CFD ANALYSIS ON LOUVERED FIN

P.Prasad[1], L.S.V Prasad[2]

[1]*Student, M. Tech Thermal Engineering, Andhra University, Visakhapatnam, India*
[2]*Professor, Dept. of Mechanical Engineering, Andhra University, Visakhapatnam, India*

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Abstract-*Radiators are used to transfer thermal energy from one medium to another for the purpose of cooling. They are used for cooling internal combustion engines, mainly in automobiles, railway locomotives, stationary power generating plants etc. The radiator essentially transfers heat from the coolant inside to the surrounding ambient air enhancing performance of the engine. A model of radiator with rectangular and louvered fins are developed using Pro/Engineer and further CFD analysis is performed with ANSYS 14.5 for a relative comparison of geometry of fins on performance of the radiator. Aluminum alloy 6061 is considered in either case to analyze the heat transfer capabilities of louvered fins and rectangular fins.*

Key words: Rectangular fin, louvered fin, Aluminum alloy 6061.

1. INTRODUCTION

All internal combustion engines generate a huge amount of heat which is transferred to cylinder walls, piston, valves and other components by conduction. This heat is carried away by the coolant that circulates through the engine, especially around combustion chamber and the cylinder head area of the engine block. The coolant pumped through the engine block, after absorbing the heat is circulated to the radiator where the heat is dissipated to the surrounding atmosphere. The coolant is then transferred back into the engine to repeat the process. Two types of tubular finned radiators are considered for the analysis, louvered fins and rectangular fins respectively made of Aluminum alloy 6061 compared for better heat transfer capabilities. The schematic diagram of thermal resistance considered across the radiator tube is shown in Fig. 1.

$$r_{COND} = \frac{R_{COND}}{L_{PIPE}} \qquad \text{Eq 1}$$

$$R_{COND} = \frac{L_{fin}}{k_{fin} A_{fin}} \qquad \text{Eq 2}$$

$$r_{CONV} = \frac{R_{CONV}}{L_{PIPE}} \qquad \text{Eq 3}$$

$$R_{CONV} = \frac{L_{fin}}{h A_s} \qquad \text{Eq 4}$$

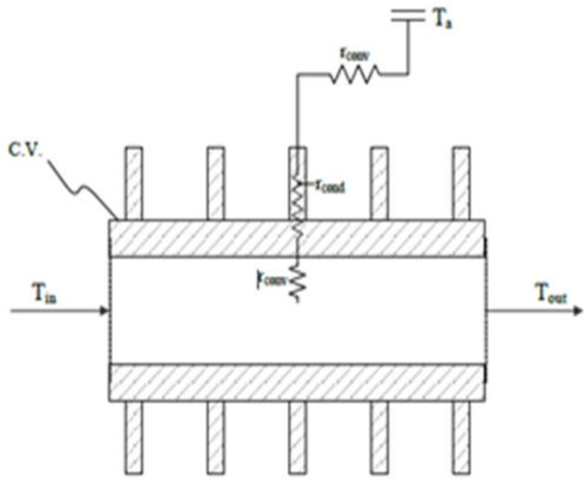

Fig-1: Thermal Resistance Diagram

T_{in} represents the inlet fluid temperature, T_{out} represents the outlet fluid temperature, and T_a represents the ambient air temperature. Durgesh Kumar Chavan et al., [1] Experimental tests of forced convective heat transfer in an Al_2O_3/water nano fluid has experimentally been compared to that of pure water in automobile radiator. The results demonstrate that increasing the fluid circulating rate can improve the heat transfer performance. Yadav et al., [2] Performed numerical parametric studies on automotive radiator and the modeling of radiator by two methods, namely finite difference method and thermal resistance concept. In the performance evaluation, a radiator is installed into a test-setup and the various parameters including mass flow rate of coolant, inlet coolant temperature were varied. Junjanna et al., [3] conducted the numerical analysis by modifying geometrical and flow parameters like louver pitch, air flow rate, water flow rate, and louver thickness, by varying one parameter the results were compared. Manjunath et al., [4] Performed high thermal resistance on the air side, the optimization of such fins is essential to increase the performance of heat exchanger. Optimization of louvered fin geometry in such heat exchangers is essential to increase the heat transfer performance and reduce weight and cost requirement. Pooranachandran karthik et al., [5] Performed a numerical analysis using fluent software for three chosen data from the experiments. The increase in the flow rate of water increases the total heat capacity of the water stream. The mass flow rate of water has a better influence in increasing the heat transfer at higher velocities of air.

2. MODELLING AND THERMAL ANALYSIS OF RECTANGULAR AND LOUVERED FIN

Geometrical model of rectangular fin and louvered fin are modeled with creo parametric 2.0 and the dimensions of rectangular fin considered for the study is given below.

Rectangular fin thickness =0.25mm
Rectangular fin length=60mm
Rectangular fin width=15mm
Rectangular tube diameter=10mm
Number of fins considered =16
Rectangular fin height=30mm

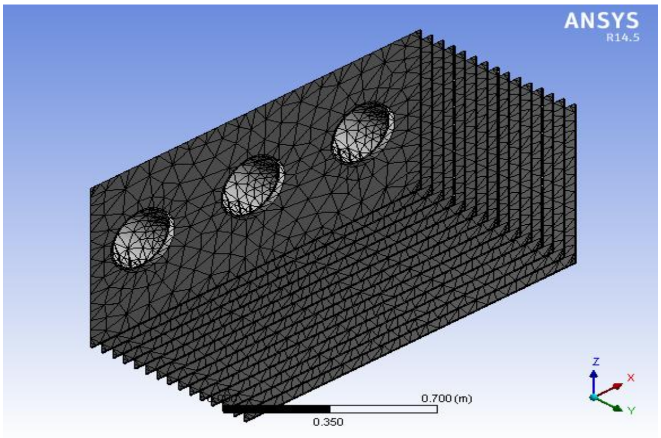

Fig-2 : Meshing of rectangular fin

The solid model developed is subjected to meshing using anysis for a rectangular fin as shown in Fig. 2. The number of nodes are 68013 and elements 32799 respectively.The dimensions of louvered fin considered for the study are as follows.

Louvered finned rectangular tube width=7.5 mm
Louvered finned rectangular tube length=15mm
Number of louvered fins considered =6

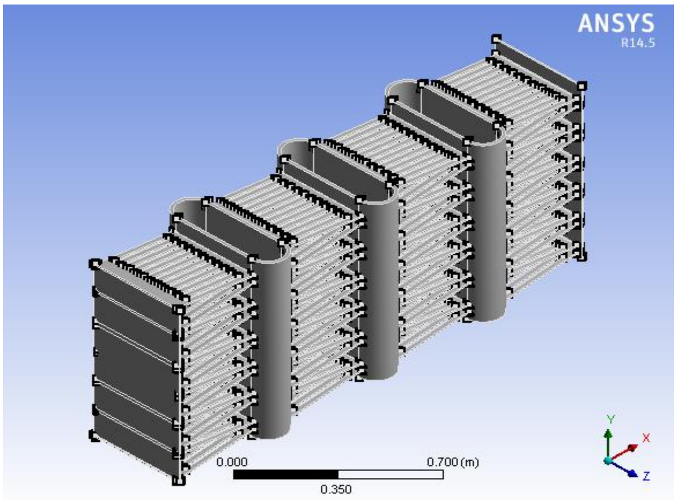

Fig-3: Louvered Fin Geometry

The solid model of louvered fin using Creo parametric 2.0 is shown in Fig. 3. The meshed model of the same is shown in Fig. 4. The number of nodes and elements were 463271 and 223429 respectively.

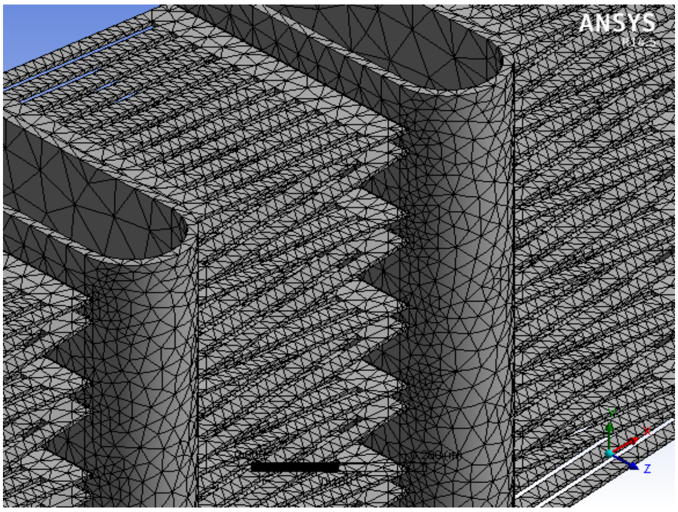

Fig-4: Louvered Fin Meshing

3. ALUMINUM ALLOY 6061 PROPERTIES

The Composition of Al6061 is given below

Mg =0.8 -1.2 %
Si =0.4-0.8 %
Cu =0.15-0.4 %
Cr =0.04-0.35 %
Mn =0.15 %
Fe =0.7 %
Zn =0.25 %
Ti =0.15 %
Al =95.85%-98.56%

Al6061 has the following advantages

- Excellent corrosion resistance to atmosphere condition
- Good weldability and brazability
- Co efficient of linear thermal expansion $23.5x10^{-6}m/^{0}C$
- Thermal conductivity 173 W/m. K
- Melting point is $580^{0}C$
- Modulus of elasticity is 70-80 G Pa.
- Poisson ratio is 0.33

4. THERMO PHYSICAL PROPERTIES OF FLUID

In automobile radiator water is used as cold fluid runs in the tubes. This water does not have sufficient strength to fight against cold weather. It becomes ice in cold weather so one other fluid mixed with this water and name is this fluid is ethylene glycol. This has sufficient antifreeze property to make help to the water to stable liquid in cold weather.

Ethylene oxide reacts with water to produce ethylene glycol according to the chemical equation.

$$C_2H_4 + 2H_2O \rightarrow HO\text{–}CH_2CH_2\text{–}OH$$

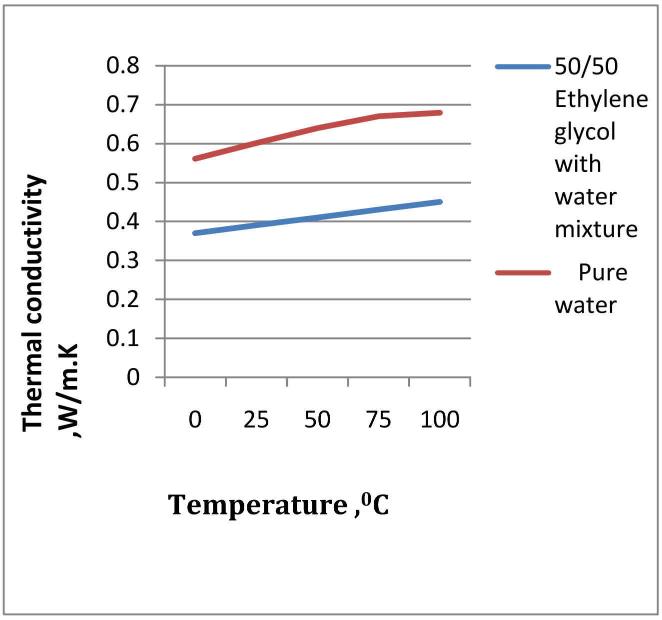

Fig-5: Variation of Thermal conductivity of 50/50 Ethylene glycol with water mixture and pure water with temperature

Variation of thermal conductivity of 50/50 Ethylene glycol with water mixture and pure water is shown in Fig. 5. Ethylene glycol mixture certainly has a higher thermal conductivity as compared to water and hence has a better heat transfer capabilities as compared to water. The presence of ethylene glycol could influence freezing temperature of fluid also.

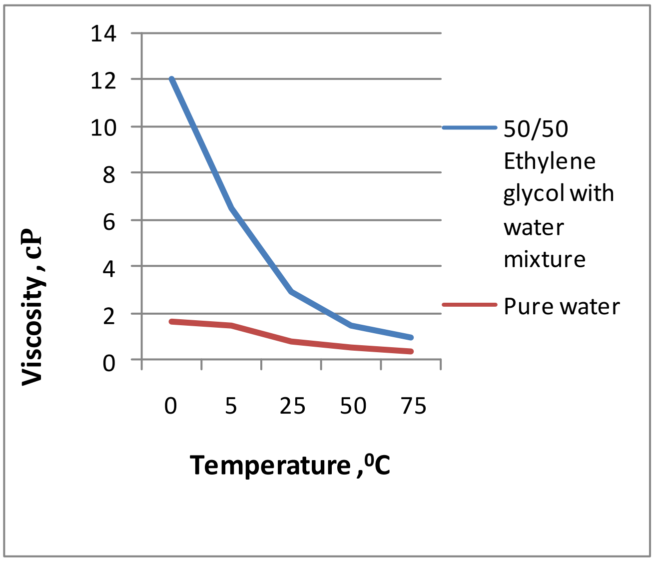

Fig-6: Variation of Viscosity of 50/50 Ethylene glycol with water mixture and pure water with temperature

Fig.6 shows the variation of viscosity with temperature. It is seen that variation of viscosity is found to be marginal within normal operating range as compared to water without compromising much of pump work required.

5. RESULTS AND DISCUSSIONS

The temperature distribution and heat flux distribution for a rectangular fin are shown in Fig. 7 and 8 respectively. A localized high temperature is observed at coolant inlet passage with not much temperature drop along the section of the fin. The thermal conductivity of the aluminum and the geometry of the fins are found to influence the temperature distribution along the tubular radiator.

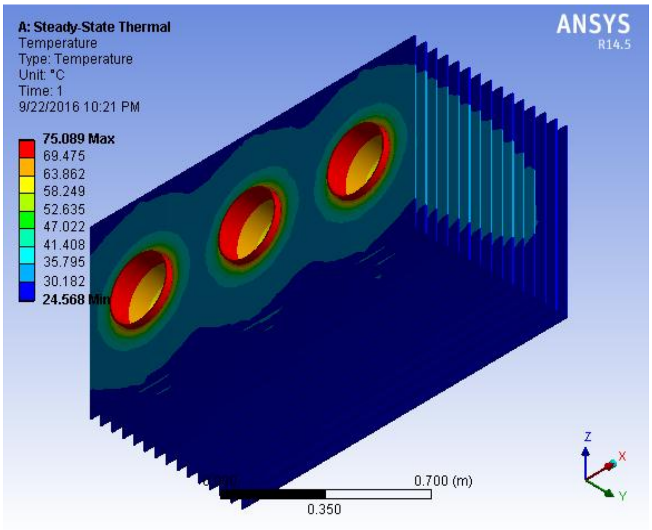

Fig-7: Temperature Distribution in rectangular fin

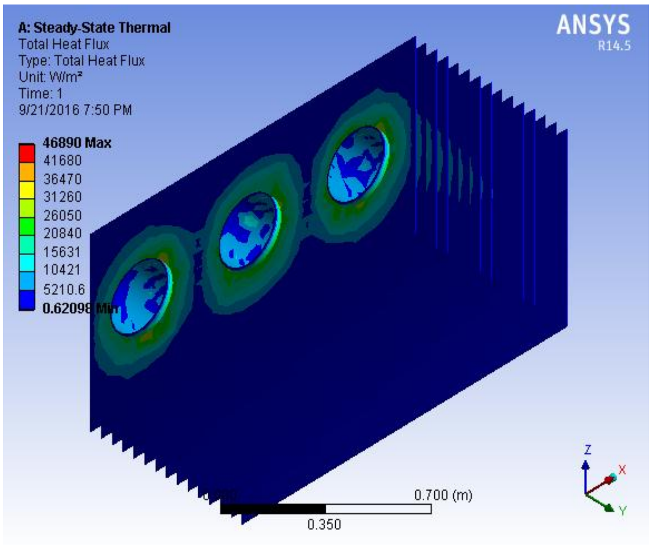

Fig-8: Total Heat Flux in rectangular fin

The maximum and minimum temperatures were found to be 75⁰C and 24⁰C respectively as seen in Fig. 7. A maximum heat flux of 31260 W/m² was found at the entry region of rectangular finned radiator as shown in Fig.8.

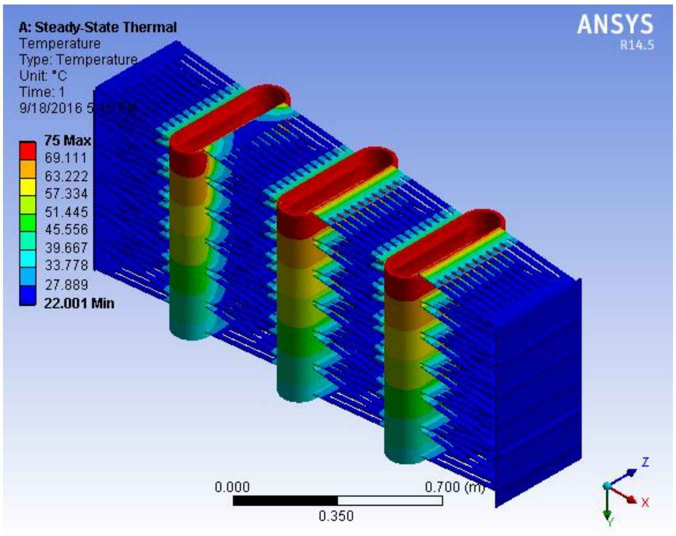

Fig-9: Temperature Distribution: Louvered fin

The temperature distribution across louvered fin radiator is shown in Fig. 9. The maximum and minimum temperature was found to be 75⁰C and 22⁰C respectively. The temperature distribution indicates that the geometry and thermal properties of louvered fin is found to have a profound influence on temperature distribution as compared to rectangular fin. The region in proximity of the coolant passage is found to be at a higher temperature with a significant drop in temperature along the fin.

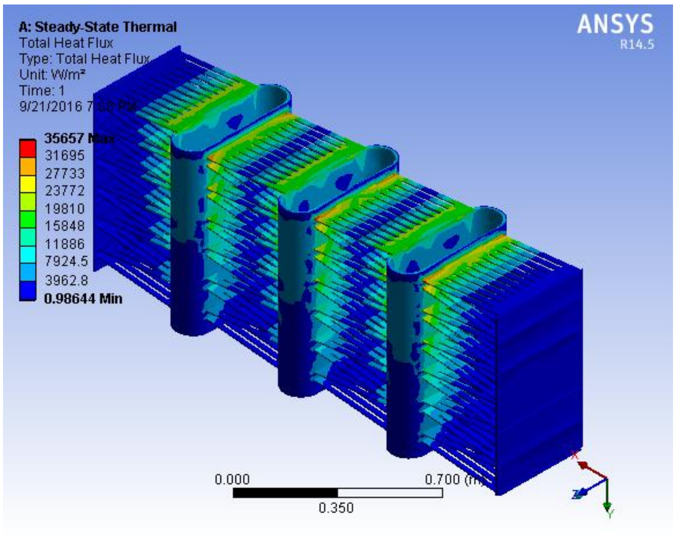

Fig-10: Total heat flux: Louvered fin

The heat flux density for louvered fin is shown in Fig. 10. The maximum heat flux of 35657W/m² is found to exist at the entry region with few concentrated zones and there is a proportionate drop in heat flux away from coolant flow passages.

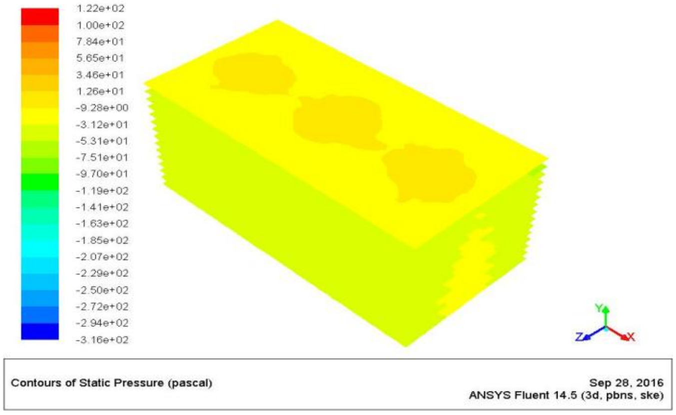

Fig-11: Static pressure in rectangular fin

The pressure distribution along the test section is shown in Fig.11. The maximum static pressure of 34.6 N/m² is found to exist at the central coolant passages for a rectangular fin. The rest of the test section is found to be exposed to a nominal pressure of 12.6 N/m².

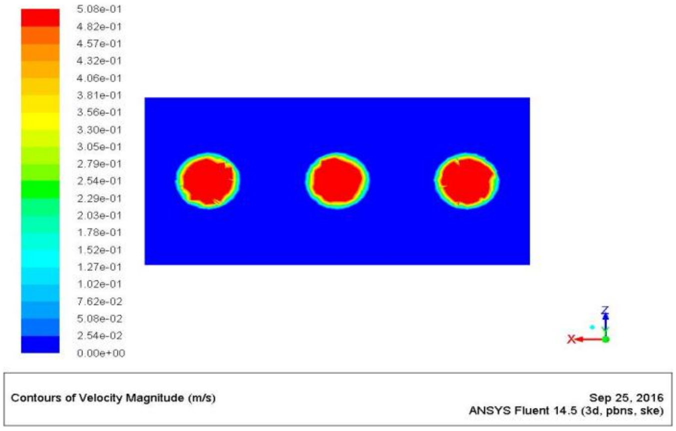

Fig-12: velocity in rectangular fin

The velocity distribution of coolant through the coolant passages is shown in Fig. 12 for test section with rectangular fin. The maximum velocity of fluid distributions is found to be 0.508 m/s.

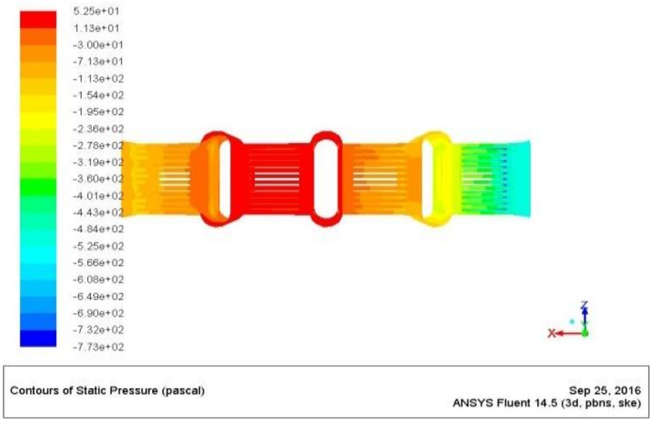

Fig-13: Static pressure in Louvered fin

The static pressure distribution in louvered fin is shown in Fig. 13. The pressure is found to be distributed across the test section with a maximum pressure of 52.5 N/m^2 found to exist across the passages attached to the louvered fins at the entry zone with marginal drop in pressure at the exit of the test section.

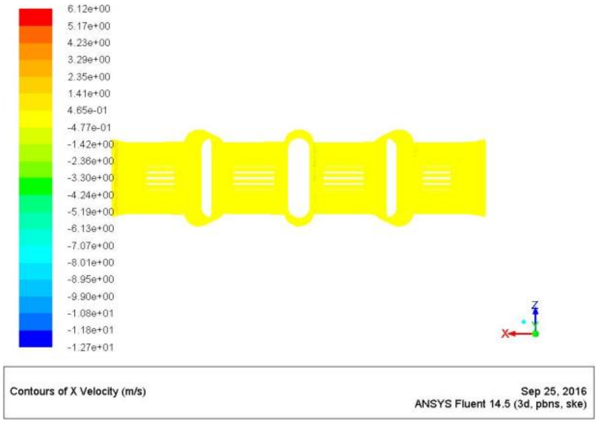

Fig-14: Velocity distribution in Louvered fin

The velocity distribution in louvered fin is shown in Fig. 14. The maximum fluid velocity of 1.41 m/s was estimated for the coolant passing through the louvered cross section.

6. COMPARSION OF RECTANGULAR AND LOUVERED FIN RESULTS

Parameter	Rectangular fin	Louvered fin
Heat Flux (W/m^2)	31260	35657
Velocity (m/s)	0.508	1.41
Temperature (K)	348	348
Total Heat Transfer rate at wall (W)	22253	45319

7. CONCLUSIONS

The comparative CFD analysis on rectangular and louvered finned heat exchanger with 50/50 Ethylene glycol and water mixture as working fluid reveals louvered fins exhibit better heat transfer characteristics as compared to rectangular fins. The heat transfer rate was found to be 49% more for louvered fins as compared to rectangular fins. The velocity was found to be significantly higher for louvered fins which might be a contributing factor for enhanced heat transfer rate in louvered fins.

8. REFERENCES

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