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Finite Element Analysis of Radiator Fins to increase the Convection Efficiency of Radiator by using Al Alloy, Cu and Brass Material

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ABSTRACT

Radiator is a device which is used as cooling system in combustion engine by convection heat transfer method, in radiator the temperature of the water at entry of the tube is high when compared to the exit, so we predict the radiation in every sq mm by ANSYS and select the suitable alloy of brass to increase the radiation efficiency by force convection and free convection. Cooling performance is compared between automobile and aircraft radiator. This paper reports a study carried out using 3-D modeling and finite element analysis for radiator. Pro-E was used for 3-D modeling then by neutral file format the model was imported in to ANSYS. Here the solid model was converted in to finite element model Boundary conditions such as maximum temperature of the cylinder, convective heat transfer coefficient, ambient temperature and material properties such as thermal conductivity are used as set of parameters for the program. Heat flux and temperature profiles were used to measure the efficiency.

Keywords - Aluminium, Copper, Engine cooling, Radiator.

1. INTRODUCTION

Finned surface are probably used in modern vehicle technology to enhance heat transfer is in the form of convection [3]. Convection takes place between a solid surface and liquid medium. Due to the combustion process heat get produced inside the engine. During explosion the temperature of metal around the engine exceeds 1000°F. In order to prevent all this overheating of engine oil, piston, and cylinder walls, valves and other component, it is necessary to dispose the heat effectively then the Frontal area must be limited in order to gain the effective heat transfer rate. Almost 30% of Combustion heat is used to run the vehicle then the next 60% released in to the atmosphere [4], the remaining heat is absorbed by the cooling system. Nowadays liquid cooling system is installed in all Car Engines. The coolant is circulated through radiator after absorbing the heat of combustion. Excessive cooling system is also a factor leads to affect engine working condition and performance. Problem to maintain the heat transfer deals with flow rates and turbulence of water flow and air flow, temperature in the inlet and outlet stage, nature of the cooling surfaces, and the geometry configuration of the radiator .

1.1 Reverse Engineering

If you want to analyze about the existing model of any automobile parts the reverse engineering is helpful in that work. In that configuration, characteristics, function had been discussed elaborately. In any important condition is not easy to determine the operating condition in cad model at that instance the Reverse Engineering provides the sample modification. It provides the information based on "3D model". Then the computer vision technique is applicable to the three dimensional placing digitizer to proceeding the process.

1.2 Future Scope

Vehicle exhausts causes the dangerous effect to living organism by the emission of Nitrous oxide and Carbon monoxide. To reduce the emission and enrich our economy status, we have planned to use the Aircraft material for Automobile fin manufacture. Corrosion resistance and durability and toughness will be more when compared to other material. Various Aluminum alloy used in the aircraft fuselage and skin construction if we seen in upper wing construction, Al6013 used and it promotes high strength than other alloy [2]. Fins involved in the transfer of heat helps to upgrade the efficiency of the radiator.

2. PROBLEM DEFINITION

The radiator model has been taken under the performance investigation in that we have planned to change fin material. First analyze the thermal conductivity of three materials. Next the core model has been altered by changing the fin arrangement and some transition held in the configuration. Extending the length leads to effective heat transfer.

3. METHODOLOGY

- Measuring all the radiator's dimensions using Reverse Engineering tool system.
- Design the radiator's solid model using Solid Works software.
- Develop Finite Element model using ANSYS, different loading and boundary conditions applied on the model.
- Evaluate the radiator's performance with Aluminum, Copper and tungsten Finite-element models. Recommendation and suggestion will be given at the end.

4. SOLID MODEL DEVELOPMENT

The radiator involved in this project is aligned with forty eight Aluminum tubes covered by the plastic cover at top and bottom. Its dimension gets explained in the figure. Core, fins and coolant flow are explained in the solid model. The convection efficiency and heat flux will be enumerated by this solid model. The heat dissipated on radiator depends on the quantity of air stream and turbulence condition in the core model. Coolant get pass through tubes and air transverse across the cross section of tube.

4.1 Material for Radiator

Radiators are involved in the enhancement of cooling progress. Commonly Radiator comprises of tubes, fin, pressure cap, transmission cooler, and inlet and outlet tank. Generally radiator installed in front of the bumper. Air gets enter from the top or side mounted grill. In Ancient period radiator construction is made from the steel pressed plate. After the development of material science Aluminium is indulge in the construction. Plastic cover is placed at top and bottom with Aluminium tubes. Copper-brass also intends in the construction it has high thermal characteristics when compare to Al alloy [2]. Tensile strength of aluminum is more reliable compared to copper and brass radiator

4.2 Radiator Core

Core is the solid model that contains the alignment of tube and fin. Aluminum and its alloy have been emphasized in the tube manufacture [1]. The existing radiator model core configuration is 17 * 323 * 422 mm. The ratio of the average total area of the cross section of the air stream to the frontal area of the core is defined by the term "Free Area". Weight of the core is either empty or filled with water, will be expressed in unit pounds per square foot frontal area. Heater Core acts as mini radiator in the progress of heat exchange from the coolant to the air flow.

4.3 Boundary and Loading Conditions

For analyzing the radiator performance Certain boundary condition has been applied to the Core. Suppose engine gives 40 kW as output. Then Loading depends on the output condition in the cooling system. If one third of power consumed for the cooling function then the total power value is 13.4 kW.

So, the load per tube is" [(cooling load*specific heat of water)/number of tubes] =power develop per tube "W".

In order to enhance the radiator cooling performance tube height is limited to 100 mm. Each tube transposes 70 W powers, which is useful in simulating the heat disposal from water per tube to the coolant.

The dissipation of heat by the radiator will have capacity to terminate the same power in the internal side of tube. When forced convection is enhanced in the heat exchange between coolants to stream of air, the efficiency aimed at higher rate.

In the Solid works, geometry of the tube and fin is presented based on the dimension of existing model, where the material has to be listed and simulation is performed in "ANSYS 14.5".

Thermal Analysis is carried for further progress. Then the material will be altered one by one. The convection heat transfer coefficient and the power have to be recognizing to reach the moderate cooling performance. Thermal conductivity is applied during the boundary condition. Fig. 1 shows the geometry view.

4.4 Mesh Generation:

- Implement the model in to Solid work.
- Import the geometry in ANSYS steady state thermal.
- Generate mesh.
- Set up the analysis by providing boundary conditions such as temperature, thermal conductivity.
- Monitor and then control the solver to get approximate analysis of fin which involves the heat flux variation on the material
- Visualize the results and create a report.

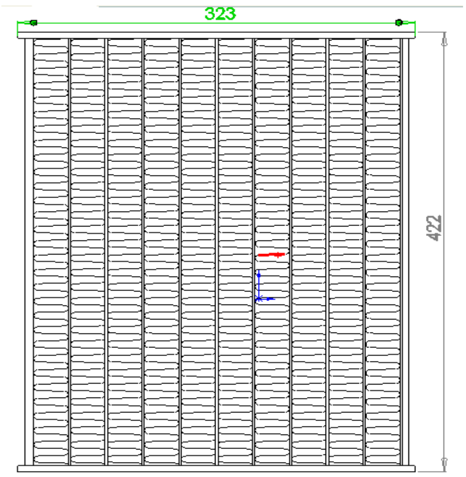

Fig. 1 Radiator Solid Model

Solid mesh has been generated using tetrahedral elements. Fig 2 shows the meshed region. In finite element analysis there is only limited possibility to do calculation for limited points and then interpolation has been done for the result [1]. 2D meshing is carried out by the thickness applied to the top and bottom of the element. Meshing was carried on mid surface. Before your geometry presentation check free edge, scar lines, duplicate surface, and intersection of any parts.

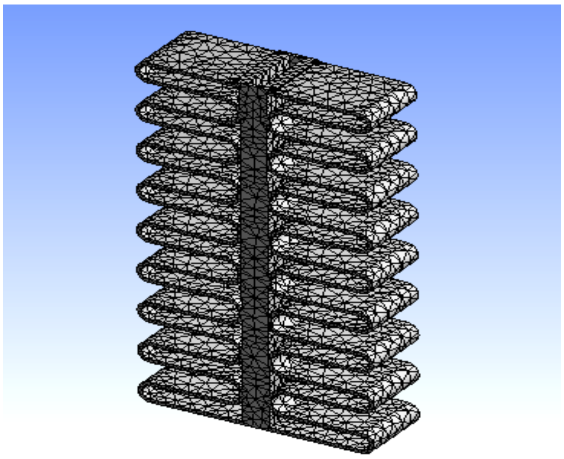

Fig. 2 Mesh region

5. FIN MATERIAL

The material used for the fin construction is discussed.

5.1 Copper and its alloy

Copper haves the thermally characteristics high compared to the Al, brass. It includes corrosion resistance, bio fouling resistance, maximum allowable stress and internal pressure, creep rupture, fatigue strength, thermal expansion, alloy ability, ease of fabrication and ease of joining.

5.2 Aluminum and its alloy

Usually, Aluminum is referred for fin design. It has the ability to emit heat effectively. Because of its light weight quality it is easier to install. It is noncorrosive. Aluminium2014, Aluminium6061, Aluminium6013 are various alloys of aluminum.

5.3 Brass

Brass belongs to the copper zinc alloy. It can be recycled. Aluminum, lead and silicon blended with brass to enhance the corrosion resistance. Problems occur is season cracking in brass. Alpha, beta, gamma and white brass are its types.

6. Boundary Condition and Results

Parameters	Brass	Copper alloy	Aluminum alloy
TEMPERATURE	150	138	145
TOTAL HEAT FLUX	0.141	0.143	0.142

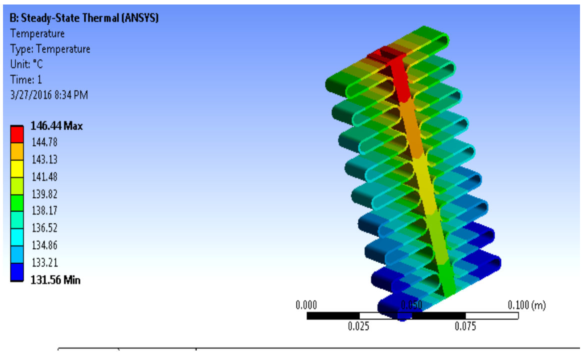

Fig. 3 Aluminium Alloy Temperature

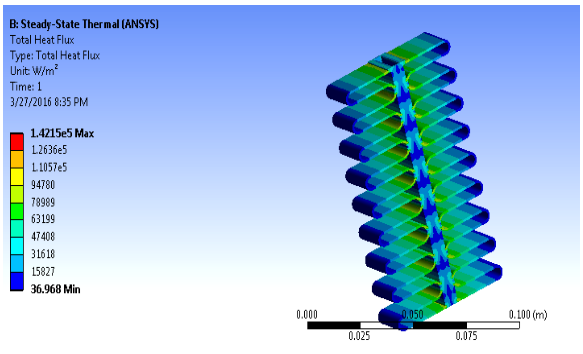

Fig. 4 Aluminium Alloy Heat flux

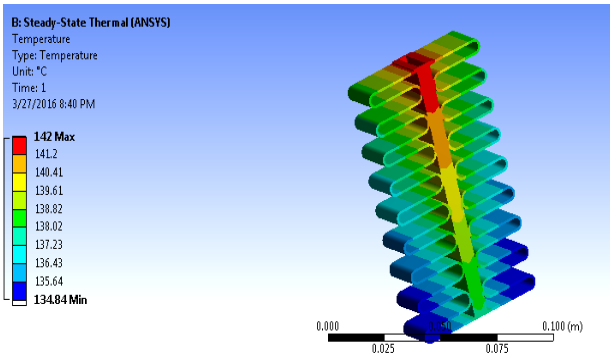

Fig. 5 Copper Alloy Temperature

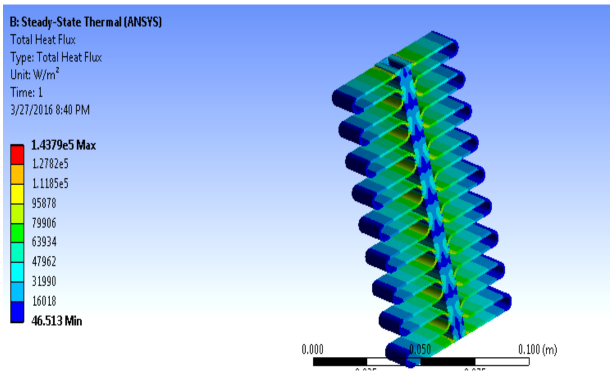

Fig. 6 Copper Alloy Heat Flux

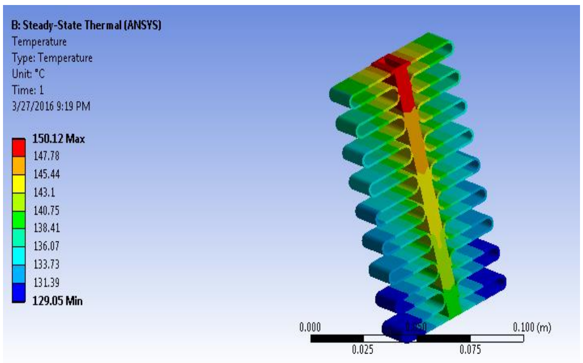

Fig. 7 Brass Temperature

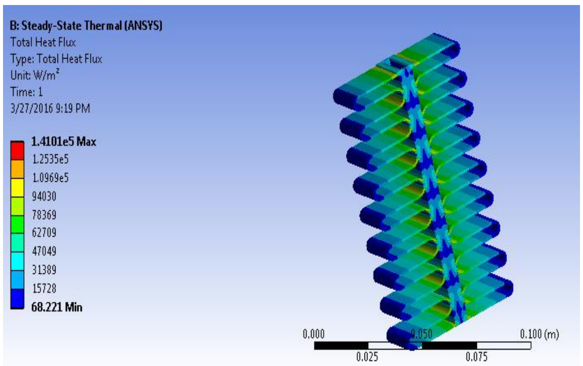

Fig. 8 Brass Heat flux

Fig. 9 Heat flux for Al alloy, cu alloy and brass

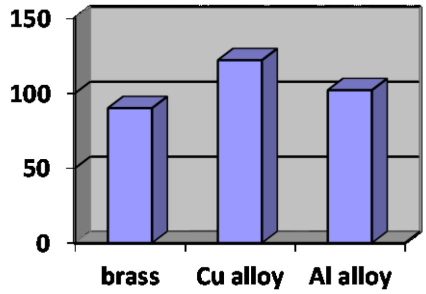

Fig. 10 Temperature variation for Al alloy, Cu alloy, Brass

7. RESULTS AND DISCUSSION

Aluminum alloy has results in temperature variation above 145 degree Celsius. Aluminum alloy has heat flux value 0.142w/m^2. For increasing length of fins, heat transfer value will be in the range of 740 watts.

The second material Copper alloy temperature is in the range of 145 degree Celsius. Copper alloy accommodates the heat transfer range above 1000 watts.

Temperature variation is 150°C for brass when compared to that Al and Cu alloy. Transfer of heat is in the range above 635 Watts for brass.

The Aluminum alloy embedded in aircraft skin material is determined to have good heat transfer compared to the car radiator fin material [6]. But its cost tends to be in average range compared to the brass and copper alloy. The oxidation stage leads to the lixiviation corrosion in brass material.

8. CONCLUSIONS

The efficiency of the internal combustion engine, cooling system depends mainly on the performance of its units. On the performance comparability it has revealed that copper alloy is more effective then the aluminum alloy fin. Aluminum alloy is best in the manufacture based on economy status.

Nowadays Copper alloy is promoted for the radiator construction in truck and cars. Copper consumes low energy in the manufacturing process and in refining also. Therefore they indulged in the environment protection by their recyclability process.

Brass is recommended for its thermal capacity range and better dissipation of heat. Dihatsu siron cooling system provides the suitable working conditions for the heat dissipation.

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