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DESIGN AND ANALYSIS OF RADIATOR FINS

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Abstract- An automobile radiator is a heart of an automotive cooling system which plays a major role in transferring the heat from the engine parts to the environment. It is a type of heat exchanger which is designed to transfer the heat from the hot coolant coming from the engine to the air blown through it by the fan. The heat transfer processes take place from the coolant to the tubes then from the tubes to the air through the fins. Therefore, the design of fin is the important one. Radiators are used for cooling internal combustion engines, mainly in automobiles & also in piston-engine aircraft, railway locomotives, power generating plant or any similar use of such an application. This study mainly concerned with the work on "Design and Analysis of Radiator Fins by Ansys and CFD" mainly focuses on the thermal design and analysis of radiator as heat exchanger with different materials namely aluminium, copper and combination of Aluminium-Copper alloys. This study contains the design and analysis of the radiator fins with different materials and to show the Edge Rounded Radiator Fin design performs how well in the thermal analysis by Ansys and flow analysis configuration by CFD. For the better efficiency, to analyse with the two different ratios of alloy combinations for the improvement of heat transfer rate is important phenomenon.

Keywords: Radiators, fins, Convection, Alloy materials, Thermal analysis, Flow analysis

1. INTRODUCTION

Automotive engine cooling system takes care of excess heat produced during engine operation. It regulates engine surface temperature for engine optimum efficiency. Most automotive engine cooling systems consist of the radiator, water pump, cooling fan, pressure cap and thermostat. Radiator is the prime component of the system. Radiator is a heat exchanger that removes heat from engine coolant passing through it. Heat is transferred from hot coolant to outside air. Radiator assembly consists of three main parts core, inlet tank and outlet tank. Core has two sets of passage, a set of tubes and a set of fins. Coolant flows through tubes and air flows between fins. The hot coolant sends heat through tubes to fins. Outside air passing between fins pickups and carries away heat. Performance of engine cooling system is influenced by factors like air and coolant mass flow rate, air inlet temperature, coolant fluid, fin type, fin pitch, tube type and tube pitch etc. While designing cooling system three worst conditions considered based on above parameters. High altitude: At high altitude, air density becomes low and hence affects air mass flow rate. Summer conditions: During summer surrounding air is hot i.e., air inlet temperature is more. Maximum power: Engine condition producing maximum power like when vehicle is climbing uphill, maximum heat rejection is required during this condition. To compensate all these factors radiator core size required may be large The present manufacturing of heat exchangers commonly used in practice in Automobiles, Internal Combustion (IC) engines, Refrigeration systems, and Power plants emphasizes on production process, materials and spacing of fins. The proposed work aims at optimizing the fan assisted heat exchanger (radiator) by improvement in the design. The objective of this investigation is to present an optimal Heat Sink for efficient cooling of automobile radiator in natural convection while using a high conducting solid aluminium, copper fins. The choice of an optimal heat sink depends on a number of geometric parameters such as fin height, fin length, fin thickness, number of fins, base plate thickness, space between fins, fin shape or profile, material etc.

C. Oliet, A. Oliva, J. Castro, C.D. Pe´rez-Segarra studied different factors which influence radiator performance. It includes air and coolant flow, fin density and air inlet temperature. It is observed that heat transfer and performance of radiator strongly affected by air and coolant mass flow rate. As air and coolant flow increases cooling capacity also increases.

JP Yadav and Bharat Raj Singh in their studies also presented parametric study on automotive radiator. In the performance evaluation, a radiator is installed into a test setup. The various parameters including mass flow rate of coolant, inlet coolant temperature; etc. are varied. Following remarks are observed during study.

Influence of coolant mass flow cooling capacity of the radiator has direct relation with the coolant flow rate. With an increase in the value of cooling flow rate, there is corresponding increase in the value of the effectiveness a cooling capacity. Influence of coolant inlet temperature with the increase in the inlet temperature of the coolant the cooling capacity of the radiator increases.

Mazen Al-Amayreh in his study, tested the thermal conductivities of ethylene glycol + water, diethylene glycol +water and triethylene glycol + water mixtures, measured at temperatures ranging from 25°C to 40°C and concentrations ranging from 25 wt. % glycol to 75 wt.% glycol. Increasing the concentration of glycol leads to decrease of thermal conductivity. Increasing the temperature of mixture resulted in slight increase in thermal conductivity. The various techniques are used to enhance the performance of automotive engine cooling system. It may be either conventional or modern approach. Conventional approach relies on fin, tube and fan design optimization. Modern techniques are based on new technologies like nano-technology, heat load averaging capacity or actuator based engine cooling system. This paper reviews some of the conventional and modern approaches focusing on radiator performance enhancement.

P. K. Trivedi, N. B. Vasava illustrated the effect of Tube pitch for best configured radiator for optimum performance. Heat transfer increases as the surface area of the radiator assembly is increased. This leads to change the geometry by modifying the arrangement of tubes in automobile radiator to increase the surface area for better heat transfer. The modification in arrangement of tubes in radiator is carried out by studying the effect of pitch of tube by CFD analysis using CFX. Results Shows that as the pitch of tube is either decreased or increased than optimum pitch of tubes, the heat transfer rate decreases.

Pitambar Gadhve and Shambhu Kumar described use of dimple surface to improve forced convection heat transfer. Heat transfer enhancement is based on principle of scrubbing action of cooling fluid inside the dimple. Surface dimplespromote turbulent mixing in flow and enhance heat transfer. An experimental set up has been designed and fabricated to study effect of dimpled surface on heat transfer in rectangular duct. Results compared with flat surface tube and found heat transfer enhancement over the later one.

P. Gunnasegaran, N. H. Shuaib, and M. F. Abdul Jalal in their study numerical simulations on fluid flow and heat transfer characteristics over louver angle fin Compact Heat Exchangers are reported. A computational domain from the fluid inlet to outlet is solved. The impacts of using variable louver angles (+2°, +4°, -2°, -4°, and uniform angle 20°) and louvered fin with variable fin pitches (1 mm, 2 mm, and 4mm) on both thermal and hydraulic of CHE are presented. The Nusselt number is higher for increased or decreased louver angle compared to uniform louver angle. The variable louver angle patterns and louver fin with smaller pitch applied in CHEs could effectively enhance the heat transfer performance with moderate degradation of pressure drop penalty compared to plain fin surface of CHE.

Prof. D. K. Chavan, Prof. Dr. G. S. Tasgaonkar explained conventional radiator size is rectangular which is difficult for circular fan to cover whole surface area. It creates lower velocity zones at corners giving less heat transfer.

Author has proposed to eliminate corners and develop circular shape radiator which is compact, more efficient and leads to minimum power consumption to drive a fan and maximum utilization of air flow. Considering limitations of conventional techniques to improve cooling system performance various new

technologies are adopted. Research is going on to stabilize the results.

K.Y. Leong, R. Saidur, S.N. Kazi, A.H. Mamun described use of nanofluid based coolant in engine cooling system and its effect on cooling capacity. It is found that nano-fluid having higher thermal conductivity than base coolant like 50%/50% water and ethylene glycol. It increases heat transfer. So for same heat transfer, radiator core area can be reduced compared to base one. It finds better solution to minimize area. Thermal performance of a radiator using nanofluid is increased with increase in pumping power required compared to same radiator using ethylene glycol as coolant.

John Vetrovec carried work on engine cooling system with heat load averaging capacity using passive heat load accumulator. Heat load accumulator is phase change material which stores heat generated during peak and dissipates stored

heat during reduced heat load condition. This is achieved by sacrificing phase change of PCM from solid to liquid or vice versa. This leads to compact heat exchanger for same heat rejection. Also it reduces load on cooling system. System can handle high transient loads and permits faster warm up during

M.H. Salah, P.M. Frick, J.R. Wagner, D.M. Dawson discussed about hydraulic actuated cooling system. Actuators can improve temperature tracking and reduce parasitic losses. Actuator based engine cooling system uses controller to control coolant pump and radiator fan operating conditions. It provides power to system component as per requirement. Thus it regulates power consumption of system component with cooling capacity.

2. ELEMENT TYPE USED IN THE PROJECT

2.1 SOLID45 Element Description

SOLID45 is used for the 3-D modelling of solid structures. The element is defined by eight nodes having three degrees of freedom at each node: translations in the nodal x, y, and z directions.The element has plasticity, creep, swelling, stress stiffening, large deflection, and large strain capabilities

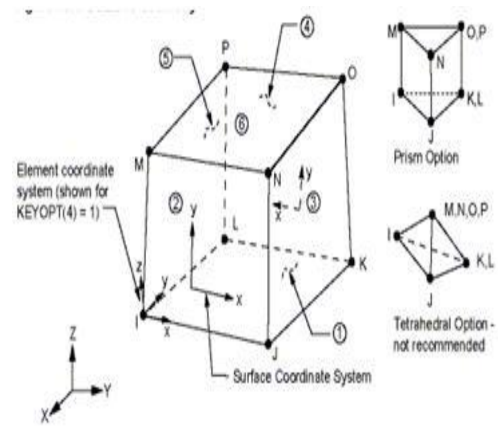

Fig -1: SOLID45 Geometry

3. MATERIALS

3.1 Aluminium

Aluminium has a very high thermal conductivity (237W/m²/K). Because of this high thermal conductivity, we have been able to design a heat exchanger that needs less surface area. This allows us to produce more compact, lightweight boiler designs. being highly resistant to the corrosion effects of condensate during operation. It is a much less expensive material than stainless steel, which requires an energy-intensive manufacturing process.

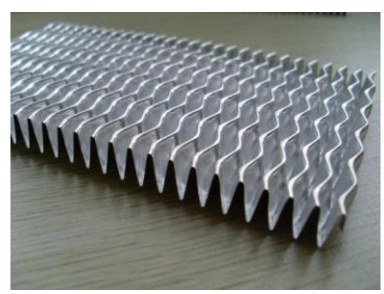

Fig -2: Aluminium as Radiator Fins

3.2Copper

The Thermal Conductivity of copper is 401W/m/K On average, the thermal conductivity of copper is 20 times that of stainless steel. But it has a lower life span due to corrosion Considering that higher efficiency and thermal conductivity was the advantage for copper .

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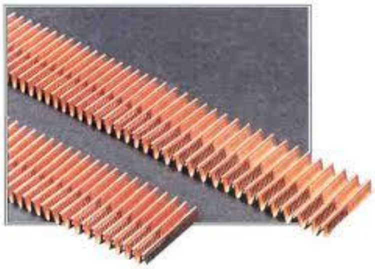


Fig -3: Copper as Radiator fins

3.3 Material composition

1. Copper
2. Aluminium
3. Aluminium80%+copper20%
4. Aluminium90%+Copper10%

4. RESULTS AND DISCUSSION

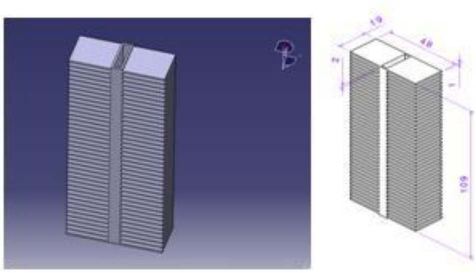


Fig -4: Image showing Normal rectangular model fins

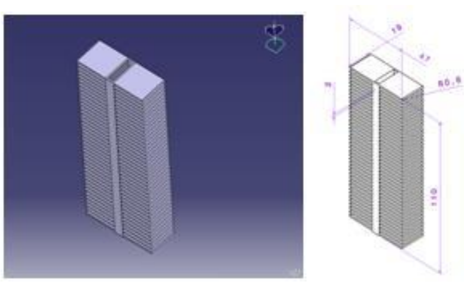
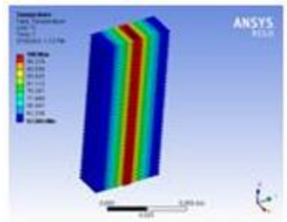
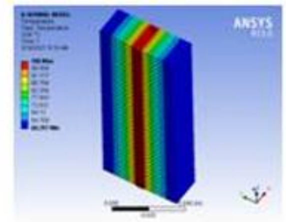


Fig -5: Image showing Edge rounded model fins

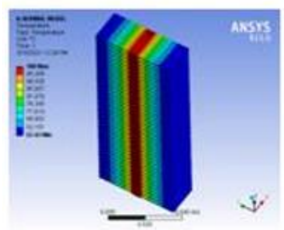
4.1 Temperature Results



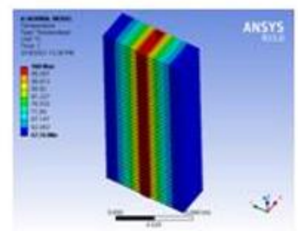
Copper



Aluminium

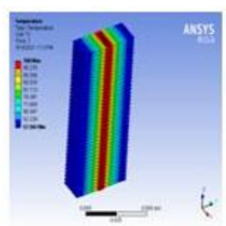


Al80%+Cu20 %

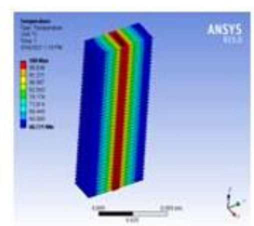


Al90%+Cu10%

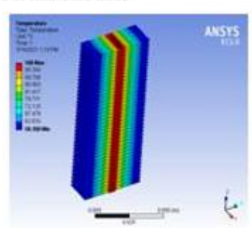
Fig -6: Normal rectangular model Fins



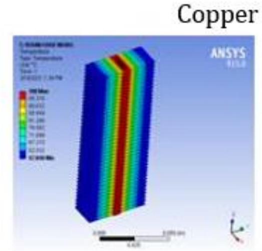
Aluminium



Copper



Al80%+Cu20 %



Al90%+Cu10%

Fig .7: Edge rounded model Fins

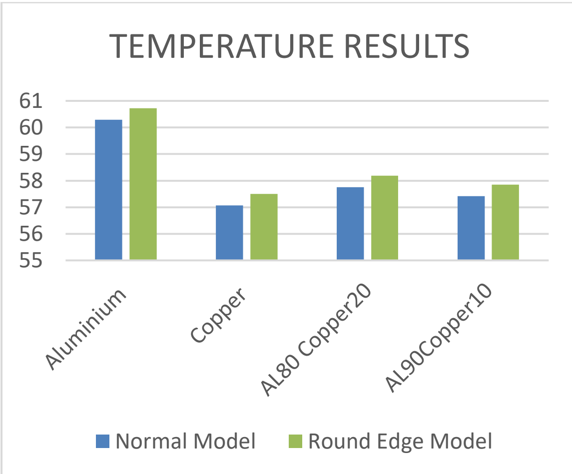


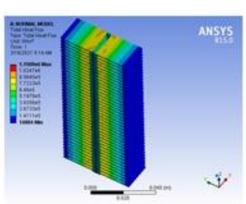
Chart-1: Comparison of Temperature results

Fins	Aluminium	Copper	Al80%+Cu20%	Al90%+Cu10%
Normal Model	60.297	57.075	57.76	57.42
Round Edge Model	60.721	57.504	58.188	57.848

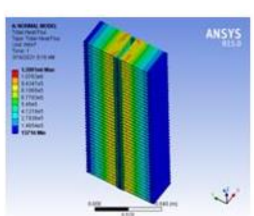
Table -1: Comparison of Temperature results

From the above **Chart 1** and **Table 1** of Temperature Result Comparison we infer that the temperature distribution and Heat dissipation is more efficient and shown a increased Heat exchange by the Edge Rounded Fin model than the Normal rectangular Fin model. Even though when compared to copper which has the highest thermal conductivity, the alloy composition of Aluminium and Copper (90%+10%) which gives good and better results very nearer to the copper alone material Design.

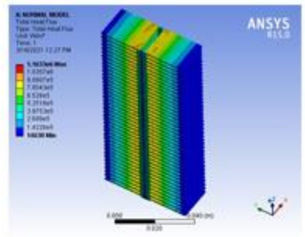
4.2 Heat flux results



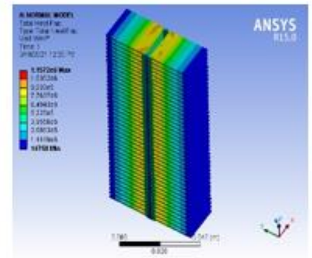
Copper



Aluminium

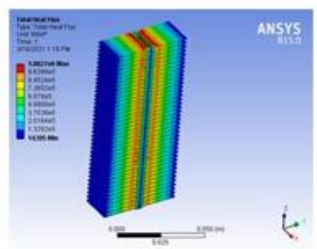


Al80%+Cu20%

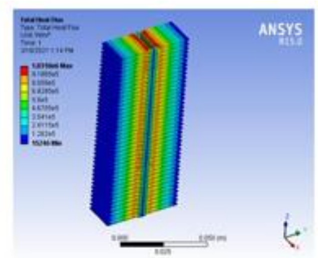


Al90%+Cu10%

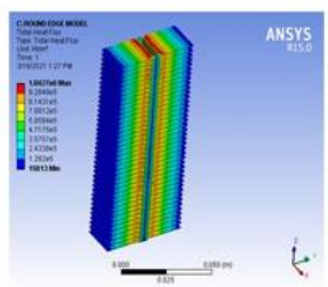
Fig -8: Normal rectangular model Fins



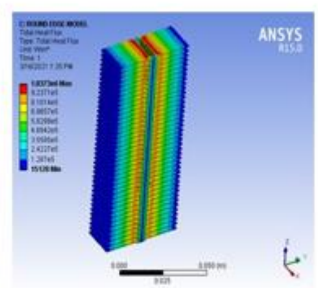
Copper



Aluminium



Al80%+Cu20%



Al90%+Cu10%

Fig -9: Edge rounded model Fins

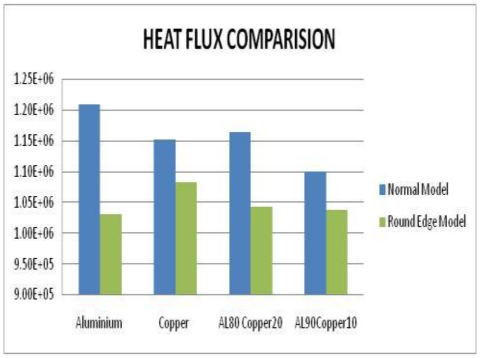


Chart -2: Comparison of heat flux results

Total Heat Flux	Aluminium	Copper	Al80% +Cu20%	Al90%+Cu10%
Normal Model Fin	1.21E+06	1.15E+06	1.16E+06	1.10E+06
Round Edge Model Fin	1.03E+06	1.08E+06	1.04E+06	1.04E+06

Table -2 : Comparison of heat flux results

From the above Chart 11 and Table 2 of Heat Flux Result Comparison we infer that the Round Edge model Fin performs better than the Normal rectangular Fin model .But both the alloy composition 0f Aluminium and Copper (90%+10%,80%+20%) gives the nearer result to the copper alone material fin .Thus from the overall results from analysis shows that the Round Edged model Fin with Aluminium and Copper (90%+10%) alloy gives the better results and very nearer to the Copper alone model fin.

5. CFD Analysis

5.1 Modelling

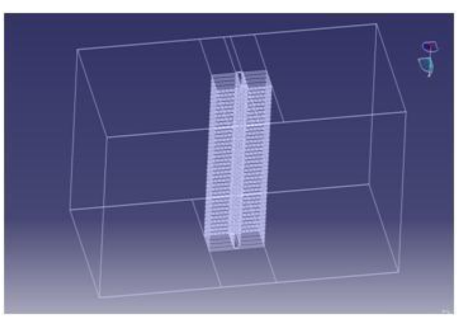


Fig -10: Normal rectangular model fins

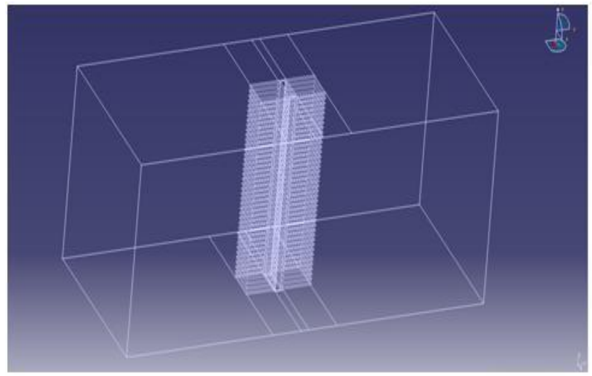


Fig -11: Edge rounded model fins

5.2 3D Model of the Domain

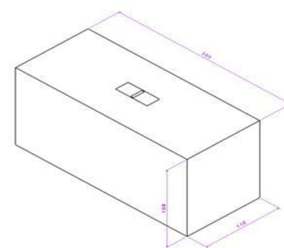


Fig -12: 3D model of domain

5.3 Mesh model of the domain

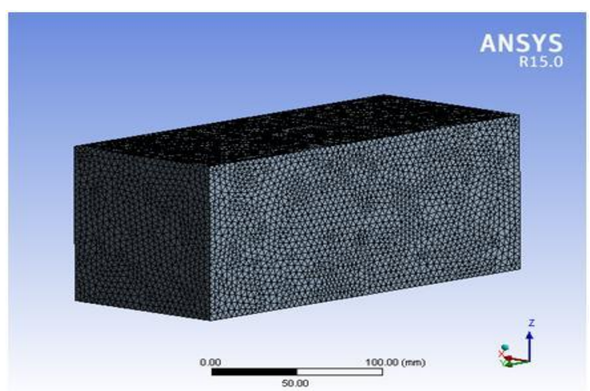


Fig -13: Normal Rectangular Model Fin

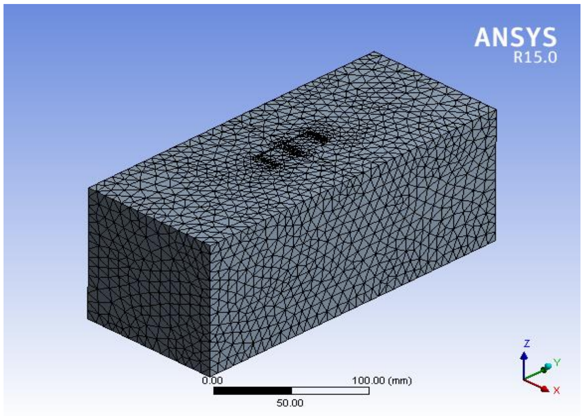


Fig -14: Edge Rounded model Fin

Table -3: Mesh details

MESH DETAIL		
	NORMAL MODEL	EDGE ROUNDED MODEL
NODES	29490	38670
ELEMENTS	142395	181789
ELEMENT TYPE	TETRAHEDRONS	TETRAHEDRONS

6. CFD Results

6.1 Pressure results

Fig -15: Normal rectangular model fin

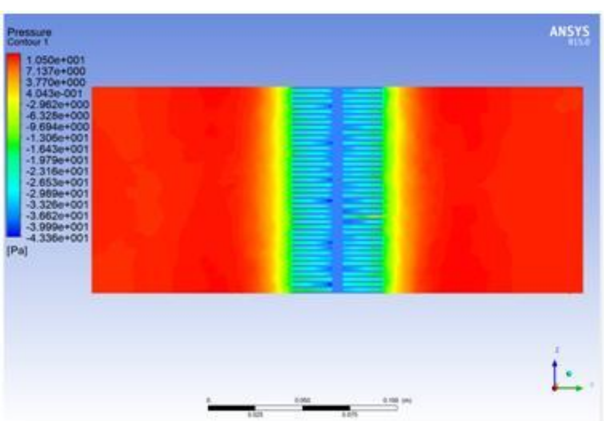
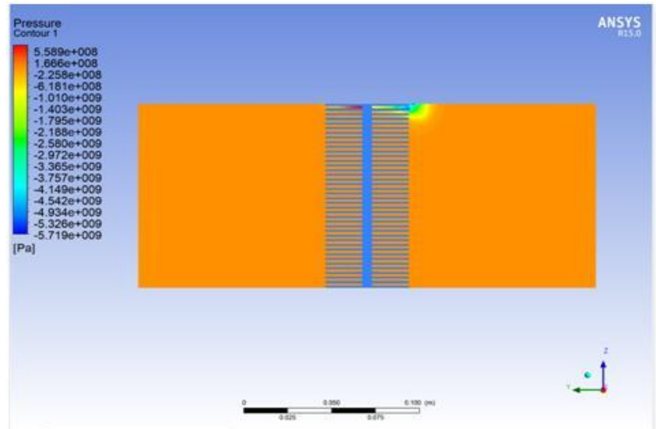


Fig -16: Edge rounded model fin



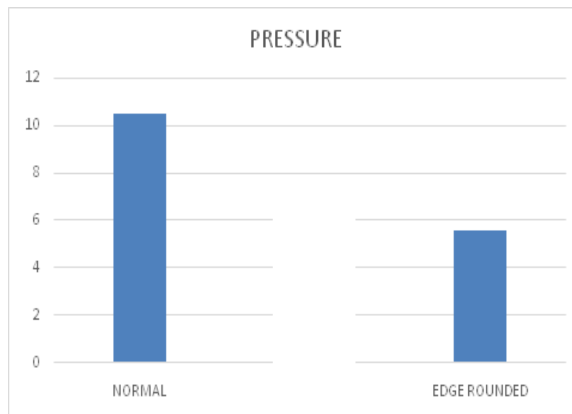


Fig -17 : Comparison of pressure results

6.2 Velocity results

Fig -18: Normal rectangular Model fin

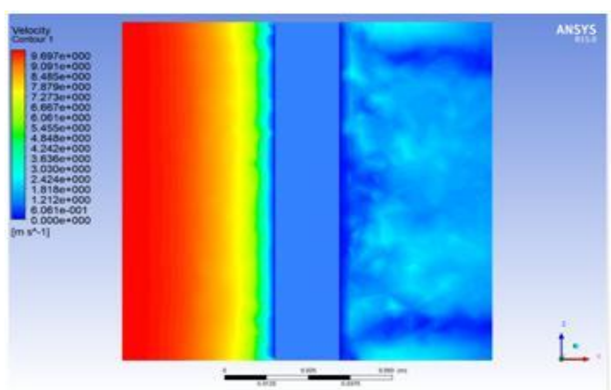
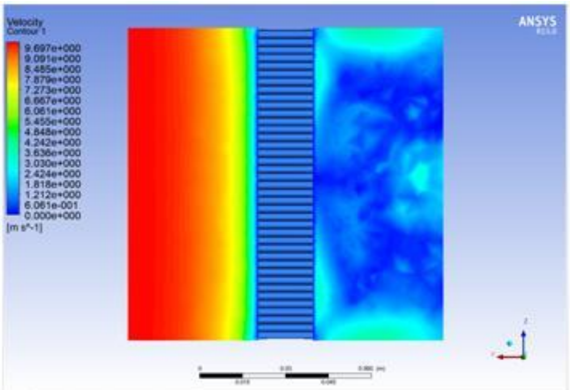


Fig -19: Edge rounded model fin



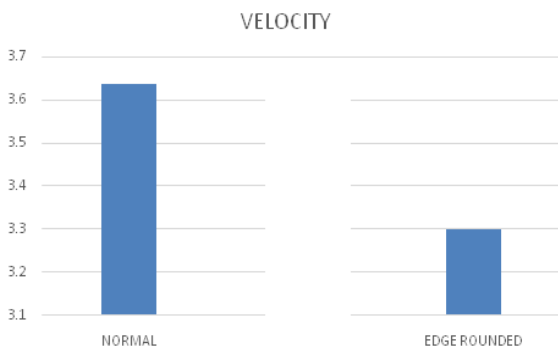


Fig -20: Comparison of velocity results

6.3 Turbulence results

Fig -21: Normal rectangular model fin

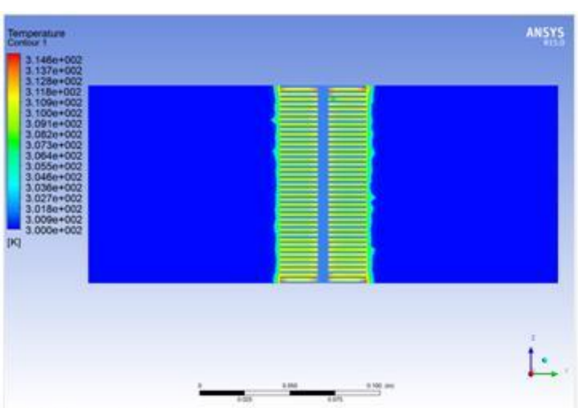
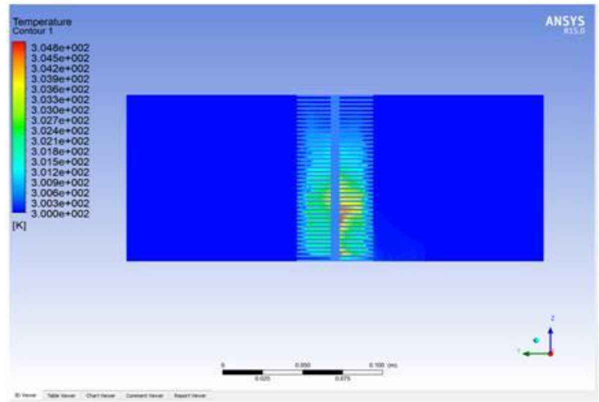


Fig -22: Edge rounded model fin



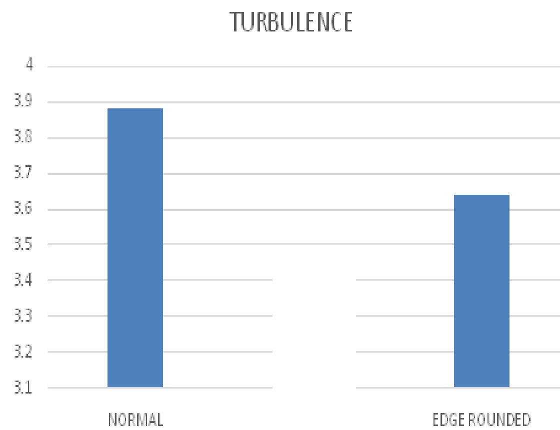


Fig -23 :Comparison of Turbulence results

6.4 Temperature results

Fig -24: Normal rectangular model fin

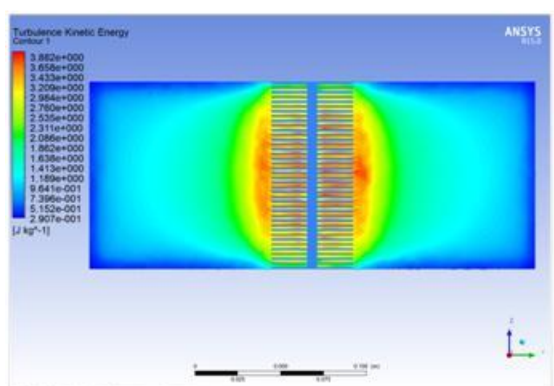
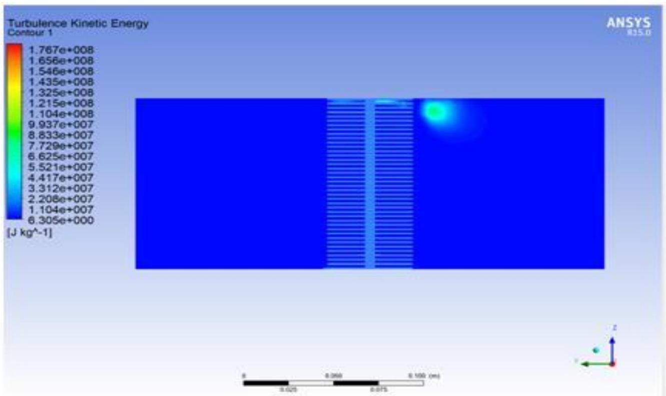


Fig -25: Edge rounded model fin



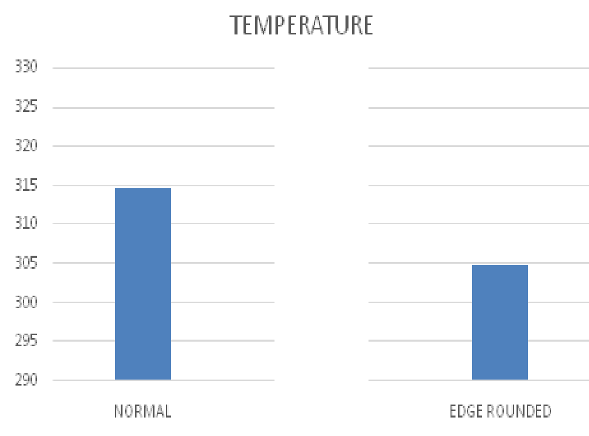


Fig -26 :Comparison of Temperature results

From the Above CFD results Flow analysis we infer that the Edge Rounded model Fin performs better in the Pressure ,velocity, Turbulence and Temperature conditions than the Normal Rectangular Fin model. this is because of the curved dynamic Structure of the Edge Rounded Fin, by this better cooling performance can be achieved.

7. CONCLUSION

The effectiveness of the radiator is being calculated on the basis of design and material selection discussed above opting certain parameters, various materials like Copper, Aluminium, and combination of both as (Al80%+Cu20% & Al90%+Cu10%) proportions are observed on the basis of their thermal conductivity taking designing parameters and materials into account a preferable radiator is constructed ,From the obtained analysis the suitable material for the radiator is (Al90%+Cu10%).Also the flow analysis is carried out by CFD software, The best cooling design taken from our analysis is the curved Edge Rounded Fin design ,Thus the better cooling performance can be achieved.

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