HEAT TRANSFER ANALYSIS AND OPTIMIZATION OF ENGINE FINS OF VARYING GEOMETRY AND THERMAL CONDUCTIVITY

In partial fulfillment of the requirements for the degree of

BACHELOR OF TECHNOLOGY

IN

MECHANICAL ENGINEERING

Submitted By

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(UGC Autonomous Institution)

Affiliated to JNTU Hyderabad
Vastunagar, Mangalpalli (V), Ibrahimpatnam (M),
Ranga Reddy (Dist.), Hyderabad – 501510, Telangana State

(2022-2023)

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Ranga Reddy (Dist.), Hyderabad – 501510, Telangana State

CERTIFICATE

This is to certify that the project work entitled "**HEAT TRANSFER ANALYSIS AND OPTIMIZATION OF ENGINE FINS OF VARYING GEOMETRY AND THERMAL CONDUCTIVITY" is being submitted by V. PAVAN KALYAN (19B81A0386) , M . SAIRAM (19B81A0397), P.JAYADEEP (18B81A03L0**) in partial fulfillment of the requirement for the award of degree of **Bachelor of Technology** in **Mechanical Engineering** , during the academic year 2022-2023.

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DECLARATION

I hereby declare that this project report titled "**HEAT TRANSFER ANALYSIS AND OPTIMIZATION OF ENGINE FINS OF VARYING GEOMETRY AND THERMAL CONDUCTIVITY**" submitted to the Department of Mechanical Engineering ,CVR College of Engineering is a record of original work done by me under the guidance of **Dr.M.Harinath Reddy,Professor** .The information and the data given in the report is authentic to the best of my knowledge. This project report is not submitted to any other university or institution for the award of any degree or diploma or published anytime before.

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ABSTRACT

The Engine cylinder is one of the major automobile components which is subjected to high temperature variations and thermal stresses. In order to cool the cylinder, fins are provided on the cylinder to increase the rate of heat transfer. By doing thermal analysis on the engine cylinder fins, it is helpful to know the heat dissipation inside the cylinder. We know that, by increasing the surface area we can increase the heat dissipation rate, so designing such a large complex engine is very difficult. The main purpose of using these cooling fins is to cool the engine cylinder by air.

The main aim of the project is to analyse the thermal properties by varying geometry, material and thickness of cylinder fins. Parametric models of cylinder with fins have been developed to predict the steady sate thermal behavior. The models are created by varying the geometry such as rectangular, circular and angular shaped fins and also by varying thickness of the fins. The 3-D modeling software used is Creo parametric. The analysis is done using ANSYS. Presently material used for manufacturing cylinder fin body is Aluminium Alloy 204 which has thermal conductivity of 110-150W/mk. We are analyzing the cylinder fins using this material and also using Aluminium alloy 6061 and magnesium alloy which have thermal conductivities.

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1. I.C – internal combustion

1.INTRODUCTION

The cylinder is one of the most important engine components that is subjected to extreme temperature changes and thermal stress. Fins on the surface of the cylinder aid in cooling and heat transfer. Fins are mechanical structures that use convection and conduction to cool buildings. Extending the fins on an IC engine is widely accepted as a way to improve heat transfer. It's much easier to build an air-cooling system than it is to build a water-cooling system. The fins in an air-cooled engine must be used effectively to maintain a consistent temperature in the cylinder. Internal combustion engines use a combustion chamber for gas combustion. Pistons, turbine blades, and nozzles all gain power as a result of the combustion of high-temperature, high-pressure air. The element can be moved using this force, resulting in useful mechanical energy over a large area. The heat produced during combustion of fuel in the cylinder is not converted into useful work completely due to some losses is listed below.

Useful work at the crank shaft = 25 %

Loss to the walls of cylinder = 30%

Loss due to Exhaust = 35%

Frictional losses = 10%

From above, heat loss through the cylinder walls is noticeable, if this heat is not controlled properly will result in pre-ignition, excess heat propagation through cylinder walls leads to severe damage to the cylinder material, lubricant will burn, seizing of piston ultimately the engine will be affected. In order to prevent the engine from severe damage due to excess heat an attempt is made to control the heat dissipation in this work, by changing different fin materials and geometry with variable thickness. However, excessive cooling is not desirable, will decrease brake thermal efficiency, lowers atomization of air fuel mixture due to increase of fuel viscosity, even though more cooling increases the volumetric efficiency but finally the overall efficiency of engine will be decreased. Because of the above reasons desirable cooling is required and any variation from the optimum cooling limit will leads to decrease in the engine overall efficiency.

Although water-cooled engines have largely replaced air-cooled engines, air-cooled engines are still used in all two wheels because they are lighter and take up less space. The buoyant forces created by temperature variations cause liquid convection, which creates a stream of liquid. Low-control-density gadget thermal management has relied on natural heat sink convection for a long time. The absence of shifting components and intensity usage, as well as the need for assistance in this cooling approach, are all causes for concern. It's also simple to use, has a high level of efficiency, and is reasonably priced. Natural convection is important for thermal transfer in a variety of devices, including electronics, which has been the subject of ongoing research for centuries.

NATURAL AIR COOLING

In normal cause, larger parts of an engine remain exposed to the atmospheric air. When the vehicles run, the air at certain relative velocity impinges upon the engine, and sweeps away its heat. The heat carried-away by the air is due to natural convection, therefore this method is known as natural air-cooling. Engines mounted on 2-wheelers are mostly cooled by natural air. As the heat dissipation is a function of frontal cross-sectional area of the engine, therefore there exists a need to enlarge this area. An engine with enlarge area will becomes bulky and in turn will also reduce the power by weight ratio. Hence, as an alternative arrangement, fins are constructed to enhance the frontal cross-sectional area of the engine. Fins (or ribs) are sharp projections provided on the surfaces of cylinder block and cylinder head. They increase the outer contact area between a cylinder and the air. Fins are, generally, casted integrally with the cylinder. They may also be mounted on the cylinder.

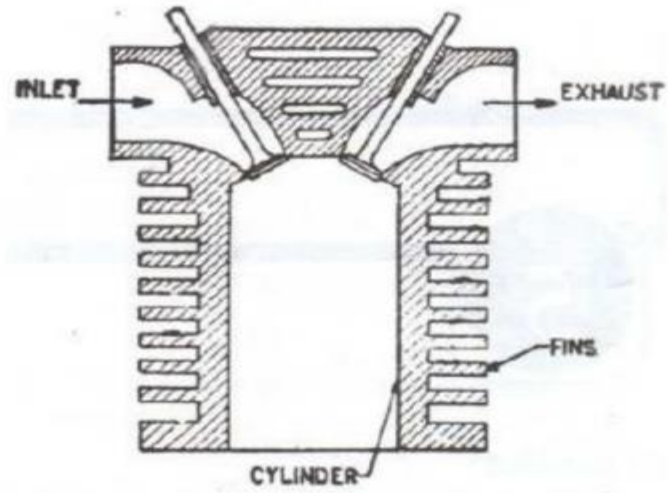

Fig.1. engine with fins

FINS

A fin is a surface that extends from an object to increase the rate of heat transfer to or from the environment by increasing convection. The amount of conduction, convection, radiation of an object determines the amount of heat it transfers. Increasing the temperature difference between the object and the environment, increasing the convection heat transfer coefficient, or increasing the surface area of the object increases the heat transfer. Sometimes it is not economical or it is not feasible to change the first two options. Adding a fin to the object, however, increases the surface area and can sometimes be economical solution to heat transfer problems. Circumferential fins around the cylinder of a motor cycle engine and fins attached to condenser tubes of a refrigerator are a few familiar examples.

1.1OBJECTIVES :

- The main focus is to design extended surfaces of the engine cylinder by changing fin material, thickness and shape such as rectangular, circular and angular .
- Evaluating themal performance of generated models based on thermal flux and weight of the body.

2.LITERATURE REVIEW

Different fin forms, fine pitch, fine setup, wind speed, content, and atmospheric circumstances all affect the heat- rejection engine cylinder, according to studies from the previous century. To better design and build stronger engine cooling fins, it's important to understand how the evolution of the cross-area affects heat exchange through expanded surfaces and the heat exchange coefficient.

i. D. Madhavi et. al. (2018) These cooling fins are intended to cool the 220cc engine cylinder. According to research, designing a 220cc motor is extremely difficult because increasing the ground area of the fin can increase the thermal dissipation speed. Heat conductivity was predicted using a parametric model of piston bore fins. In 3D modelling software, a parametric model is created using Solid functions. The fins are subjected to thermal analysis in order to determine how the temperature changes over time. The analysis is done with ANSYS. For analysis, various materials are used. The fin body is made of cast iron for the time being. In this study, the aluminium alloy 6082 is used as a substitute. The total heat flux of the aluminium alloy 6082 and zinc alloy fabrics used in the condenser and evaporator clearly exceeds that of the aluminium alloy 6082 and zinc alloy fabrics used in the condenser and evaporator, according to the study's findings. The best material for cylindrical fins is aluminium alloy.

ii. Arjun Vilay et. al. (2018) The rectangular duct floor's time zone was used to investigate heat transfer and pressure loss from various heat sink forms. Two formed propellers are used in the shark fin, cylindrical (round) rectangle study. This study focused on cylindrical pin fins, which included horizontal thermal conductivity and rectangular longitudinal fins, with the goal of determining the best size and shape. No Nusselt calculations for Laminar and Turbulent flow have yielded different outcomes. After the research is completed, an X-Y diagram and vector depicting laminar and turbulent flow rates, heat transfer, and strain loss can be used to illustrate the overall findings. According to the findings, rectangular fins are best for heat transfer, while large round Pin Fin surfaces with low pressure losses are best for increasing heat transfer rates. This conclusion is supported by the study's print data.

iii. Mahendra Kumar Ahirwar et. al. (2018) The project's goal is to investigate and compare the heat characteristics of various design, content, and density options using 100 cc Hero Honda Motorcycle fins. Several attempts to mode temporary heat conductivity with parametric cylinder designs with fins have been made. The aluminium alloy 6063 with a thermal conductivity of 200W/m^2k is currently used in production. A heat source with a temperature of 1000 degrees Celsius was used to analyse the intended designs. The energy transferred from an internal combustion engine's combustion chamber can be dissipated in three different ways. Transient thermal analyses of the engine cylinder were performed in order to improve heat transfer from the IC engine and optimise geometric parameters. The results of this project reveal a more efficient and faster rate of heat transfer from the cooling area in the IC engine, which is why ANSYS 17.0 software is recommended to replace the current model.

iv. Pradeep Kumar et. al. (2018) The thermal analysis of an engine block with fins was put to the test in this study. Thermal analysis of cylinder block caps is a good way to figure out how much heat the cylinder dissipates. Fins, which are mechanical components, are used in convectional cooling systems. The majority of their design is hampered in some way by the system's configuration. However, by modifying certain parameters and geometry, it is still possible to improve heat transfer. The most common types of fin geometry are rectangular and circular fins. A lot of experimental work has been done to improve the performance of fines in internal combustion engines. The engine block fins model was created using ANSYS 14.5 3D software, and the transient state temperature variability with gaps was calculated using a continuous thermal analysis on the fins and block. ANSYS software was used to analyse thermal conductivity.

v. S. Karthik et. al. (2018) This report summaries the final products for various applications. Fins can be used as economizers, heat exchangers, and numerous other applications. Internal combustion engines use cylinder blocks to create the wall of a combustion chamber, which is where air and fuel mixtures are ignited. The cylinder wall is exposed to high temperatures during the combustion cycle, and heat is transferred through the cylinder blades. If the heat is not properly absorbed, the engine's performance will suffer. How quickly heat moves through the fins is determined by the fabric's thermal conductivity and other properties. A standard Pin-Fin sample is used for analytical purposes. By confirming that the ANSYS 16.1 operation is functioning properly. The evaluation output can be fed into an Artificial Neural Network to generate the required metal material characteristics With the help of this system, choosing the right finishing products for different applications becomes a lot easier.

vi. Raviulla et. al. (2018) The main goal of this research is to compare the heat transfer properties of different cylinder fin geometries. When evaluating the heat output of filters with large temperature differences between the fine foundation and the surrounding fluid, the temperature-dependent thermal conductivity of the fine material must be taken into account. As a result of Lava Kumar's efforts, Researchers were able to reduce the weight of the fin body while increasing the heat transfer rate and fin effectiveness by changing the fin shape to a triangular form.

3.EXPERIMENTAL PROCESS

The work is divided into two steps first we need to design and model the fins of varying geometry and thickness in 3D software Creo parametric. After that these models are imported to Ansys workbench and thermal analysis is to be done by varying different materials .

3.1MODELLING

The geometries such as rectangular ,circular and angular fins each with two different thickness i.e 2.5mm and 2mm are to be generated in cad software CREO . So we need to genereate six models.

The modeling of 100cc engine with below specifications is to be done .

Table 1. Engine specifications

S.NO	PARAMETER	VALUE
1	Engine capacity	100cc
2	Bore	49.5mm
3	Stroke	50mm
4	No of fins	7

(a) Rectangular fin with 2.5 mm thickness

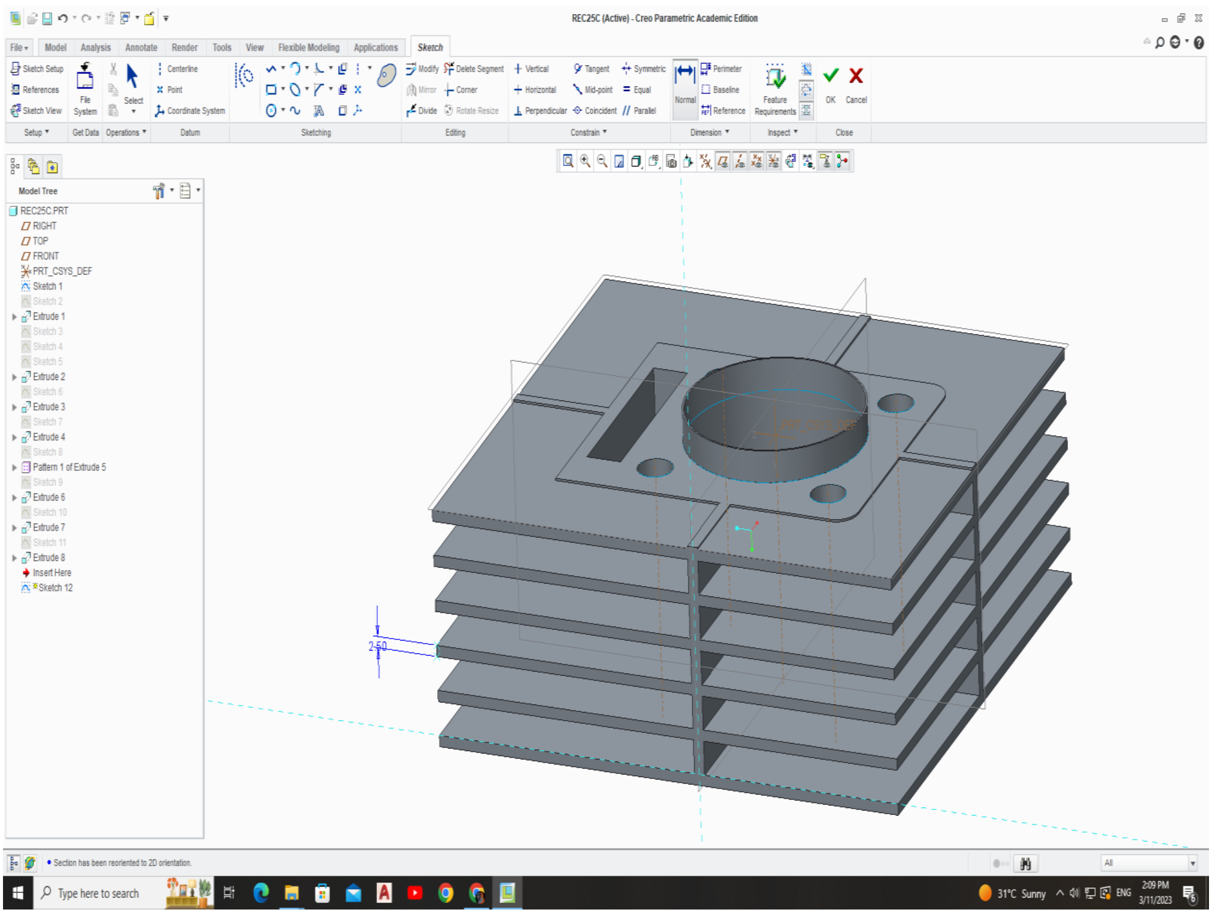

Fig.2. 3D view of rectangular fin of 2.5 mm thickness

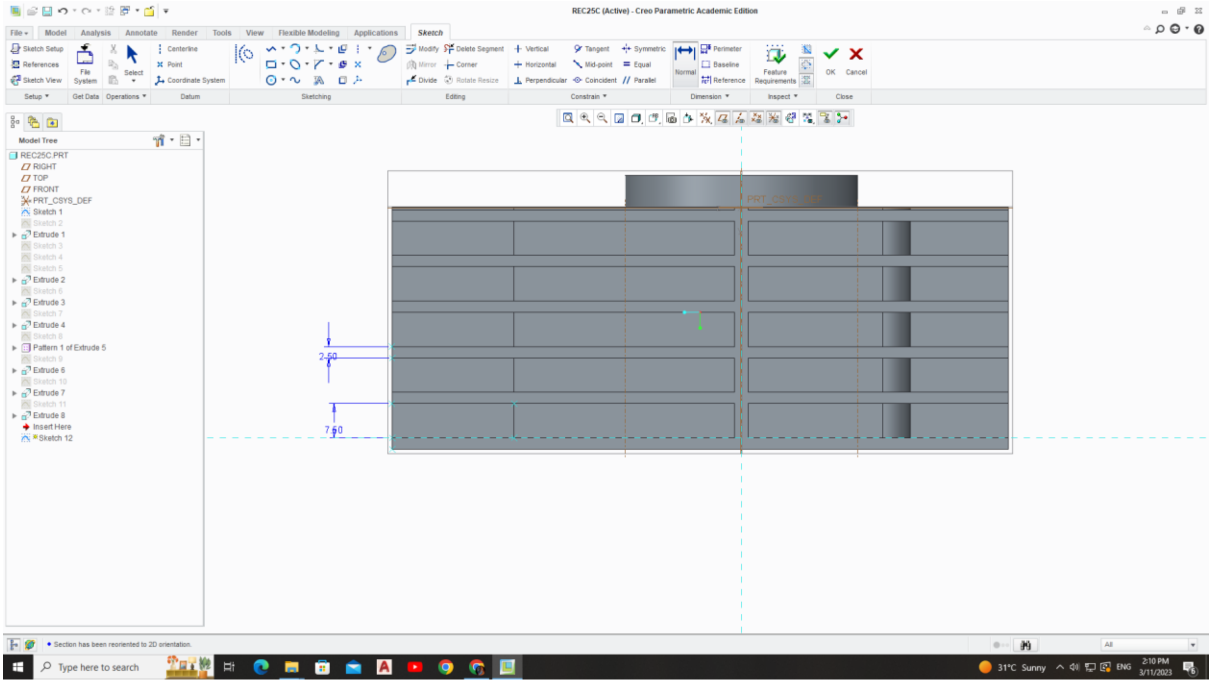

Fig.3.Front view of rectangular fin of 2.5mm thickness

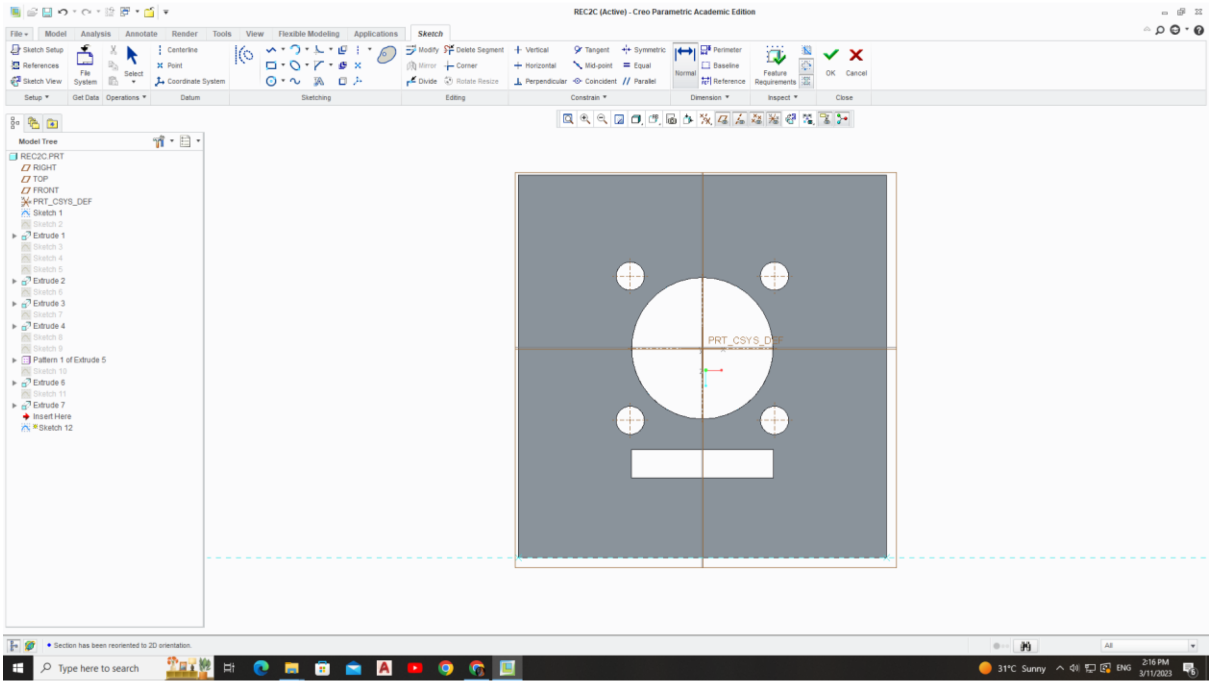

Fig.4.Top view of rectangular fin of 2.5 mm thickness

(b)rectangular fin of 2mm thickness

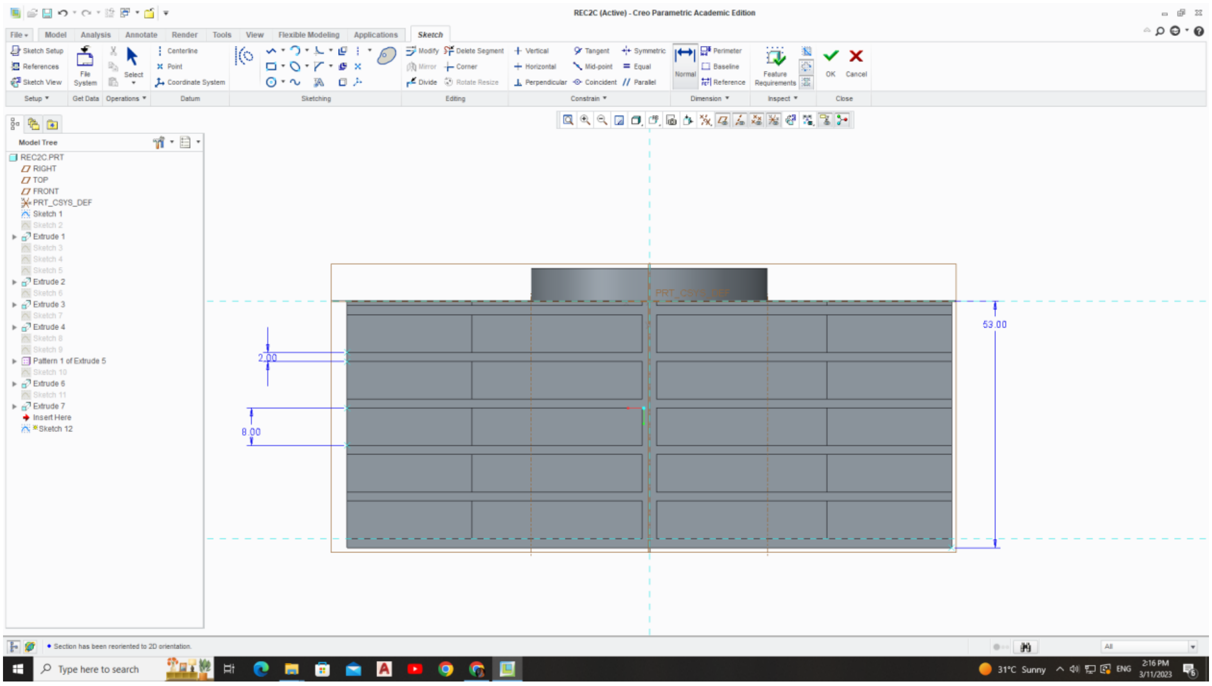

Fig.5. front view of rectangular fin of thickness 2mm

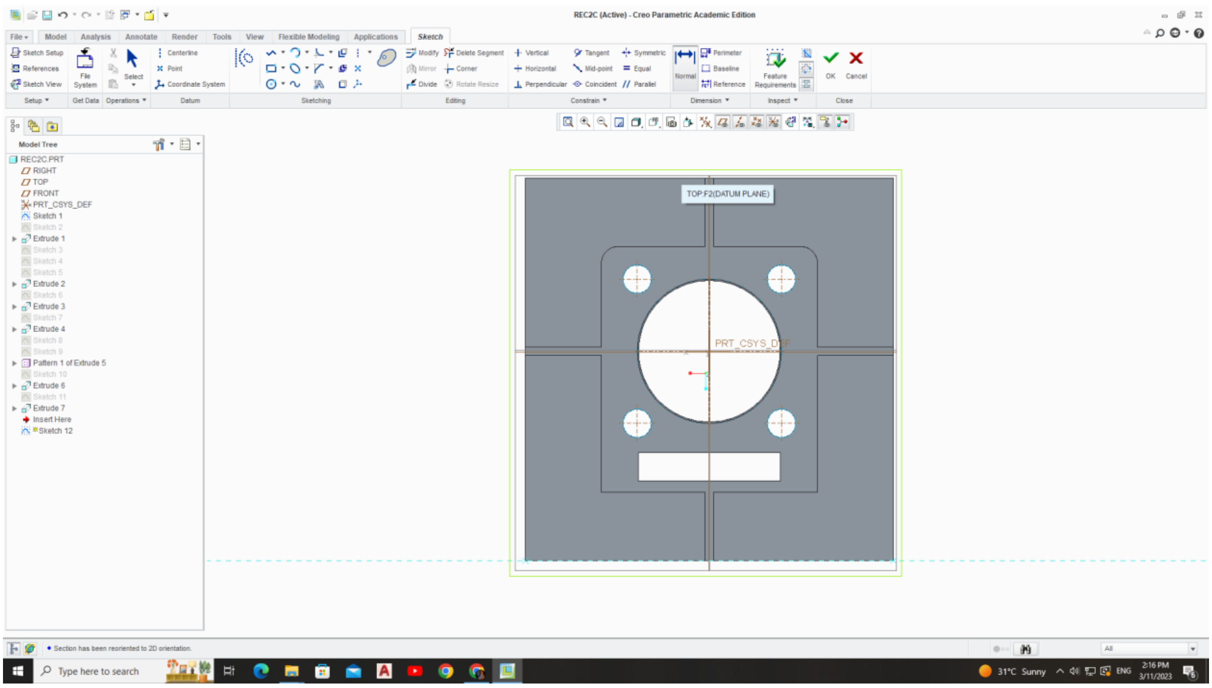

Fig.6. top view of rectangular fin of thickness 2mm

(c)circular fins of 2.5mm thickness

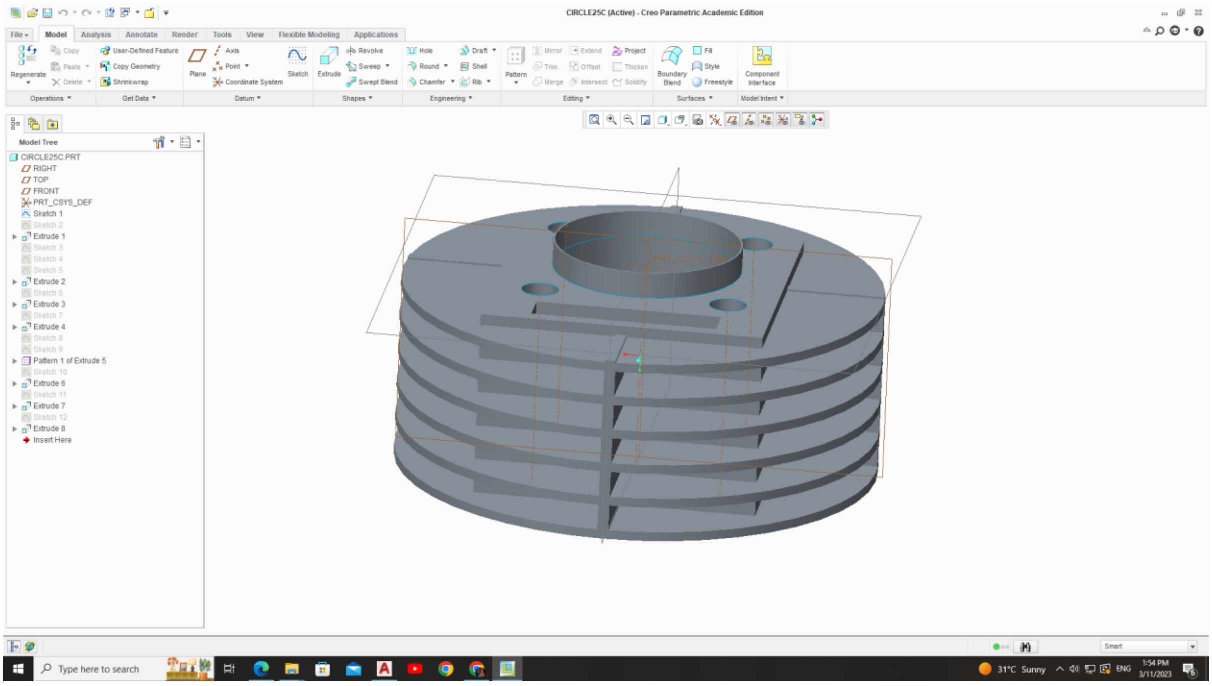

Fig.7. 3D model of circular fin of thickness 2.5mm

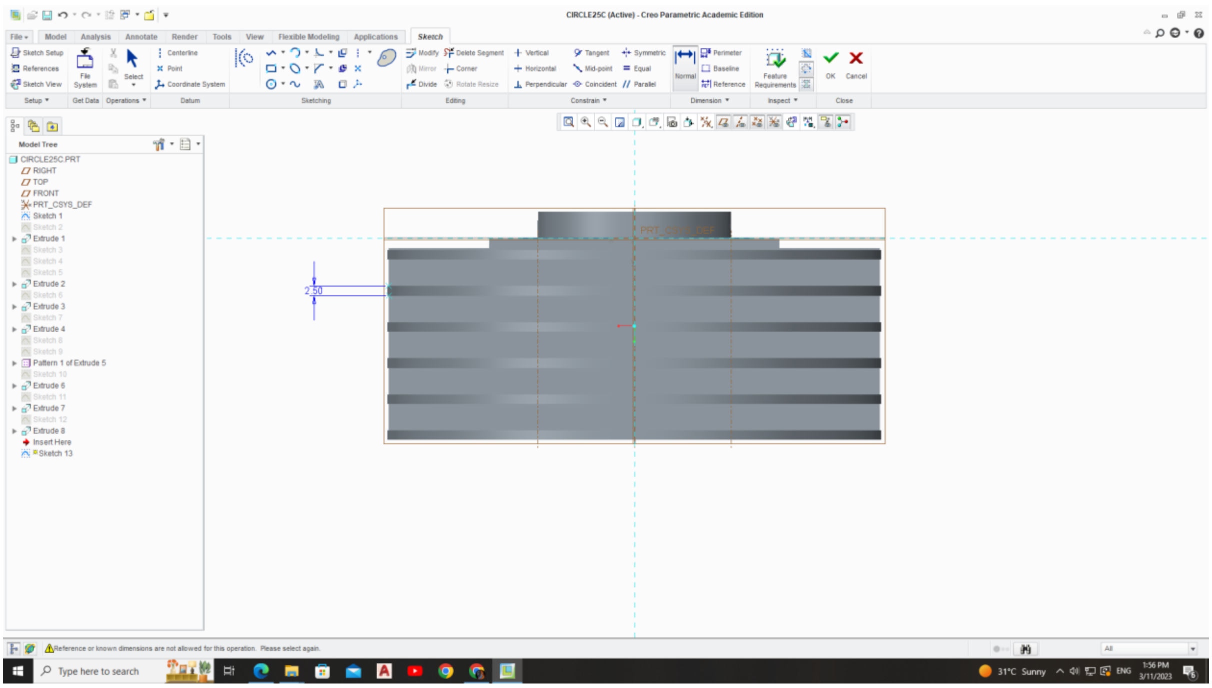

Fig.8. front view circular fin of thickness 2.5mm

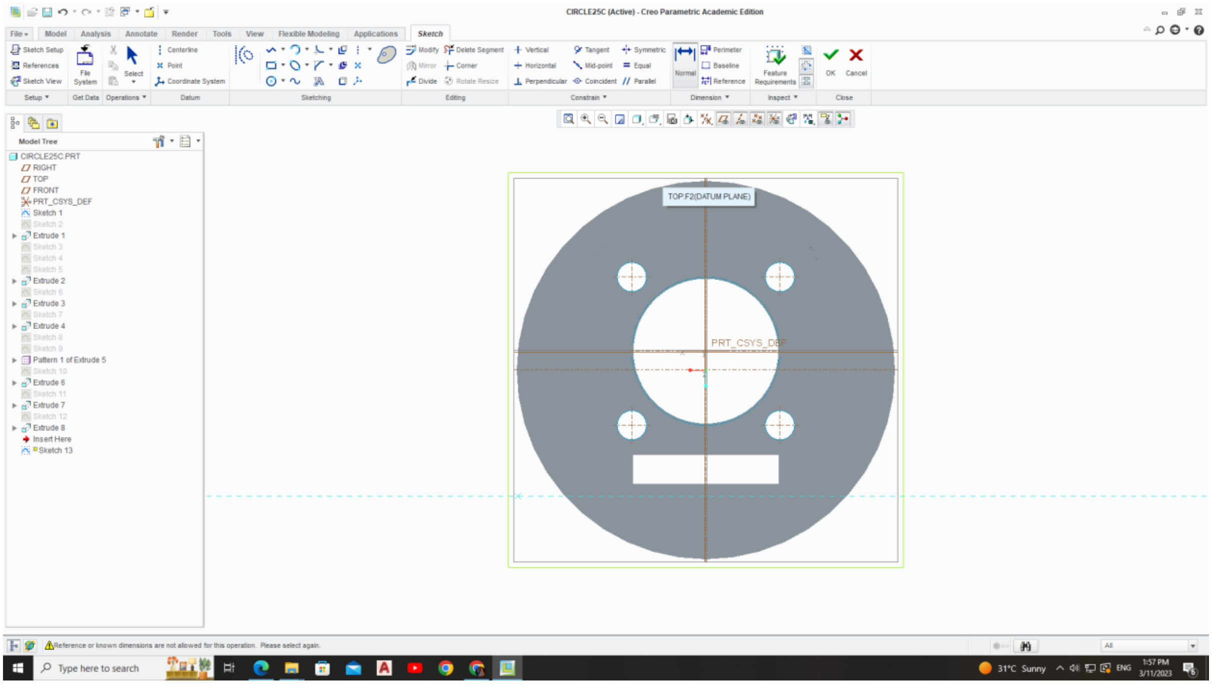

Fig.9. top view circular fin of thickness 2.5mm

(d)circular thickness of 2mm thickness

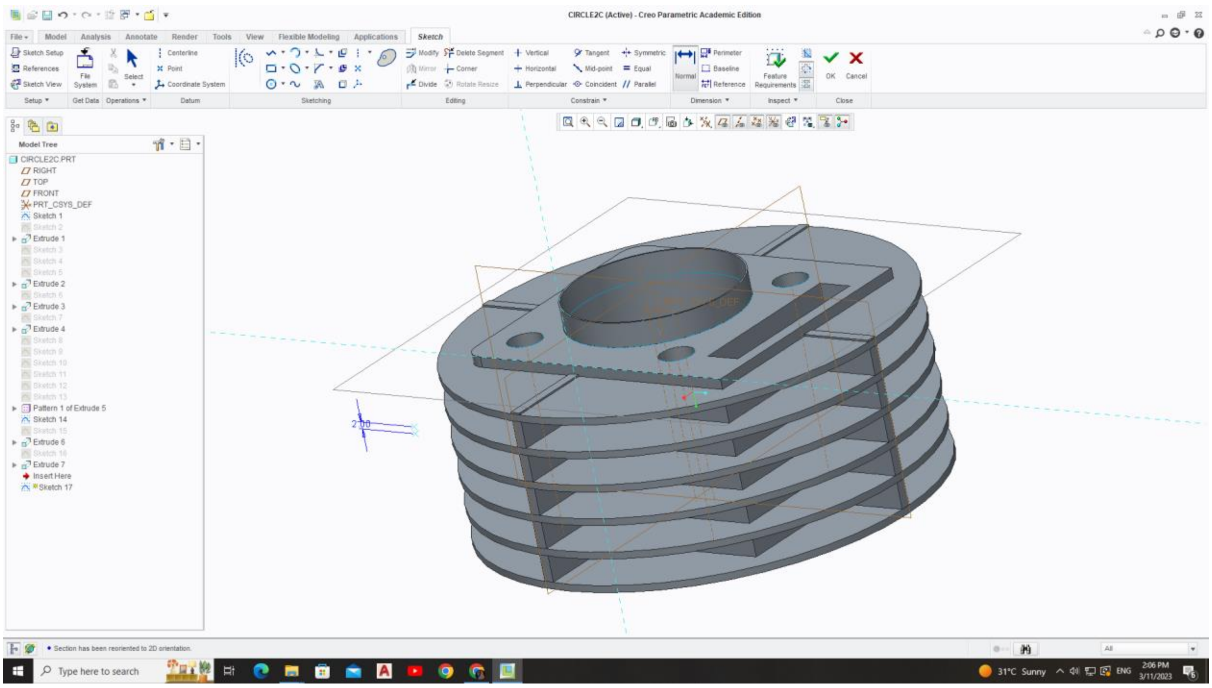

Fig.10. 3D model of circular fin of thickness 2mm

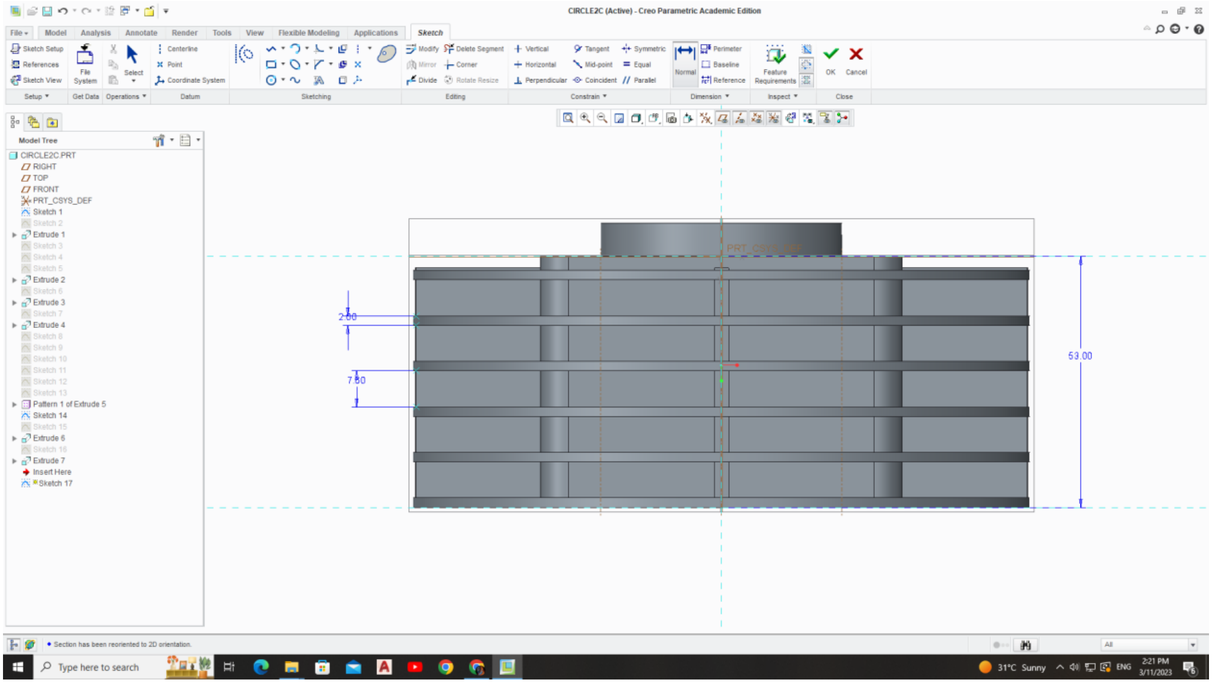

Fig.11. front view of circular fin of thickness 2mm

(e)angular fins of 2.5mm thickness

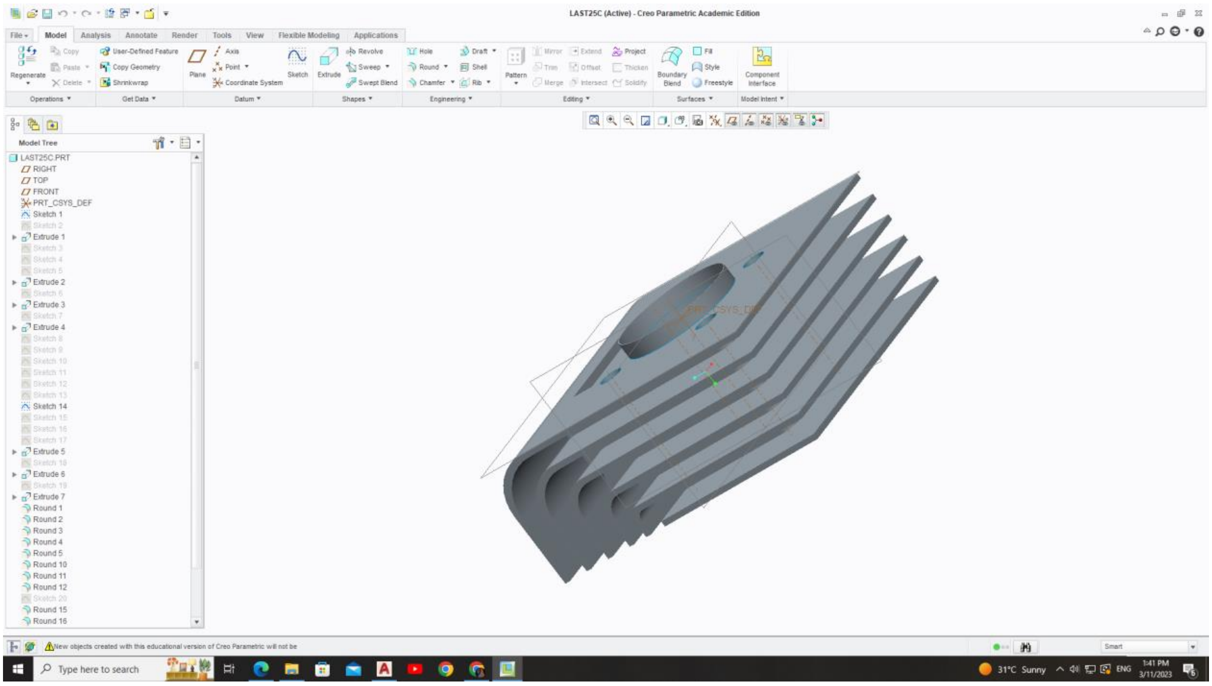

Fig.12. 3D model of angular fin of thickness 2.5 mm

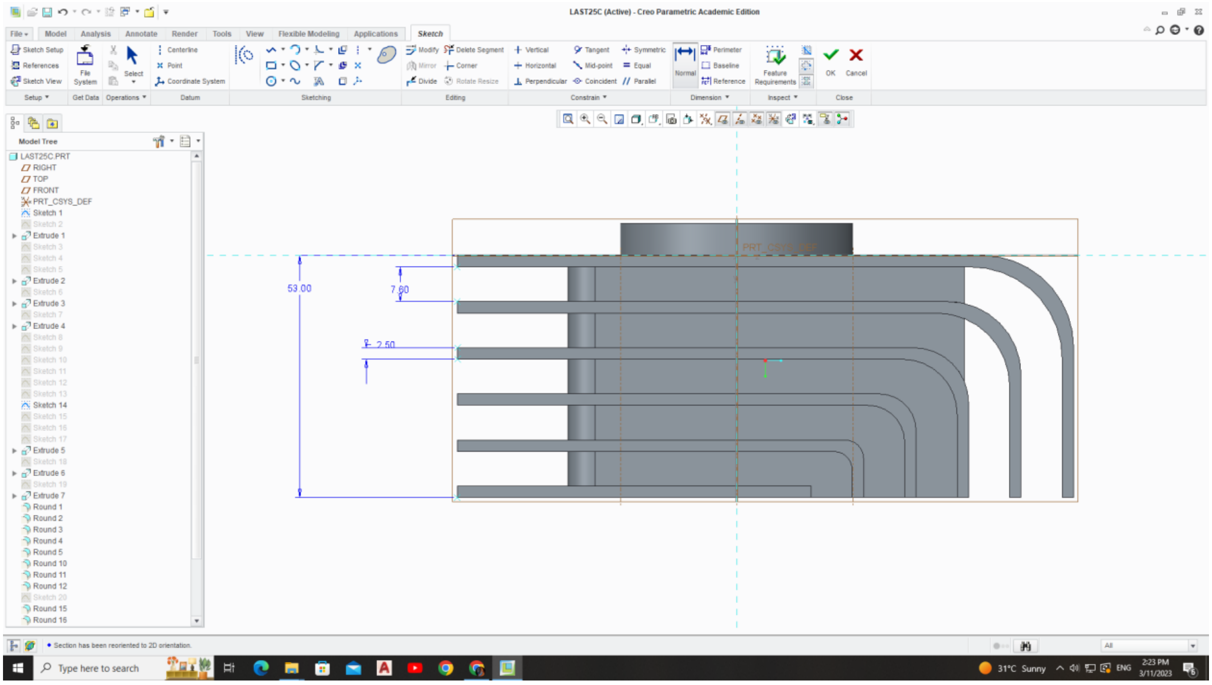

Fig.13. front view angular fin of thickness 2.5 mm

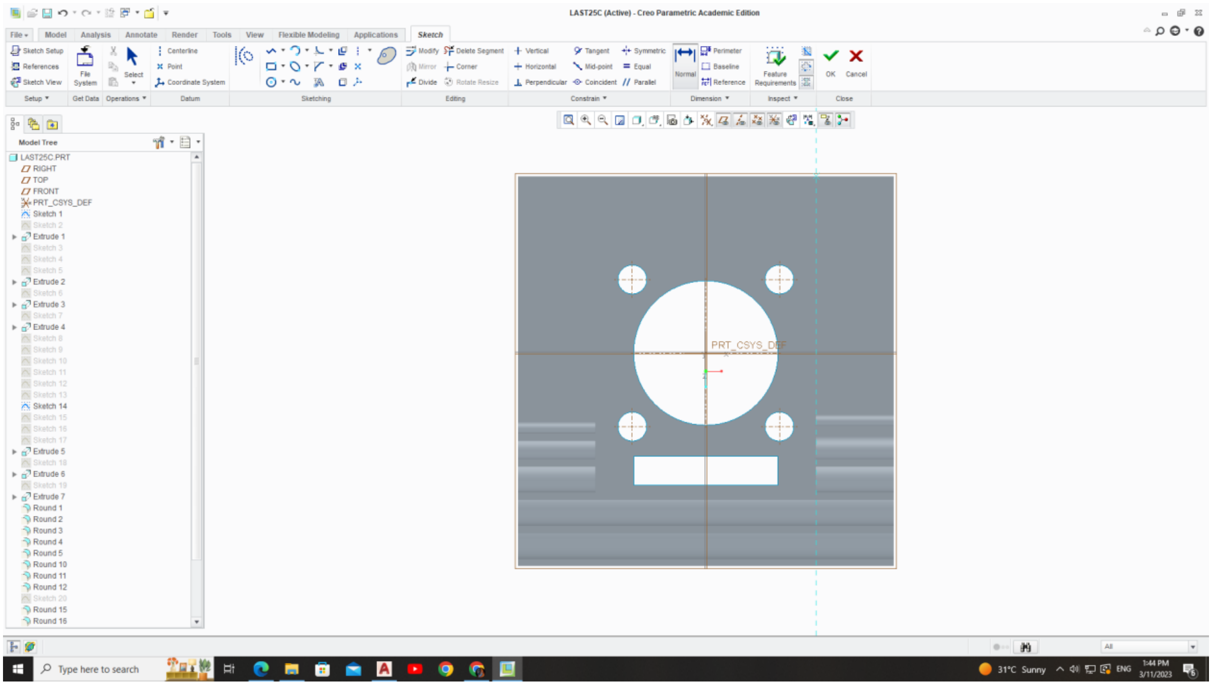

Fig.14. top view angular fin of thickness 2.5 mm

(f)angular fins of 2mm thickness

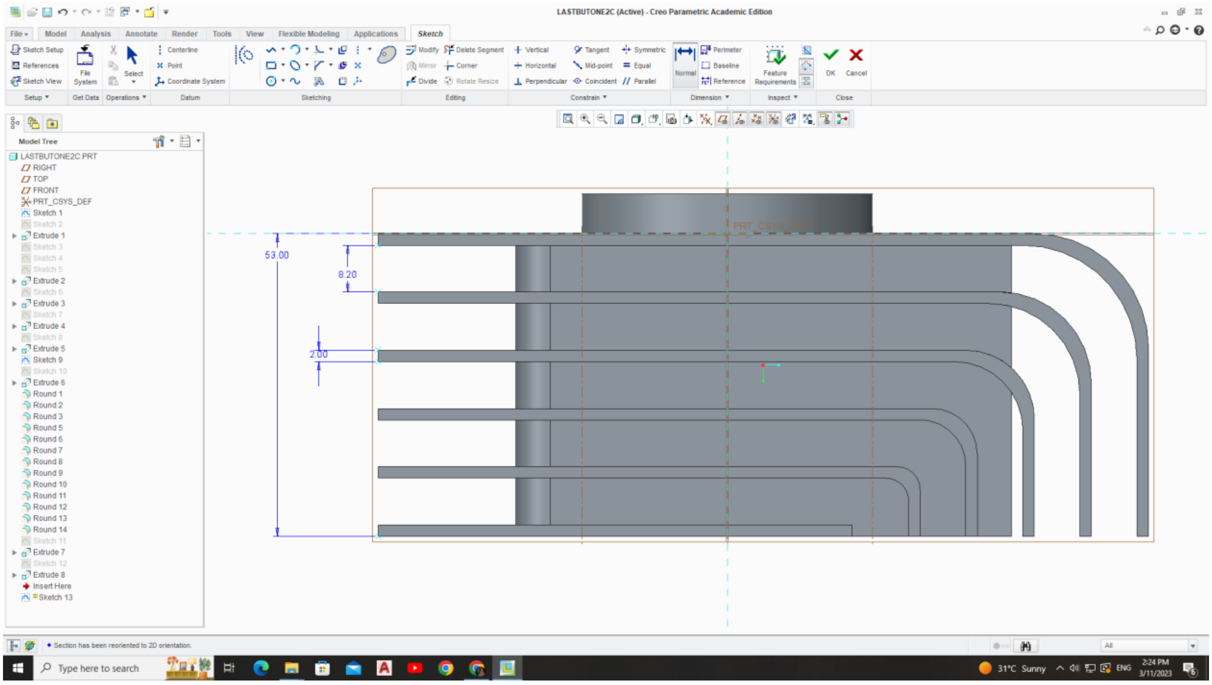

Fig.15. front view of angular fin of thickness 2mm

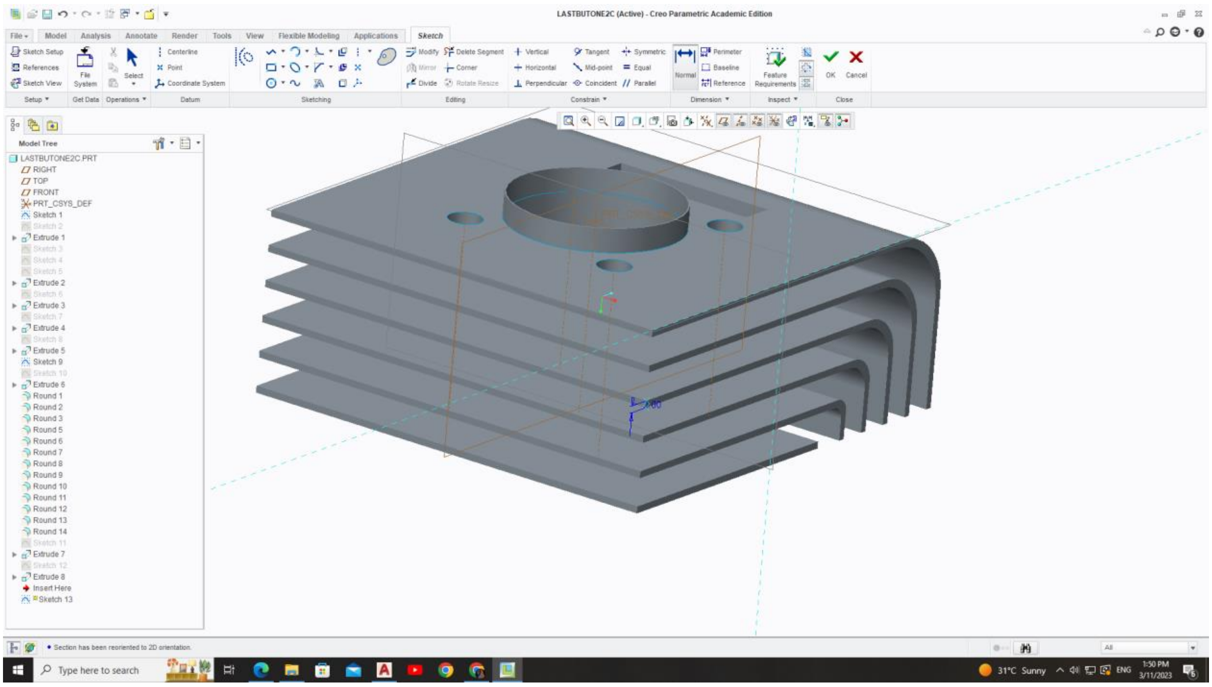

Fig.16. 3D model of angular fin of thickness 2mm

3.2 Analysis of models

The analysis of 18 models are done in ansys workbench by importing the above models into ansys workbench .

Steady state thermal analysis is performed using below loads ;

Temperature: 558K

Film coefficient- 25W/m^2K

Bulk temperature (ambient temperature): 313K

Steps to be followed :

1. Importing geometry
2. Material assignment (select anyone of below)
    i. Aluminium alloy Al6061
    ii. Aluminium alloy Al204
    iii. Magnesium Alloy
3. Meshing
4. Applying loads
    i. Temperature of 558K
    ii. Convection
5. Solve
6. Select parameter outputs
    i. Heat flux
    ii. Temperature distribution

3.2.1 Rectangular fin Analysis

(a) rectangular fin of 2.5mm thickness of material Al6061

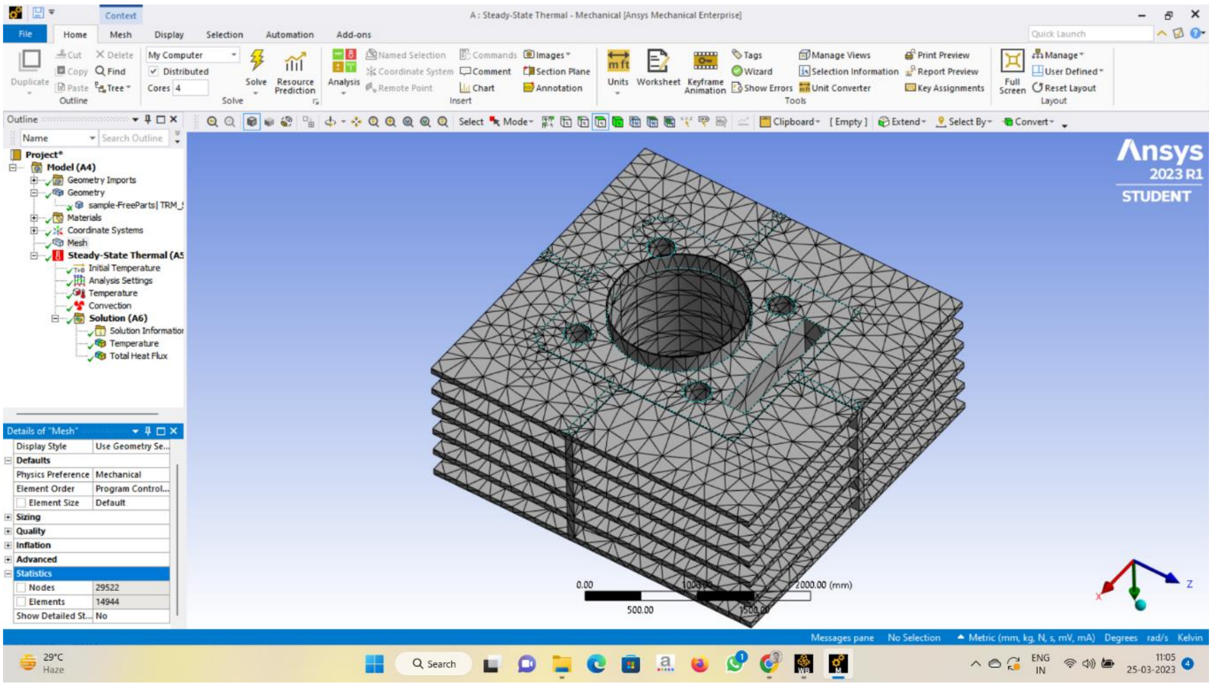

Fig.17. Meshing of rectangular fin of 2.5mm of Al6061

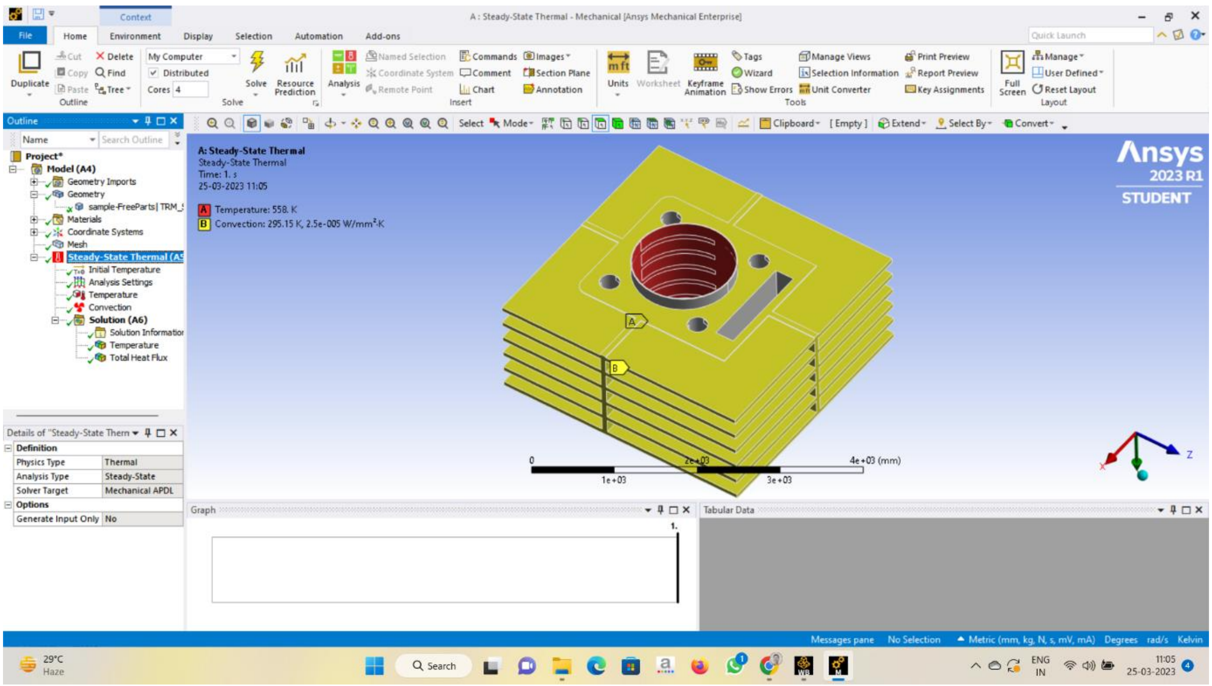

Fig.18. applying loads of rectangular fin of 2.5mm of Al6061

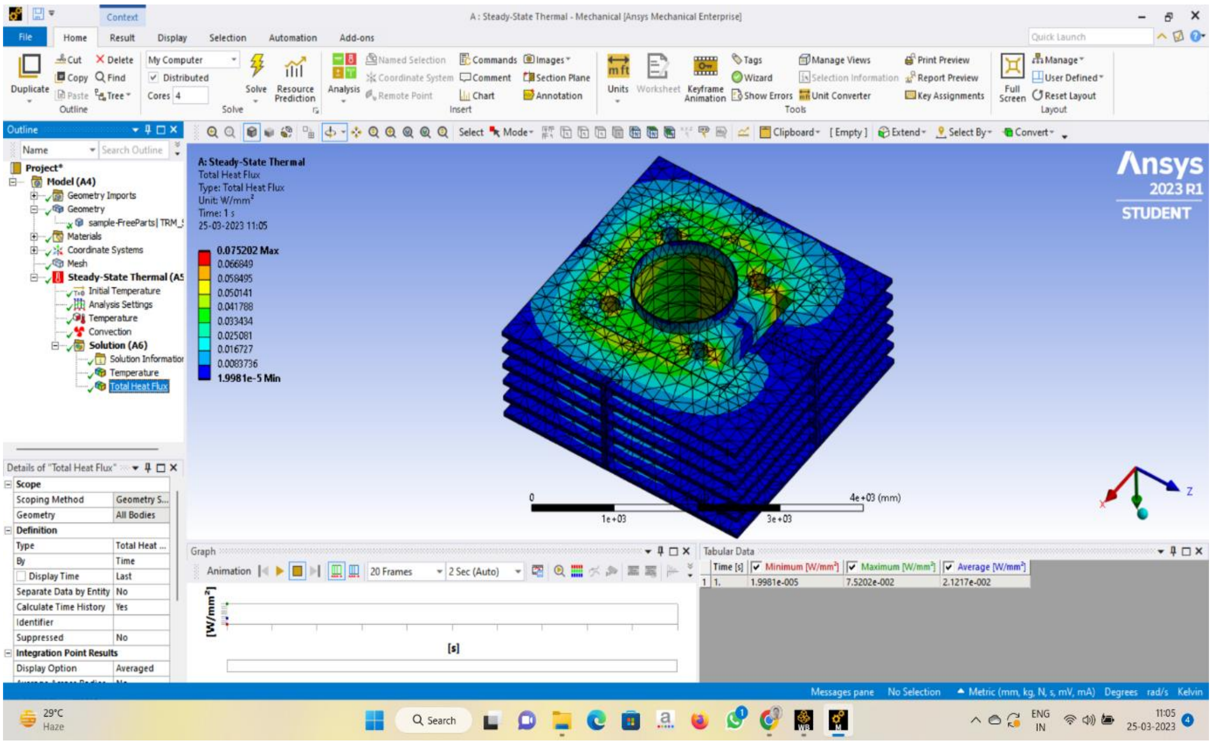

Fig.19. Heat flux of rectangular fin of 2.5mm of Al6061

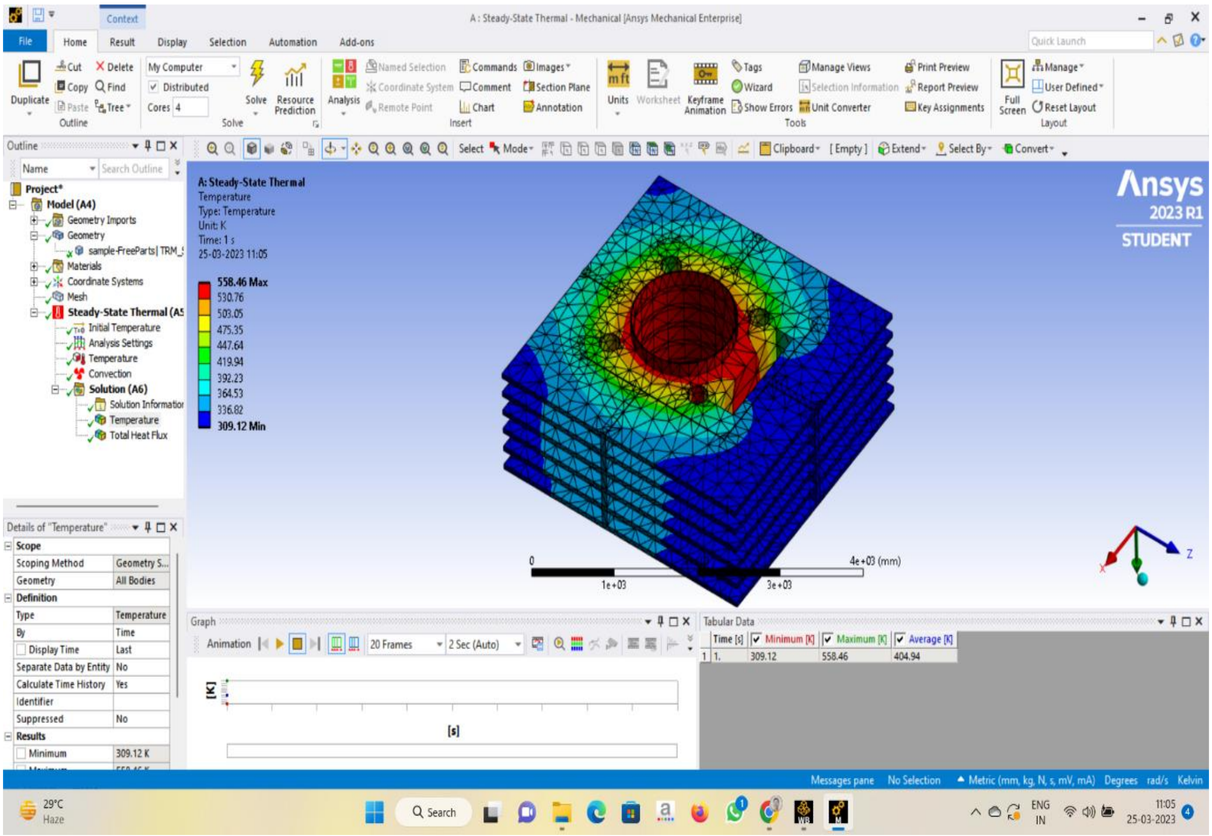

Fig.20. temperature distribution of rectangular fin of 2.5mm of Al6061

(b) rectangular fin of 2mm thickness of Al6061

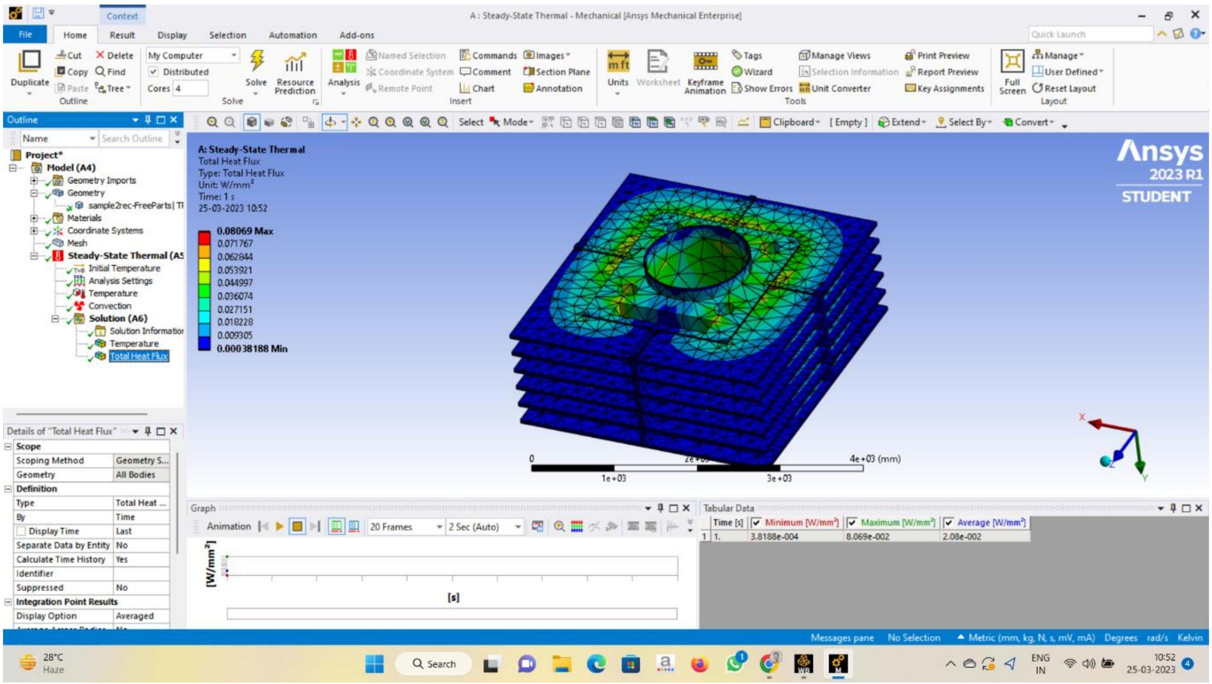

Fig.21. Heat flux of of rectangular fin of 2mm of Al6061

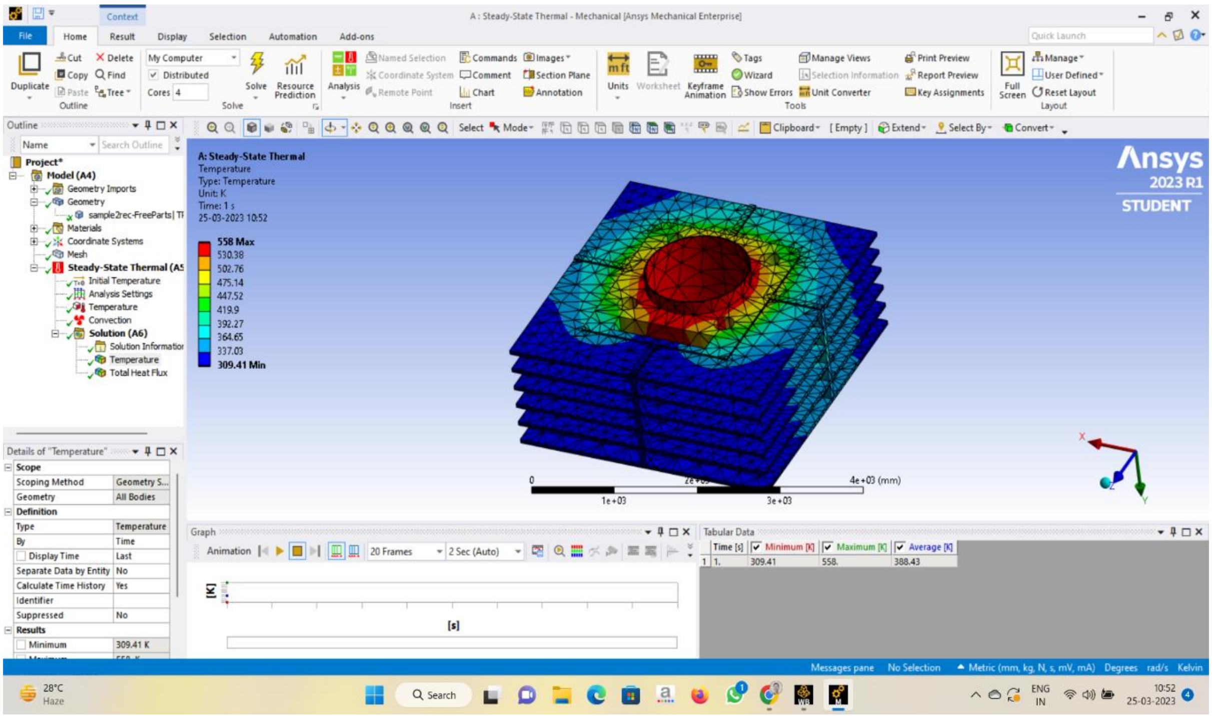

Fig.22. Temperature distribution of rectangular fin of 2mm of Al6061

(c) rectangular fin of 2.5mm thickness Al204

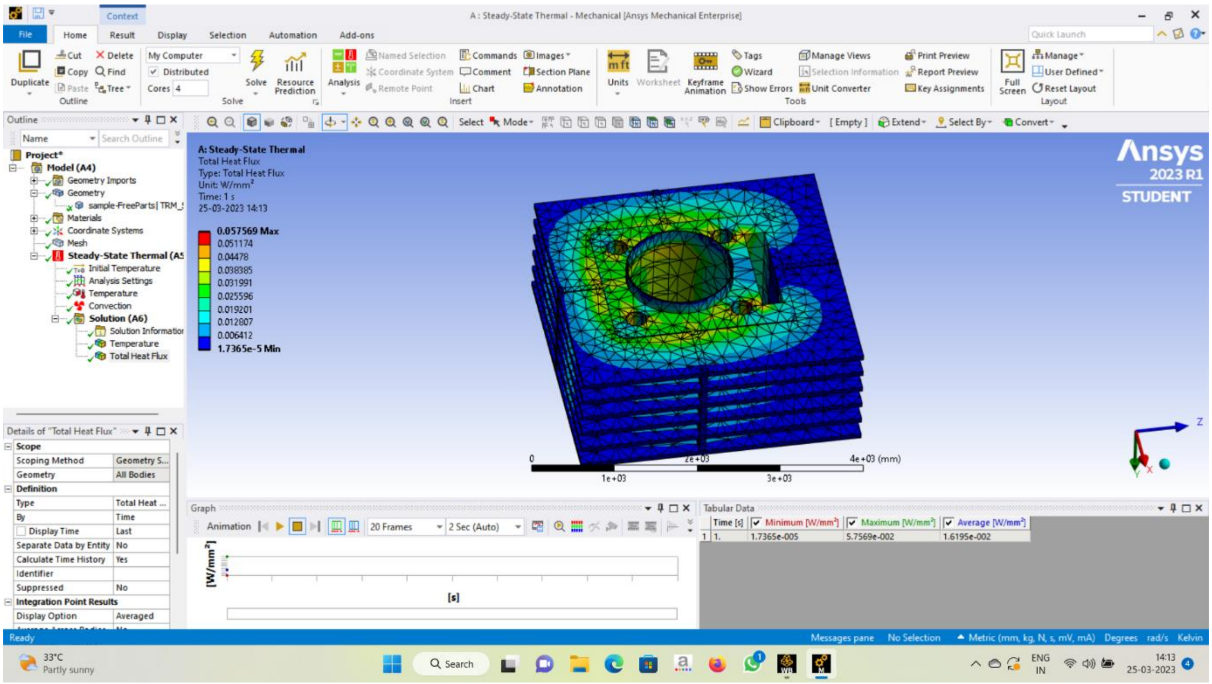

Fig.23. Heat flux of rectangular fin of 2.5mm of Al204

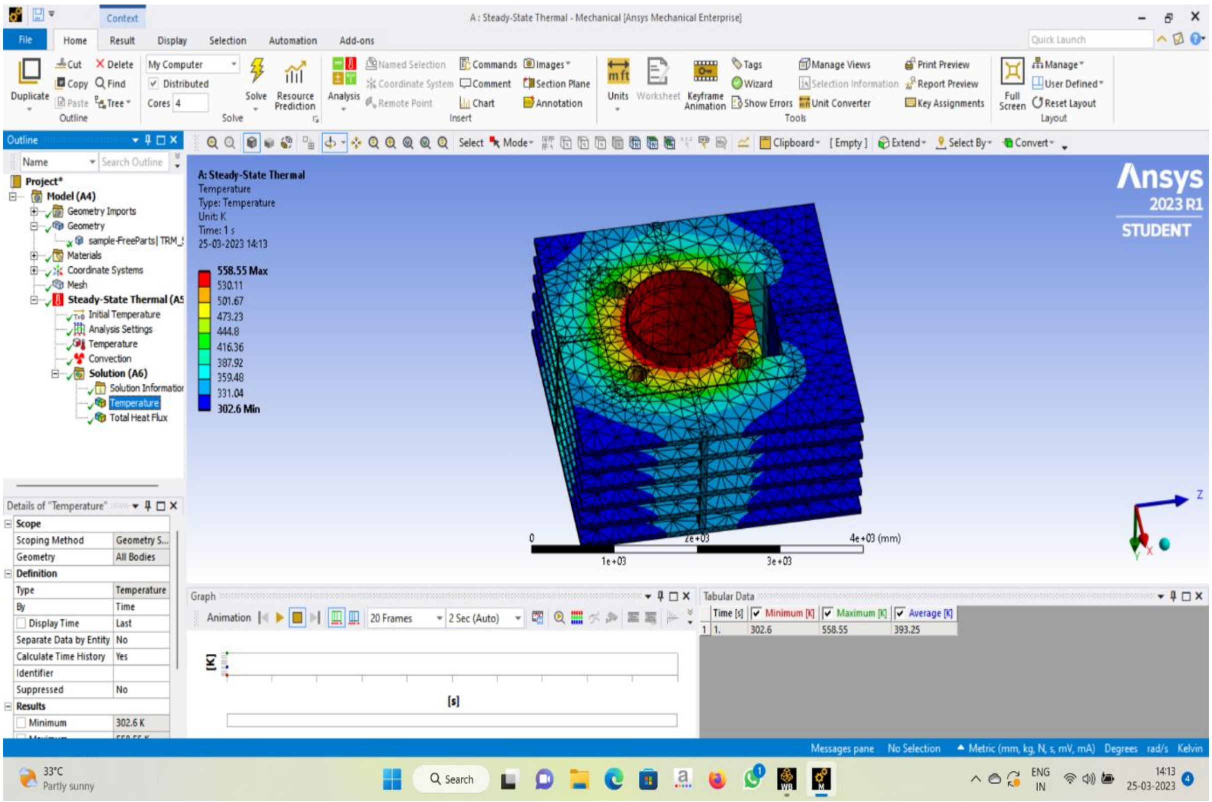

Fig.24.Temperature distribution of rectangular fin of 2.5mm of Al204

(d)rectangular fin of 2mm thickness of Al204

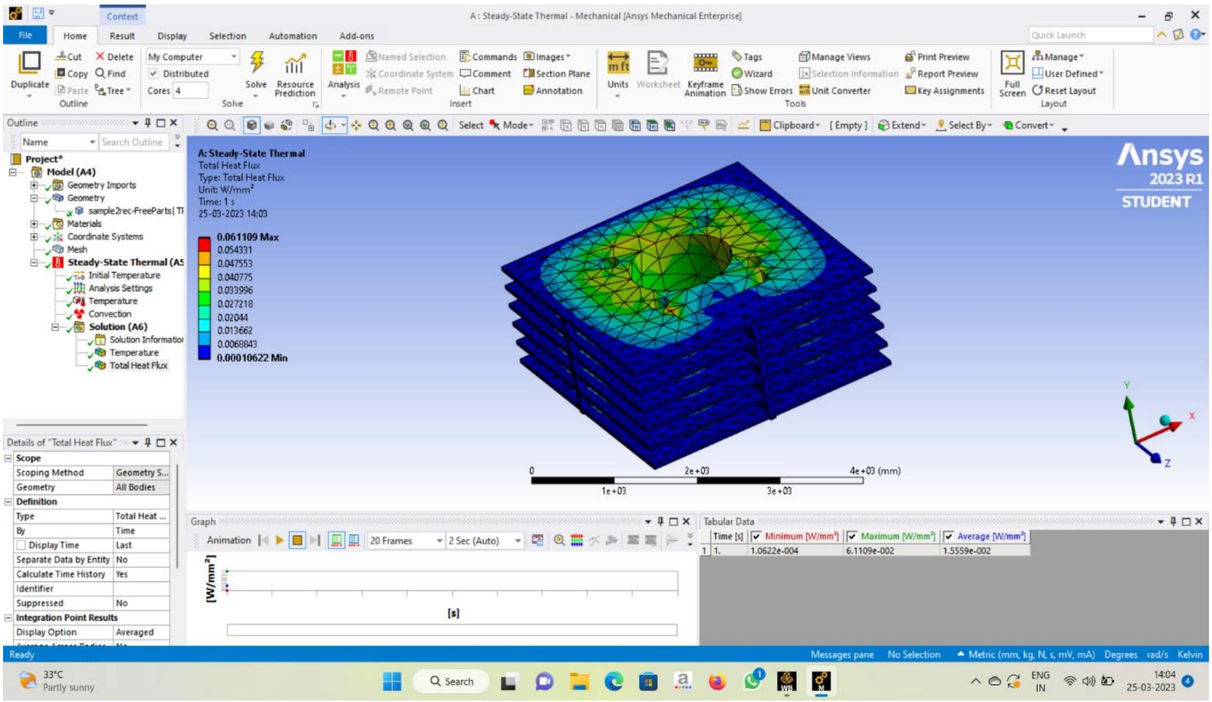

Fig.25. heat flux of rectangular fin of 2mm of Al204

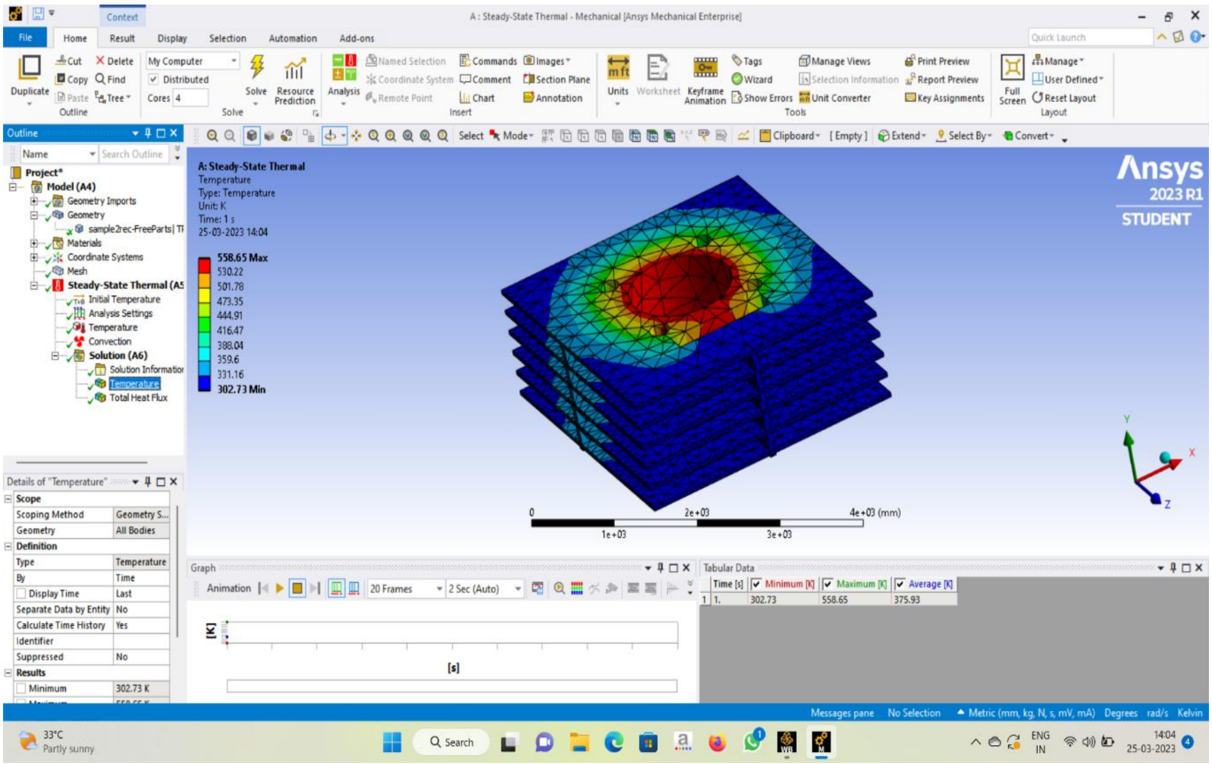

Fig.26. Temperature distribution of rectangular fin of 2mm of Al204

(e)rectangular fin of 2.5mm thickness of material Magnesium alloy

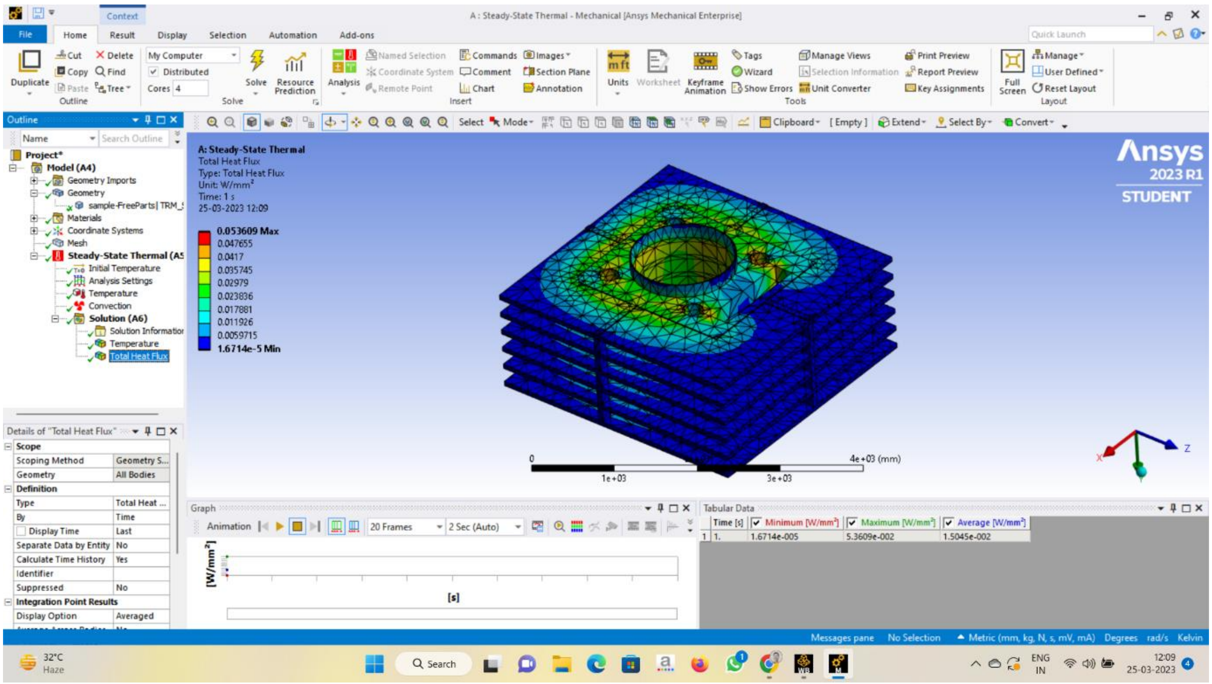

Fig.27. heat flux of rectangular fin of 2.5mm of Mg alloy

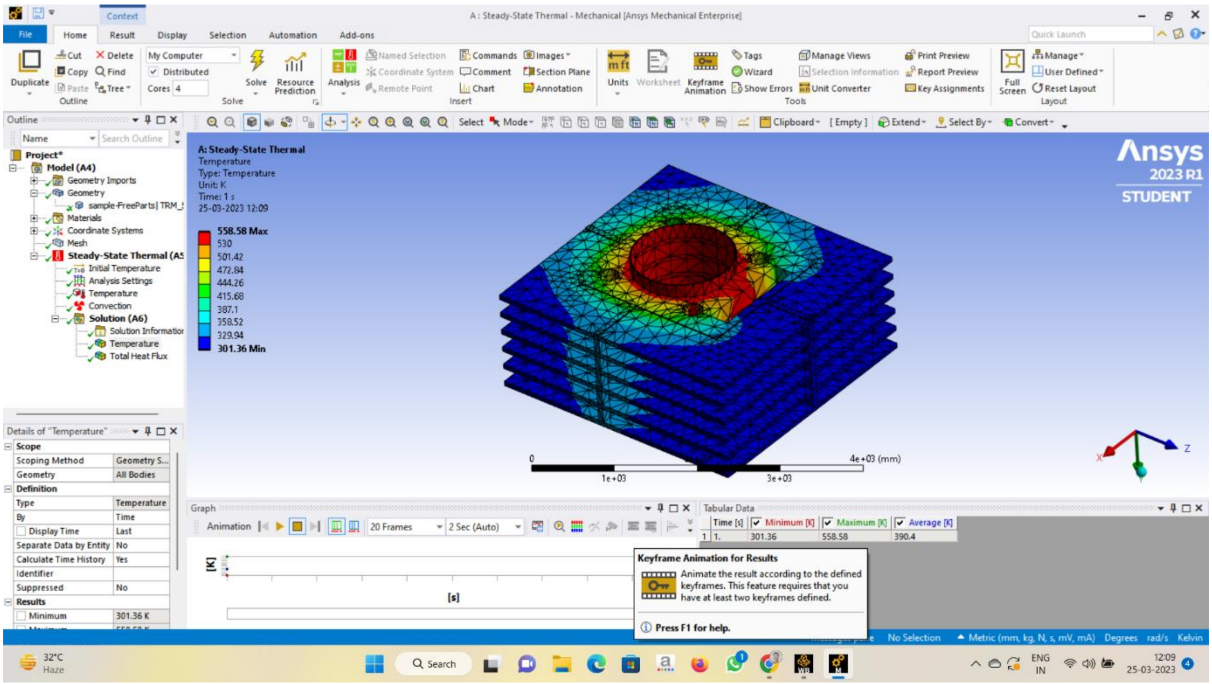

Fig.28. Temperature distribution of rectangular fin of 2.5mm of Mg alloy

(f)rectangular fin of 2mm thickness of material magnesium alloy

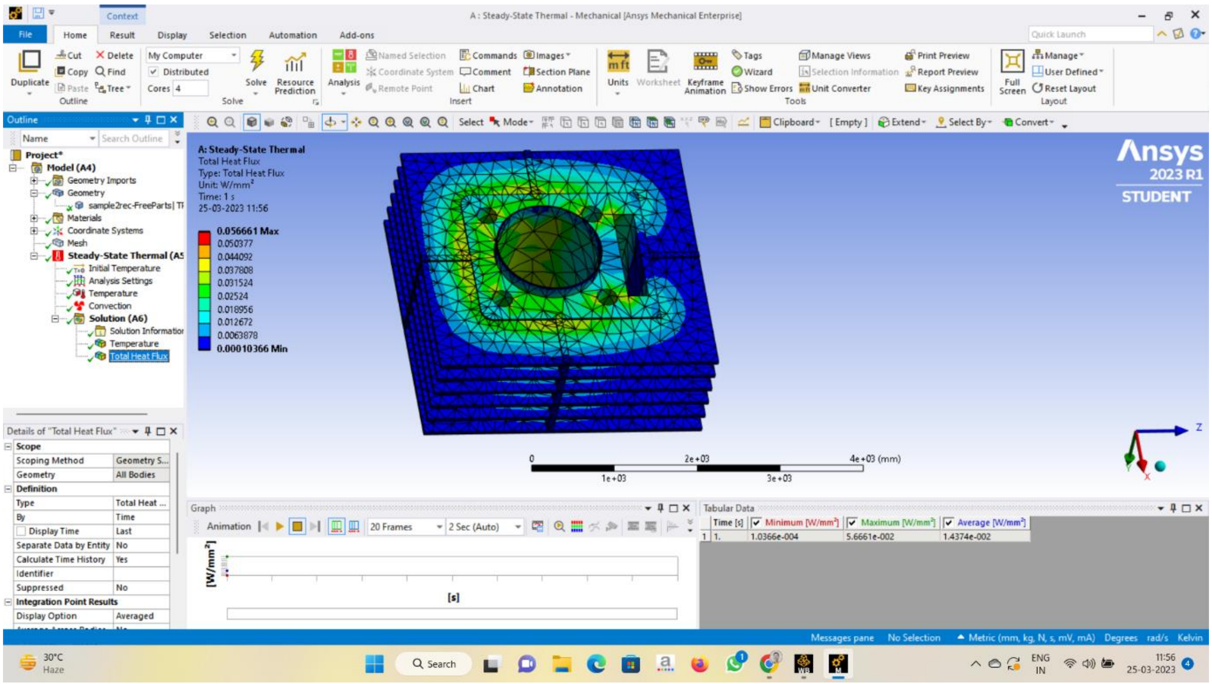

Fig.29. heat flux of rectangular fin of 2mm of Mg alloy

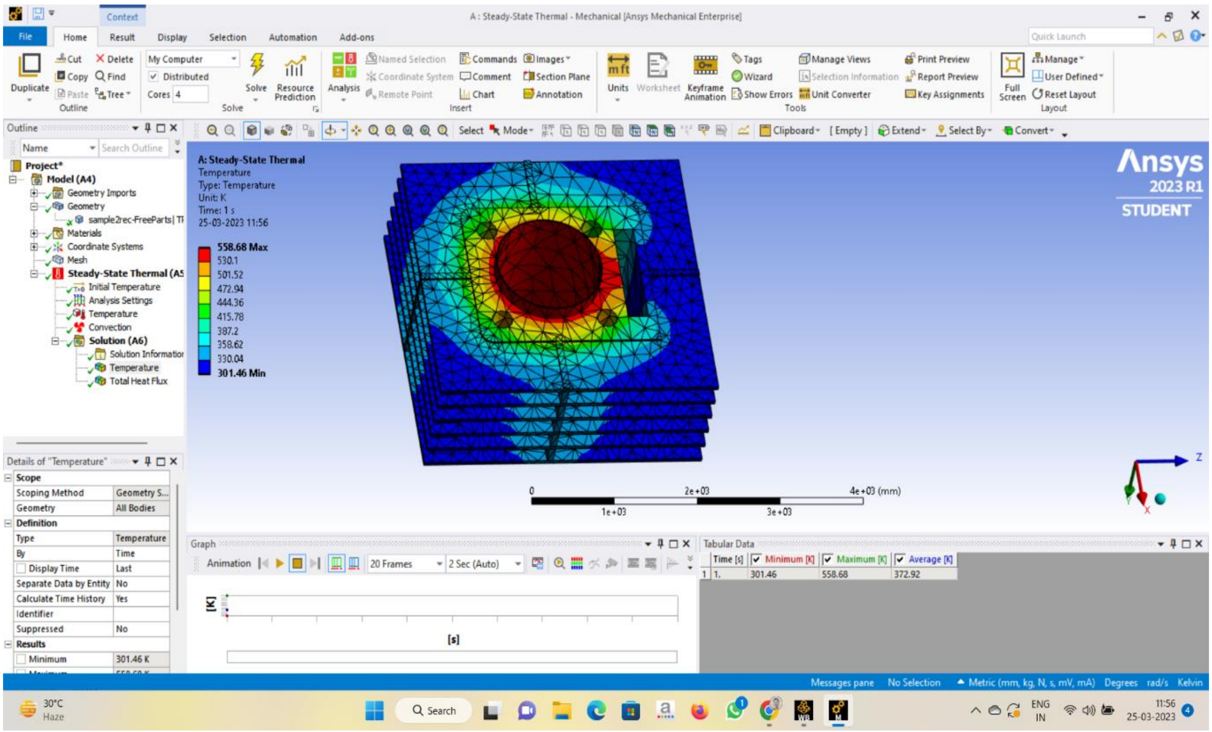

Fig.30. Temperature distribution of rectangular fin of 2mm of Mg alloy

3.2.2 Analysis of Circular fins

(a) circular fin of 2.5mm thickness of material Al6061 alloy

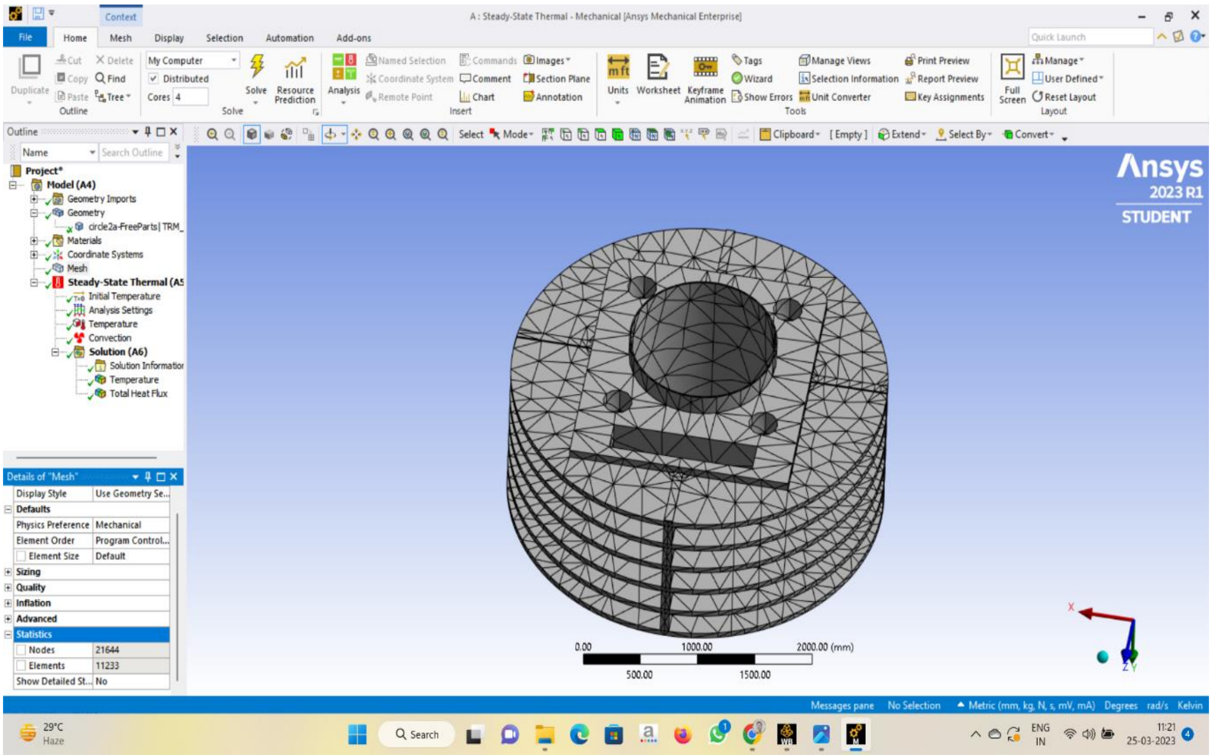

Fig.31. meshing of circular fins of 2.5mm thickness of Al6061

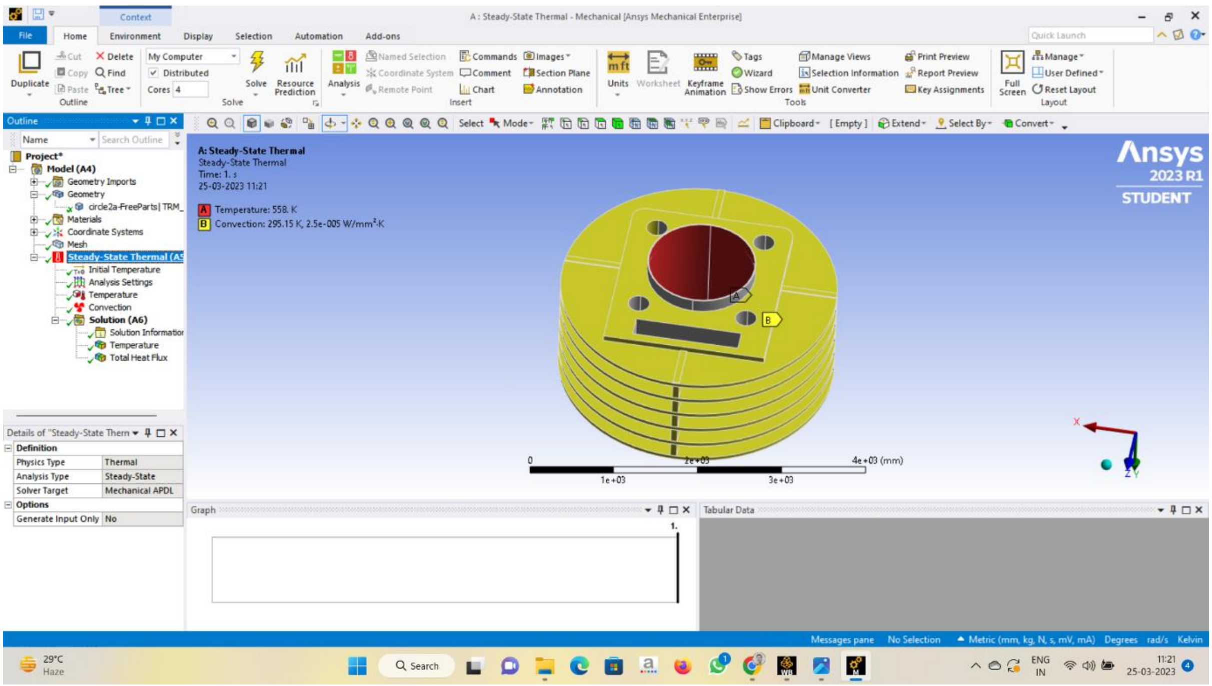

Fig.32. applying loads on circular fins of 2.5mm thickness of Al6061

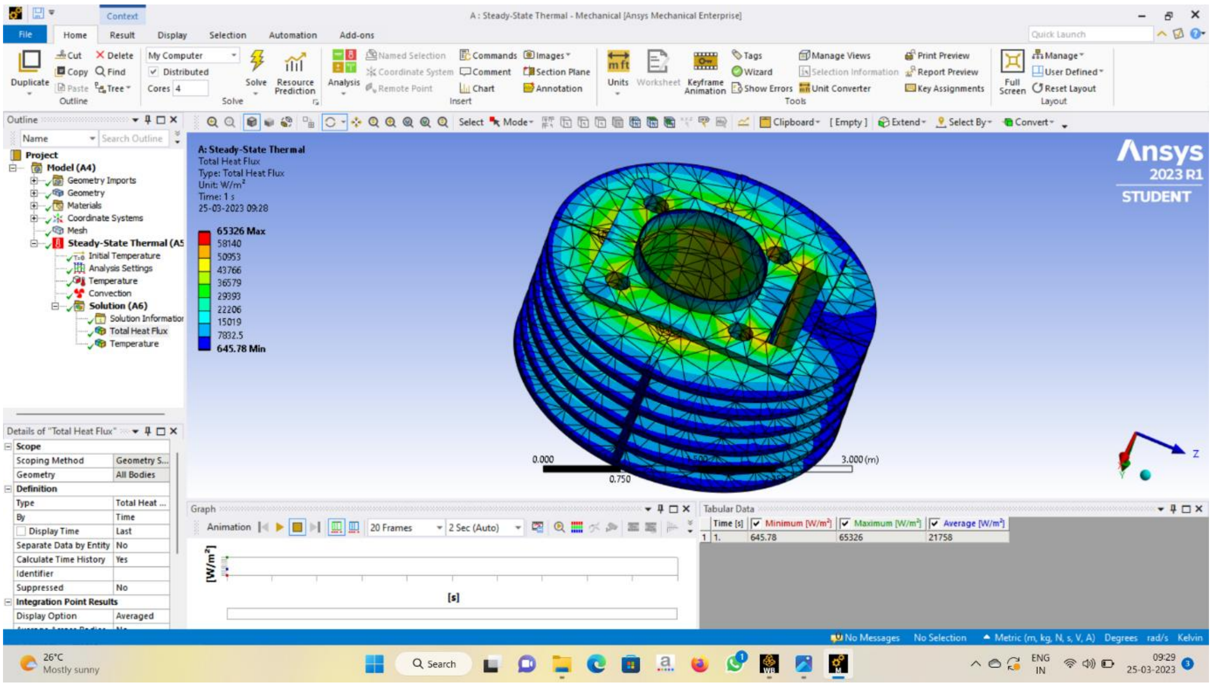

Fig.33. heat flux of circular fins of 2.5mm thickness of Al6061

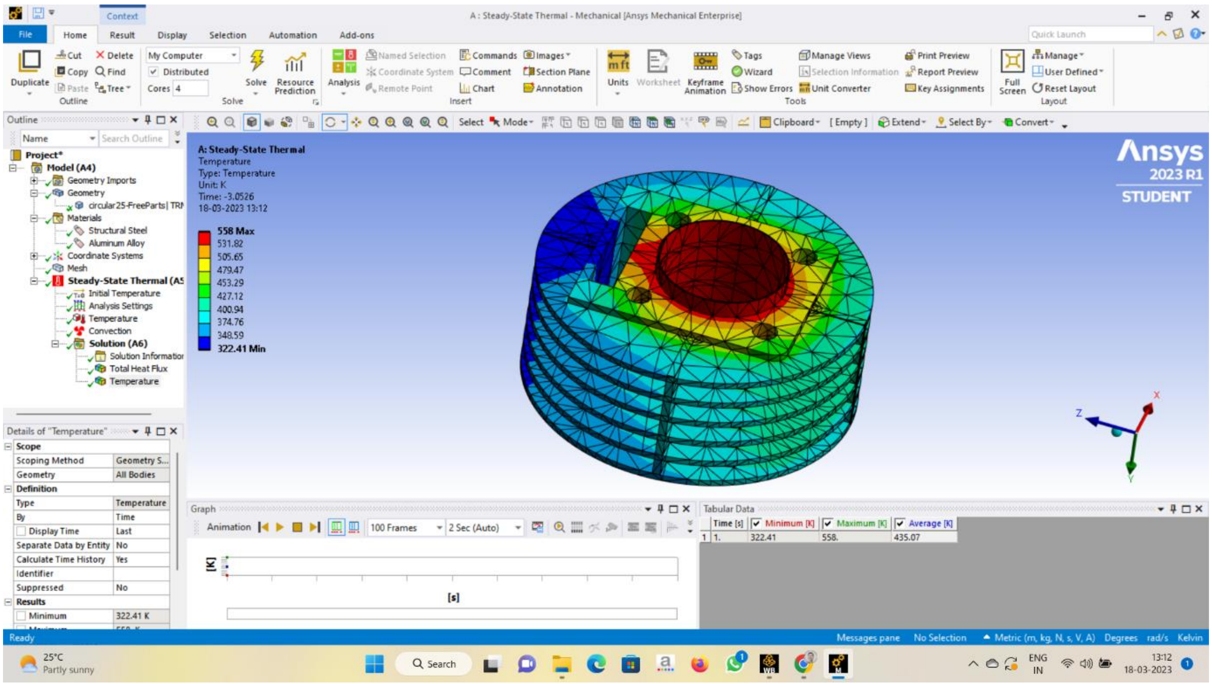

Fig.34. temperature distribution circular fins of 2.5mm thickness of Al6061

(b)circular fin of 2mm thickness of Al6061 alloy

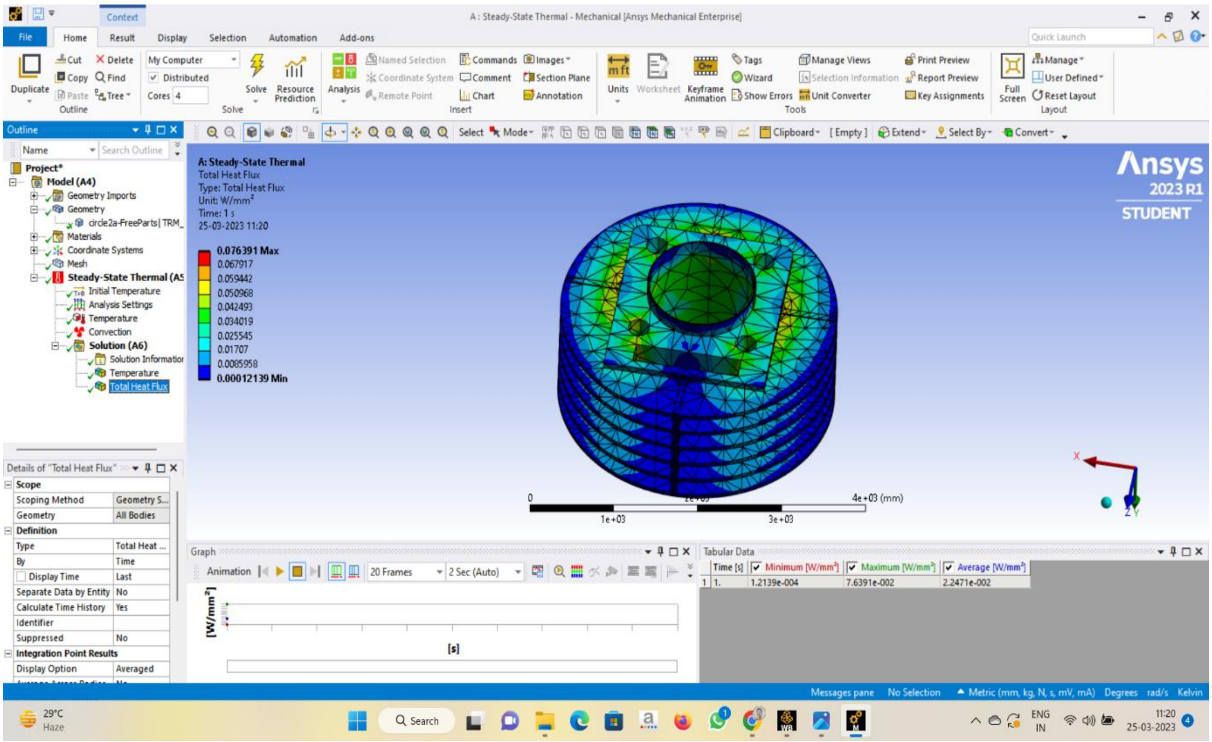

Fig.35. heat flux circular fins of 2mm thickness of Al6061

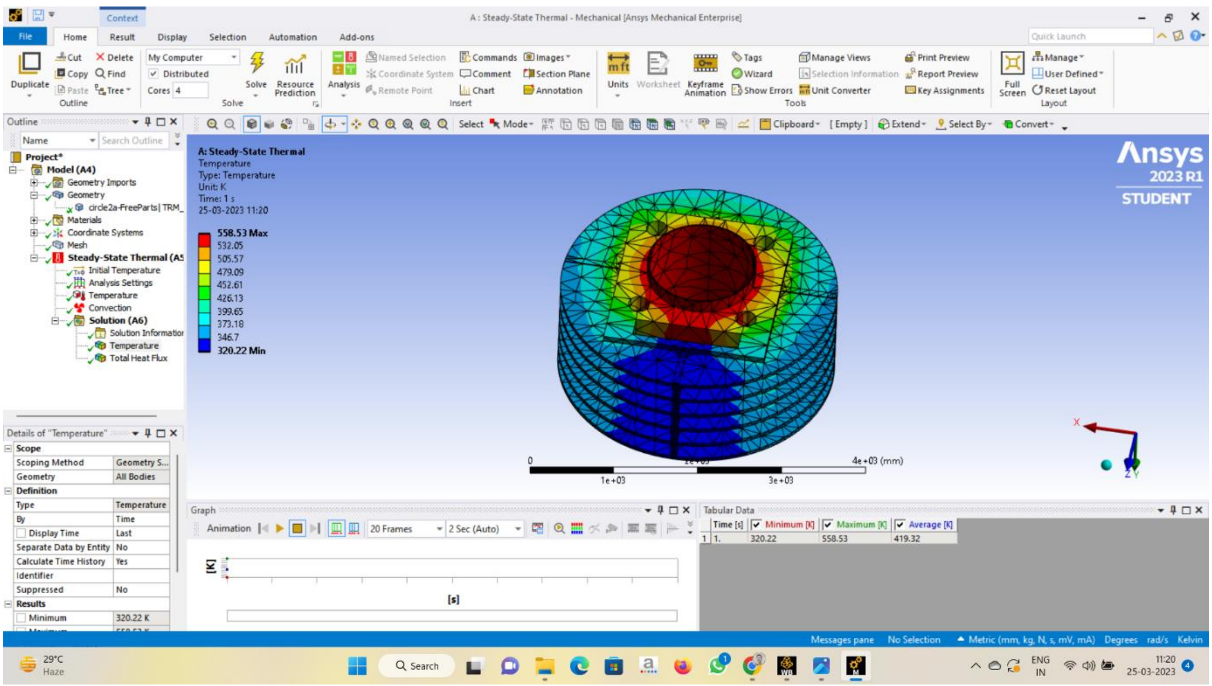

Fig.36. temperature distribution circular fins of 2mm thickness of Al6061

(c)circular fin of thickness 2.5mm of material Al204

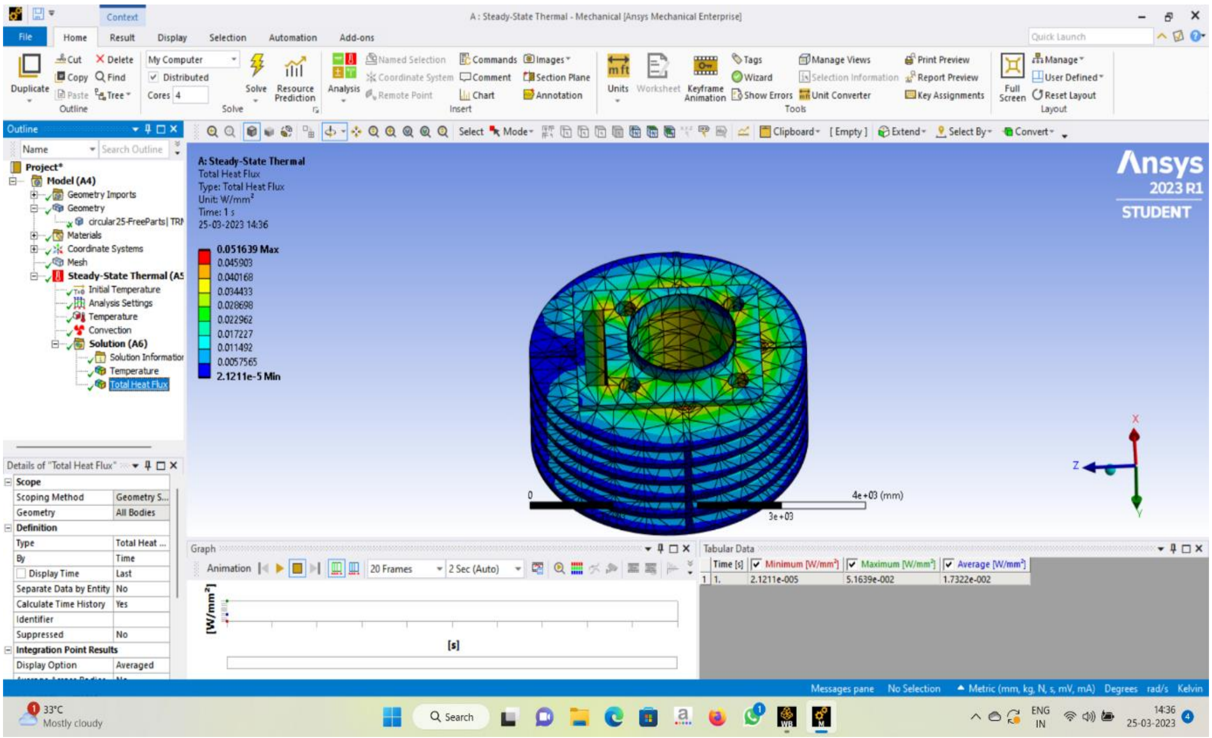

Fig.37. heat flux circular fins of 2.5mm thickness of Al204

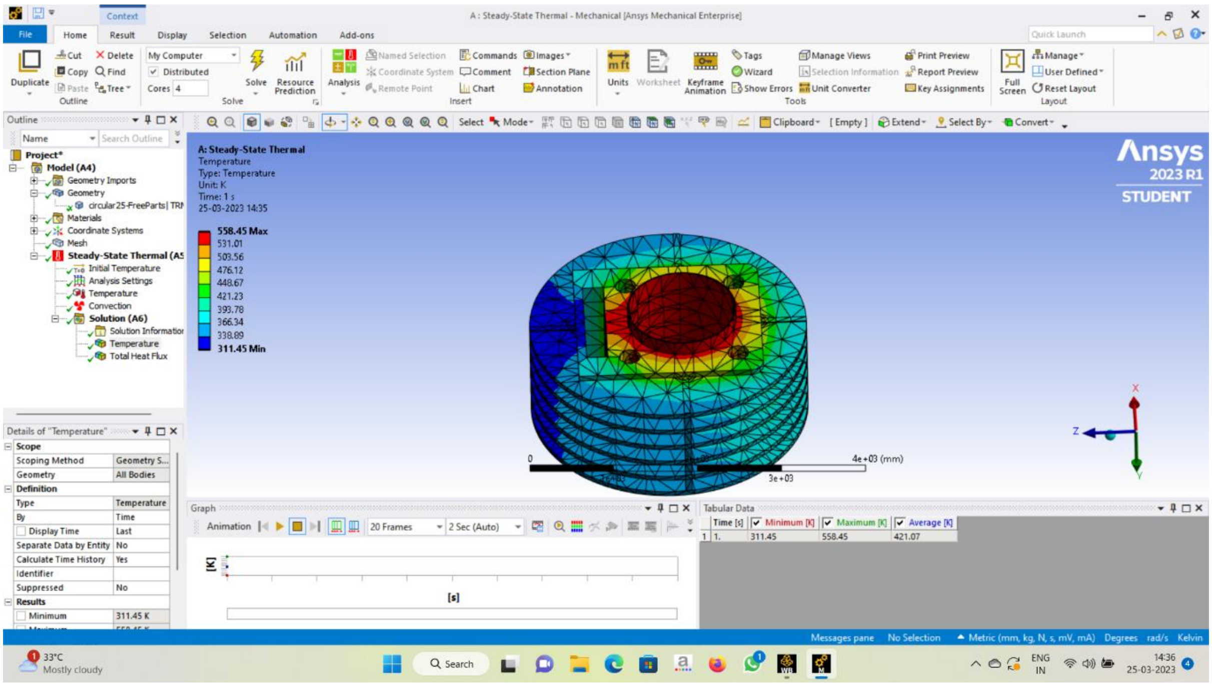

Fig.38. temperature distribution circular fins of 2.5mm thickness of Al204

(d)circular fin of 2mm thickness of Al204 Alloy

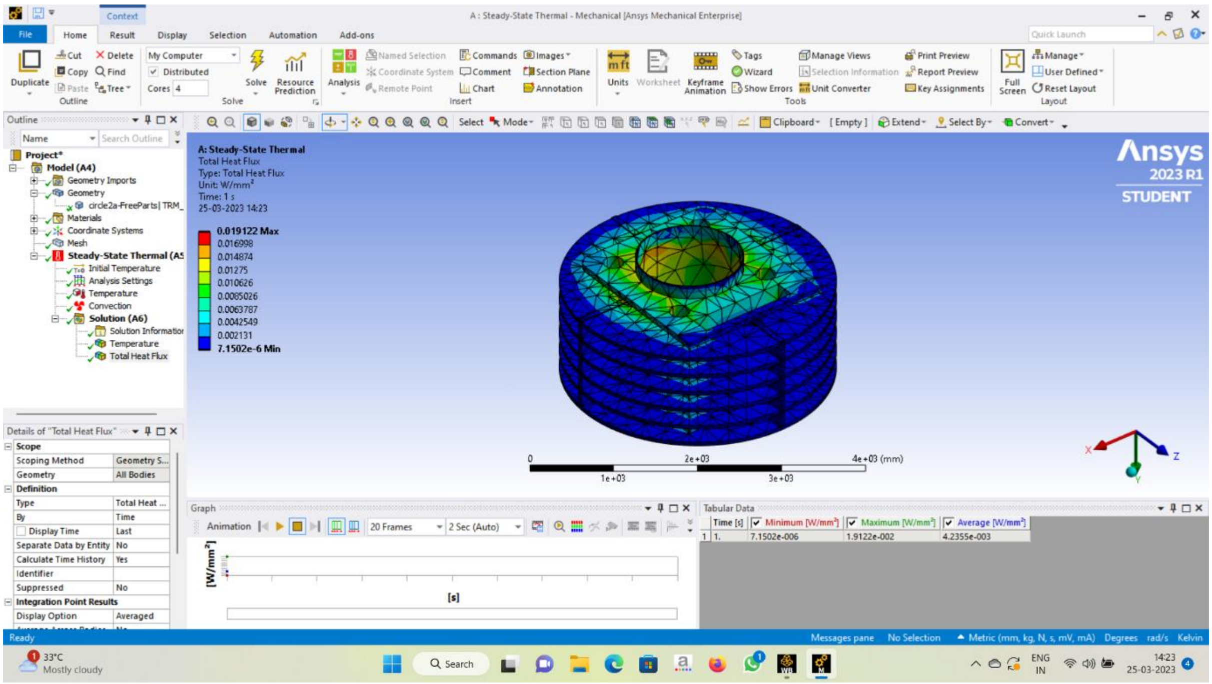

Fig.39. heat flux circular fins of 2mm thickness of Al204

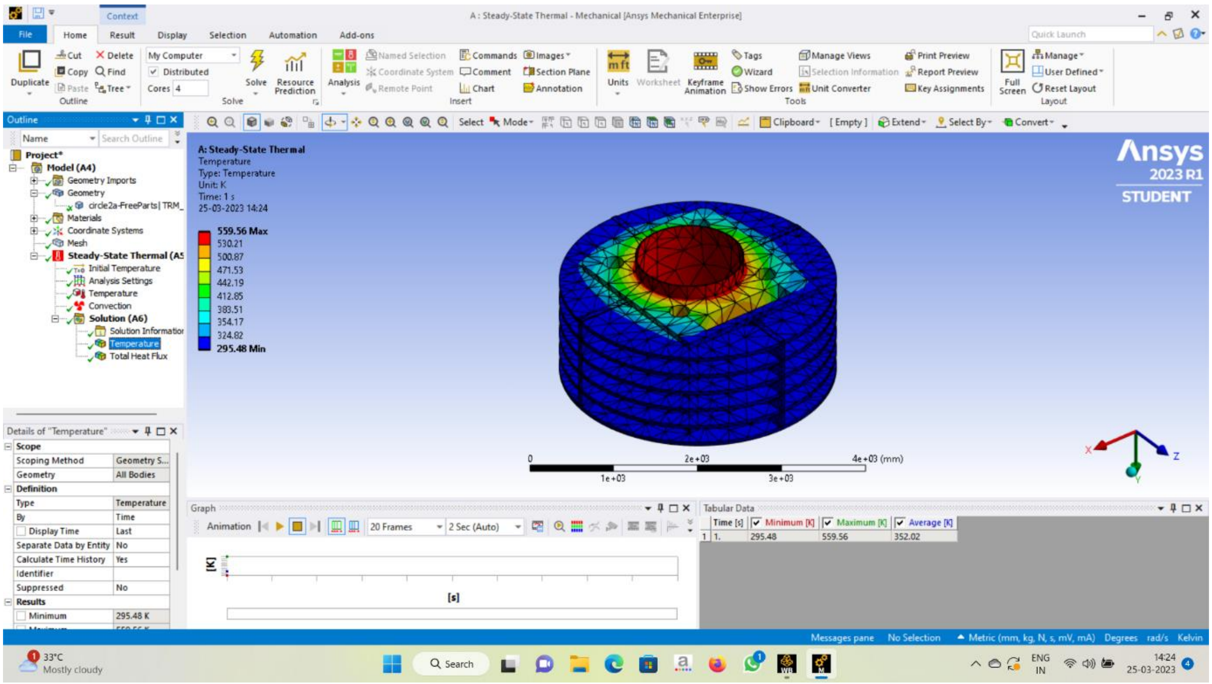

Fig.40. temperature distribution circular fins of 2mm thickness of Al204

(e)circular fin of 2.5mm thickness of material Magnesium alloy

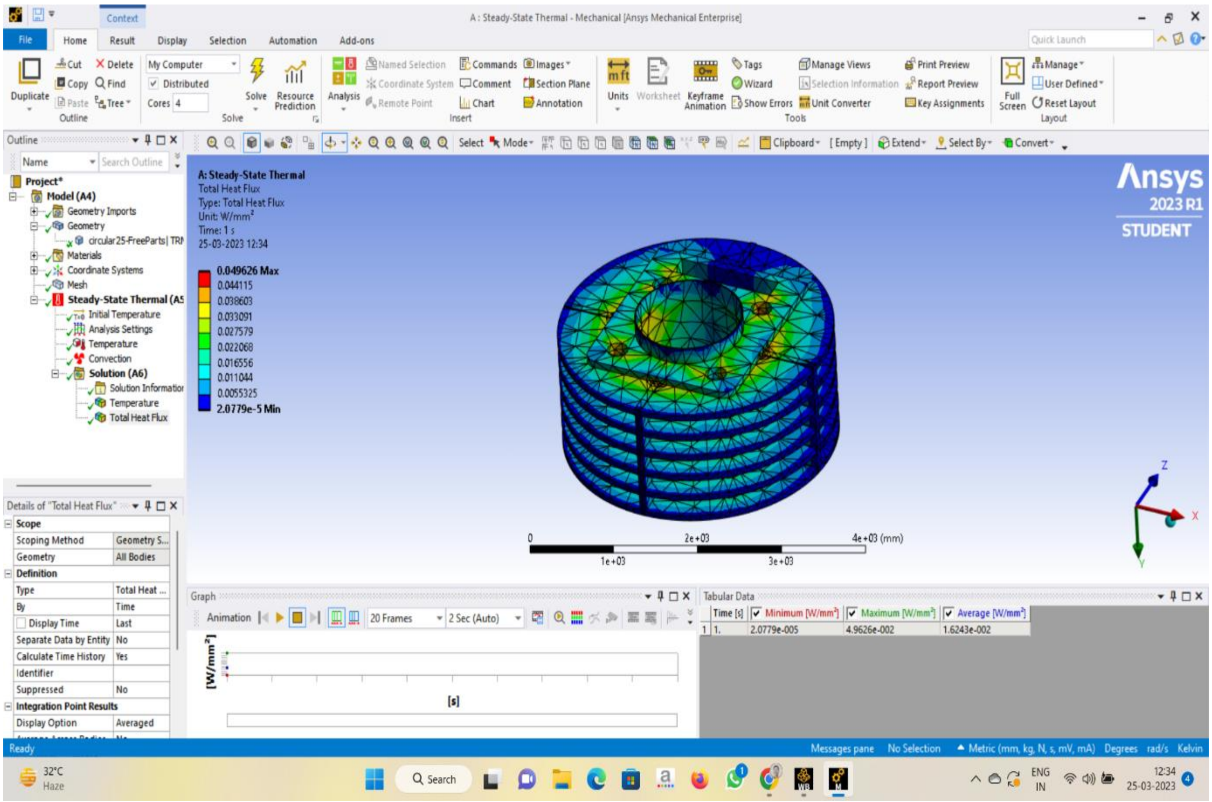

Fig.41. heat flux circular fins of 2.5mm thickness of Mg alloy

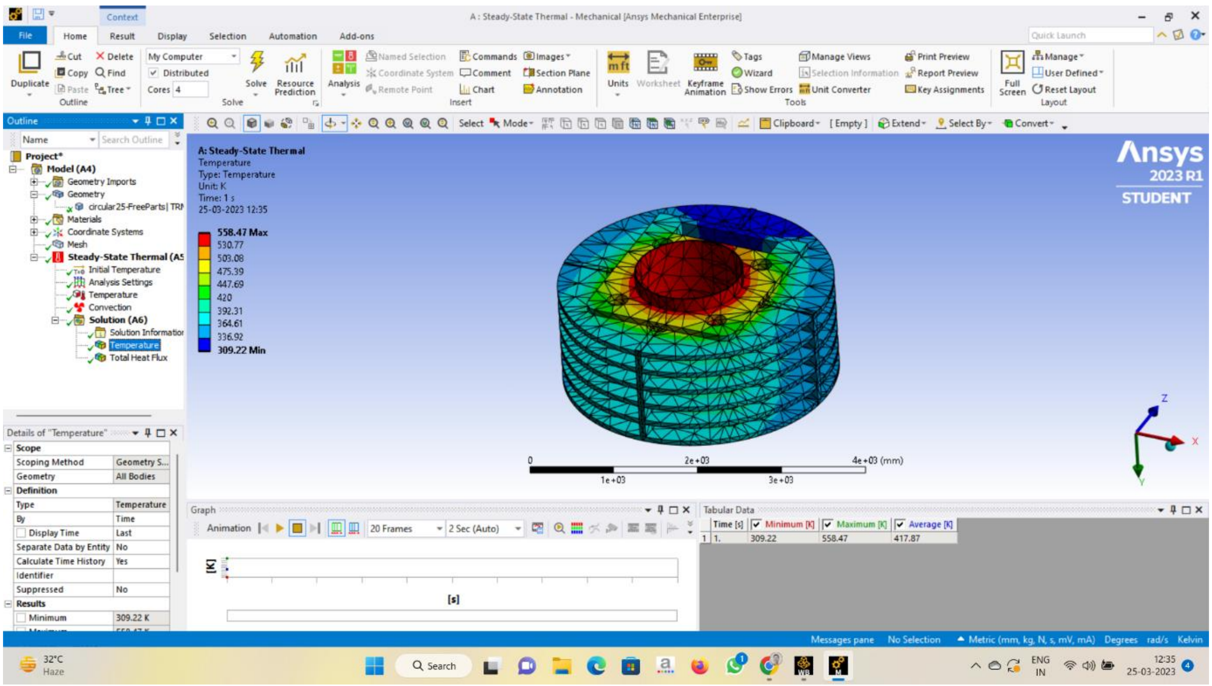

Fig.42. temperature distribution circular fins of 2.5mm thickness of Mg alloy

(f)circular fin of thickness 2mm of material Magnesium alloy

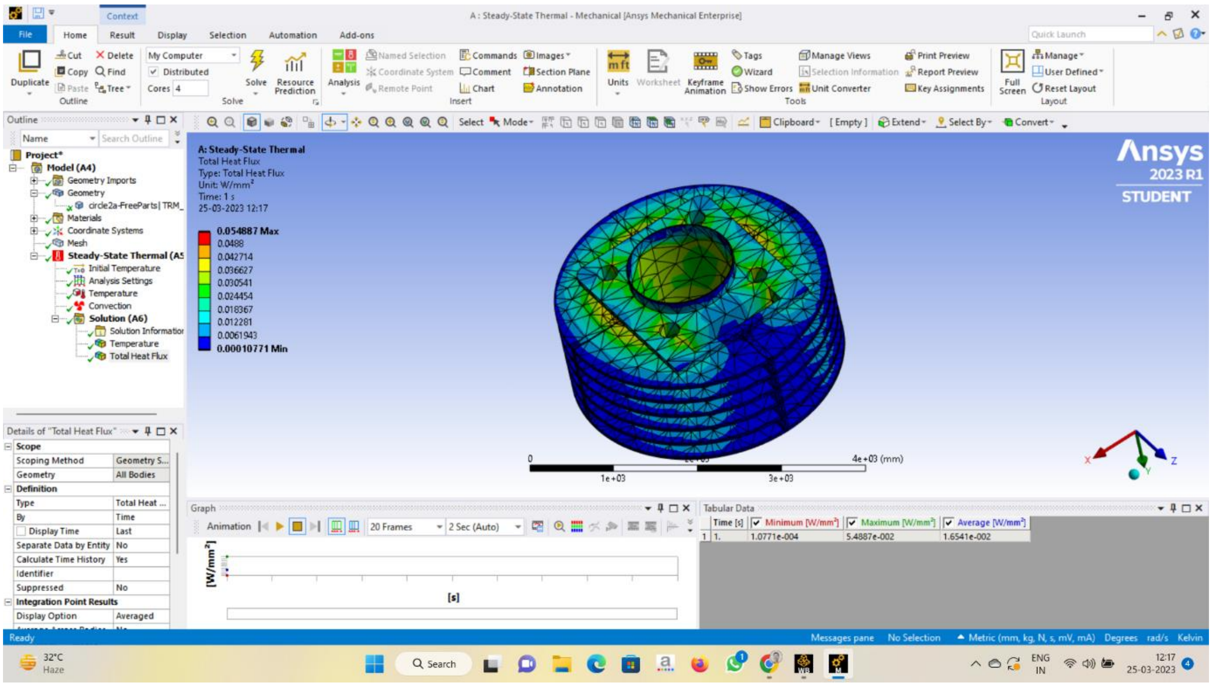

Fig.43. heat flux circular fins of 2mm thickness of Mg alloy

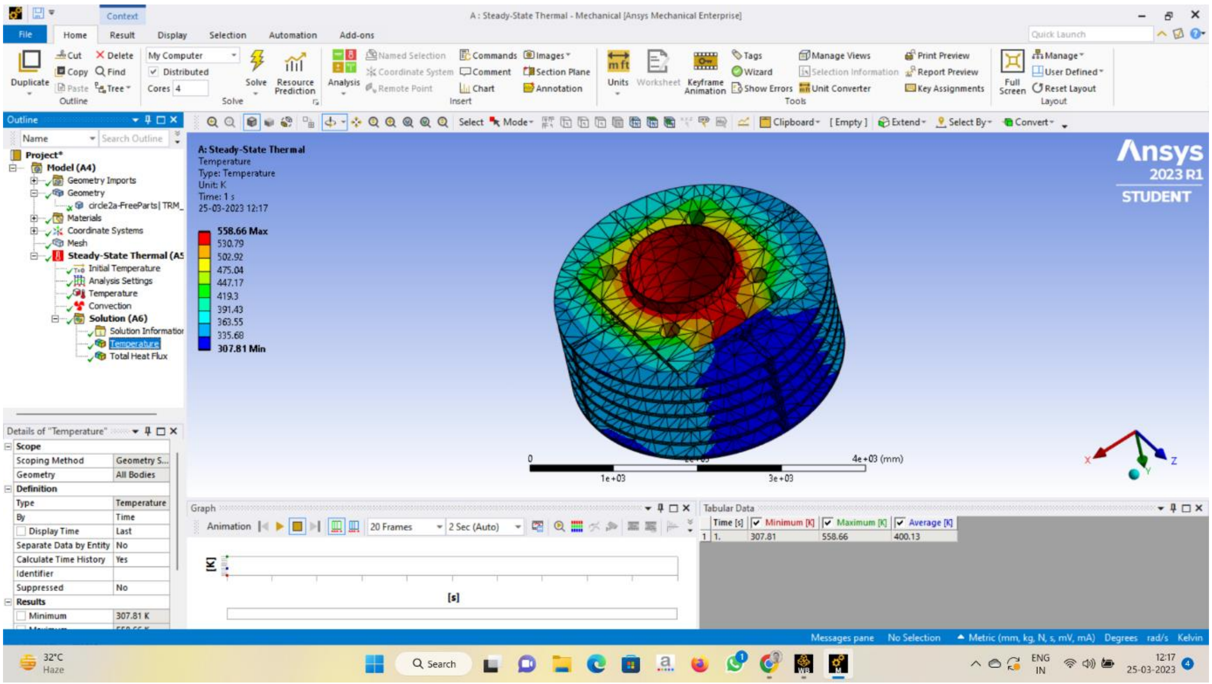

Fig.44. temperature distribution circular fins of 2mm thickness of Mg alloy

3.2.3 Analysis of Angular fins

(a) Angular fin of 2.5mm thickness of material Al6061

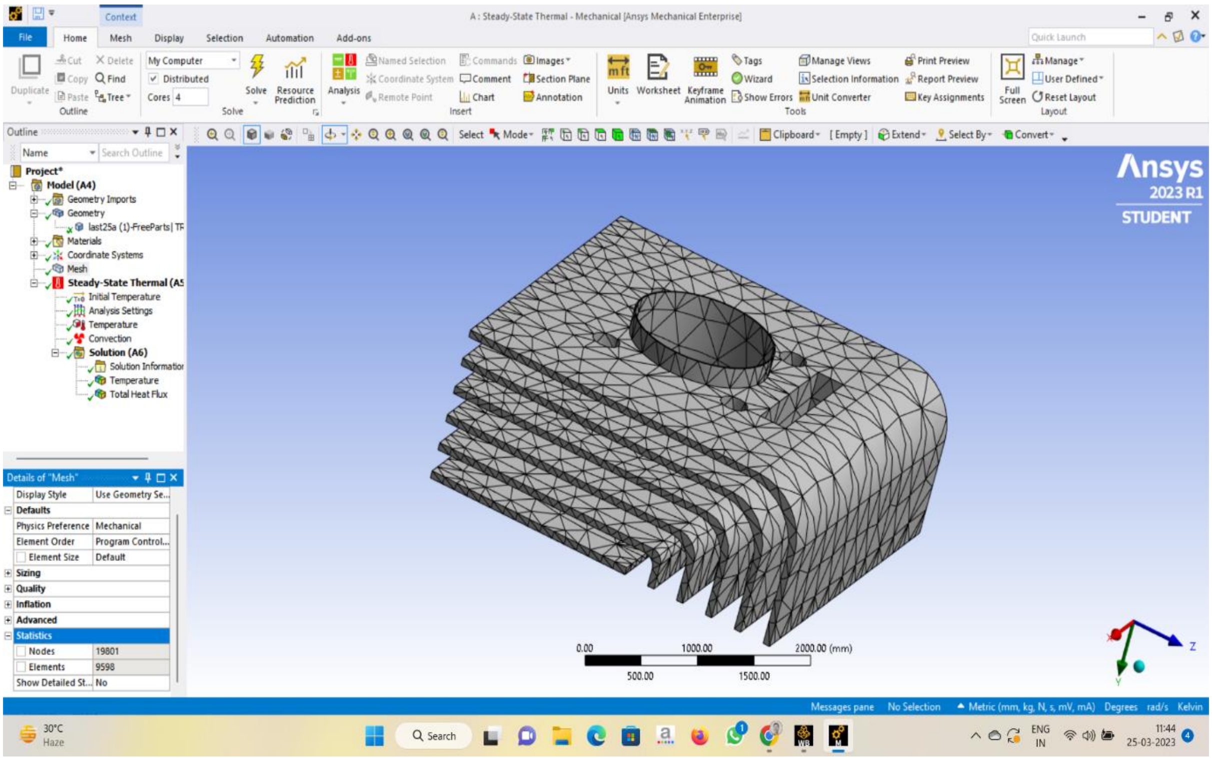

Fig.45. meshing of angular fin of 2.5mm thickness of Al6061

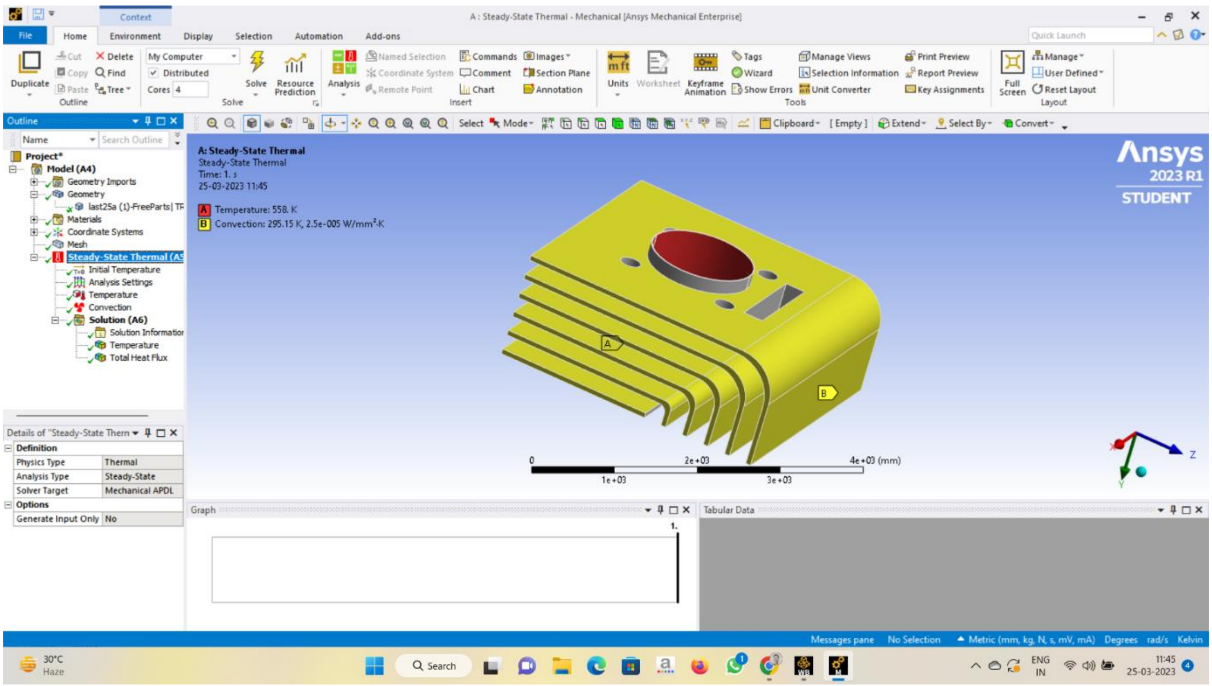

Fig.46. applying loads on angular fin of 2.5mm thickness of Al6061

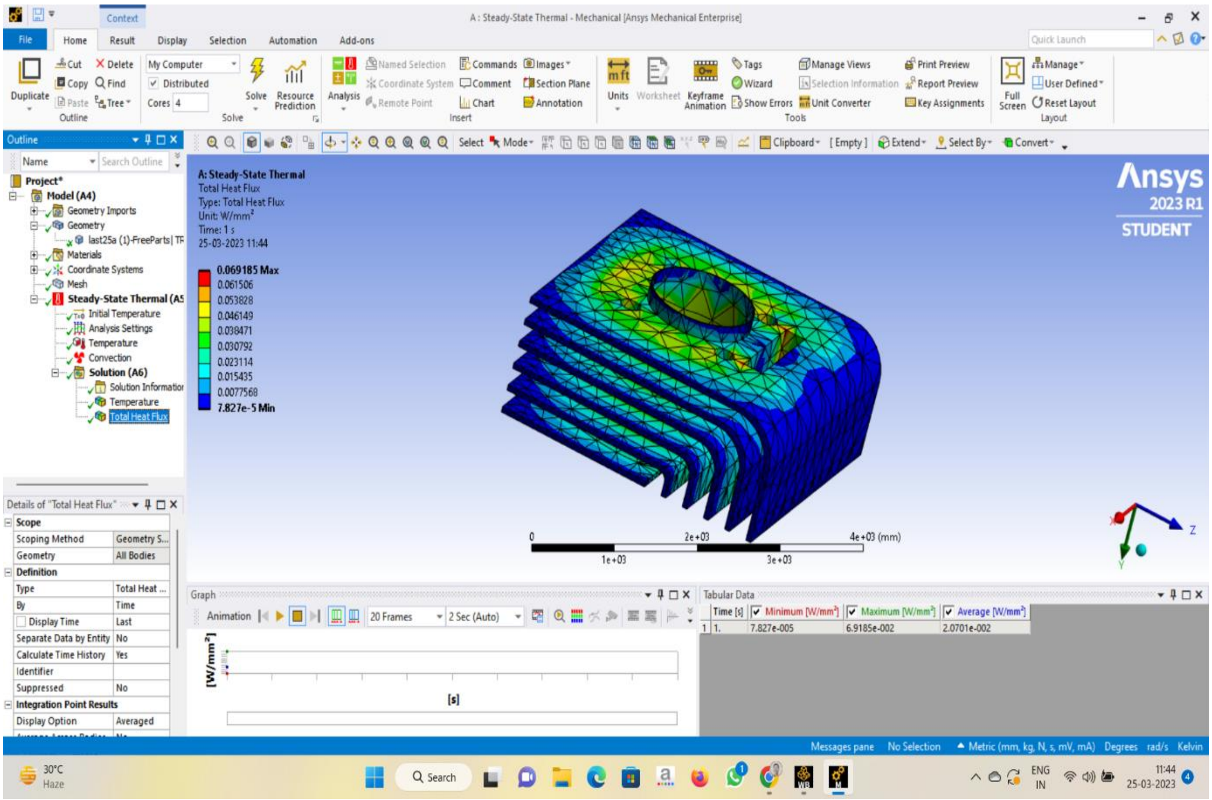

Fig.47. heat flux of angular fin of 2.5mm thickness of Al6061

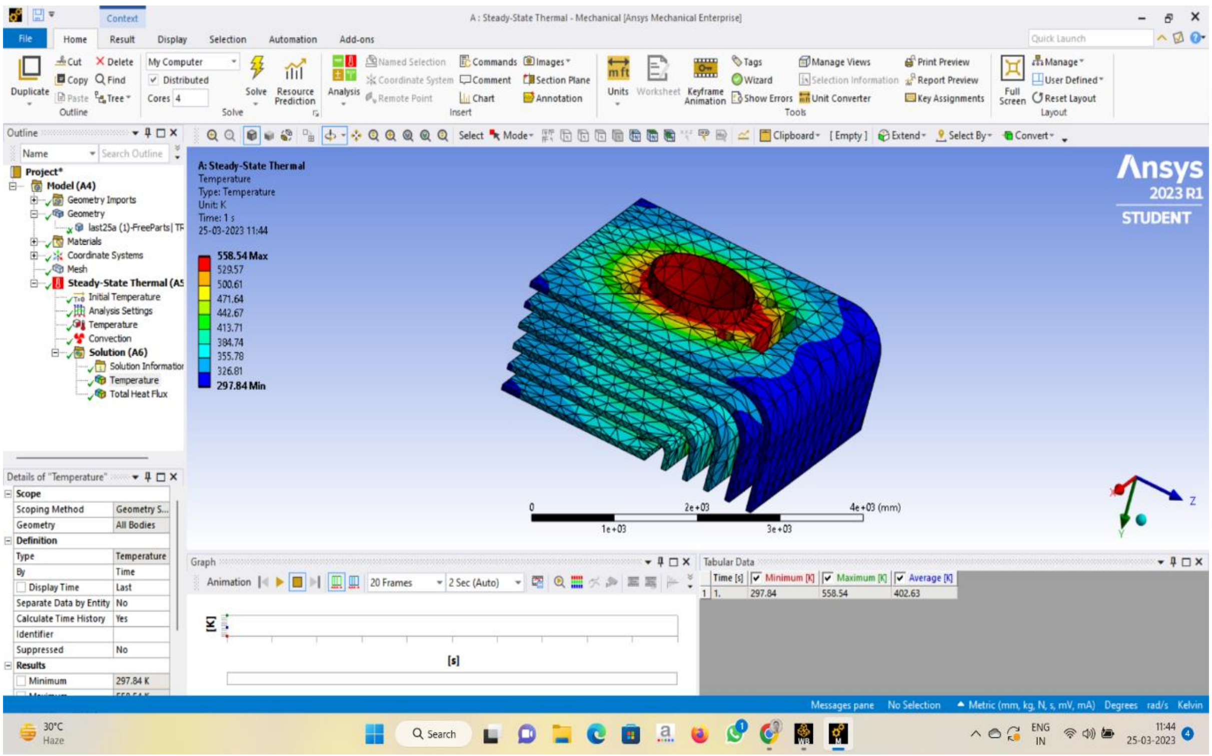

Fig.48. temperature distribution of angular fin of 2.5mm thickness of Al6061

(b)Angular fin of thickness 2mm of material Al6061

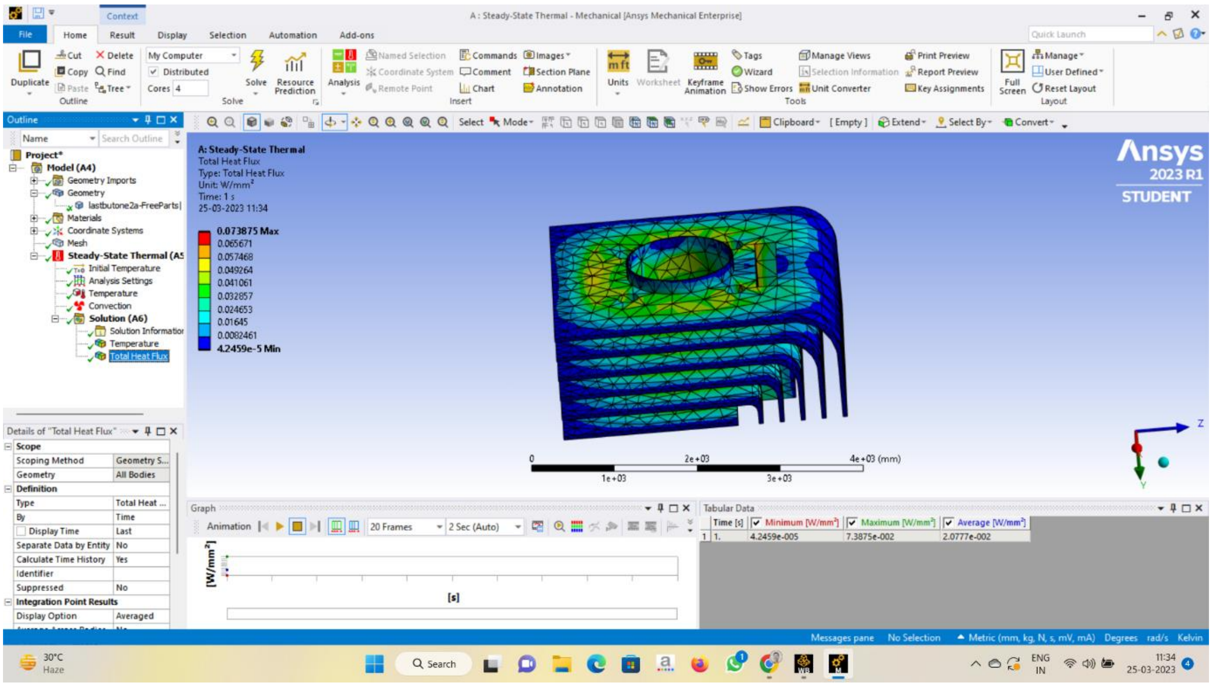

Fig.49. heat flux of angular fin of 2mm thickness of Al6061

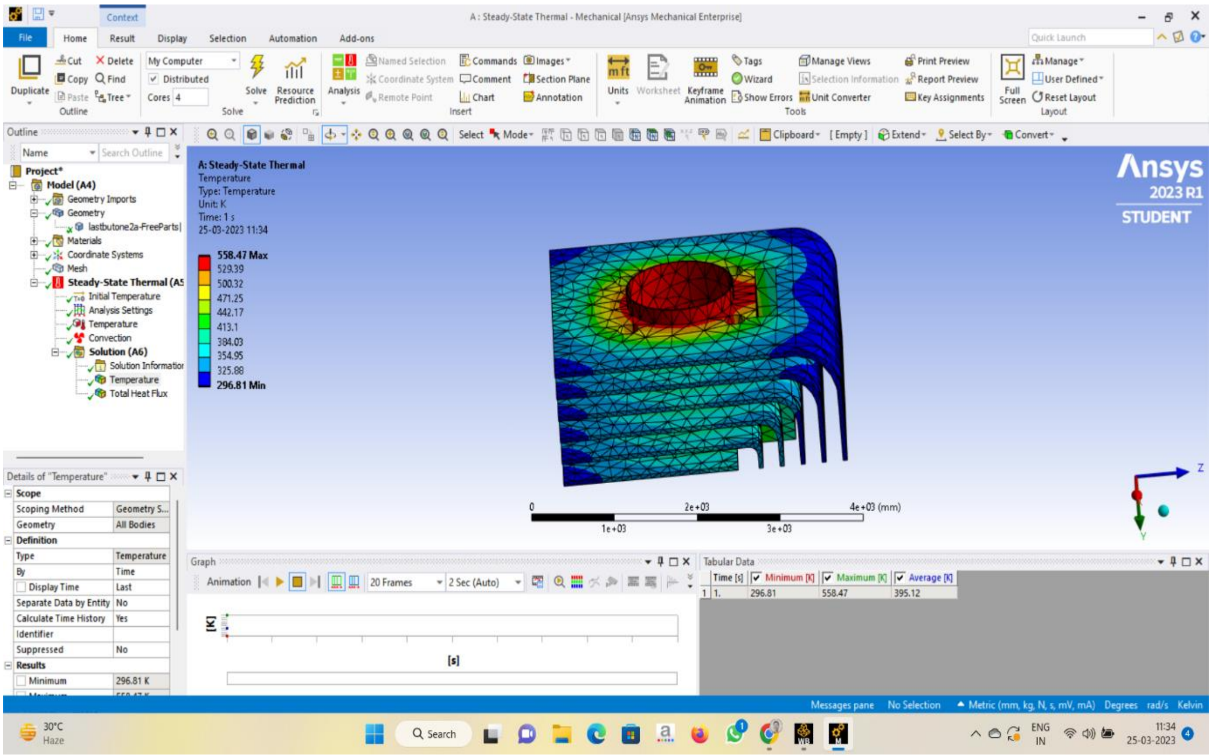

Fig.50. temperature distribution of angular fin of 2mm thickness of Al6061

(c)Angular fin of thickness 2.5mm thickness of material Al204

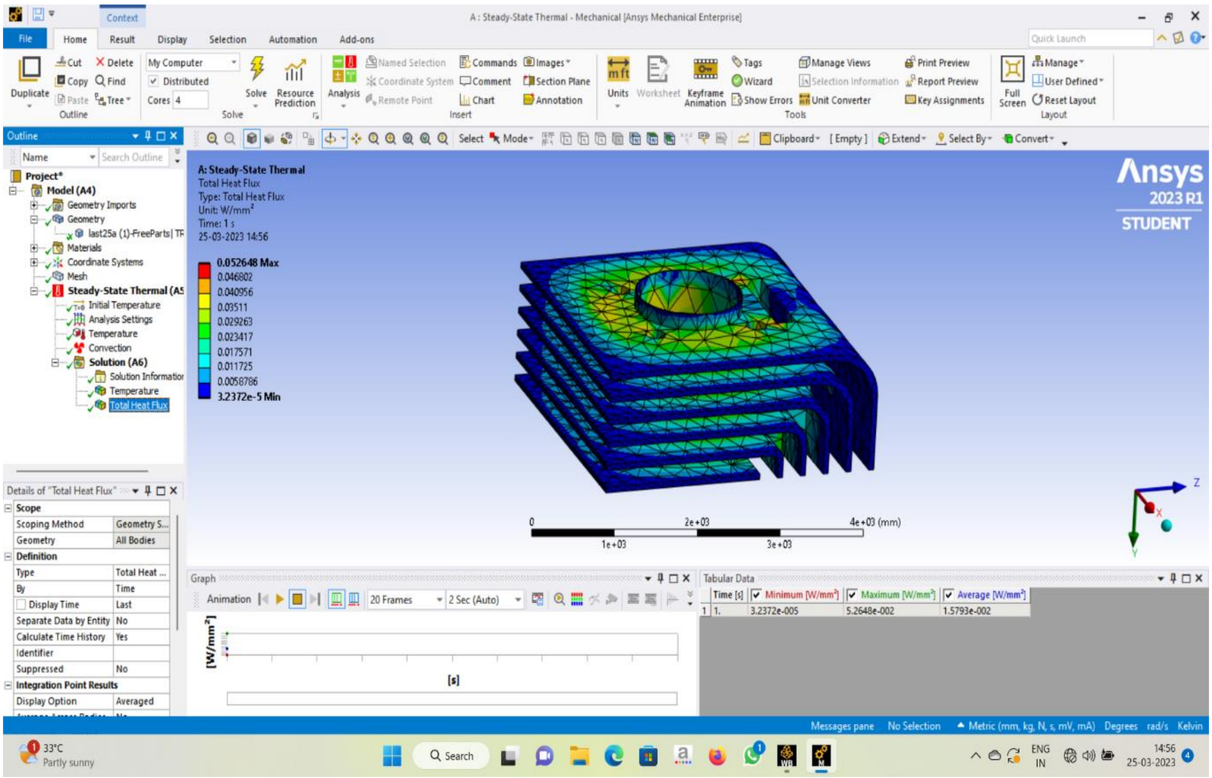

Fig.51. heat flux of angular fin of 2.5mm thickness of Al204

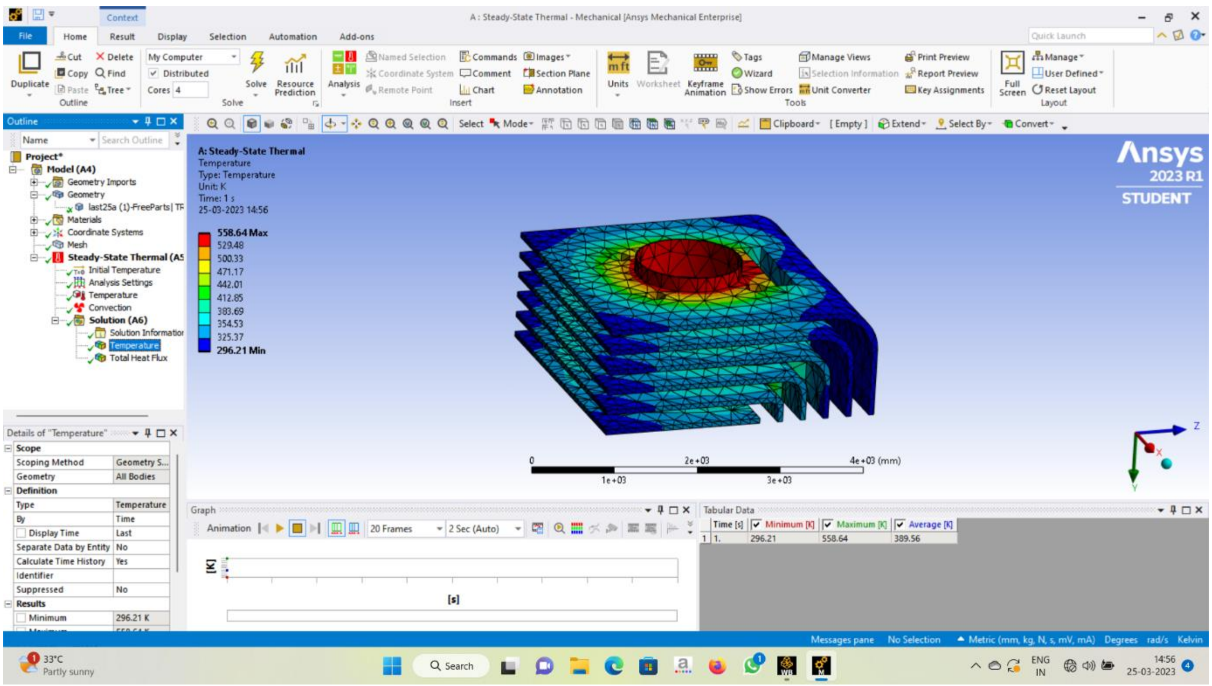

Fig.52. temperature distribution of angular fin of 2.5mm thickness of Al204

(d)Angular fin of thickness 2mm of material Al204

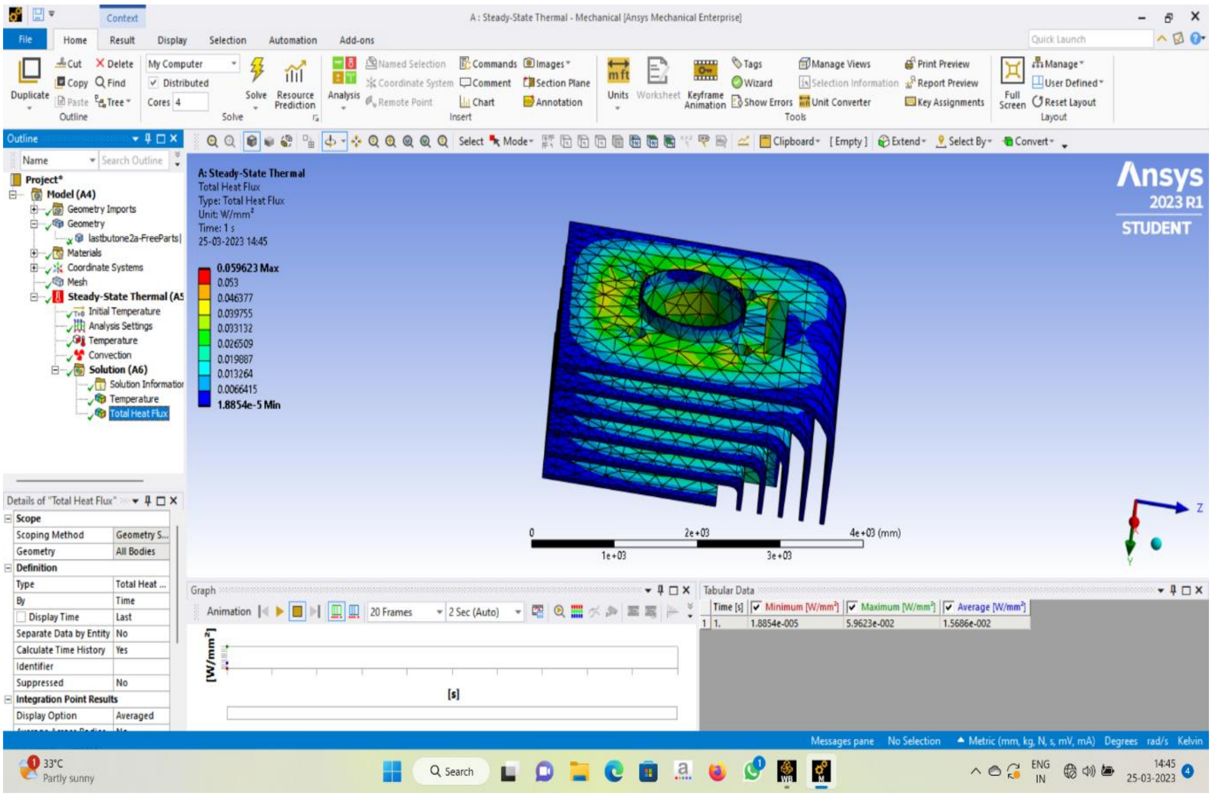

Fig.53. heat flux of angular fin of thickness 2mm of Al204

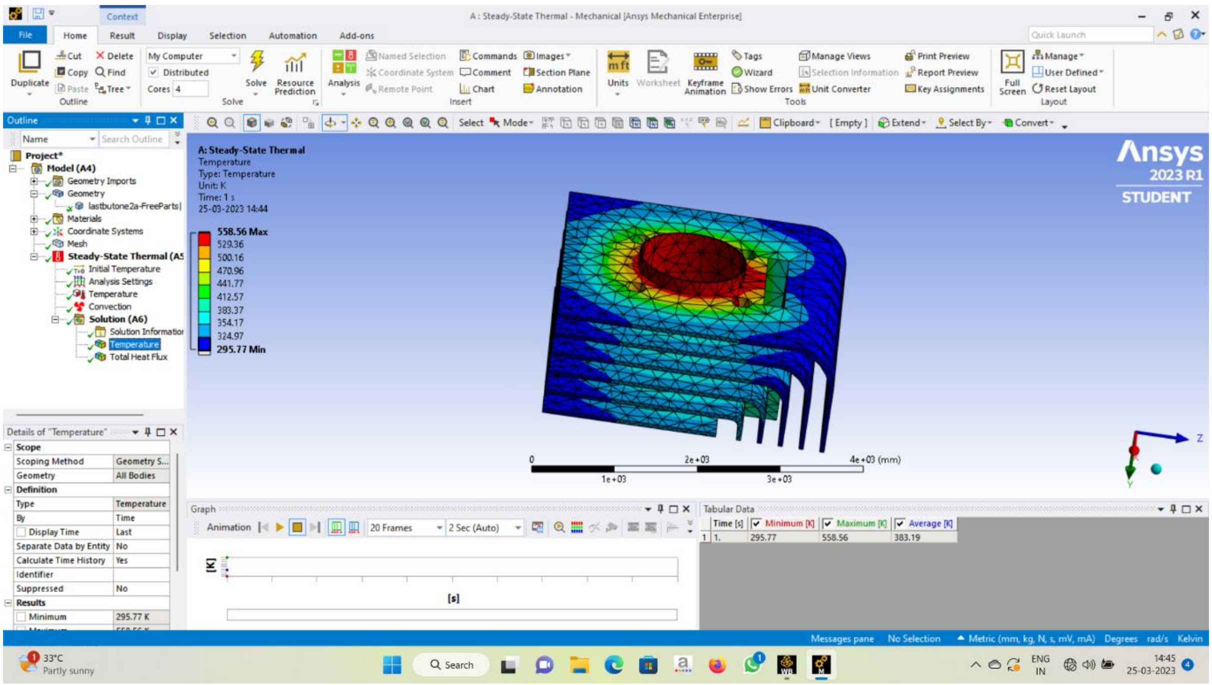

Fig.54. temperature distribution of angular fin of thickness of 2mm of Al204

(e)Angular fin of 2.5mm thickness of material Magnesium alloy

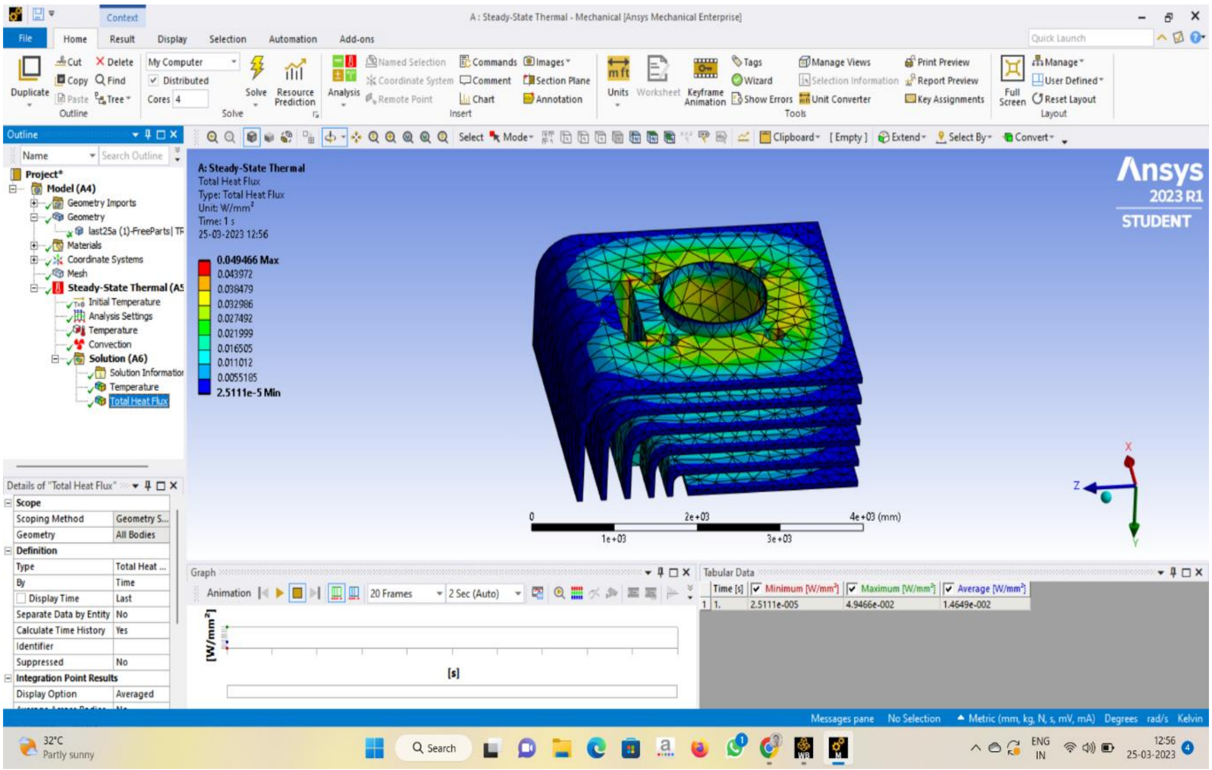

Fig.55. heat flux of angular fin of thickness 2.5mm of Magnesium alloy

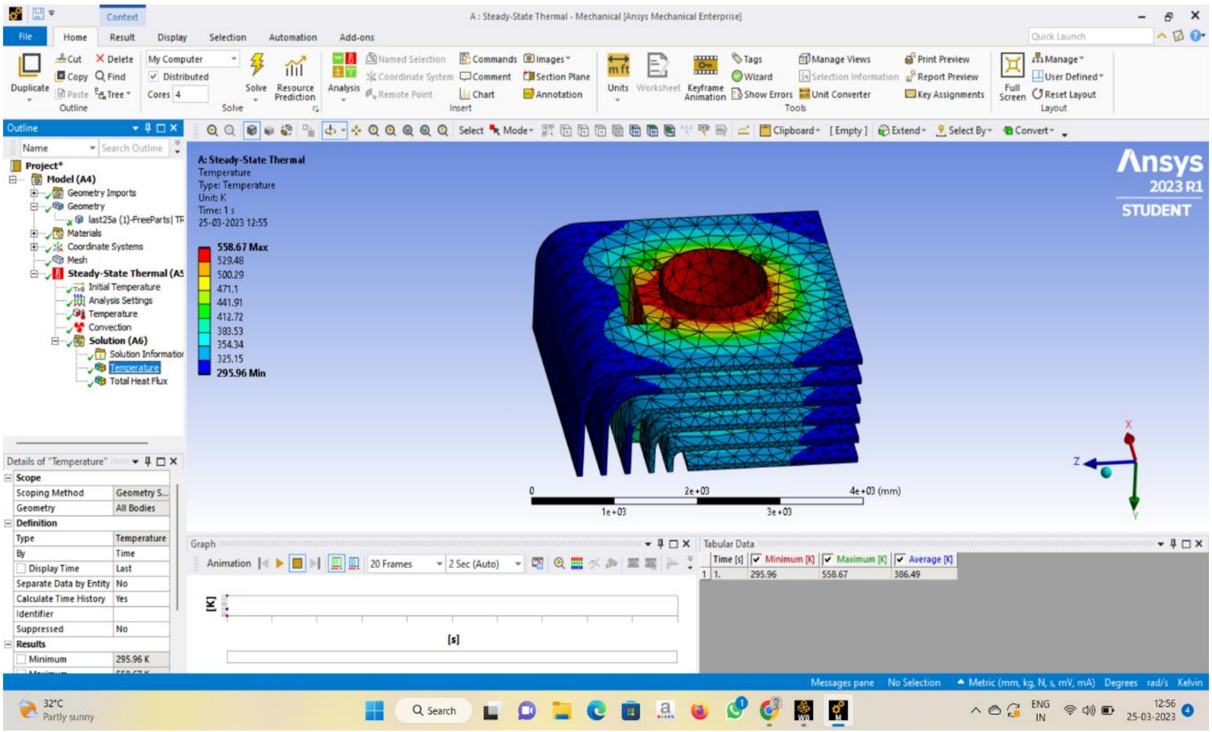

Fig.56. temperature distribution of angular fin of thickness 2.5mm of Magnesium alloy

(f) Angular fin of 2mm thickness of material Magnesium Alloy

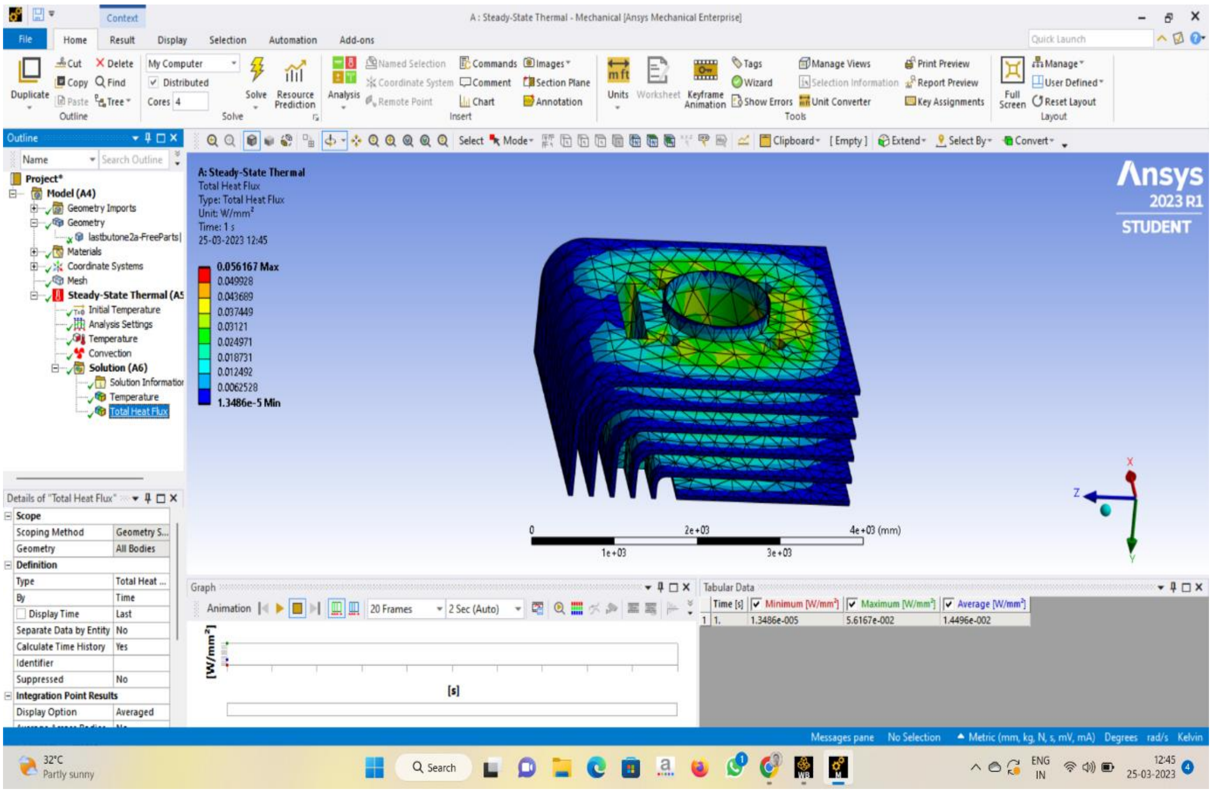

Fig.57. heat flux of angular fin of thickness 2mm of Magnesium alloy

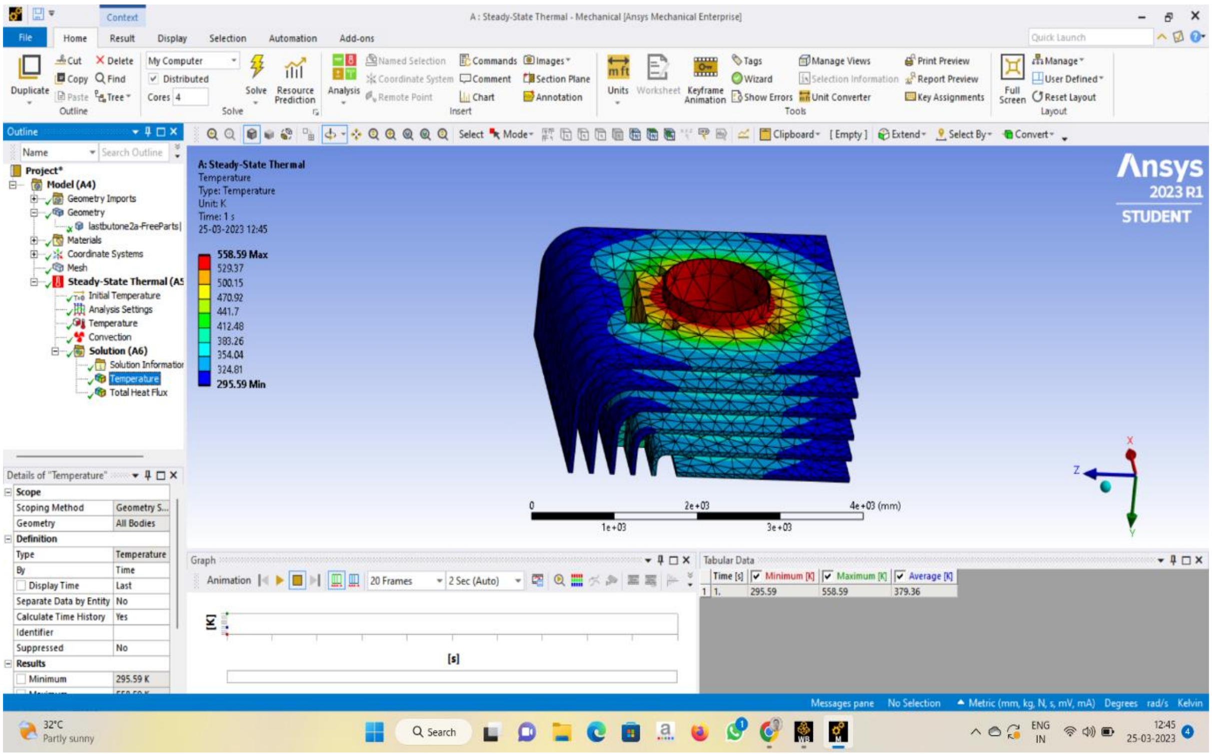

Fig.58. temperature distribution of angular fin of thickness 2mm of Magnesium alloy

3.3 Weight of the fin body

It is computed from creo software by giving material properties as input.

Steps to find weight :

i. File
ii. Prepare
iii. Model properities
iv. Material assignment
v. Input parameters (i,e.Density)
vi. Units
vii. Mass properties
viii. Calculate
ix. Mass

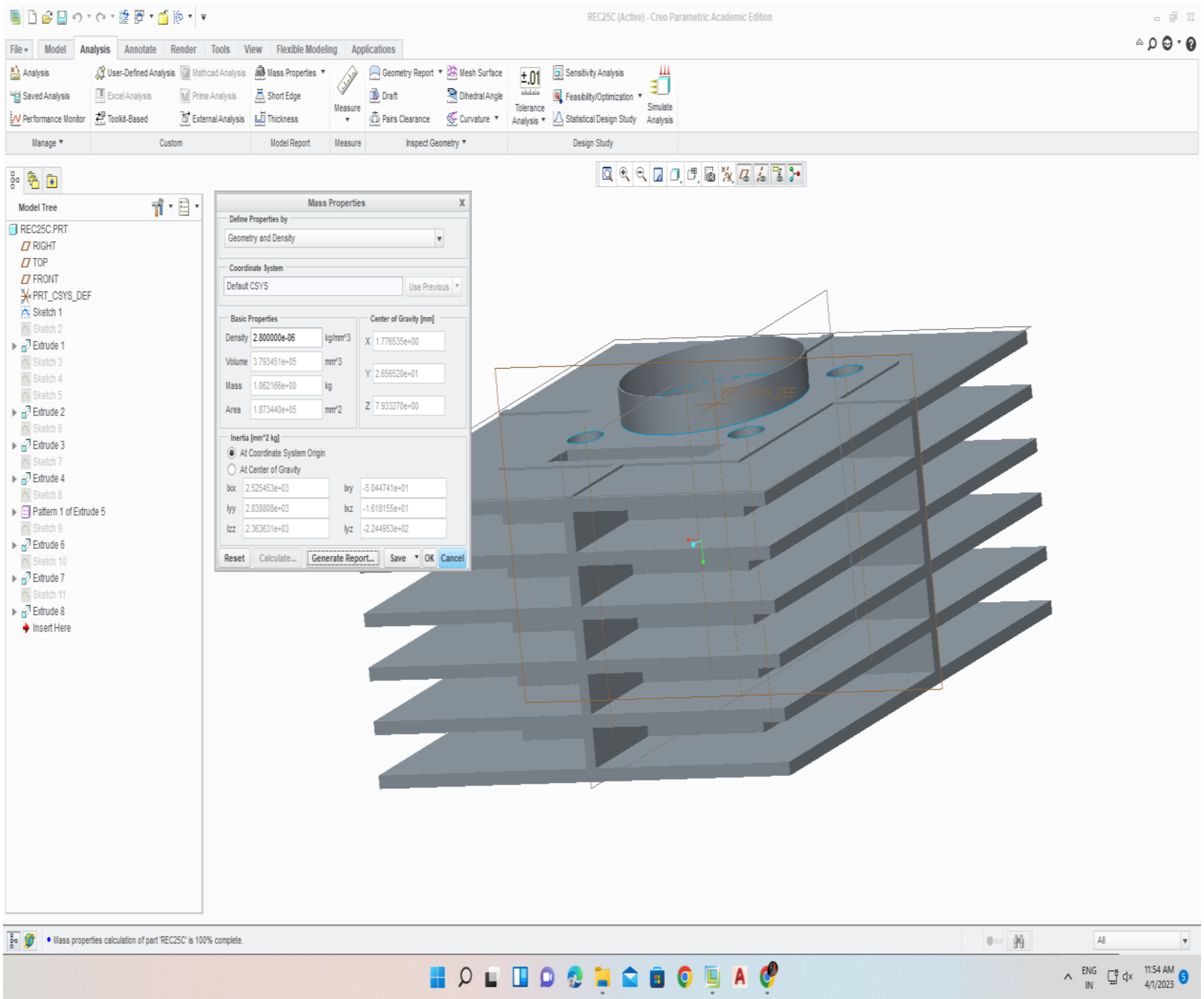

Fig.58. mass properties of rectangular fins

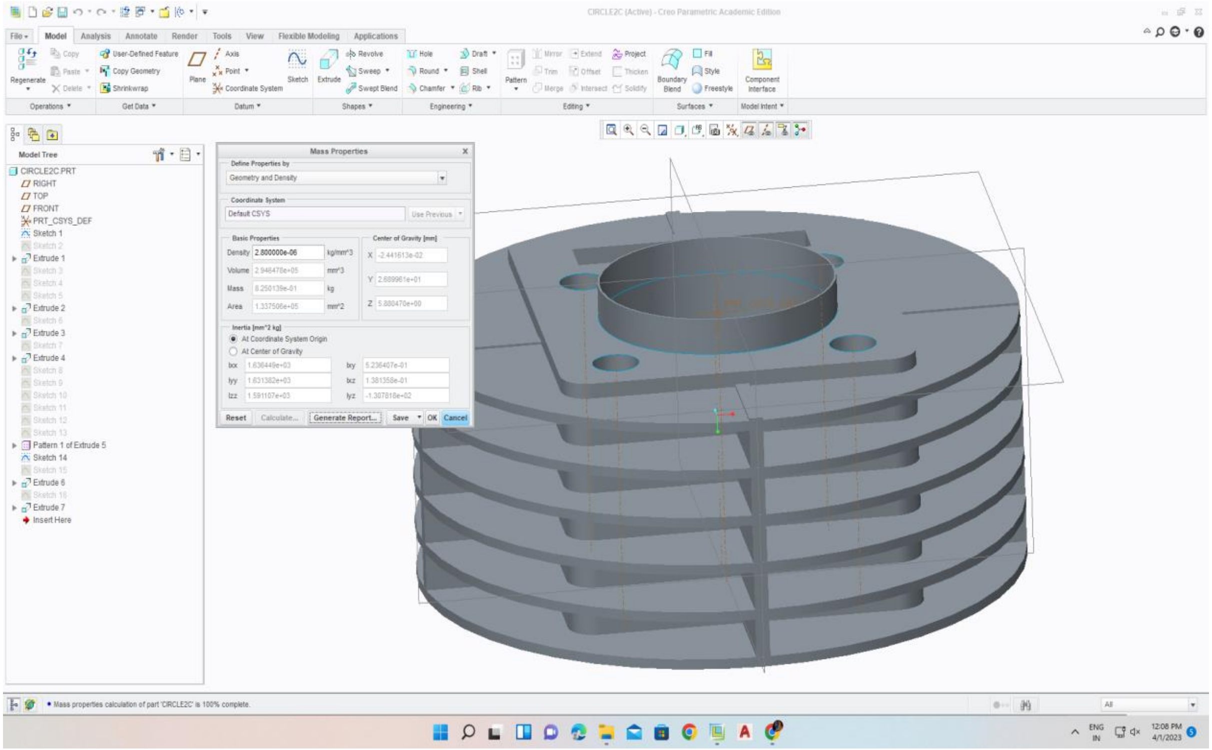

Fig.59. mass properties of circular fins

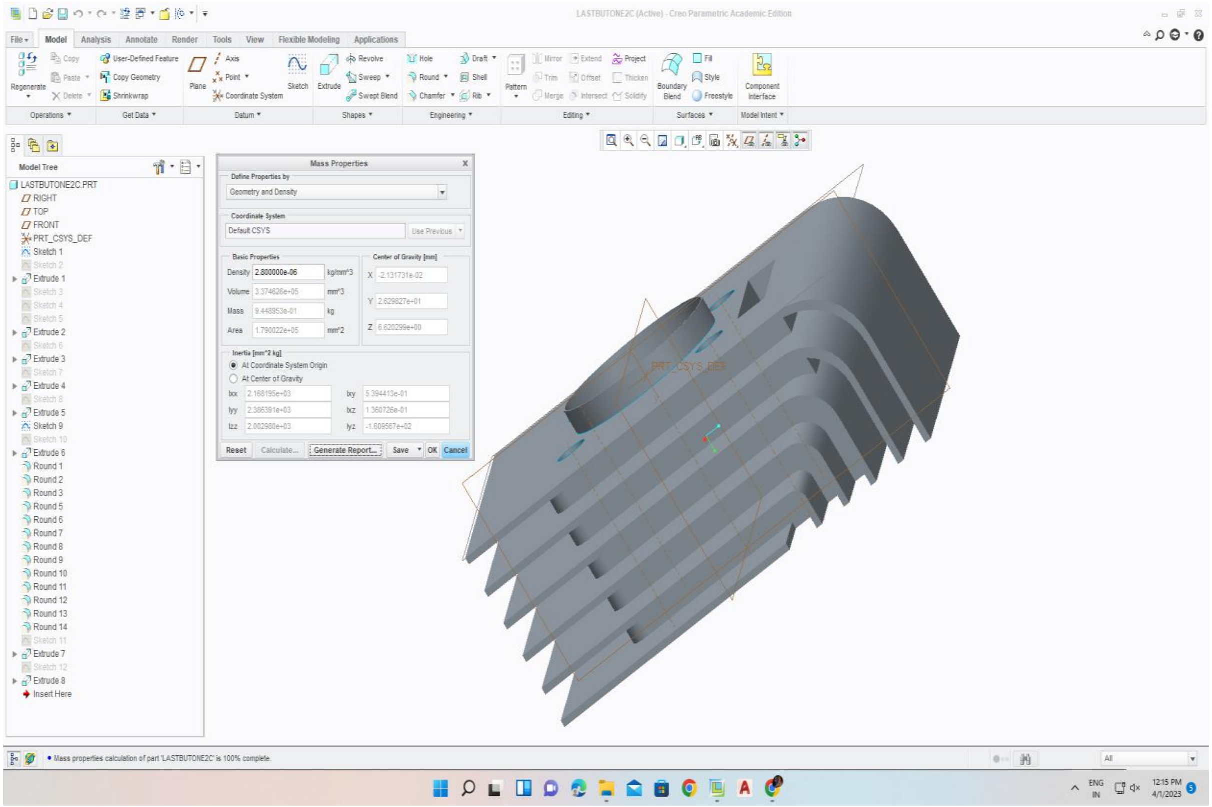

Fig.60. mass properties of angular fins

4. RESULTS

Table 2 . results

S.NO	Cross section	Thickness	Material	Heat flux (W/mm^2)	Weight of body(Kg)
1	Rectangular	2.5mm	Al6061	0.000019	1.0242
2	Rectangular	2.5mm	Al204	0.000017	1.0620
3	Rectangular	2.5mm	Mg alloy	0.000016	0.0620
4	Rectangular	2mm	Al6061	0.00038	0.9380
5	Rectangular	2mm	Al204	0.00010	0.9720
6	Rectangular	2mm	Mg alloy	0.00010	0.6250
7	Circular	2.5mm	Al6061	0.0006	0.8470
8	Circular	2.5mm	Al204	0.000021	0.878
9	Circular	2.5mm	Mg alloy	0.000020	0.564
10	Circular	2mm	Al6061	0.00012	0.795
11	Circular	2mm	Al204	0.0000071	0.825
12	Circular	2mm	Mg alloy	0.00071	0.530
13	Angular	2.5mm	Al6061	0.000070	0.982
14	Angular	2.5mm	Al204	0.000032	1.018
15	Angular	2.5mm	Mg alloy	0.000035	0.654
16	Angular	2mm	Al6061	0.000040	0.911
17	Angular	2mm	Al204	0.00010	0.944
18	Angular	2mm	Mg alloy	0.000013	0.607

5.CONCLUSION

- Among the 3 geometries i.e. rectangular, circular and angular, the circular fins are of low weight and among the three, rectangular fins have higher heat flux.
- So among 18 models which we performed thermal analysis Rectangular fin with 2mm thickness when Al6061 material is used it gives high heat transfer rate.
- Circular fin of thickness 2mm with magnesium alloy is of low weight than other models
- By reducing thickness of fins we witnessed an increase in heat flux.
- We concluded that rectangular fin with reduced thickness i,e. 2mm is more efficient than other models.

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