Extended Surface & Analysis for Different Extrusions On Rectangular Fins

Arpit Gupta[1] Shilesh Dwivedi[2] Akash Agnihotri[3] Deepak Gupta[4]
[1,3,4]B.E. Student [2]Assistant Professor
[1,2,3,4]Department of Mechanical Engineering
[1,2,3,4]VITS, Satna, India

Abstract— In this segment we have discussed about extended fins or surfaces and how the rate of heat transfer is increase by using extended fins instead of unfinned material. We've also discussed how various type of extension like parallel rectangle extension, perpendicular extension and curl or spline extension are used to enhance or increase heat transfer from a plane wall or bared surface to finned surface. About 2.178% of decreased in temperature at fin tip and 48% to 124% of heat transfer rate can be increased by above mentioned extrusion instead of bare surface without extension. Fins with different extrusion are designed with the help of design and analysis software ANSYS®. ANSYS Workbench [ANSYS Multiphysics] is used for thermal analysis which shows that least temperature at the tip is obtained in parallel extrusion and maximum total heat flux is obtain in spline extrusion as compared to other extrusion as discussed above.

Key words: Extended surface or fins, applications, ANSYS, thermal analysis, spline structure, total heat flux.

I. INTRODUCTION

We know that convection heat transfer between a surface at Tm and the fluid surrounding surface is at T∞ is given by

$$Q=hAdT$$

This is Newton Law of Cooling.

Where h is heat transfer coefficient and A is the surface area of heat transfer.

There are three methods or ways to increase the rate of heat transfer

- By increasing the convection heat transfer coefficient h.
- To increase the surface area A.
- By decreasing T∞ so as to increase the temperature difference (Tm - T∞).

Since increasing h means increasing fluid velocity for which we have to install blower or power pump which is quite expensive. Although, increasing h even probably to maximum value is often insufficient to obtain desired heat transfer rate as it increase cost for installation of various mechanical devices. Increasing h also decreases the fluid temperature T∞ which is impracticable. So the third option to increase surface area A of material which is an alternative to increase the rate of heat transfer which is practicable and effective. So heat transfer rate is increased by increasing the surface area A across which convection is done.

Increasing area also create the problem to cost and mass as increasing area results in increasing material for production which result in greater cost as the actual product do. And the second disadvantage is that there will be less direct contact of fluid with material.

That's why some space between materials is given to decrease cost and increase convection area so as to increase the heat transfer. This may be done by using fins that extends from the wall of the material into the surrounding fluid.

An extended surface or fin is a surface that is being extruded or extends from a surface of an object to increase the rate of heat transfer to or from the environment by increasing surface area and hence increase the contact of fluid (mostly air) flowing around the surface without altering h so, as much as the surface area increases much more fluid to come under contact to increase the rate of heat transfers from the base surface as compare to fin without the extrusion provided to it.

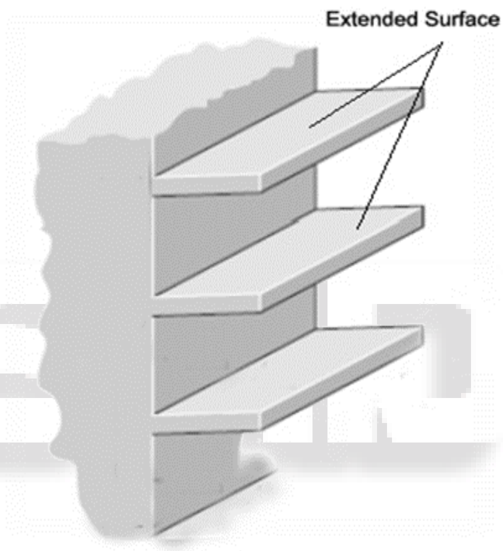

Fig. 1: Extended Surfaces or Fin

Fins increases heat transfer from a surface by exposing a larger surface area for radiation and conduction heat transfer. Finned surfaces are made by welding or extruding a thin metal sheet on a surface.

Application of Extended Fins

- The thin plate fins of a car radiator greatly increase the rate of heat transfer to the air.
- Rod pins above the processor of CPU.
- Air cooled engine.
- Refrigerators, Air Conditioners (A.C.).
- Cooling fins, Condensers, Heat exchangers, etc.

Types of Fins

- Straight rectangular fins
- Straight triangular fins
- Straight parabolic fins
- Circular fins of rectangular profile
- Pin fins of rectangular profile
- Pin fins of triangular profile
- Pin fins of parabolic profile
- Pin fins of parabolic profile (blunt tip)

II. LITERATURE REVIEW

Pardeep Singh, Harvinder lal, Baljit Singh Ubhi [6] "Had studied by designing different types of fin in AutoCAD® about the performance of fin and natural convection heat transfer and analyzed it with various extrusions on rectangular fin like rectangular extrusions, circular segmental extrusions, triangular extrusions and trapezium extrusions. And on analyzing it on simulation he found that about 5% to 13% more heat transfer can be achieved with following types of extrusions on fin as compare with same geometrical dimension of fin without these extrusions. The effectiveness of fin with rectangular extrusions is also greater than as compare to other extrusions on fin. He also concluded that on comparison with other extrusions, rectangular extrusions provide on fin gives the greatest heat transfer than that of other extrusions having the same geometry like length l and width b attached to surface. Not only heat transfer rate is increased but the effectiveness of fin with rectangular extrusions is also greater than other extrusions and temperature at the end of extrusions is also minimized."

Abdullah, H. Alessa and Mohammed, Q. Al-Odat[11] "Had studied that by using equilateral triangular perforation on rectangular fin can increase the natural convection heat transfer rate. The effect of geometrical dimensions of the perforated fin was studied in detail. The heat release rate from the perforated fin is also compared to that of the equivalent solid one without fins. They concluded that, For certain values of triangular dimensions, the perforated fin can result in increase in heat transfer. The amount of increase is proportional to the fin thickness and its thermal conductivity k of the material. The extrusion of fins not only increases heat dissipation rates but at the same time it also decreases the expenditure of the fin material by decreasing the material, mass and weight of the object."

Daniel Dannelley[12] "had studied and work to find a method to improve extended surface heat transfer rate through the use of fractal-like geometrical patterns like Sierpinski Carpet, Modified Koch Snowflake extrusions. When fractal-like geometries extrusion are considered, significant gains in the available surface area for fins can be achieved without large increases in fin volume and weight. For certain fractal patterns, the surface area of a fin can even be increased while the volume and weight of the fins are reduced. He concluded that fractal-like fins could result in enhanced fin effectiveness per unit mass by 59%. These geometries are use where the size and weight of the fins and objected is a big issue of concern. Fin effectiveness per unit mass was increased by a minimum of 37%. Finally, an iteration investigation of radiation heat transfer from fractal-like fins showed that fin effectiveness per unit mass increased by a minimum of 25%."

III. DESIGN AND ANALYSIS OF FIN WITH EXTENSIONS

In the analysis of fins, we consider steady state operation with no heat generation in the fin i.e. q=0, and we assume that the convection heat transfer coefficient h to be constant and uniform over the entire surface of the fin for convenience in the analysis. We also assume that the thermal conductivity k of the material is constant throughout the cross section of material and material property as:

Properties	
Volume	1.e-003 m^3
Mass	7.85 *kg*

A. *Designing Of Fins With ANSYS:*

Firstly following fins model are made in Design Modeler of specified dimension as
Length L = 50mm.
Width w = 200mm.

Various command like line, rectangle, spline etc, were use and the extruded to make 3Dimensional model. And extruded with depth or thickness of 20mm.

Then meshed model is created with fine grain material with 69208 nodes and 14640 elements. Isometric Models are

1) Simple Rectangular fin.
2) Rectangular fin with rectangular extrusion perpendicular to surface.
3) Rectangular fin with rectangular extrusion parallel to surface.
4) Rectangular fin with Spline extrusion.

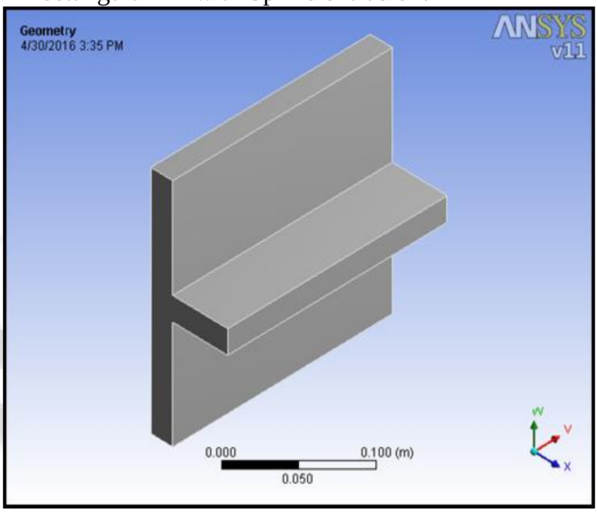

Fig. 2: Simple Rectangular fin

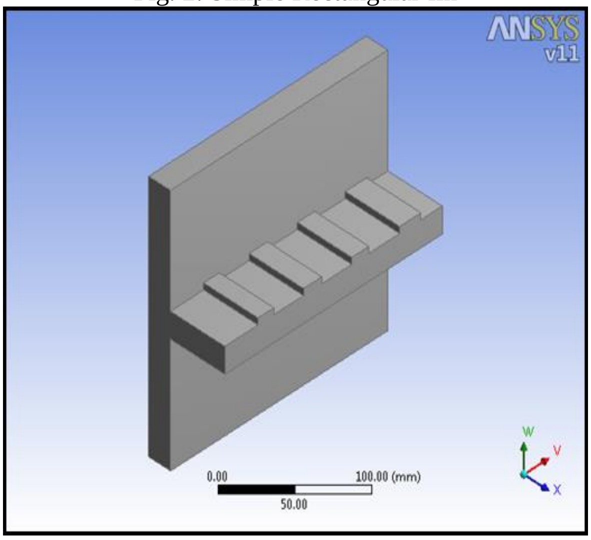

Fig. 3: Rectangular fin with rectangular extrusion perpendicular to surface

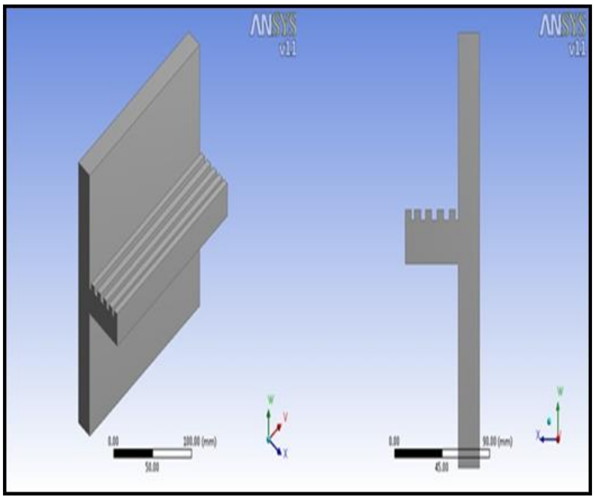

Fig. 4: Rectangular fin with rectangular extrusion parallel to surface

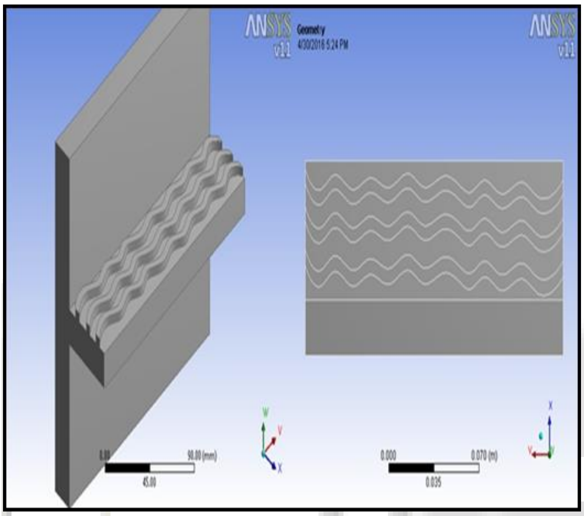

Fig. 5: Rectangular fin with Spline extrusion

B. *Assigning Load And Constraints To The Meshed Model:*

- In this assign the material having thermal conductivity, convection coefficient of heat transfer for fluid, temperature of surface and ambient temperature as:
- Thermal conductivity, k = 60.5 W/m °C = 0.0605 J/(s mm °C)
- Convection coefficient of heat transfer, h = 5W/m2 °C = 0.000005 J/(s mm2 °C)
- Specific heat = 434 J/kg•°C

C. *Thermal Analysis Of Fin For Heat Transfer With ANSYS Workbench:*

After the meshed model is prepared the model file is imported in thermal simulation and using Steady-State Thermal condition Temperature and convection attributes is given to different face of the model.

- Temperature of wall surface at which fin attached, tm = 100 °C
- Ambient temperature, t∞ = 22 °C ramped Stagnant air-simplified case.

And solution on Temperature, Total heat flux, Directional heat flux is obtained.

Temperature distribution or contour of fins for following conditions is shown respectively:

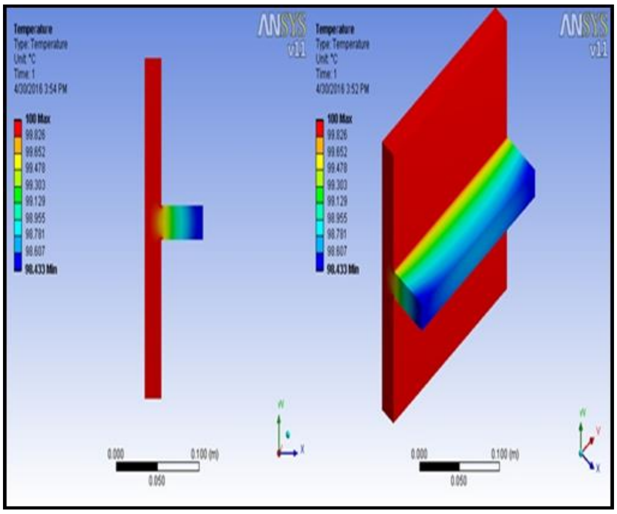

Fig. 6: Temperature distribution for simple rectangular fin

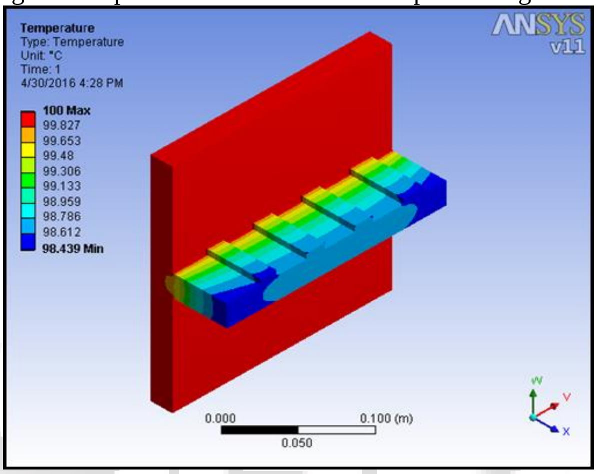

Fig. 7: Temperature distribution for Rectangular fin with rectangular extrusion perpendicular to surface

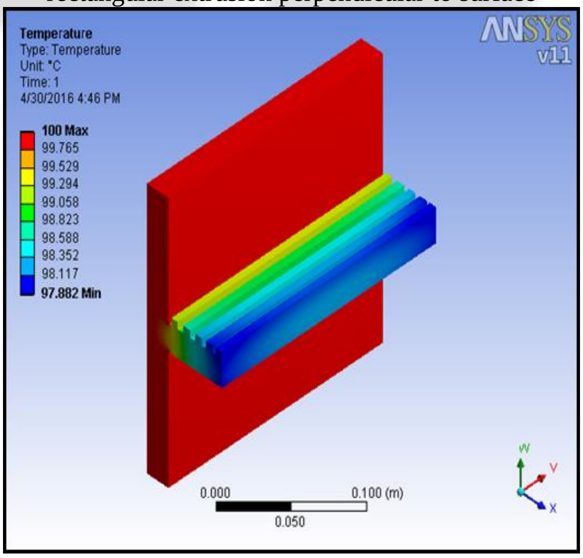

Fig. 8: Temperature distribution for Rectangular fin with rectangular extrusion parallel to surface

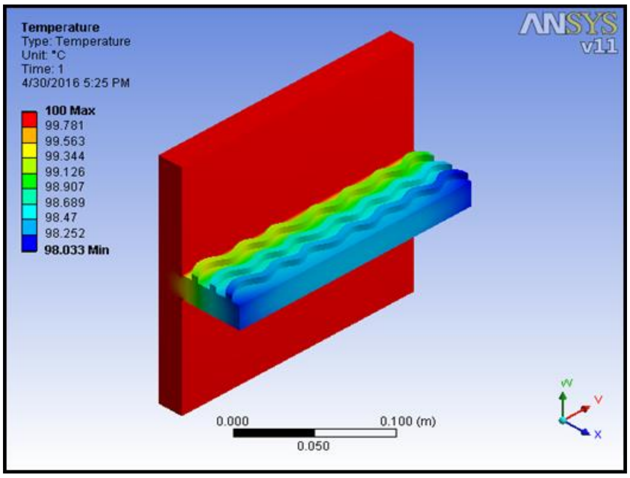

Fig. 9: Temperature distribution for Rectangular fin with Spline extrusion

Total heat flux & Directional heat flux distribution or contour of fins for following conditions is shown respectively

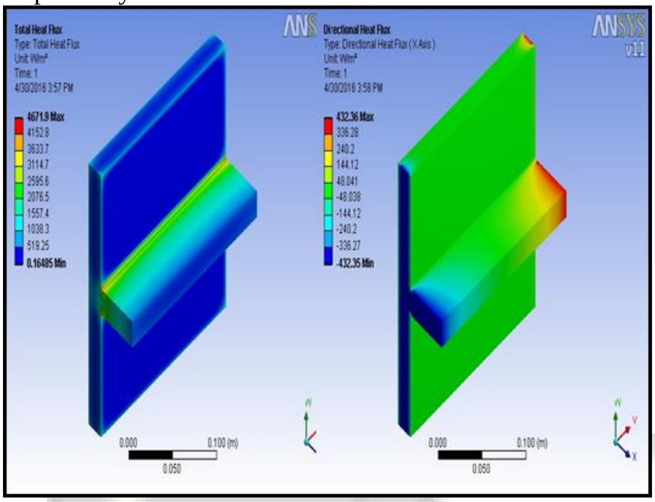

Fig. 10: Total heat flux & Directional heat flux distribution or contour for simple rectangular fin

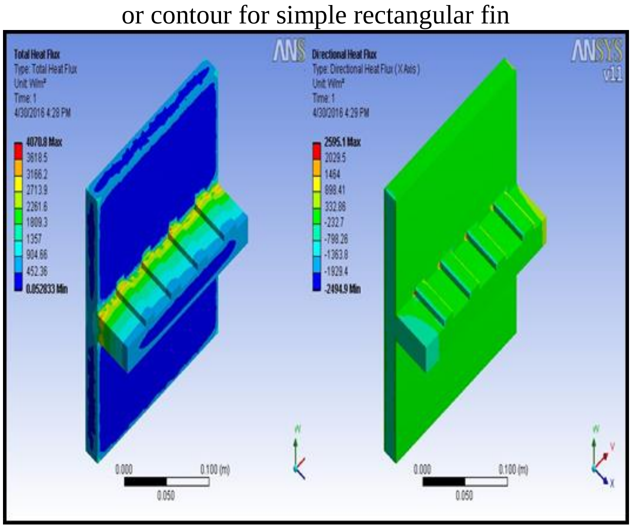

Fig. 11: Total heat flux & Directional heat flux distribution or contour for rectangular fin with rectangle extrusion perpendicular to surface

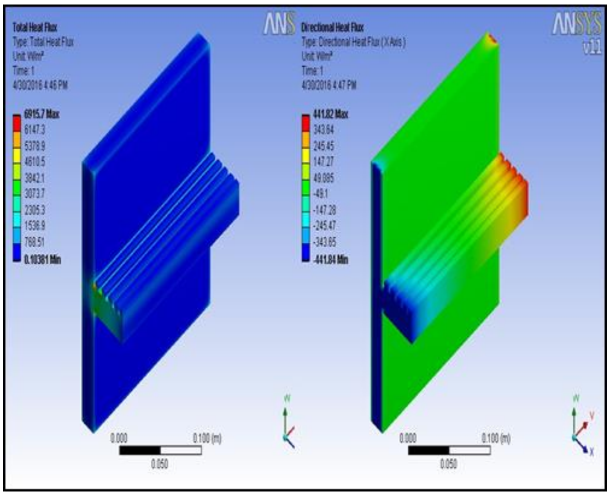

Fig. 12: Total heat flux & Directional heat flux distribution or contour for rectangular fin with rectangle extrusion parallel to surface

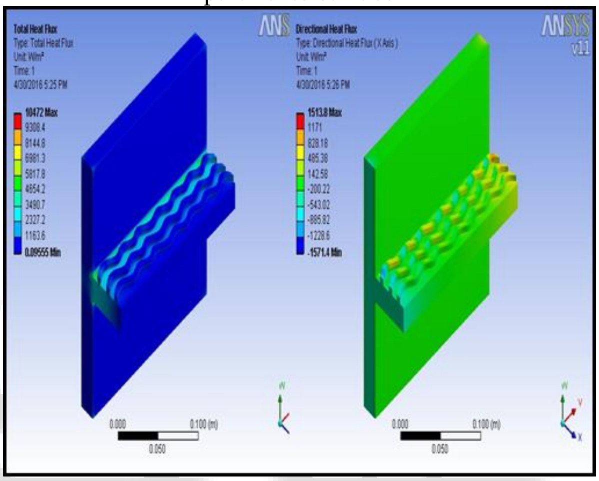

Fig. 13: Total heat flux & Directional heat flux distribution or contour for rectangular fin with spline extrusion

IV. RESULT AND DISCUSSION

Following result were gained for L=50mm and maximum temp. = 100°C

S. No.	Extension on Rectangle fin	Temp(min) at tip in °C	Percentage of temperature at fin tip decreases
1	No extension	98.433	1.567%
2	Parallel extension	*97.822*	*2.178%*
3	Perpendicular extension	98.439	1.561%
4	Spline extension	98.033	1.967%

Table 1: Comparison of temp. Variation in different types of extrusion

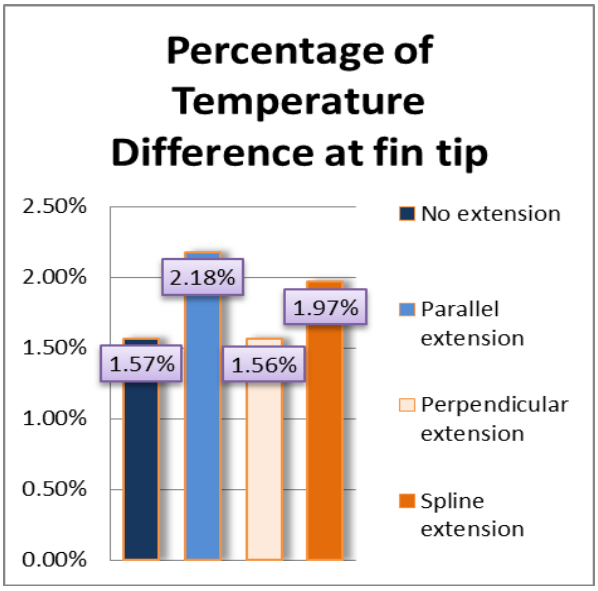

Fig. 14: Percentage of temp. Difference

S No.	Extension on Rectangular fin	Total Heat Transfer in (W/m^2)		Directional Heat Transfer in (W/m^2)		Percentage of total heat flux increase
		Max	Min	Max	Min	
1	No extension	4671.9	0.16485	432.36	-432.35	-
2	Parallel extension	6915.7	0.10381	441.82	-441.84	48%
3	Perpendicular extension	4070.8	0.052833	*2595.1*	-2494.9	4.25%
4	Spline extension	*10472*	0.09555	1513.8	-1571.4	124.16%

Table 2: Comparison of total heat transfer & Directional heat transfer

V. Conclusion

The use of above mentioned extrusion provides following changes to heat transfer rate:

- Minimum temperature at fin tip is obtained in parallel extrusion which shows about 2.178% of temperature is decreased resulting increase in heat transfer rate.
- Maximum directional heat transfer flux is in case of perpendicular extrusion means maximum heat transfer along length of fin i.e. X axis.
- Maximum Overall heat transfer flux is in case of spline extension and hence about 124.16% extra heat transfer takes place in this extrusion.

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