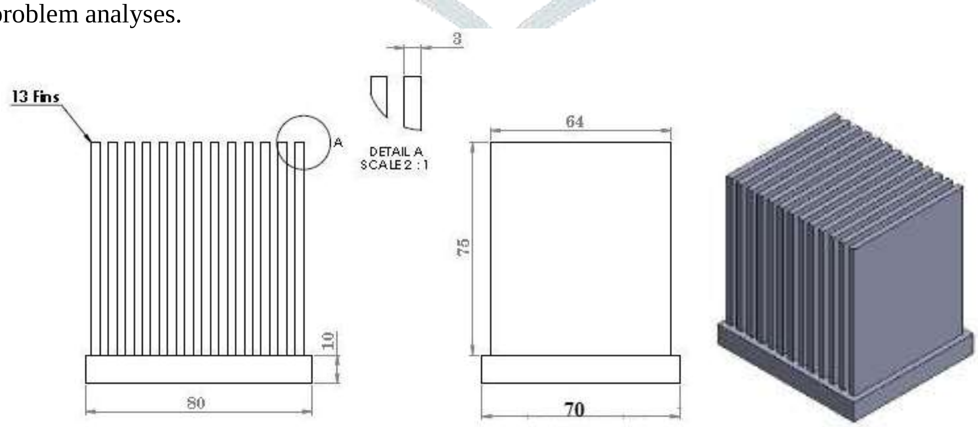

Figure 2: Plate Fins Designed Model in Ansys

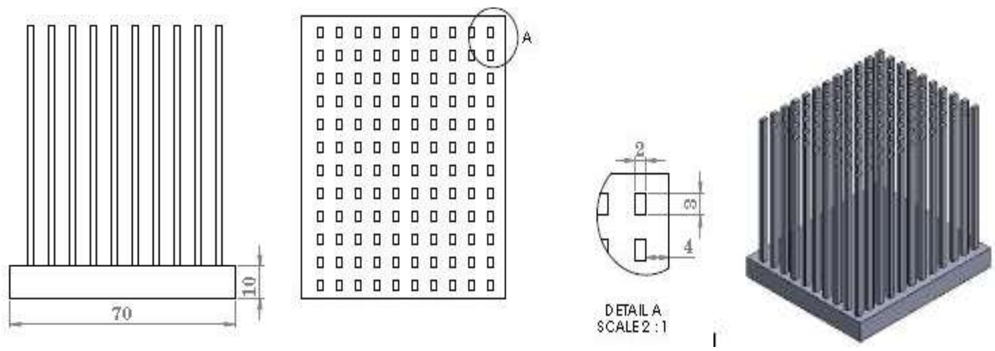

Figure 3: Rectangular Pin Fins Designed Model in Ansys

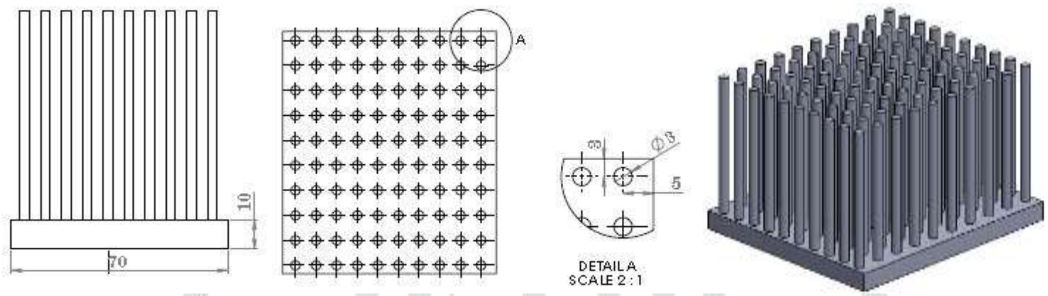

Figure 4: Circular Pin Fins Designed Model in Ansys

b. Applying boundary conditions

Figure represents the applied boundary conditions on Fins Model has Heat Flow 13 W, and convection conditions 22 ^{0}c while convection on the top surface of the Fins has been applied, to optimize Maximum and minimum temperature also optimize maximum heat flow rate for high heat transfer. Figure shows the applied boundary conditions of Fins Model.

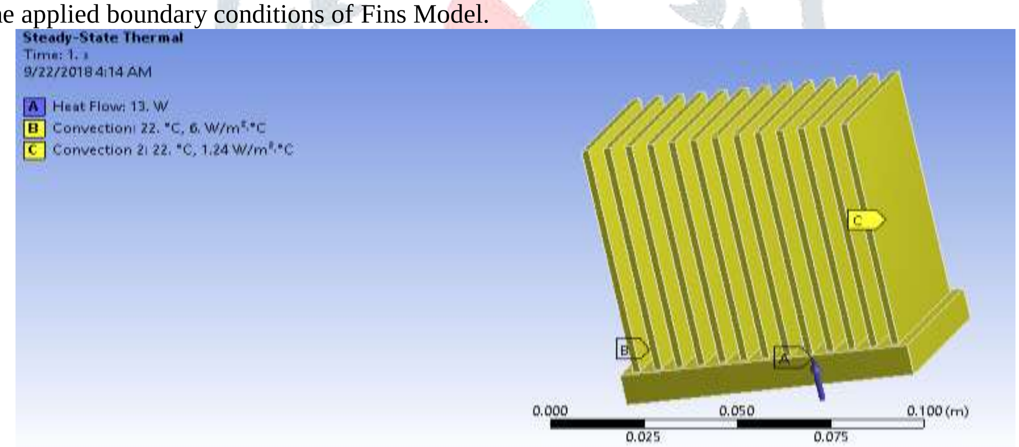

Figure 5: Applied Boundary conditions on Plate Fins

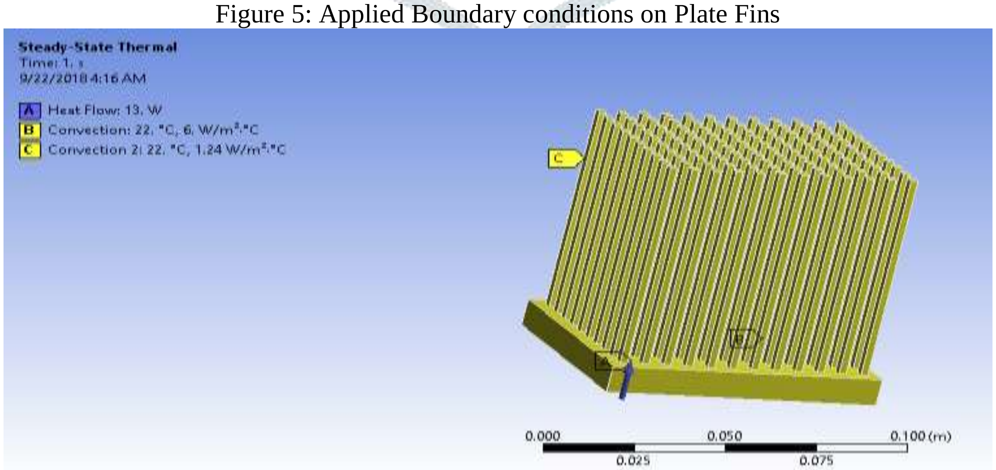

Figure 6: Applied Boundary conditions on Circular Pin Fins

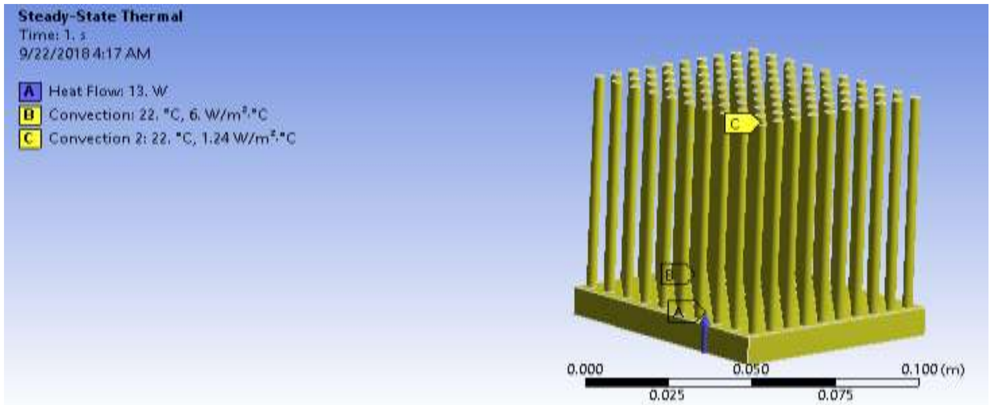

Figure 7: Applied Boundary conditions on Rectangular Pin Fins

V. Results and Discussion

The Fins model to research is subdivided into a mesh of limited measured components of the basic frame. Inside every segment, the distinction of displacement is thought to be computed by basic polynomial profile capacities and nodal Temperature. Conditions for the strains and stresses are created as far as the obscure nodal temperature. From this, the conditions of balance are collected in a grid shape which can be easily customized. Temperature variation across various Fins heights in steady state condition shows and boundary conditions applied shown in figures Maximum temperature at top. After processing solution, the Temperature and Total Heat Flux in thermal analysis compared with the plate fins and pin fins models. These results as part of structural and thermal analysis are obtained for all three conditions i.e. Plate fins, Fins with circular Pins and Fins with rectangular Pins. Figures shows the simulation study in Ansys of Fins models

- **Temperature distribution analysis of Fins Models**

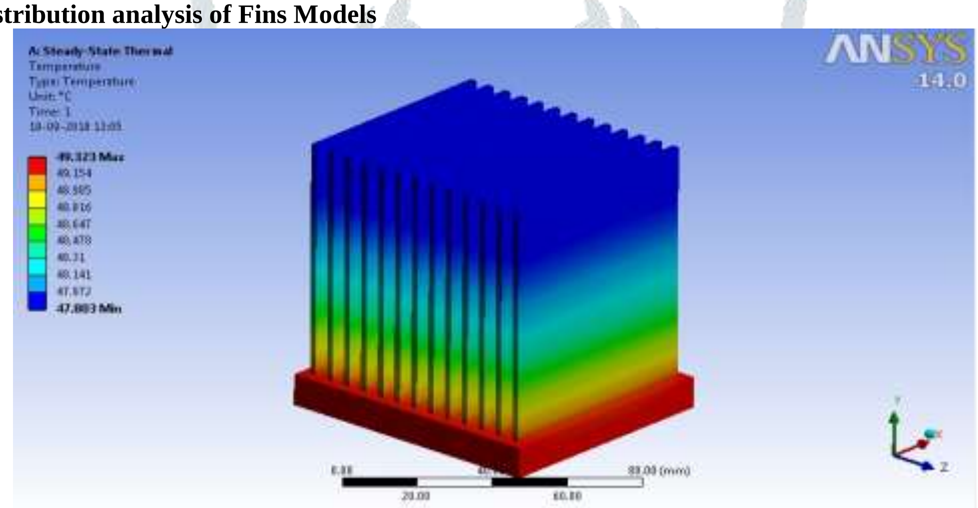

Figure 8: Temperature Distribution of Plate Fins

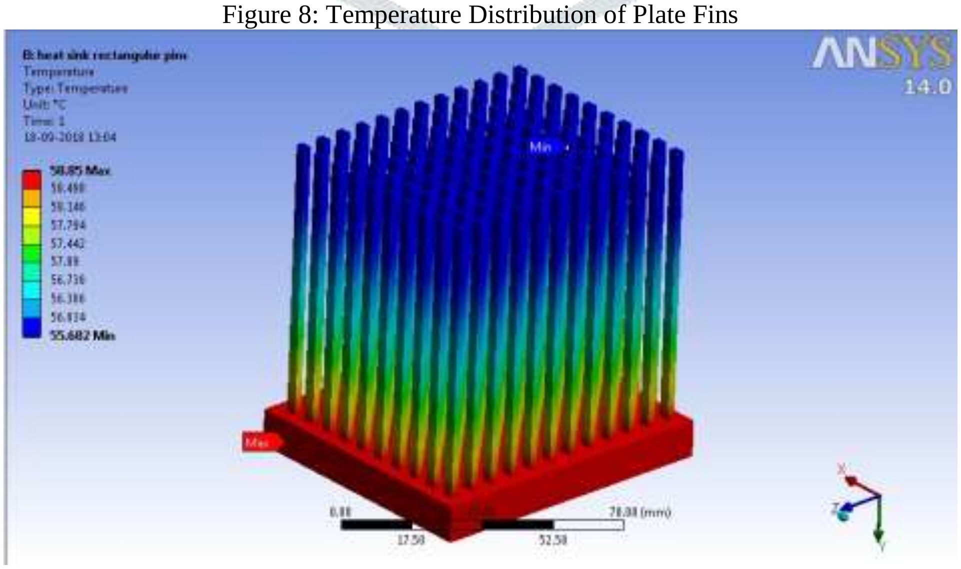

Figure 9: Temperature Distribution of Rectangular Pin Fins

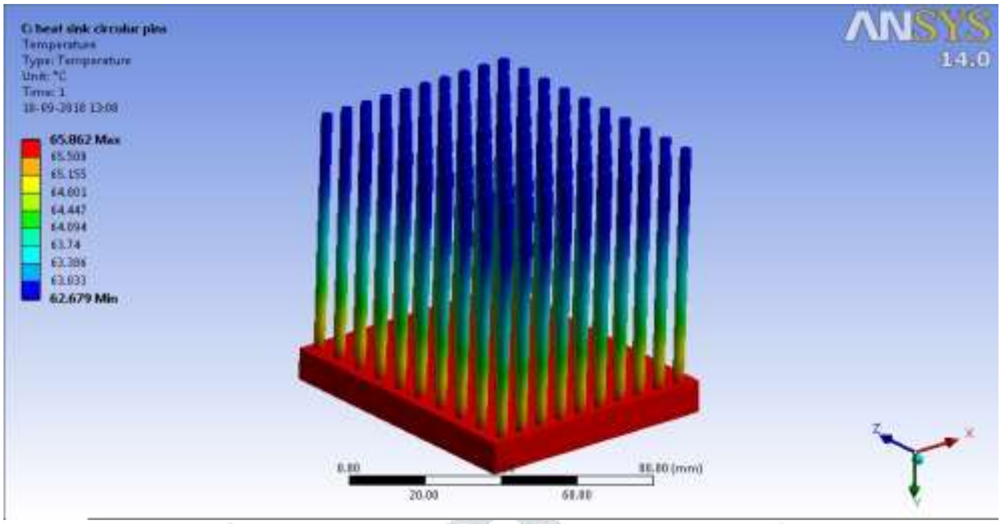

Figure 10: Temperature Distribution of Circular Pin Fins

- **Heat Flux analysis of Fins Models**

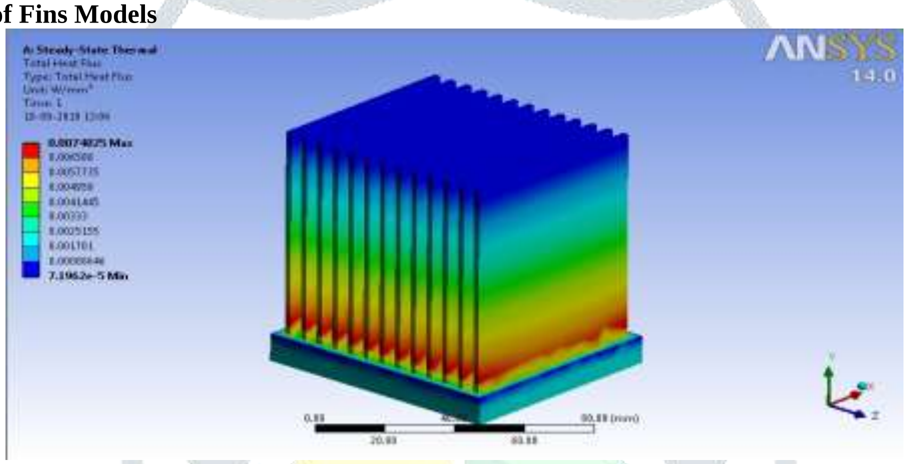

Figure 11: Heat Flux of Plate Fins

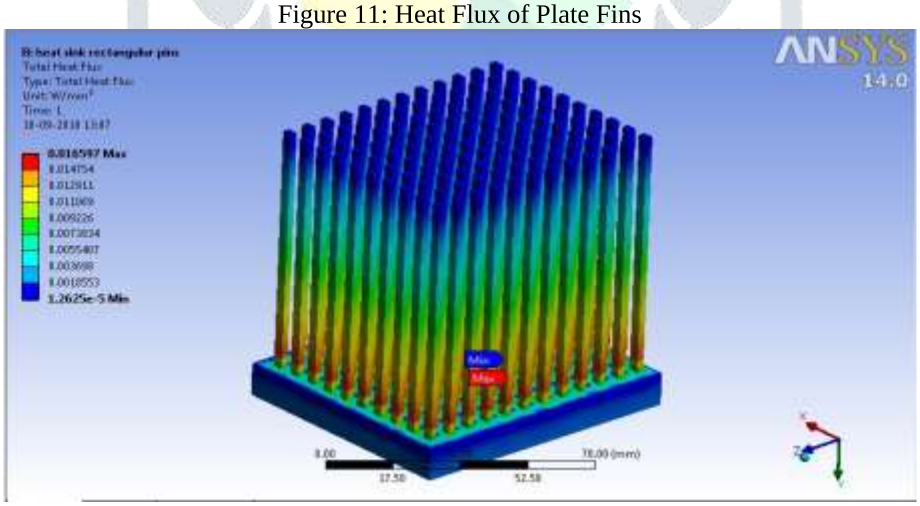

Figure 12: Heat flux of Rectangular Pin Fins

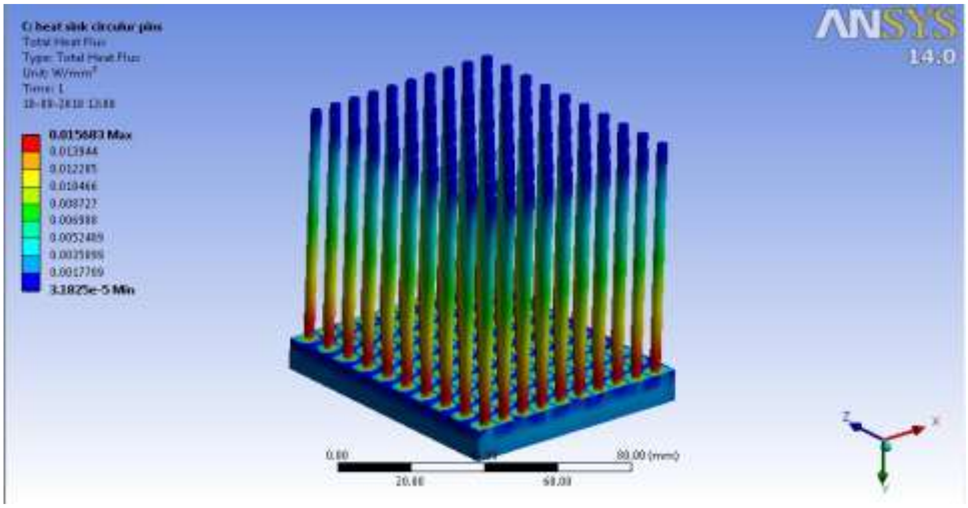

Figure 13: Heat flux of Circular Pin Fins

Table 2: Temperature Variations of Fins Models

Geometry Condition	Max Temperature (°C)	Min Temperature (°C)	Temperature drop(°C)
Heat Sink with Plate Fins	49.32	47.8	1.52
Heat Sink with Rectangular Pin Fins	58.85	55.68	3.17
Heat sink with Circular Pin Fins	65.86	62.67	3.19

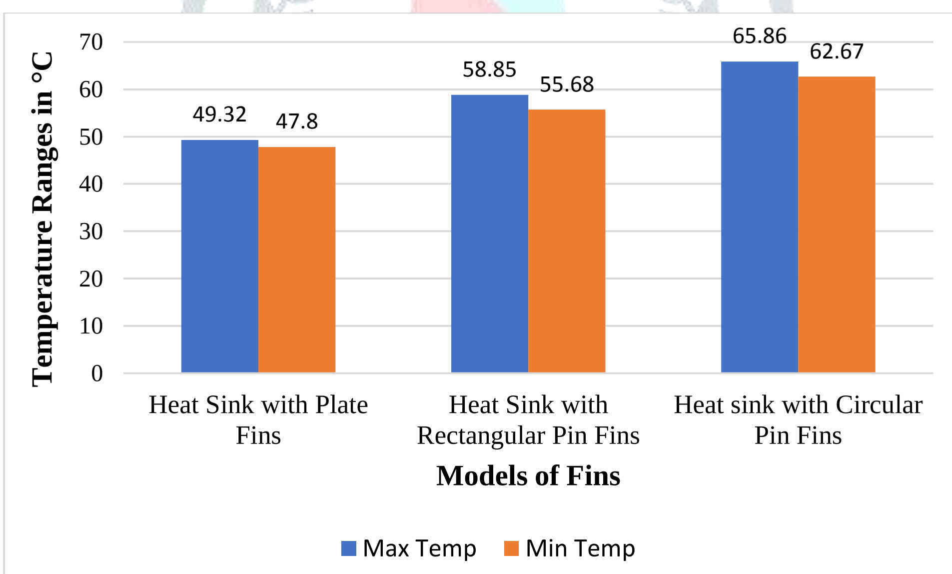

Figure 14: Temperature Variations in Models of Plate Fin and Pin Fin

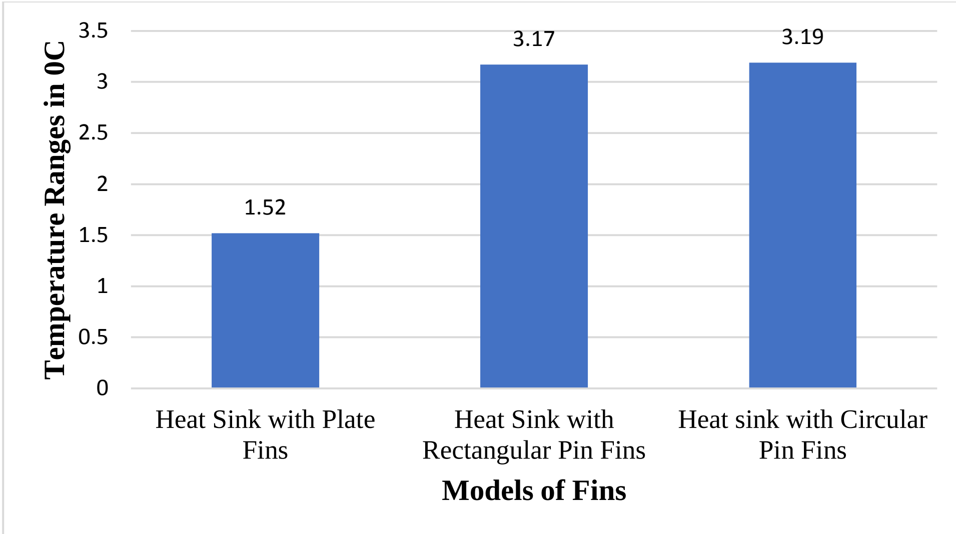

Figure 15: Total Temperature Drop in Plate Fin and Pin Fin Models

Table 3: Heat Flux Found on All conditions of Fin Models

Geometry Condition	**Heat Flux (w/mm^2)**
Heat Sink with Plate Fins	0.0074
Heat Sink with Rectangular Pin Fins	0.0166
Heat sink with Circular Pin Fins	0.0157

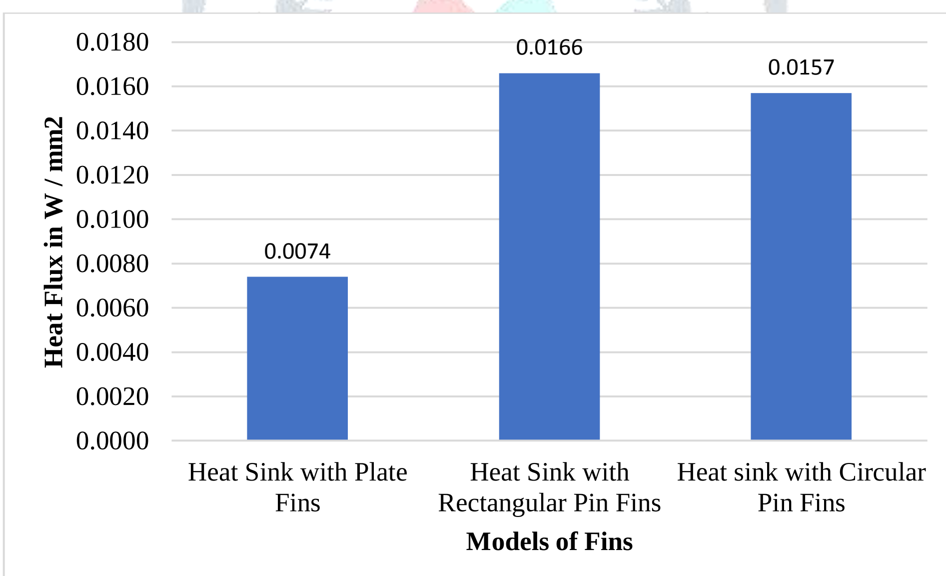

Figure 16: Comparison of Heat flux of Fin Models

VI. Conclusion

From the comparative analysis of Plate fins and pin Fins study conclusion is that the Total heat flux found maximum 0.0166 W/mm^2 in Rectangular Pin fins. Maximum temperature found in Circular Pin Fins is 65.86 ^{0}C and Minimum Temperature found in Plate Fins is 49.32 ^{0}C. so, it is concluded that Pin Fins with Rectangular profile is shows better Heat transfer properties in this analysis. Thus, better heat transfer for fins or an experimental result shows that Fins rectangular profile having better than plate Fins. The overall analysis is performed on ANSYS 14.5 FEM analysis Tool. Thus, further research can be carried with the advance materials and different designing, analysis tools. From the above study work the following conclusions are made:

- The thermal analysis of fins by modifying its certain parameters such as geometry and Plate fins and Pin fins has been completed.
- By observing the analysis results, we can easily say; using triangular fin with material Aluminum alloy 1060 is better since the temperature drop and the heat transfer rate in a Rectangular Pin Fins much more compared to Plate fins.

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