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Design of Fin for Various Variables

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ABSTRACT

In this paper, the heat transfer of fin without and with various extensions such as rectangular extensions, triangular extensions and trapezium extension is analyzed by changing its material (such as Aluminium alloy, Copper alloy and Structural steel), and then a comparison is made between them. After comparison near about 12% more heat transfer is observed in the fin with various extensions in compare to fin without extensions for all the material. Here maximum heat transfer is obtained for the fin with rectangular extension for each material and the material for which heat transfer is maximum is copper. So after overall comparison it is found that that Copper alloy with rectangular extension gives the maximum heat transfer. Here copper alloy fin with rectangular extensions gives higher effectiveness compare to other extensions of fin.

I. INTRODUCTION

A fin is a extruded surface that are basically used to increase the surface area of an object so that the rate of heat transfer is increased. Here fins are taken with different extensions which are made up of different material. Types of extensions provided on these fins are as (a) Rectangular extensions, (b) Trapezium extensions, (c) Triangular extensions. And the material of fin are as (a) Aluminium alloy (b) Copper alloy (c) Structural steel.

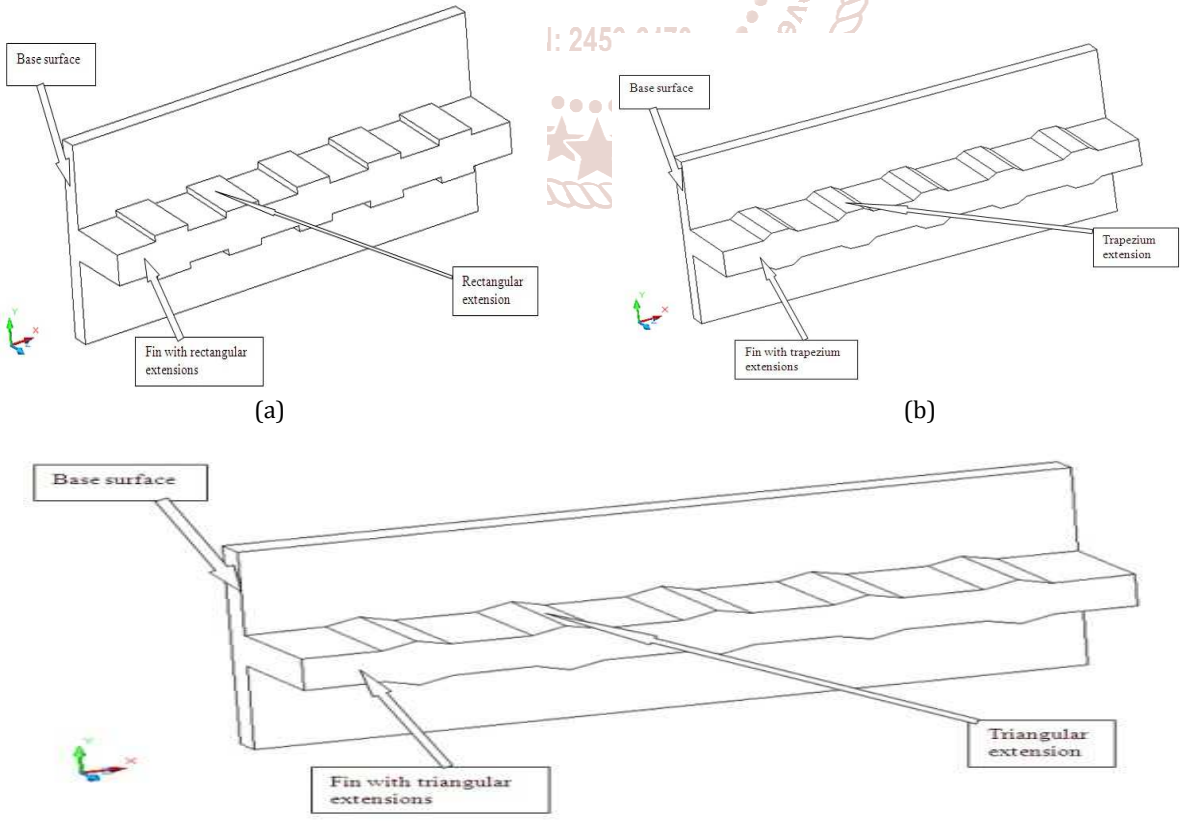

Fig. 1: Fin with (a) Rectangular extensions, (b) Trapezium extensions, (c) Triangular extensions

II. LITERATURE REVIEW

Baljit Singh Ubhi et.al. [1] has studied the heat transfer through fin by giving different extensions on the base fin (which has rectangular geometry) for structural steel material. After studying he compared the heat transfer through fin with extensions and without extension, then he found that fin with extension gives higher heat transfer compare to fin without any extension.

Dr. I. Satyanarayana et.al [2] has studied the natural convective heat transfer from inclined narrow plate in which he investigated the steady state natural convection from heat sink from narrow plate-fins having parallel arrangement mounted on inclined base .The dimensions of model are L=200mm, W=140mm & height=20mm and he concluded that temperature and heat flux is varying while changing the fins height and also which material is most suitable for the thermal boundary conditions.

Mayank Jain et.al [3] has studied the heat transfer analysis and optimization fins by variation in geometry in which he analyzed the thermal heat dissipation of fins by varying its geometry such as rectangular, circular, triangular, and fins with extension. After modeling and analysis, he found that triangular fin with material Aluminium alloy 6061 is better since temperature drop and heat transfer in a triangular fin is much more compared to others.

Mulukuntla Vidya Sagar et.al.[4] has studied the heat transfer through fin provided on engine cylinder by varying the geometry of fin. In this study he has taken two geometry which was analyzed for two different material by varying the thickness of fin. In this analysis he found that circular fin of aluminium alloy gives maximum heat transfer compare to others.

III. DESIGN AND ANALYSIS OF FIN WITH AND WITHOUT EXTENSIONS FOR DIFFERENT MATERIALS

A. Designing of fins

Here fins without and with various extensions are designed with the help of design software Solidworks2018.

The specification of the fin without any extensions i.e. main fin is as:
Length = 40mm, width = 240mm and thickness = 15mm
And specification of various extensions provided on the base fin is shown below and number of extensions used on main fin is 10 nos.

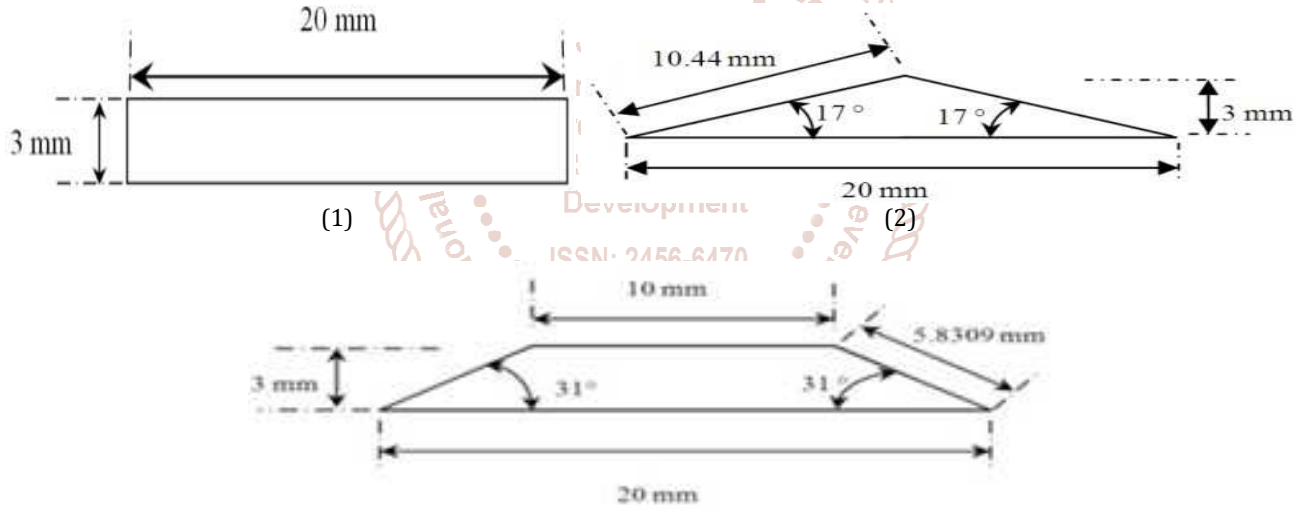

Fig. 2: (1) Rectangular extension, (2) Triangular extension, (3) Trapezium extension

B. Analysis of fin for Heat Transfer with Simulation Software

After the designing process the analysis of fin for heat transfer is performed by using software ANSYS Workbench 19.2 (ANSYS Academic Teaching Mechanical & CFD). Here in this software firstly we imported the design model SLDPRT file in ANSYS Workbench 19.2 and then it makes the result as ANSYS FEA model wbpj file format. After this select the analysis as thermal analysis for steady state heat transfer process. After assigning the unit system select the material of fin. Now from the 3D mesh setting set the fine mesh and generate the mesh of design. Here the mesh type is rectangular for fin with trapezium and triangular extensions and triangular mesh type for fin with rectangular extensions and without extension.

C. Input to the Meshed Model

this the load and constraints assigned to the meshed

In model is as:
Thermal conductivity of Aluminium alloy, K_a= 156 W/m ^oC
Thermal conductivity of Copper alloy, K_c = 401 W/m ^oC
Thermal conductivity of structural steel, K_s = 60.5 W/m ^oC
Convection coefficient of heat transfer, h = 40 W/m^2 ^oC
Temperature of wall surface at which fin attached, t_o = 55 ^oC
Ambient temperature, t_a = 30 ^oC

D. Results from the analysis

After generation of mesh and giving the input parameters, run the simulation for the models. Hence, the temperature contour will obtained. The temperature contour for fin made up of different material without and with various extensions is as:-

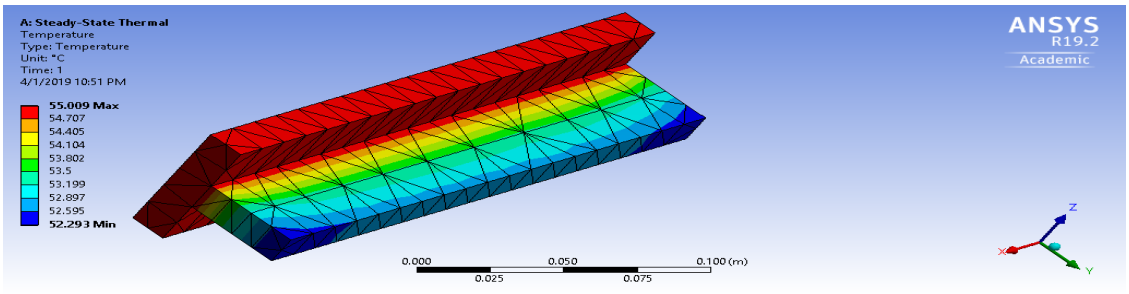

Fig. 3: Temperature contour of fin **without extension for Structural steel**

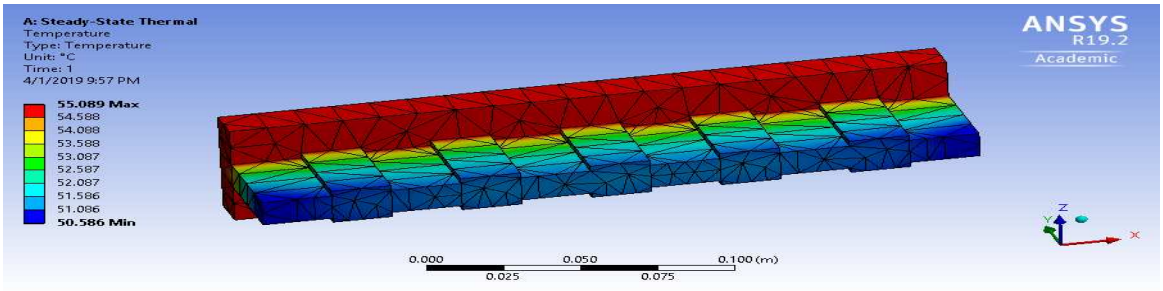

Fig. 4: Temperature contour of fin with **rectangular extension for Structural steel**

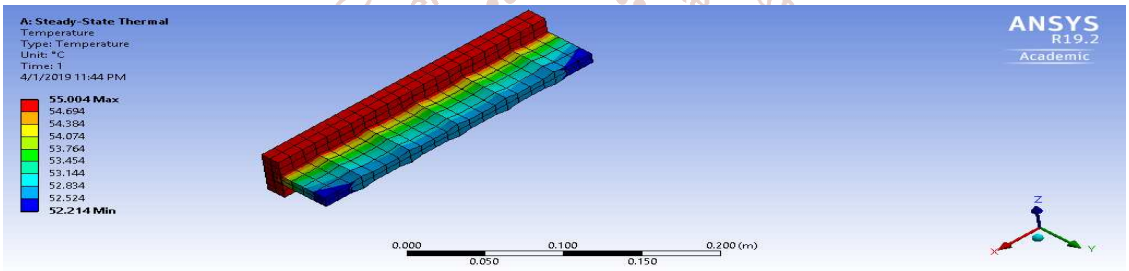

Fig. 5: Temperature contour of fin with **triangular extension for Structural steel**

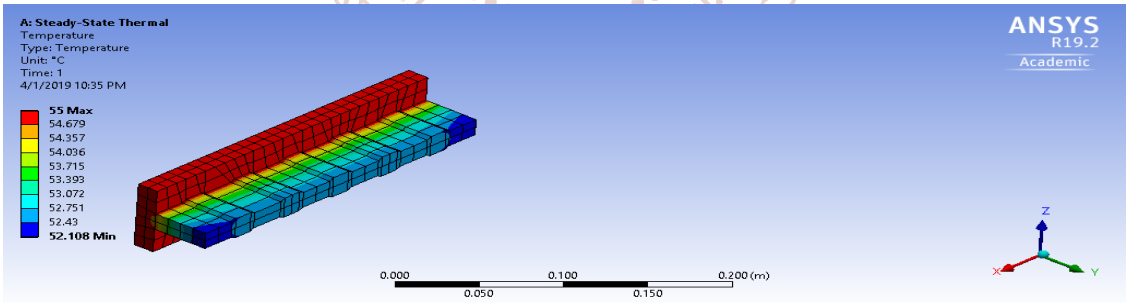

Fig. 6: Temperature contour of fin with **trapezium extension for Structural steel**

After this, the comparison is made for these geometry of fin as:

Length of fin(mm)	Fin with different type of extensions (Temp. in ^{0}c)							
	Present work				Previous work [1]			
	Rectangular	Trapezium	Triangular	Without extension	Rectangular	Trapezium	Triangular	Without extension
5	54.281	54.323	54.364	54.559	53.903	53.944	53.938	53.914
10	53.912	53.921	53.973	54.206	53.538	53.592	53.584	53.552
15	53.584	53.598	53.743	53.884	53.173	53.241	53.231	53.190
20	53.293	53.322	53.414	53.574	52.807	52.889	52.877	52.828
25	52.049	53.088	53.199	53.342	52.442	52.537	52.523	52.466
30	52.852	52.886	52.984	53.111	52.077	52.185	52.169	52.105
35	52.726	52.741	52.861	52.881	51.711	51.833	51.816	51.743
40	52.607	52.644	52.738	52.800	51.346	51.482	51.462	51.381

TABLE-1 Temperature distribution along the length of fins for **Structural steel**

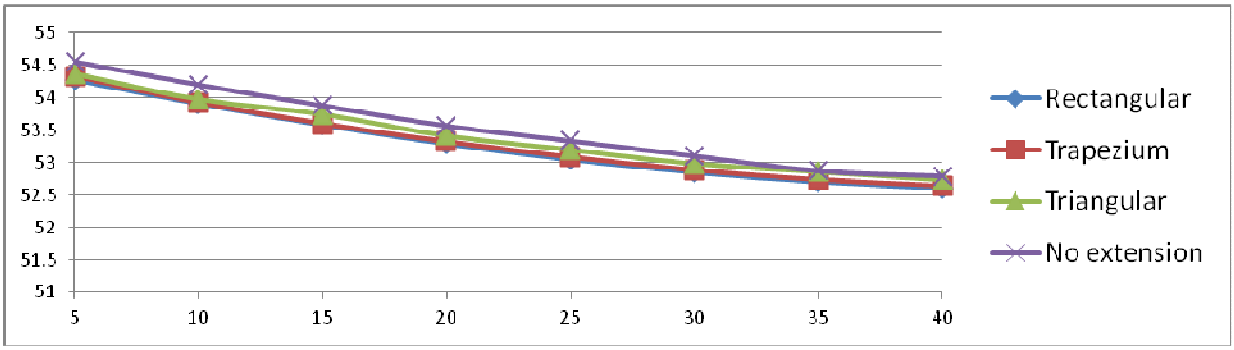

Fig. 7: Plot showing the temperature variation along length of fin with different extensions and fin without extension for Structural steel

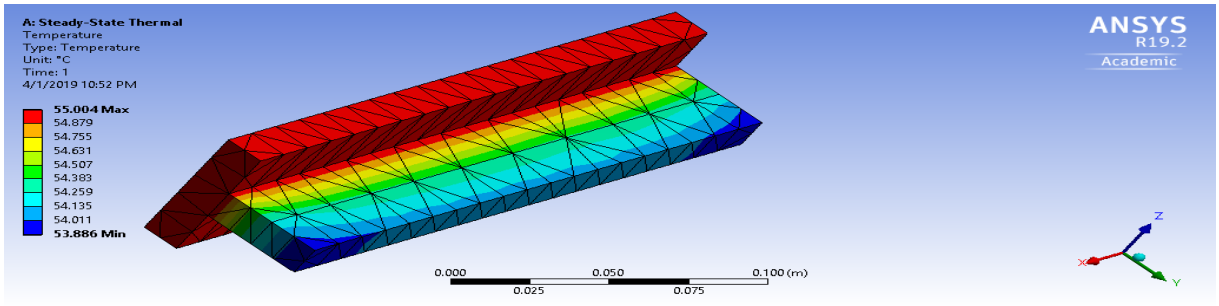

Fig. 8: Temperature contour of fin **without extension for Aluminium alloy**

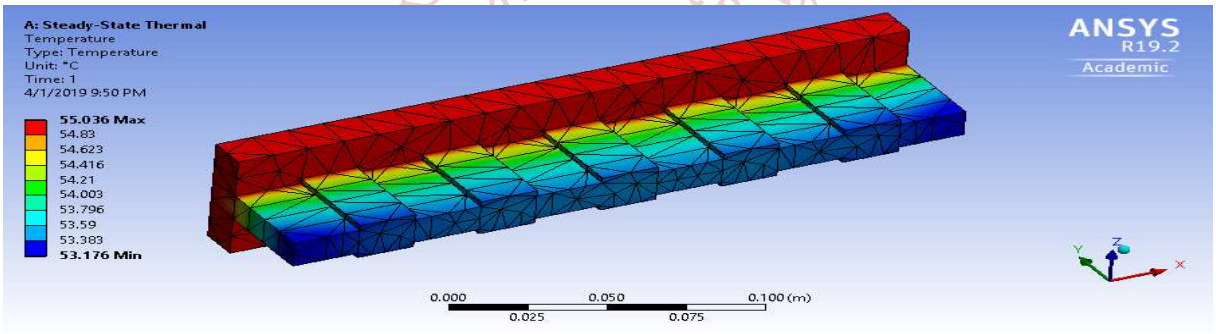

Fig. 9: Temperature contour of fin **with rectangular extension for Aluminium alloy**

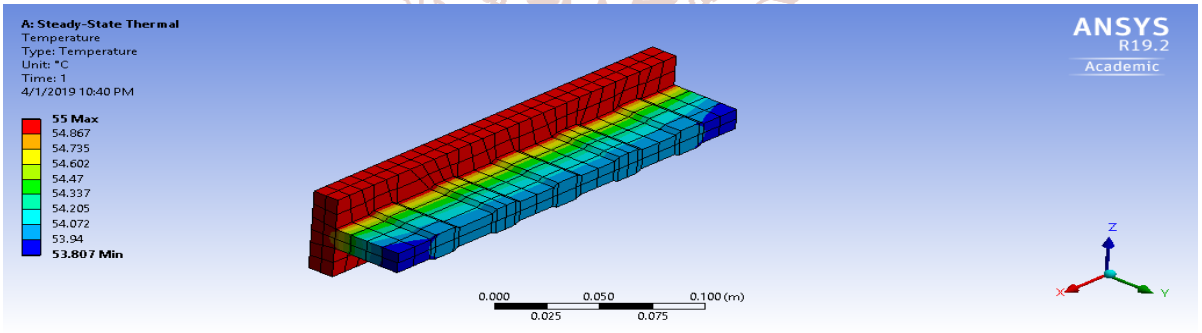

Fig. 10: Temperature contour of fin with **trapezium extension for Aluminium alloy**

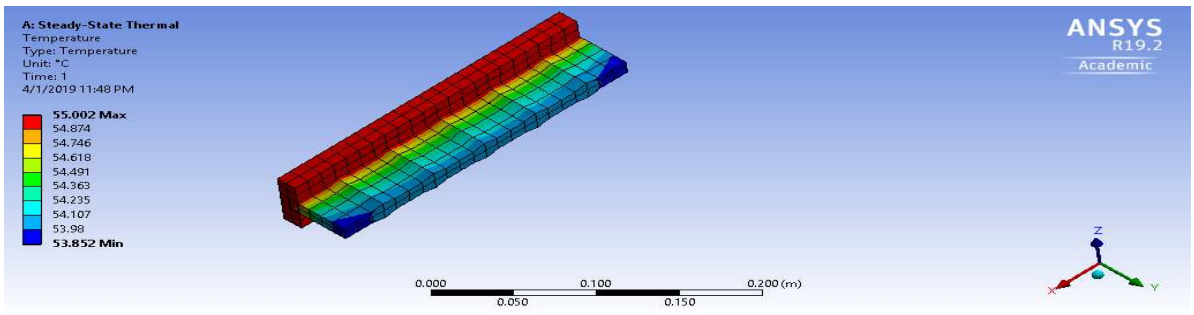

Fig. 11: Temperature contour of fin **with triangular extension for Aluminium alloy**

After this, the comparison is made for these geometry of fin as:

Length of fin(mm)	Fin with different type of extensions (Temp. in ^{0}c)			
	Rectangular	Trapezium	Triangular	Without extension
5	54.503	54.724	54.741	54.820
10	54.281	54.556	54.622	54.676
15	54.079	54.427	54.487	54.532
20	53.902	54.314	54.352	54.418
25	53.753	54.214	54.264	54.323
30	53.634	54.134	54.175	54.227
35	53.544	54.074	54.125	54.129
40	53.484	54.034	54.050	54.074

TABLE-3 Temperature distribution along the length of fins for Aluminium alloy

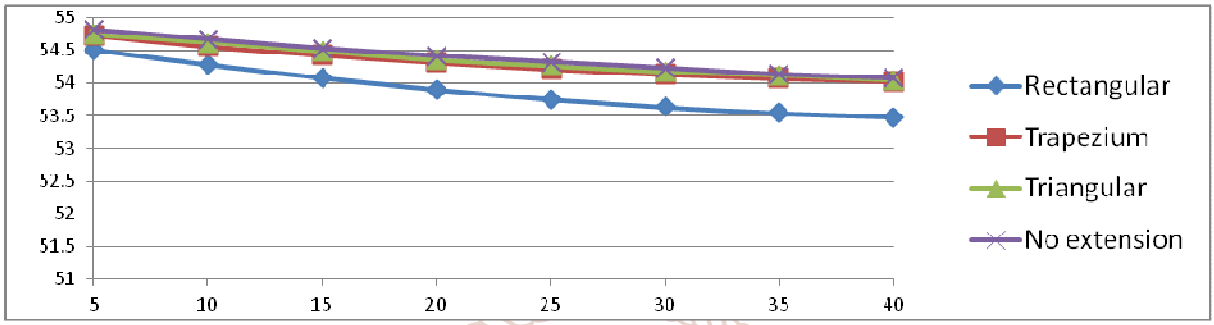

Fig. 12: Plot showing the temperature variation along length of fin with different extensions and fin without extension for Aluminium alloy

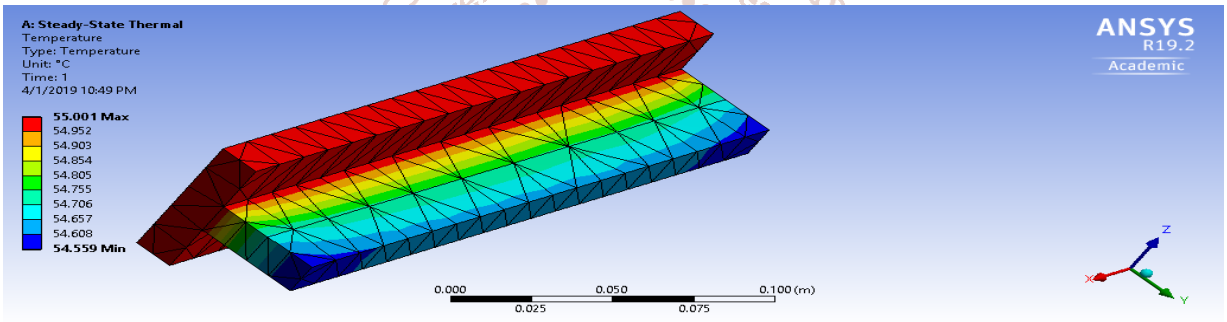

Fig. 13: Temperature contour of fin **without extension for Copper alloy**

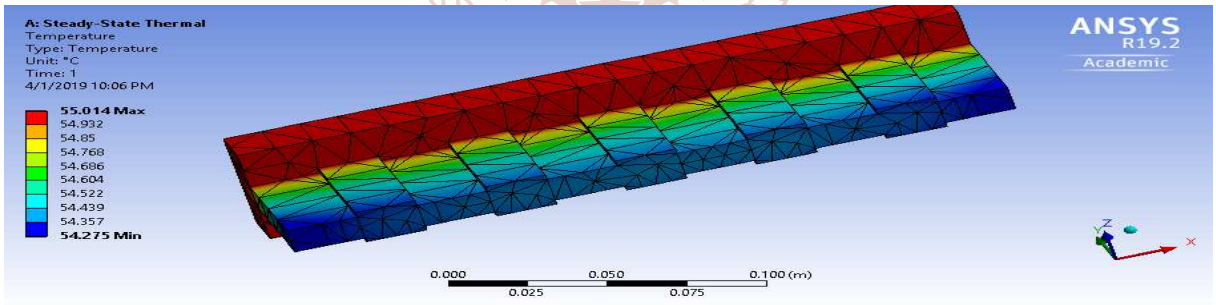

Fig. 14: Temperature contour of fin **with rectangular extension for Copper alloy**

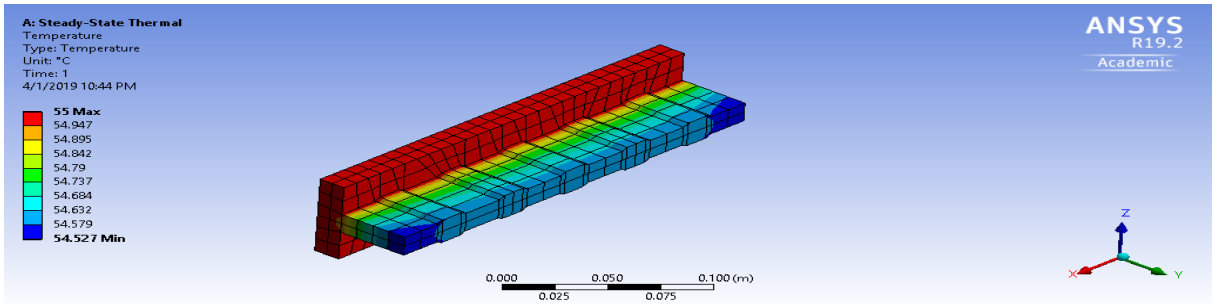

Fig. 15: Temperature contour of fin **with trapezium extension for Copper alloy**

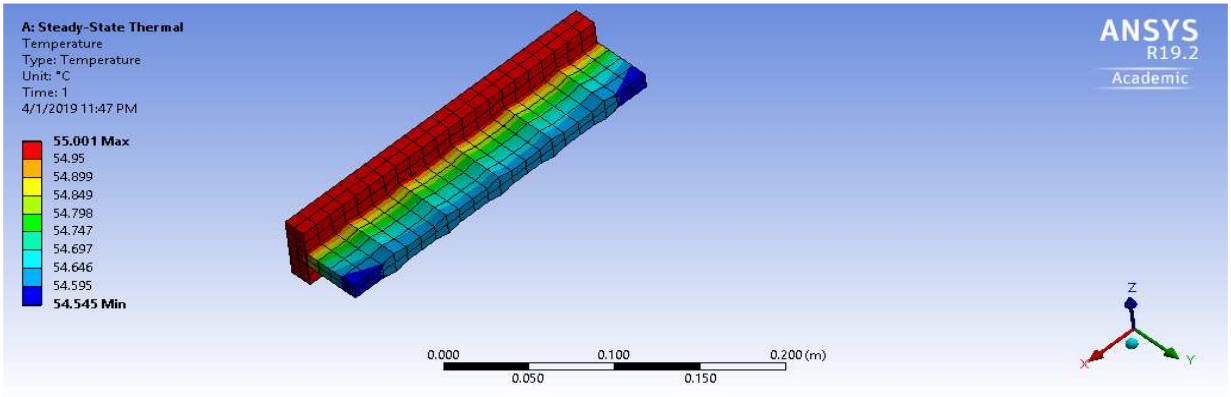

Fig. 16: Temperature contour of fin **with triangular extension for Copper alloy**

Length of fin(mm)	Rectangular	Trapezium	Triangular	Without extension
5	54.803	54.891	54.898	54.929
10	54.715	54.825	54.851	54.872
15	54.635	54.774	54.797	54.815
20	54.565	54.729	54.744	54.770
25	54.506	54.689	54.709	54.732
30	54.450	54.657	54.674	54.694
35	54.423	54.634	54.654	54.655
40	54.399	54.618	54.634	54.648

After this, the comparison is made for these geometry of fin as:

TABLE-4 Temperature distribution along the length of fins for Copper alloy

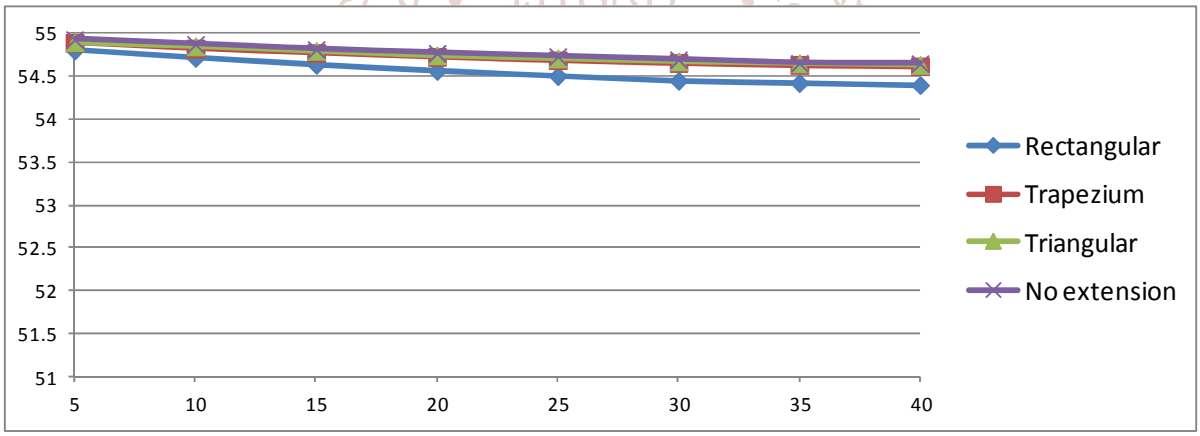

Fig. 17: Plot showing the temperature variation along length of fin with different extensions and fin without extension for Copper alloy

IV. RESULTS AND DISCUSSION

Here heat transfer for fin having convected tip is calculated by following formula:

$$Q_{fin} = \sqrt{hPkA_{cs}}(to - ta)\left[\frac{\tanh[ml]+\frac{h}{km}}{\left(1+\frac{h}{km}\tanh[ml]\right)}\right]$$

for which length of fin = 0.04 m, cross section area (A_{CS}) and perimeter (P) of fin with rectangular extensions is 4200 X 10^{-6} m^2 and 0.57 m respectively, cross section area (A_{CS}) and perimeter (P) of fin with triangular extensions is 3900 X 10^{-6} m^2 and 0.518 m respectively and cross section area (A_{CS}) and perimeter (P) of fin with trapezium extensions is 4050 X 10^{-6} m^2 and 0.526 m respectively .The fin without extension have 21.766 W heat transfer value.

Type of extensions	Heat transfer(in W)	Increase in heat transfer(in W)	Percentage increase in heat transfer(in %)
Fin with rectangular extension	25.32	2.85	12.68
Fin with trapezium extension	23.57	1.10	4.89
Fin with triangular extension	23.13	0.66	2.93

TABLE-5 Heat transfer comparison for **Structural steel**

Type of extensions	Heat transfer(in W)	Increase in heat transfer(in W)	Percentage increase in heat transfer(in %)
Fin with rectangular extension	26.30	2.93	12.54
Fin with trapezium extension	24.47	1.10	4.71
Fin with triangular extension	24.03	0.66	2.83

TABLE-6 Heat transfer comparison for **Aluminium alloy**

Type of extensions	Heat transfer(in W)	Increase in heat transfer(in W)	Percentage increase in heat transfer(in %)
Fin with rectangular extension	26.72	3.05	12.91
Fin with trapezium extension	24.83	1.16	4.92
Fin with triangular extension	24.39	0.72	3.06

TABLE-7 Heat transfer comparison for **Copper alloy**

The effectiveness of extension on fin made up of different material is calculated by formula below:

Effectiveness of extensions on fin, $\epsilon = \frac{Q_{fin\ with\ extension}}{Q_{fin\ without\ extension}}$

Material/Geometry	Fin with rectangular extension	Fin with trapezium extension	Fin with triangular extension
Structural steel	1.1268	1.0489	1.0290
Aluminium alloy	1.1258	1.0470	1.0280
Copper alloy	1.1294	1.0490	1.0300

TABLE-8 Comparison of effectiveness of extensions on fin

V. CONCLUSIONS

The overall conclusion of the whole analysis:

- Extensions provided on fin gives 12% more heat transfer compare to fin without any other extensions.
- Compare to all other extensions rectangular extension provides maximum heat transfer.
- Heat transfer through fin made up of Copper alloy is higher as compare to Aluminium alloy and Structural steel.
- Compare to all other extensions rectangular extension gives minimum temperature at the end of fin.
- Temperature at the end of fin made up of Copper alloy is maximum compare to fin made up of other materials.
- Compare to all other extensions effectiveness of rectangular extension is maximum.
- The effectiveness of fin made up of Copper alloy is greater than other two materials.

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