PERFORMANCE IMPROVEMENT OF AN AUTOMOBILE RADIATOR USING CFD ANALYSIS

LEELA KRISHNA GOLE
M.Tech (MECH), Department of Mechanical Engineering, Helapuri Institute of Technology and Science, Eluru, A.P.

Mr.P.IRSHAD KHAN
Assistant Professor, Department of Mechanical Engineering, Helapuri Institute of Technology and Science, Eluru, A.P.

Abstract

Radiators are used to transfer thermal energy from one medium to another for the purpose of cooling. Radiators are used for cooling internal combustion engines, mainly in automobiles but also in piston-engine aircraft, railway locomotives, motorcycles, stationary generating plant. The radiator transfers the heat from the fluid inside to the air outside, thereby cooling the fluid, which in turn cools the engine. In this thesis, the computational analysis tool ANSYS is used to perform a CFD analysis on a radiator at different mass flow rates. The present model of radiator has no louvered fins, in this thesis the radiator is replaced with louvered fins. In this thesis CFD analysis is performed for radiator with and without louvered fins. Heat transfer analysis is performed to analyze the heat transfer rate. The material used for fins of radiator is Aluminum alloy 6061. Modeling is performed in Pro/Engineer and analysis is performed in ANSYS.

Keywords*: Ansys, Milling, Taguchi, H13 Steel.*

I. INTRODUCTION

A. Introduction to Automobile Radiator

Radiators are heat exchangers used to transfer thermal energy from one medium to another for the purpose of cooling and heating. The majority of radiators are constructed to function in automobiles, buildings, and electronics. The radiator is always a source of heat to its environment, although this may be for either the purpose of heating this environment, or for cooling the fluid or coolant supplied to it, as for engine cooling. Despite the name, radiators generally transfer the bulk of their heat via convection, not by thermal radiation, though the term "convector" is used more narrowly; see radiation and convection, below. The Roman hypocaust, a type of radiator for building space heating, was described in 15 AD. The heating radiator was invented by Franz San Galli, a Polish-born Russian businessman living in St. Petersburg, between 1855 and 1857.

B. Radiation and Convection

One might expect the term "radiator" to apply to devices that transfer heat primarily by thermal radiation (see: infrared heating), while a device which relied primarily on natural or forced convection would be called a "convector". In practice, the term "radiator" refers to any of a number of devices in which a liquid circulates through exposed pipes (often with fins or other means of increasing surface area), notwithstanding that such devices tend to transfer heat mainly by convection and might logically be called convectors. The term "convector" refers to a class of devices in which the source of heat is not directly exposed.

2. WORKING OF AUTOMOBILE RADIATORS

Almost all automobiles in the market today have a type of heat exchanger called a radiator. The radiator is part of the cooling system of the engine as shown in Figure below. As you can see in the figure, the radiator is just one of the many components of the complex cooling system. Most modern cars use aluminum radiators. These radiators are made by brazing thin aluminum fins to flattened aluminum tubes. The coolant flows from the inlet to the outlet through many tubes mounted in a parallel arrangement. The fins conduct the heat from the tubes and transfer it to the air flowing through the radiator.

The tubes sometimes have a type of fin inserted into them called a tabulator, which increases the turbulence of the fluid flowing through the tubes. If the fluid flowed very smoothly through the tubes, only the fluid actually touching the tubes would be cooled directly. The amount of heat transferred to the tubes from the fluid running through them depends on the difference in temperature between the tube and the fluid touching it. So if the fluid that is in contact with the tube cools down quickly, less heat will be transferred. By creating turbulence inside the tube, all of the fluid mixes together, keeping the temperature of the fluid touching the tubes up so that more heat can be extracted, and all of the fluid inside the tube is used effectively. Radiators usually have a tank on each side, and inside the tank is a transmission cooler. In the picture above, you can see the inlet and outlet where the oil from the transmission enters the cooler. The transmission cooler is like a radiator within a radiator, except instead of exchanging heat with the air, the oil exchanges heat with the coolant in the radiator.

3.CFD ANALYSIS OF RADIATOR

Fig.2. Model of Radiator.

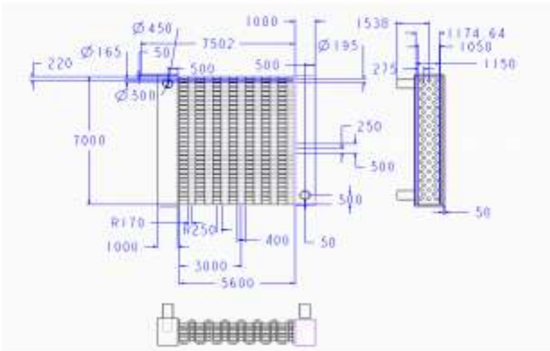

Fig.3. 2D Drawing.

Density – 0.0000027 Kg/mm3
Thermal Conductivity – 180W/mK
Specific Heat – 896 J/Kg K

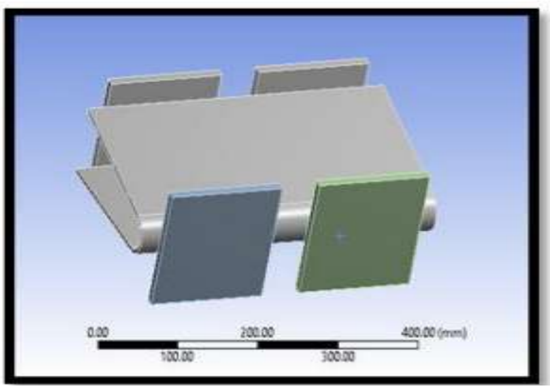

Fig.4. Imported Model.

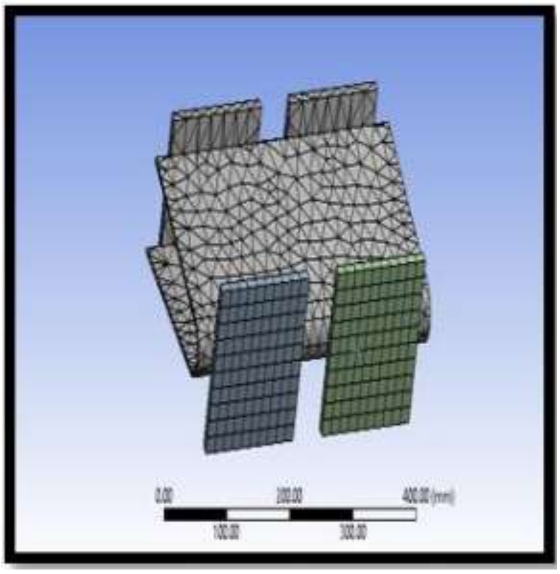

Fig.5. Meshed model.

4.results

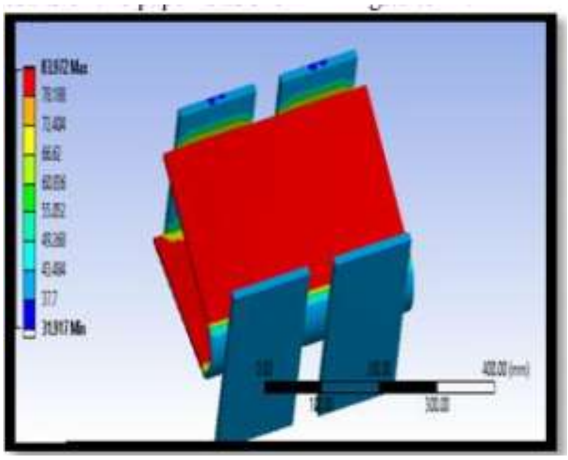

Fig.6. Temperature.

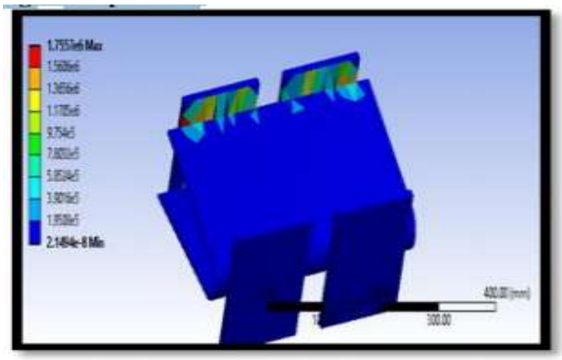

Fig.7. Thermal error.

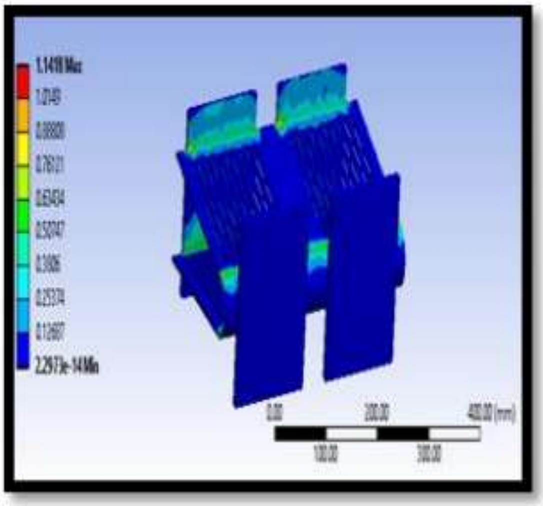

Fig.12. Heat flux.

TABLE I: Original Model

	Mass flow rate (Kg/sec)			
	0.08 kg/sec	0.140 kg/sec	0.210 kg/sec	0.280 kg/sec
Pressure (Pa)	1.56e+01	2.82e+01	4.35e+01	5.94e+01
Velocity (m/s)	1.02e+00	1.77e+00	2.64e+00	3.51e+00
Temperature (K)	3.53e+02	3.53e+02	3.53e+02	3.53e+02
Mass Flow Rate (Kg/S)	1.147e-06	9.8341e-07	2.5331e-07	5.3644e-07
Total Heat Transfer rate at wall (W)	2749	3011	3149	3225

TABLE II: With Louver FINS

	Mass flow rate (Kg/sec)			
	0.08 kg/sec	0.140 kg/sec	0.210 kg/sec	0.280 kg/sec
Pressure (Pa)	1.17e+02	2.14e+02	3.37e+02	4.68e+02
Velocity (m/s)	1.44e+00	2.50e+00	3.73e+00	4.94e+00
Temperature (K)	3.53e+02	3.53e+02	3.53e+02	3.53e+02
Mass Flow Rate (Kg/S)	4.616e-06	2.920e-06	2.840e-06	3.069e-06
Total Heat Transfer rate at wall (W)	5961	7463	8346	8872

TABLE III: Thermal Results

	With louvers	Without louvers
Temperature (°C)	81.264	83.972
Thermal Error	1.5396e6	1.7557e6
Heat Flux (W/mm^2)	1.1418	0.98837

5. CONCLUSION

In this project a radiator is designed without louver fins and with louver fins. The original radiator has no louver fins, it has been modified by specifying louver fins. 3D model is designed in Pro/Engineer. The analysis tool ANSYS is used to perform CFD analysis on radiator at different mass flow rates. By observing the analysis results, the velocity is increased by 29.16%, pressure is increased by 86.66% and heat transfer rate at walls is increased by 53.88% for the modified model than the original that is the radiator with louvered fins. Heat transfer analysis is performed to analyze the heat transfer rate to determine the thermal flux. The material taken is Aluminum alloy 6061 for thermal analysis. By observing the thermal analysis results, thermal flux is increased by 13.43% for the modified model. So it can be concluded that modifying the radiator model with louver fins yields better results. Ultimately it can be summarized that by providing louvers for the radiator and increasing the louver pitch helped in reducing the pumping power requirements with increase in heat transfer rate. This will help in increasing the power output per unit mass of the radiator. Hence it is recommended to increase the louver spacing for the geometry under consideration.

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