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# Design and Material Optimization of Cooling Fins in Electric Motors

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**ABSTRACT**
This project is about a comparative study of different types of fins and with different types of materials. The main aim of this research is to optimize the cooling rate of the fin in electric motors. Since now a day's the fossil fuels are deteriorating gradually, so the automobile industry is changing to E-Vehicles. In EV's the motor is the very important part, if that motor has a best design for fins to eliminate heat from the motor then it will be helpful for the efficient running of the vehicle. So, to resolve the heat transfer problem various designs of motor fins are modeled in 3-D modeling software (DSS-Solidworks) and analyzed by the analysis software (Ansys-2016) for their heat transfer properties. To improve the results even more a research has been done and by the help of various research paper study, the materials are selected. Those materials are first applied to the 3 basic verities of the fins. Then by the results we can able to find out the best material among the chosen 3 materials. Then to improve the results even more another 3 hybrid models are created and analyzed by applying only the best material which was found and find out the best design with the best material.

**KEYWORDS**
Ansys, Solidwork 3D Modeling, Fins, Electric Motor.

## Introduction

We all are in the world filled with machines, gadgets, and electricity. These machines are powered by electricity and works with respect to their purposes. In most of the cases the generated heat is only used for some extent and the remaining is just left out as a loss. For this issue our scientist created a small design modification in the place where the heat is generated is the FINS. But these fins too, does not completely eliminate the residual heat so to increase the rate of heat dissipation the variations in the fins are invented and with respect to the purpose & design structure they are used. We all know that the necessity is the mother of invention, so to increase the heat dissipation even more than better the cooling fans are introduced. This project's main goal is to improve the rate of convection through the fins of any hot bodies like heat sinks, motors, etc.

The electric energy into mechanical energy transformation is known as electric motor. It is one of the most imperative application of electromagnetism. It is the main end-use of electric energy in industries in general, and its used more in this area is due to its simple construction model and applying load in wide range.In vacuum the heat transfer of radiation is more effective. Radiation energy is transported by electromagnetic waves. Fins are the extended surfaces that are joined with any of the surface in order to increase the rate of heat transfer from that surface. It will transfer the heat from the solid medium to another solid medium and that solid medium into a liquid or gas medium is called fins. Motor to fins it will be a conduction heat transfer. The solid medium to the liquid or gas medium is named as the convection heat transfer. Fins are available in many shapes and forms.

## System Model

Modeling of the model which provides a complete set of design and manufacturing capabilities. These capabilities include Solid modeling, Surfacing, Rendering, Simulation and NC and tooling design. Since the cooling system of the engine uses air, convection boundary is defined on all the outer surfaces (at fins) of the engine assembly. Modeling is performed by SOLIDWORKS 2017 software Analysis work performed on ANSYS 14.5. In ANSYS 14.5 we calculate various thermal properties of the material. Thermal properties are calculated by transient thermal analysis, which is the part of ANSYS 14.5. Modeling of the model which provides a complete set of design and manufacturing capabilities. These capabilities include Solid modeling, Surfacing, Rendering, Simulation and NC and tooling design. Since the cooling system of the engine uses air, convection boundary is defined on all the outer surfaces (at fins) of the engine assembly. Modeling is performed by Solidworks 2017 software Analysis work performed on ANSYS 14.5. In ANSYS 14.5 we calculate various thermal properties of the material. Thermal properties are calculated by transient thermal analysis, which is the part of ANSYS 14.5.

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## Material Selection

There are many types of materials available but, we are choosing the material which has high thermal conductivity.

**A6061-T6:** (Si 0.4-0.8%, Cu 0.15-0.40%, Zn 0.25%, Mg 0.8-1.2%, Fe 0.7%, Cr 0.04-0.35%, rest is Al)

**B390-**(Si 16-18%, Fe 1.3%, Cu 4-5%, Mg 0.45-0.65%, Mn 0.5%, Ni 1.5%, Tin 0.1%, rest is Al)

**C443-**(Si 4.5 to 6.0%, Fe 0 to 2.0%, Cu 0 to 0.6%, Ni 0 to 0.5%, Zn 0 to 0.5%, Sn 0 to 0.15%, Mg 0 to 0.1%, rest in Al)

## Solidwoks Dimensions

Select the front plane to draw two circles outer diameter of circle is 155 mm and inner diameter of circle. Extrude the circle for 150 mm and select the front plane and draw straight line perpendicular to outer layer circle 25 mm joint that line with parallel to 15 outer layers of circle with length 3.50mm create rectangle. Extrude the rectangle till the circle extrude and by using pattern tool create more rectangle fin around the cylinder outer face. The loft feature is used to generate complex geometry in a single feature and making transition between profiles. For hybrid model we have twisted the extruded fin at angle of 45 degree.

## Designs

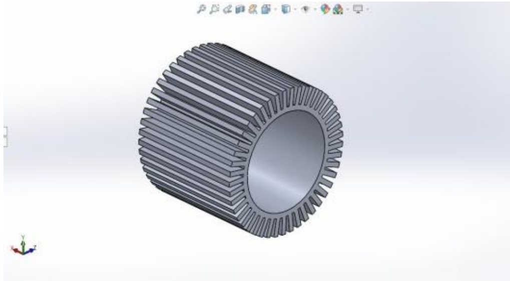

**Fig. 1.**Existing Model

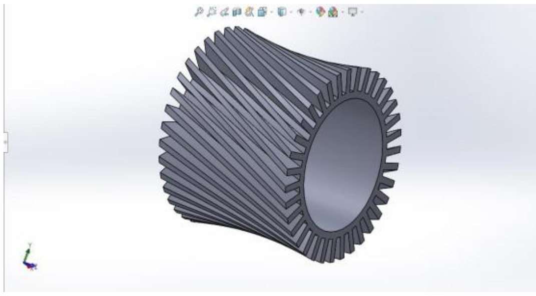

**Fig. 2.**Hybrid type 1

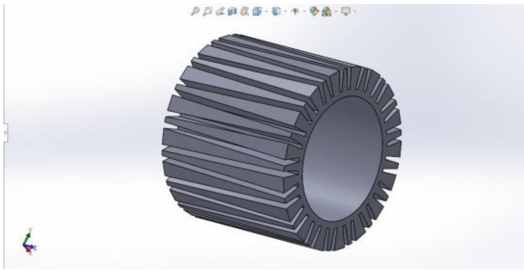

**Fig. 3.**Hybrid type 2

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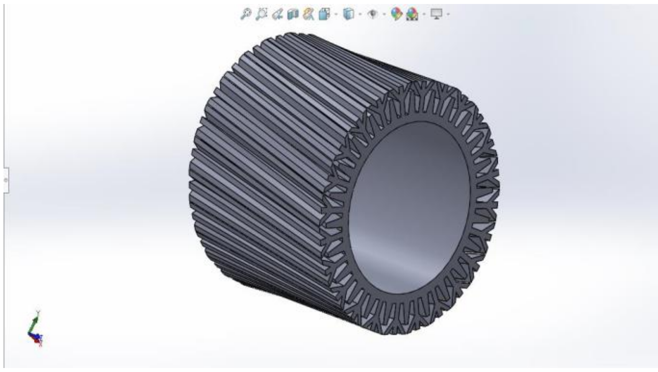

**Fig.4.**Hybrid type 3

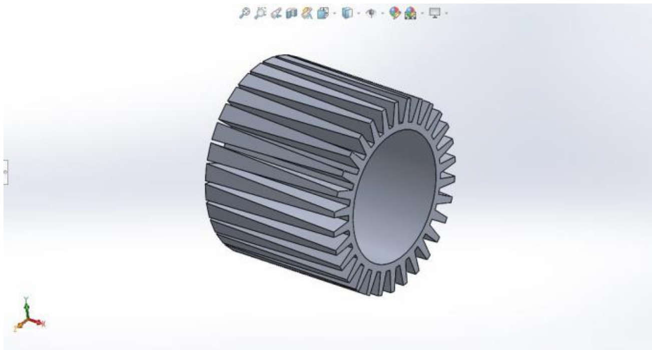

**Fig. 5.** Type 1

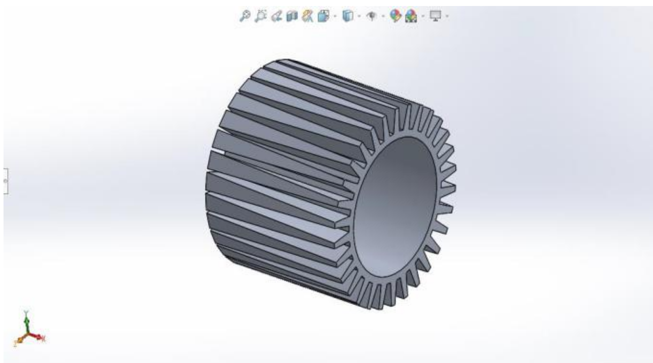

**Fig.6.** Type 2

## Analysing

Preprocessing also called Meshing is the first step in solving a problem in Finite Element Analysis Here the entire domain is discredited (divided) into meaningful divisions often called "Elements". These elements form the building block on which the Boundary conditions and external effects are specified.
Meshing a domain would consist of the following tasks

1. Defining a domain to Mesh

    - Importing a CAD Geometry (Computer Aided Geometry) OR
    - Creating your own Geometry OR
    - Creating node-based elements

2. Selecting the analysis type (Ex: 3-Dimensional, 2-Dimensional, 1-Dimensional)

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3. Creating the mesh
4. Choosing the element type
5. Validating the mesh. Check for Errors, Connectivity, Quality etc.

## Constrains

1. Ideal Temperature generated in the inner surface:200°C
2. Nature of convection:Straight Air Simplified
3. Ambient Temperature:22°C
4. Mesh Sizing:0.003m
5. Nature of Mesh:Fine Meshing

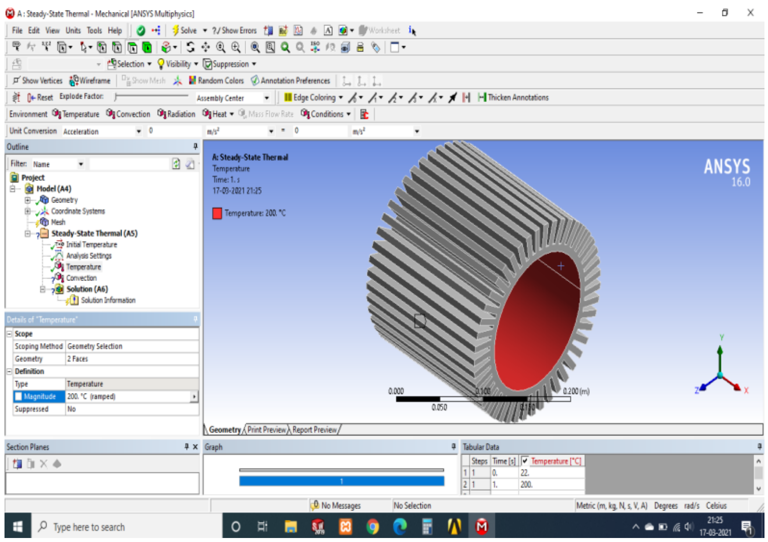


**Fig. 7.**Temperature Provided - 200°C

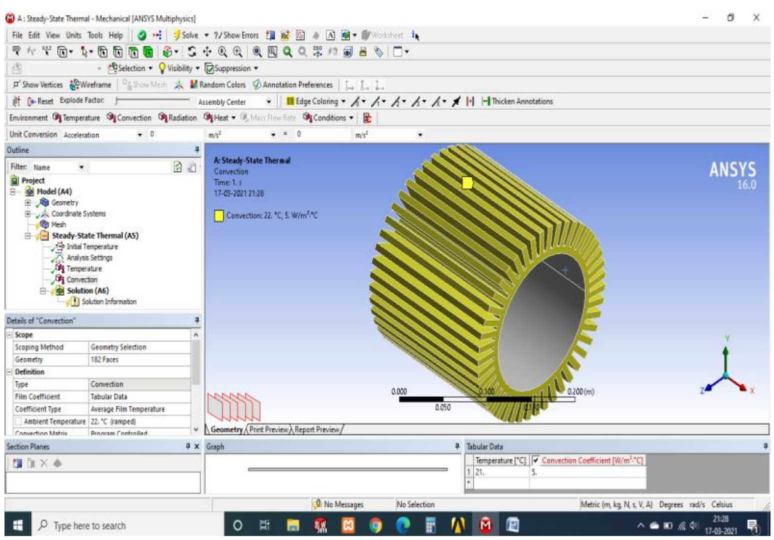


**Fig. 8.**Convection Provided – Straight Air Simplified

## Engineering Data

| MATEI | THERMAL CONDUCTIV | TEMPERATURE |
|---|---|---|
| Alumini | 152 w/m. k | 25 |
| Brass | 108 w/m. k | 25 |
| Cast Iro | 53 w/m. k | 25 |

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Before going to analysis, we need to mesh the component fin; Meshing is integration process which is used to discrete single part into small part. It increases the accuracy and speed of simulation. Selecting the element size is very important for meshing click mesh>>sizing>>element size-0.003m>>select all part>>apply>>generate mesh. Select state thermal for applying convection, temperature.

Convection selects the outer region of the fin, in film coefficient data will import from material based and simplify. Select temperature>>inner face of fin>>magnitude-2000C

## Analysis of Cast Iron

| S.NO | Model | Total Heat Flux | Directional Heat Flux |
|---|---|---|---|
| 1 | Existing Model | 40.387 | -972.1 |
| | | 92.21 | 972.1 |
| 2 | Type I | 412.92 | -990.2 |
| | | 9518.9 | 990.37 |
| 3 | Type II | 855.08 | -995.48 |
| | | 20958 | 995.15 |

## Total Heat Flux

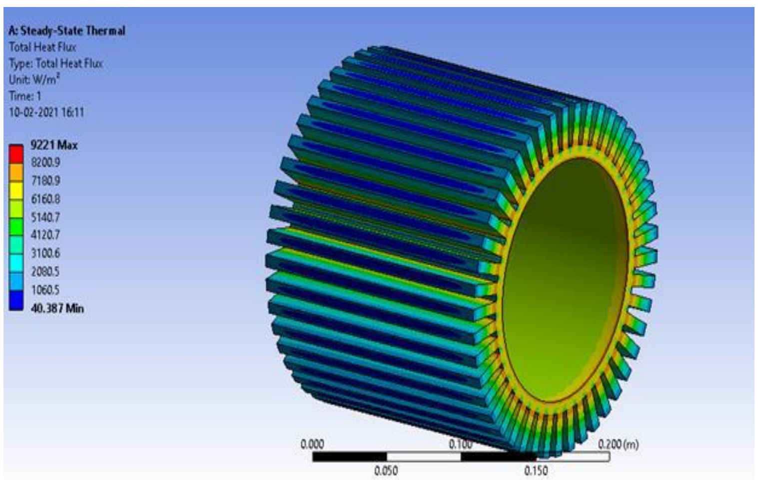


**Fig. 9.**Existing model

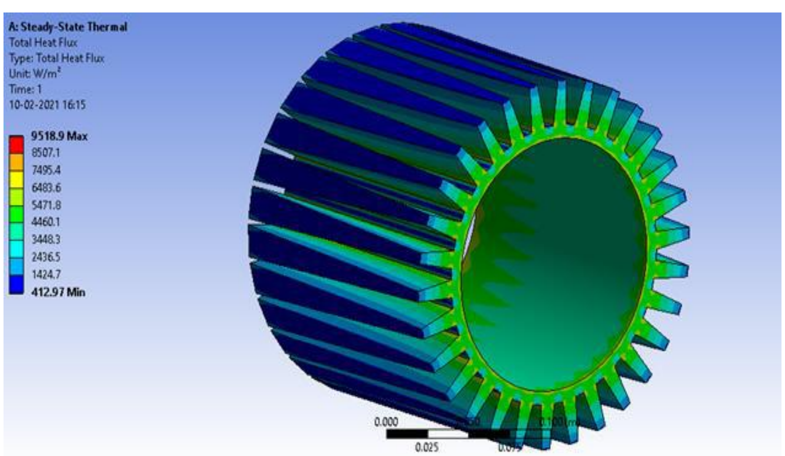


**Fig. 10.**Type 1

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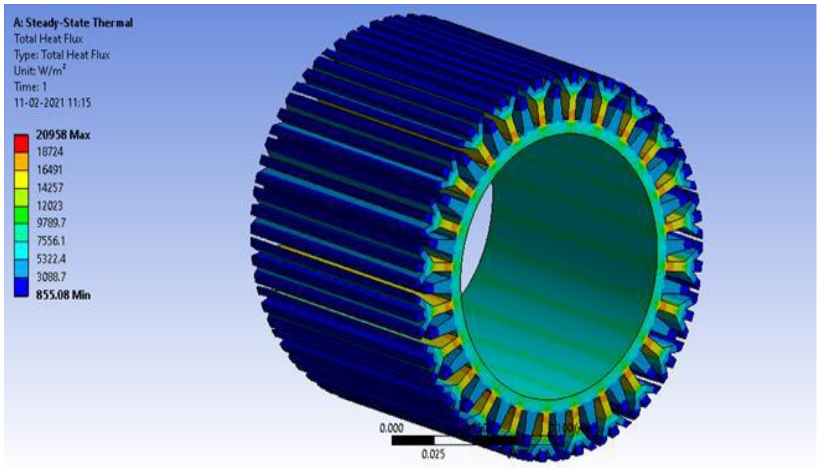


**Fig. 11.**Type 2

## Directional Heat Flux

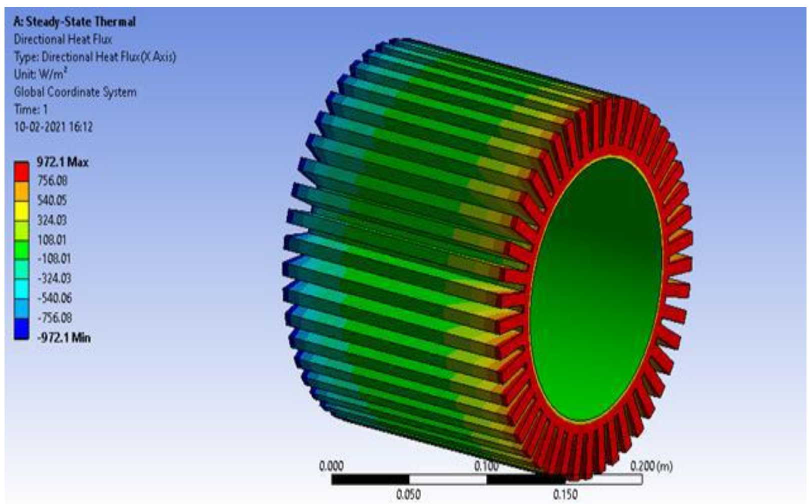


**Fig. 12.** Existing Model

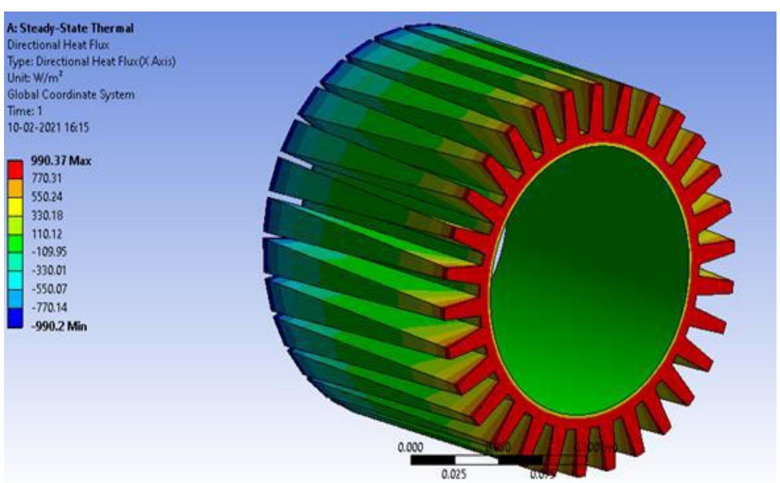


**Fig. 13.**Type 1

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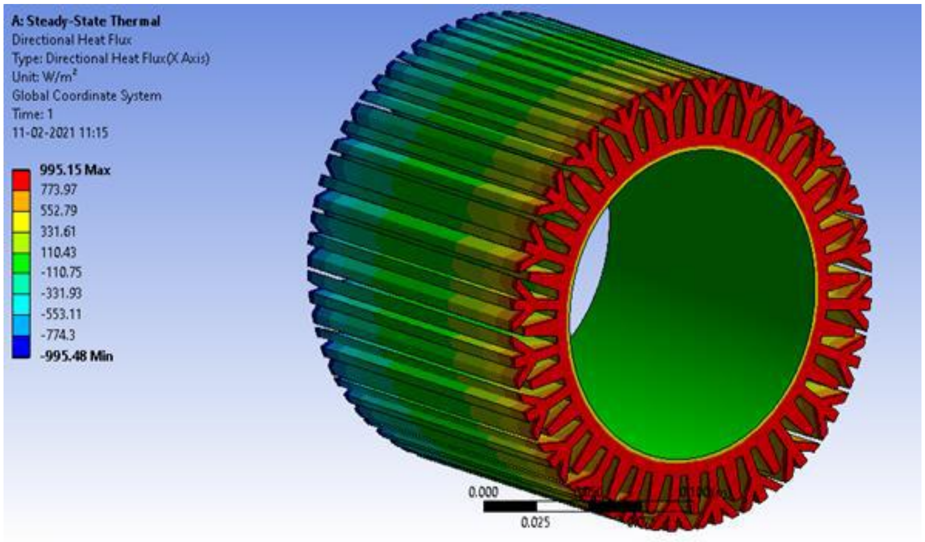


**Fig. 14.**Type 2

## Analysis with Brass

| S.NO | Model | Total Heat Flux | Directional Heat Flux |
|---|---|---|---|
| 1 | Existing Model | 43.779 | -971.82 |
| | | 9293.1 | 971.86 |
| 2 | Type I | 427.72 | -993.64 |
| | | 9376.7 | 993.9 |
| 3 | Type II | 870.38 | -996.62 |
| | | 21314 | 996.3 |

## Total Heat Flux

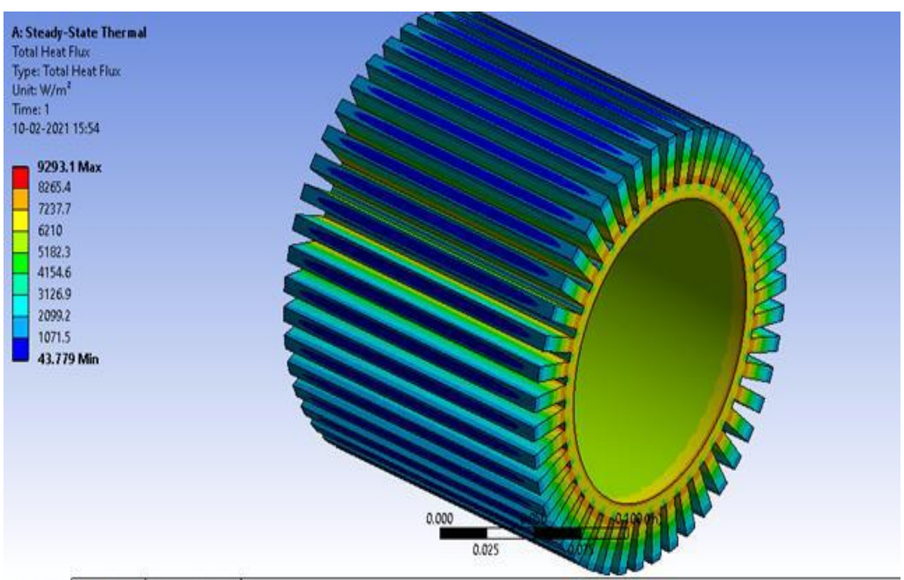


**Fig. 15.**Existing Model

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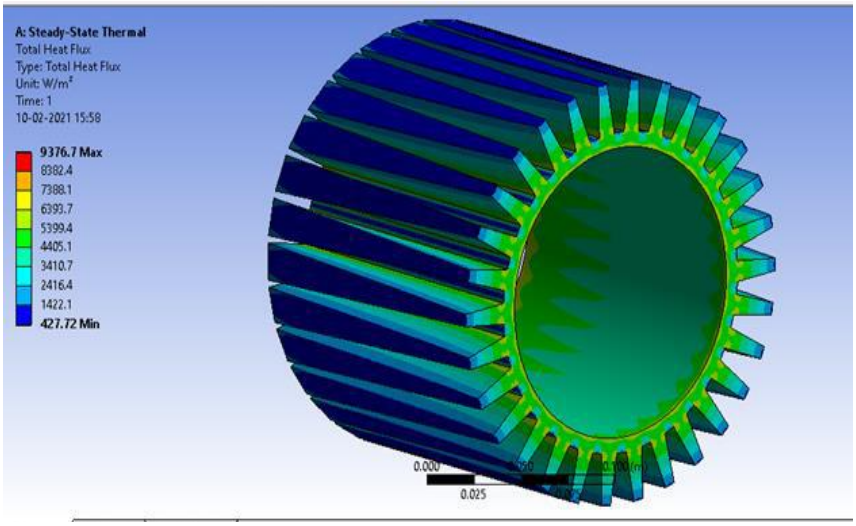


**Fig.16.** Type 1

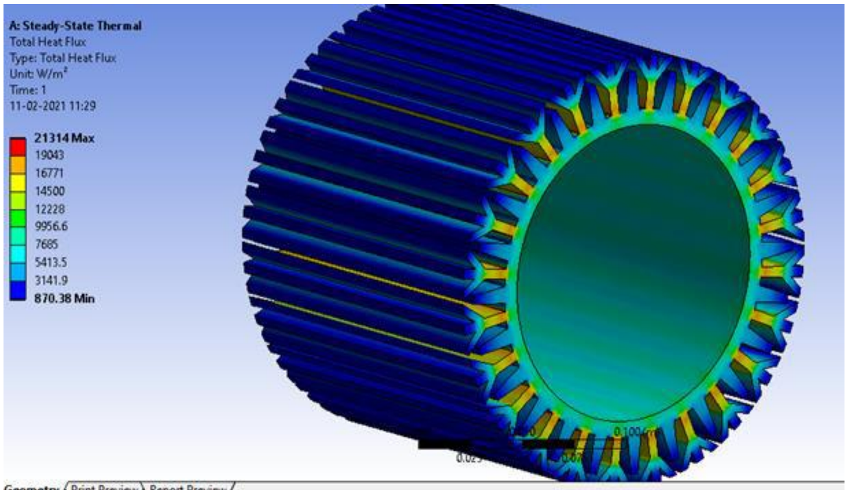


**Fig.17.** Type 2

## Directional Heat Flux

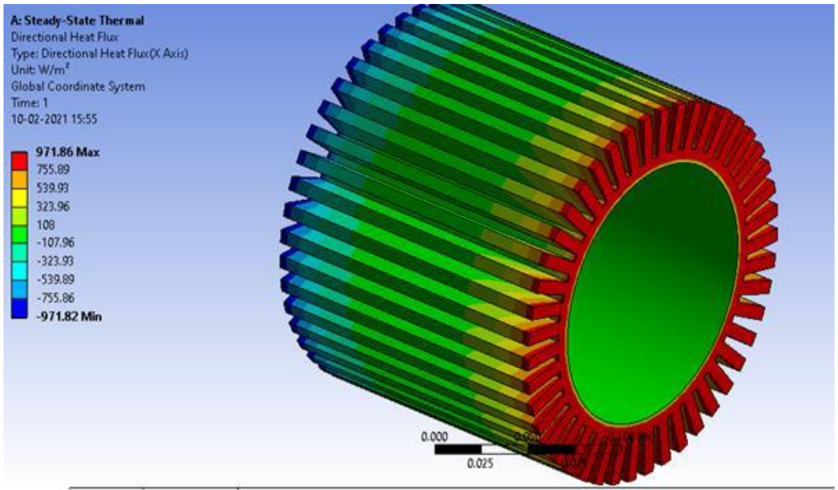


**Fig. 18.**Existing Model

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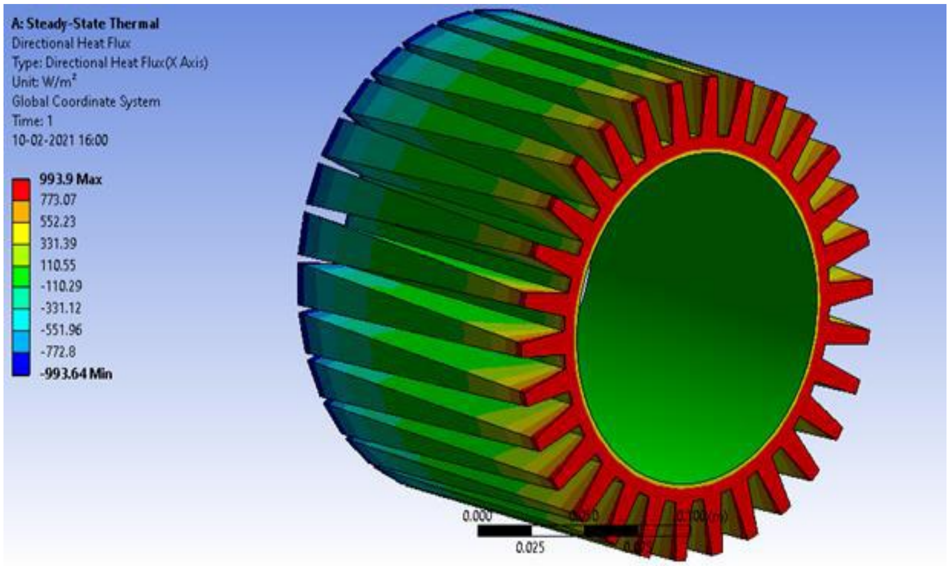


**Fig.19.**Type 1

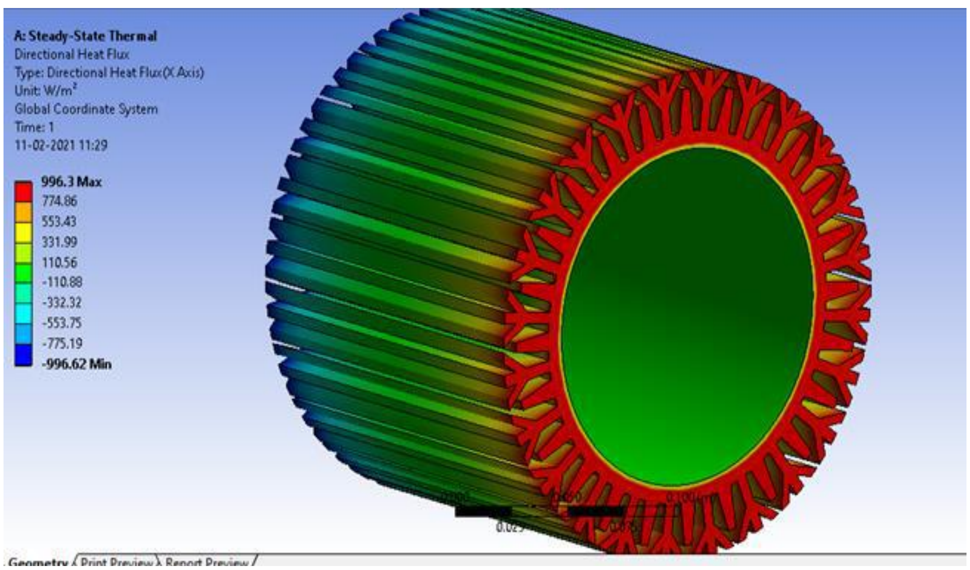


**Fig. 20.**Type 2

## Analysis of Aluminum

| S.NO | Model | Total Heat Flux | Directional Heat Flux |
|---|---|---|---|
| 1 | Existing Model | 40.898 | -973.25 |
| | | 9300.9 | 973.25 |
| 2 | Type I | 411.51 | -991.48 |
| | | 9590.5 | 991.47 |
| 3 | Type II | 874.41 | -996.92 |
| | | 21408 | 996.6 |

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## Total Heat Flux

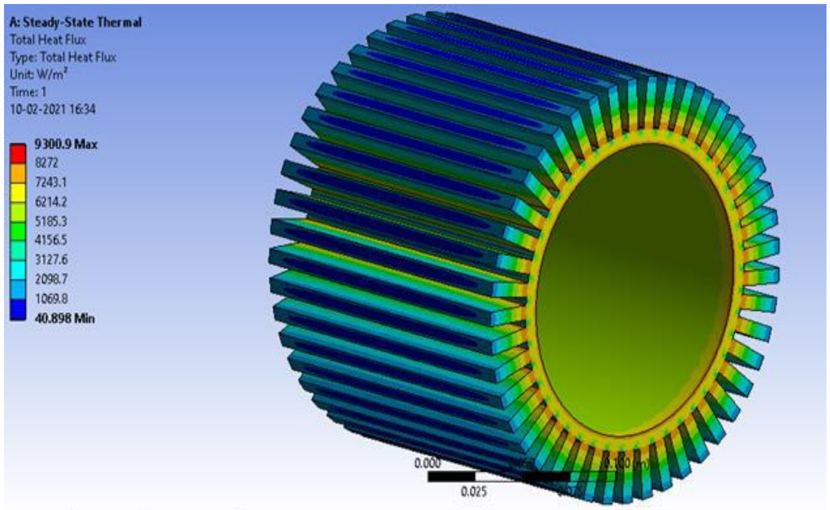


**Fig. 21.** Existing Model

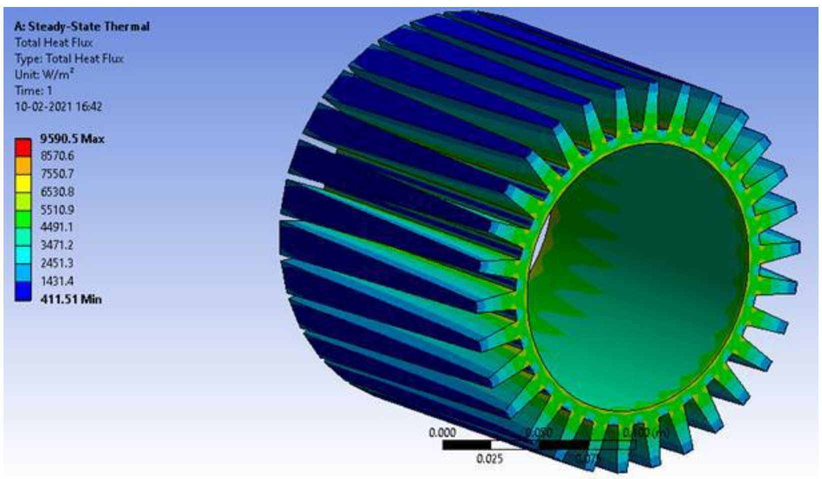


**Fig. 22.** Type 1

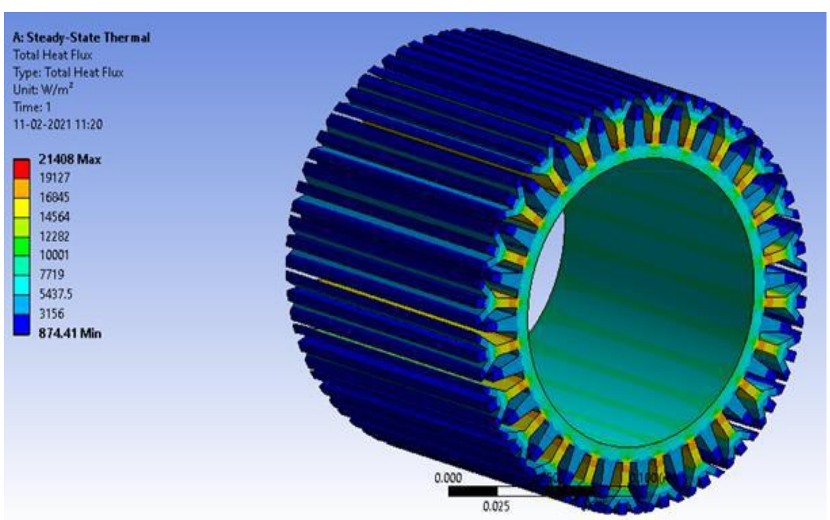


**Fig. 23.** Type 2

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## Directional Heat Flux

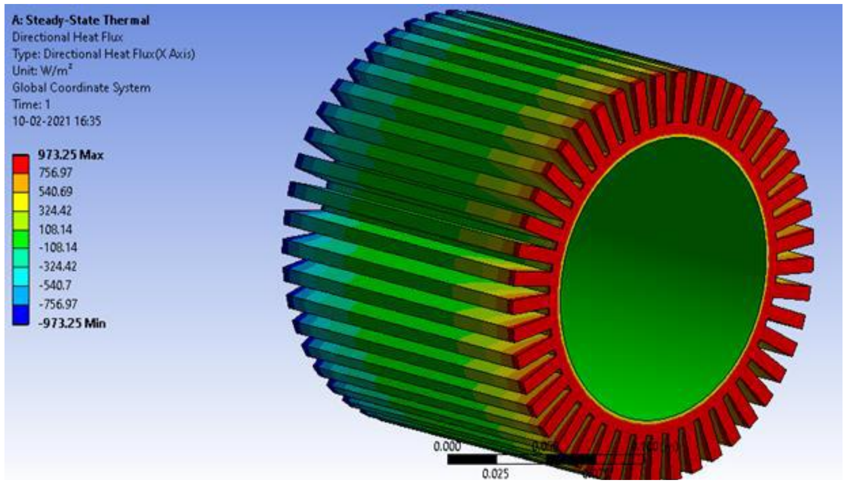


**Fig. 24.**Existing Model

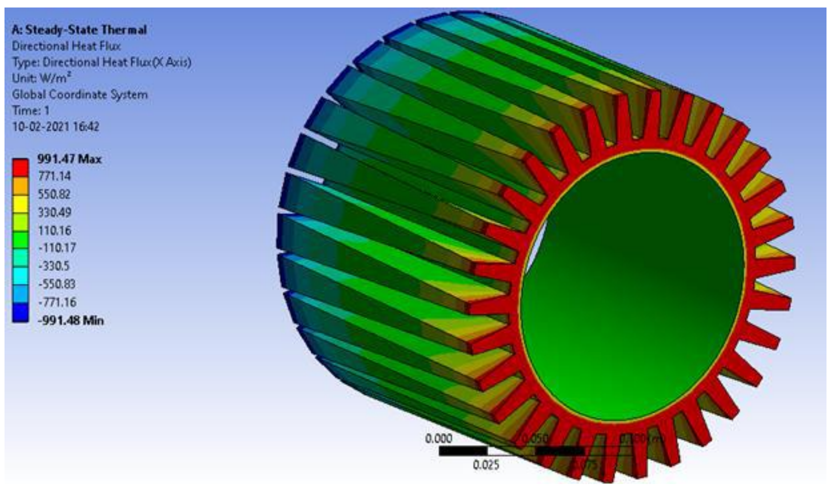


**Fig.25.** Type 1

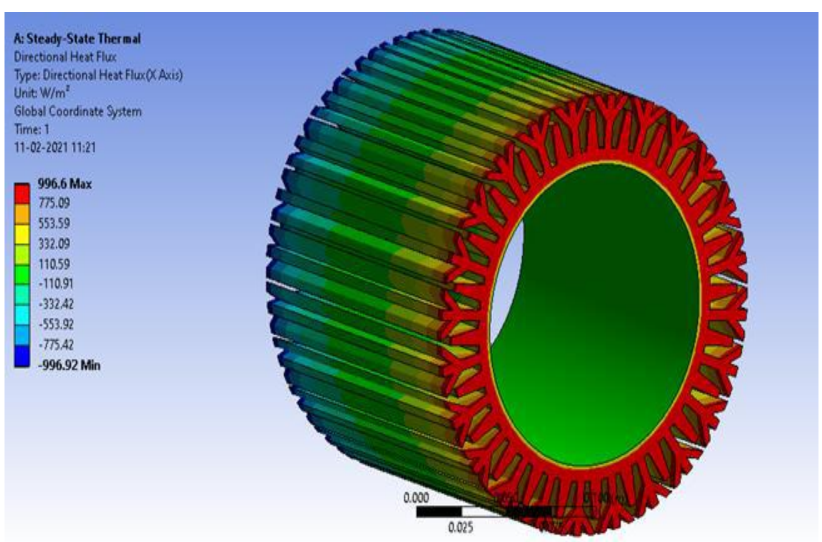


**Fig. 26.**Type 2

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## Results

By the above analysis we found the best material among the chosen material which is **Aluminum**.

## Hybrid Model

| S.NO | Model | Total Heat Flux | Directional Heat Flux |
|---|---|---|---|
| 1 | HYBRID TYPE 1 | 45.619 | -9237.9 |
| | | 9330.1 | 9265.2 |
| 2 | HYBRID TYPE 2 | 125.85 | -9795.2 |
| | | 10237 | 9727.2 |
| 3 | HYBRID TYPE 3 | 879.87 | -22107 |
| | | 23341 | 22808 |

## Total Heat Flux

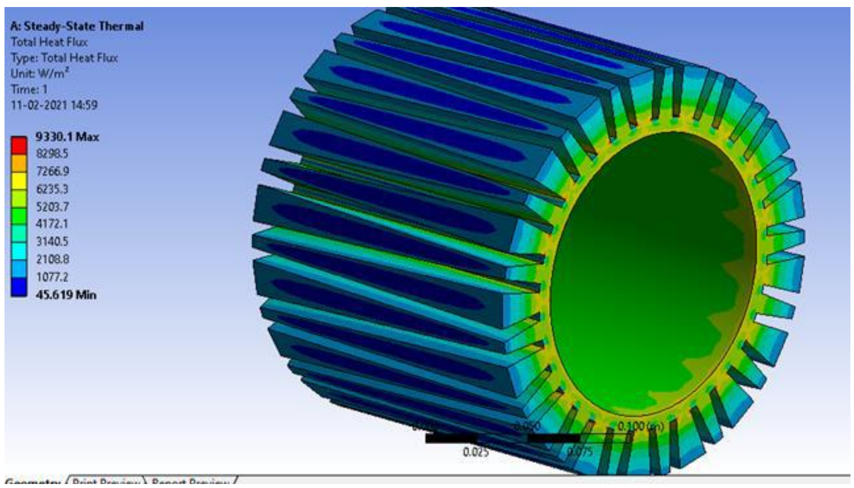


**Fig.27.**Hybrid type 1

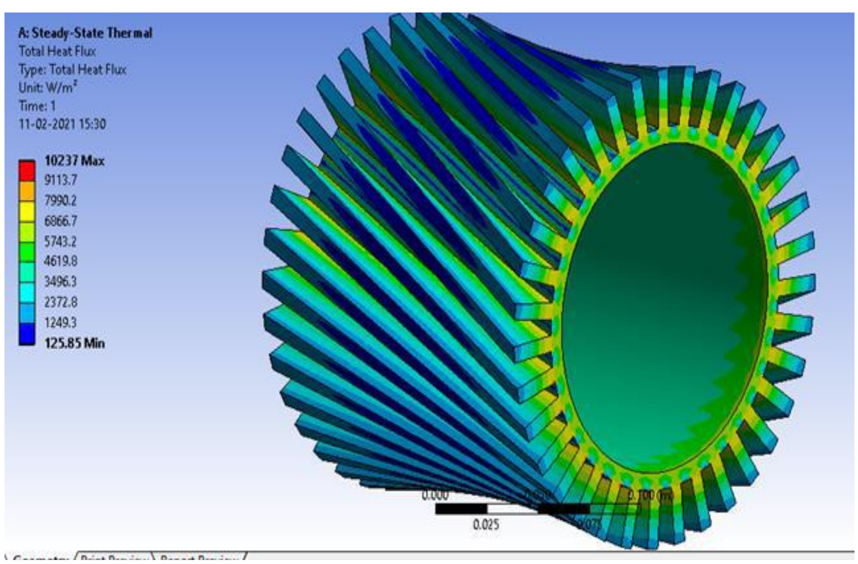


**Fig. 28.**Hybrid type 2

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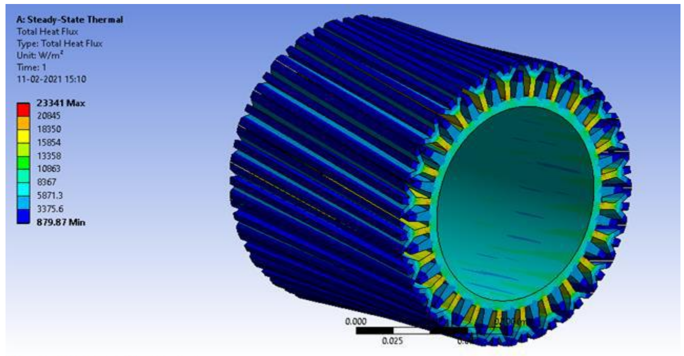


**Fig. 29.**Hybrid type 3

## Directional Heat Flux

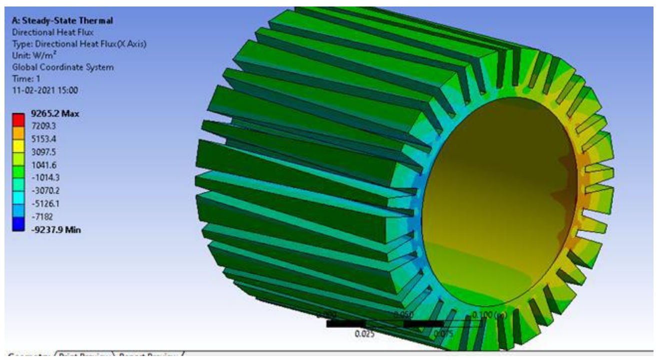


**Fig.30.**Hybrid type 1

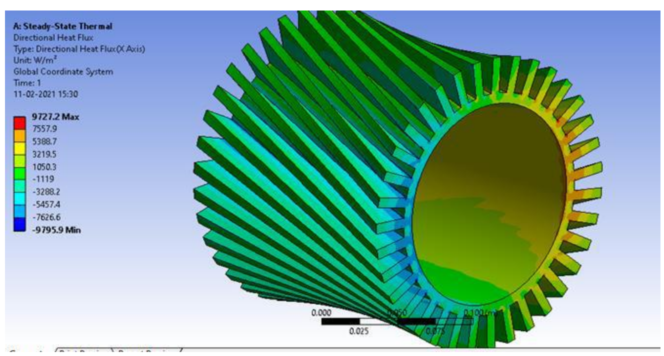


**Fig.31.** Hybrid type 2

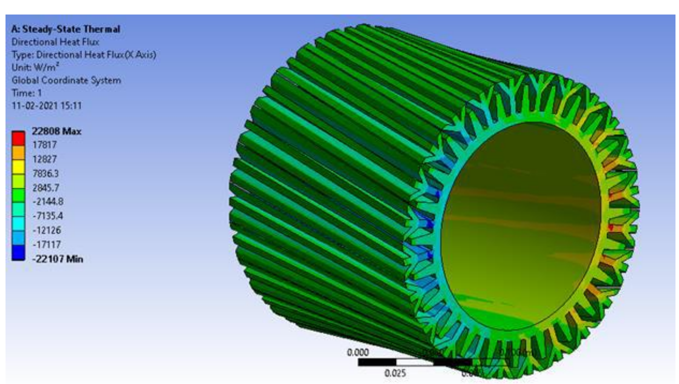


**Fig. 32.**Hybrid type 3

By comparing all the materials, we had got high Thermal Conductivity in aluminum 6061. So, we had taken the material for this special hybrid type designs and achieved high Heat flux rate.

## Conclusion

By the help of all the analytical results, we got the material Aluminum [Al-6061(T6)] is the best material among the selected 3 materials which is the Aluminum [Al-6061(T6)], Brass and Cast Iron. Since we had taken steps to arrive at an improved heat transfer fins as the category of hybrids, in that the last variation (i.e.) the Hybrid Type – III is the best design for the manufacturing of hybrid fins with the best material is that the Aluminum [Al-6061(T6)] is the suitable material to achieve higher amount heat transfer rate and the convection rate of the fins. There is also a possibility of taking this project to the next level. As the days pass on by the technological development is going beyond our expectation limits. So, in the future as new alloys and composite materials invented, those material can be applied to the models which this journal deals with, to produce better results than its predecessors. In this research only the thermal properties such as the Total Heat Flux and the Directional Heat Flux are taken in to consideration to arrive at the result, to elaborate this research, other characteristics of the fins can be taken as a criterion and by those results, we can able to make a detailed study in the field of cooling fins with its modifications and optimizations.

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