International Journal of Advanced Technology in Engineering and Science
Vol. No.5, Issue No. 07, July 2017
www.ijates.com
ijates
ISSN 2348 - 7550

Design & Analysis of Radiator

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ABSTRACT

Many researchers & scientist started working for making the arrangement to dissipate the heat of considerable amount to avoid such bigger problem otherwise engine will seize. After a lot of research work on different types of materials to conduct the heat efficiently they came to conclusion that copper is the best material having good thermal conductivity of 385 watt/m-K can be used in the form of heat exchanger & finally they designed a radiator called "COPPER RADIATOR".

Attempts have been tried on different kinds of materials & finally found that Aluminium can solve our problem & it will meet most of our objectives & requirements. So, finally it has been decided to make "Aluminium Radiator" in place of Copper radiators which will give benefits in performance, reliability, cost, availability, easy in handling & manufacturing.

The result obtained has been summarized as below: (a) Aluminium Radiator is able to transfer the heat of 27.95 KW same as Copper Radiator. This is the 1/3rd amount of heat generated in the engine to be dissipated. (b) Cost Reduction of Amount Rs 1923/- it is about 49% saving against existing cost of Copper Radiator. (c) Weight Reduction of 5 Kg, it is 52.08% reduction in weight due to use of Aluminium Radiator.(d) Reliability & Field Performance is as per copper Radiator, there is no field failure within the warranty period in all types of applications.

I. INTRODUCTION

Modern automotive internal combustion engines generate a huge amount of heat. This heat is created when the gasoline and air mixture is ignited in the combustion chamber. This explosion causes the piston to be forced down inside the engine, levering the connecting rods, and turning the crankshaft, creating power. Metal temperatures around the combustion chamber can exceed 1000° F. In order to prevent the overheating of the engine oil, cylinder walls, pistons, valves, and other components by these extreme temperatures, it is necessary to effectively dispose of the heat. It has been stated that a typical average-sized vehicle can generate enough heat to keep a 5-room house comfortably warm during zero degree weather (and I'm not talking about using the exhaust pipe). Approximately 1/3 of the heat in combustion is converted into power to drive the vehicle and its accessories.

Another 1/3 of the heat is carried off into the atmosphere through the exhaust system. The remaining 1/3 must be removed from the engine by the cooling system. Modern automotive engines have basically dumped the Air Cooled System for the more effective Liquid Cooled System to handle the job. In a liquid cooled system, heat is carried away by the use of a heat absorbing coolant that circulates through the engine, especially around the combustion chamber in the cylinder head area of the engine block. The coolant is pumped through the engine, then after absorbing the heat of combustion is circulated to the radiator where the heat is transferred to the atmosphere. The cooled liquid is then transferred back into the engine to repeat the process. Excessive cooling system capacity can also be harmful, and may affect engine life and performance. You must understand that coolant temperatures also affect oil temperatures and more engine wear occurs when the engine oil is below 190° F. An effective cooling system controls the engine temperature within a

Specific range so that the engine stays within peak performance.

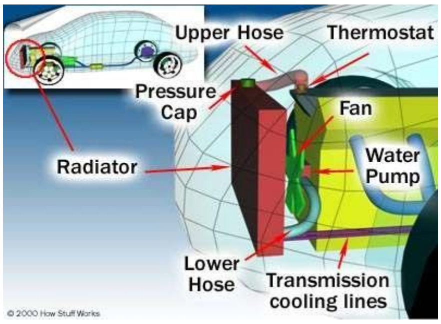

FiG.1 cooling system

II. COOLING SYSTEM TYPES

2.1 Air Cooling- Some older cars, motorcycle and very few modern cars, are air-cooled. Instead of circulating fluid through the engine, the engine block is covered in aluminum fins that conduct the heat away from the cylinder. A powerful fan forces air over these fins, which cools the engine by transferring the heat to the air.Since most cars are liquid-cooled, we will focus on that system in this project.

2.2 Liquid Cooling System- Figer illustrates the cooling system components, and in these sections we'll talk about each part of the system in more detail.

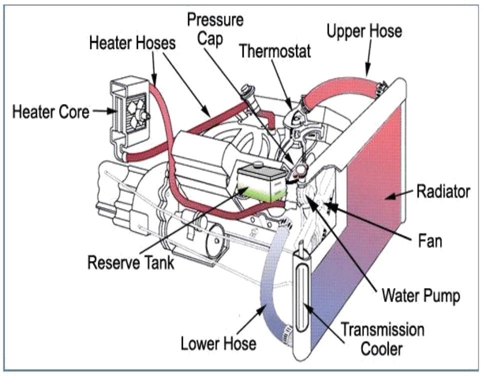

Fig.2 cooling system components

III. RADIATOR

Radiators are heat exchangers used for cooling internal combustion engines, mainly in automobiles but also in piston-engine aircraft, railway locomotives or any similar use of such an engine.

Internal combustion engines are often cooled by circulating a liquid called engine coolent through the engineblock, where it is heated, then through a radiator where it loses heat to the atmosphere, and then returned to the engine. Engine coolant is usually water-based, but may also be oil. It is common to employ a water pump to force the engine coolant to circulate, and also for an axial fan to force air through the radiator.

IV. PROJECT OBJECTIVES

1. Studying a sub-module such as the cooling system in order to absorb its technology for the purpose of future technology transfer in auto industry.
2. Testing how the redesigned cooling system will work due to design and material properties restriction using finite element software.
3. Developing of a Finite-element model of a radiator to simulate different boundaries and loading conditions.
4. Using the developed model to simulate and evaluate the thermal loading on the radiator.

V. METHODOLOGY

1. Measuring all the radiator's dimensions and features using reverse engineering tool system.
2. Developing the radiator's solid model using Solid Works software.
3. Developing a finite-element model using COSMOS Works, considered at different loading and boundary conditions on the model.
4. Evaluate the radiator's performance with Aluminum and Copper Finite-element models.
5. Modify the radiator tubes and fins design and evaluate its performance using Finite-element model.

VI. CSMOS WORK

COSMOS Works Designer is a software used for the definition, preparation and visualization of all the data related to a numerical simulation. This data includes definition of the material, geometry, boundary conditions and other parameters. All material and conditions are defined by the user. The meshing is done by the program itself once the problem has been defined.

VII. RADIATOR SOLID MODEL DEVELOPMENT

The radiator consists of forty eight Aluminum tube, thin fins between the tubes and two plastic covers. The radiator consists of forty five aluminum tube, fins between tubes, upper & lower cover had been made from plastic. The overall dimensions of radiator assembly were obtained. Next, radiator disassembly is carried to measure and obtain the actual dimensions to be used in solid model development. To increase the performance of computer during solid model development, it is decided to reduce number of tubes to nine

Fig.3 radiator The Radiator Core

It is made from Aluminum and consists of forty eight tubes. The general out dimensions of radiator core is : 17 * 323 * 422 mm

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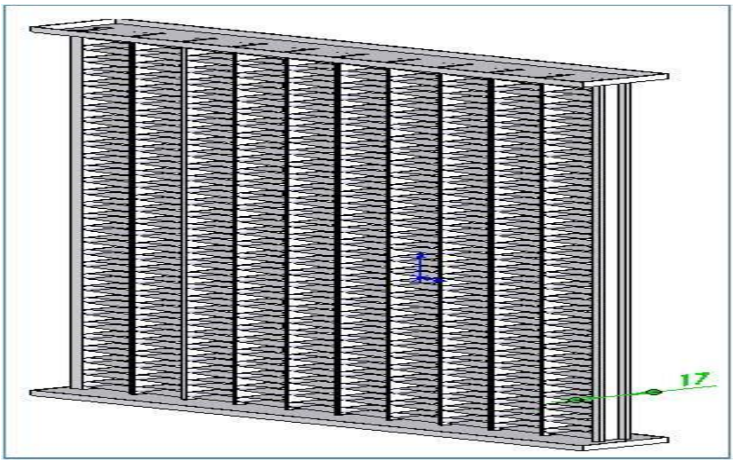


Fig.4 Radiator core model

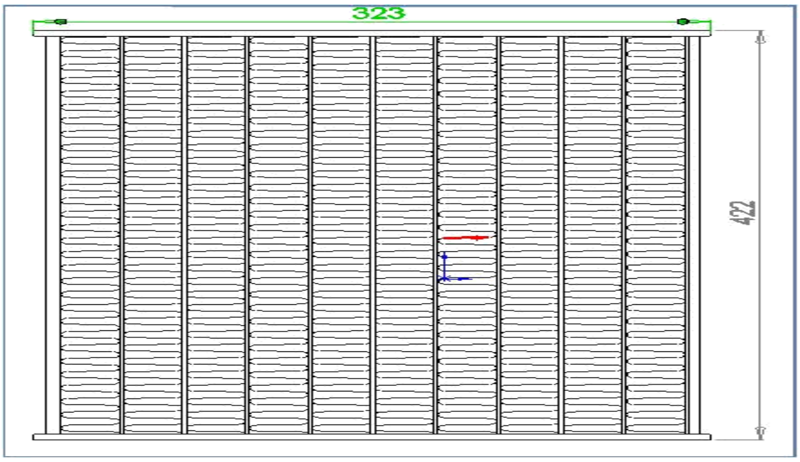


Fig.5 Radiator (front view)

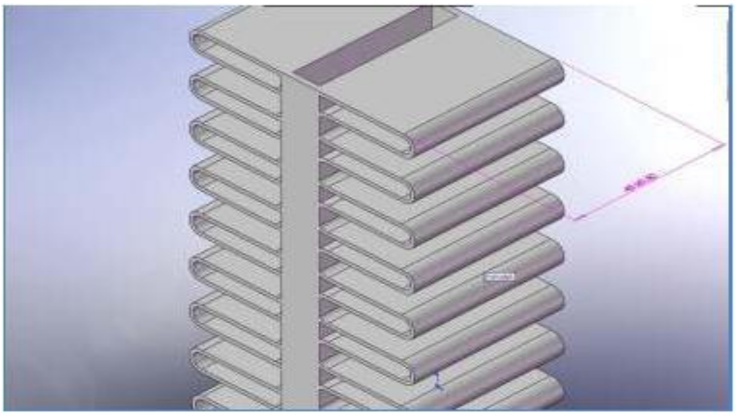


Fig.6 Radiator tube and fin model

VIII. FINITE-FINITE- ELEMENT ANALYSIS

Radiator tube and fins will be used through the finite-element analysis in this chapter. Aluminum Alloy: 1060 Alloy

Specifications

Copper Alloy :

Specifications:

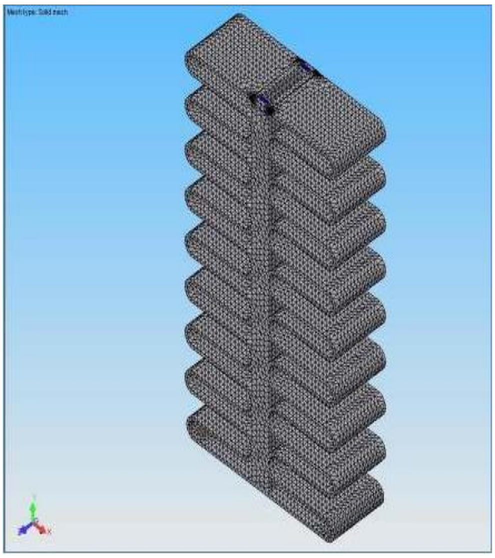
Description	Value	Units
Elastic modulus	1.10E+11	N/m^2
Poisson ratio	0.37	
Shear modulus	4 E+10	N/m^2
Mass density	8900	Kg/m^3
Tensile strength	394380000	N/m^2
Yield strength	258646000	N/m^2
Thermal expansion Coefficient	2.40E-005	/kelvin
Thermal conductivity	390	W/(m.K)
Specific heat	390	J/(kg.K)

IX. MESH GENERATION

Solid mesh has been generated using Tetrahedral elements.

Total number of Nodes = 1154165

Total number of Elements = 75974. The mesh has been done by COSMOS Works software.



X. COMPUTATION

Steady State Analysis has been done using a desktop computer with specification: P4, CPU 3.2 GHz and 512 GB of RAM. The computation running time is 30 minutes. Fig (25-27) shows the temperature for Aluminum and Copper tube temperature. The figures show that the Cooper radiator has dropped the water temperature by (3.56 %.) comparing with the Aluminum radiator. Fig.(28) shows the contour of temperature distribution in the Aluminum radiator, The figure demonstrate that the temperatures is higher in the upper section of the radiator and lower in the bottom section due to the water flow and the effect of forced convection induced by the fan. Fig.(27) shows that the Copper radiator is more efficient than aluminum one. Since, it resulted in reducing the radiator water temperature by 3.56% .It’s recommended to use Copper radiator rather than Aluminum radiator due to higher temperature drop

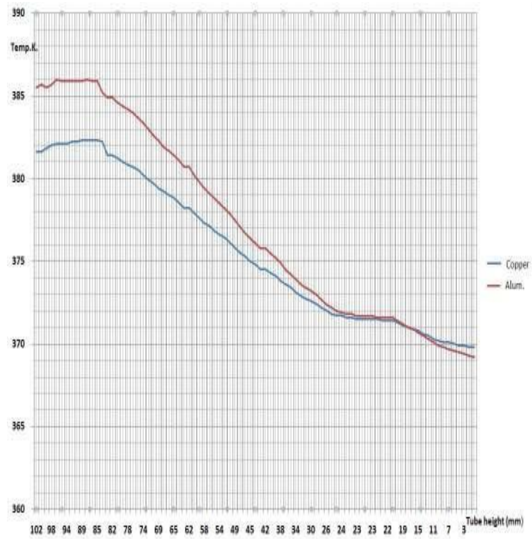


Fig.7 Alu and copper heat distribution

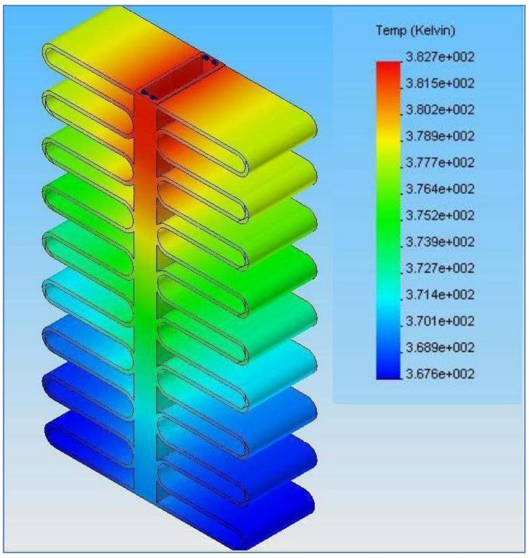


Fig.8 Alu Temp Distribution

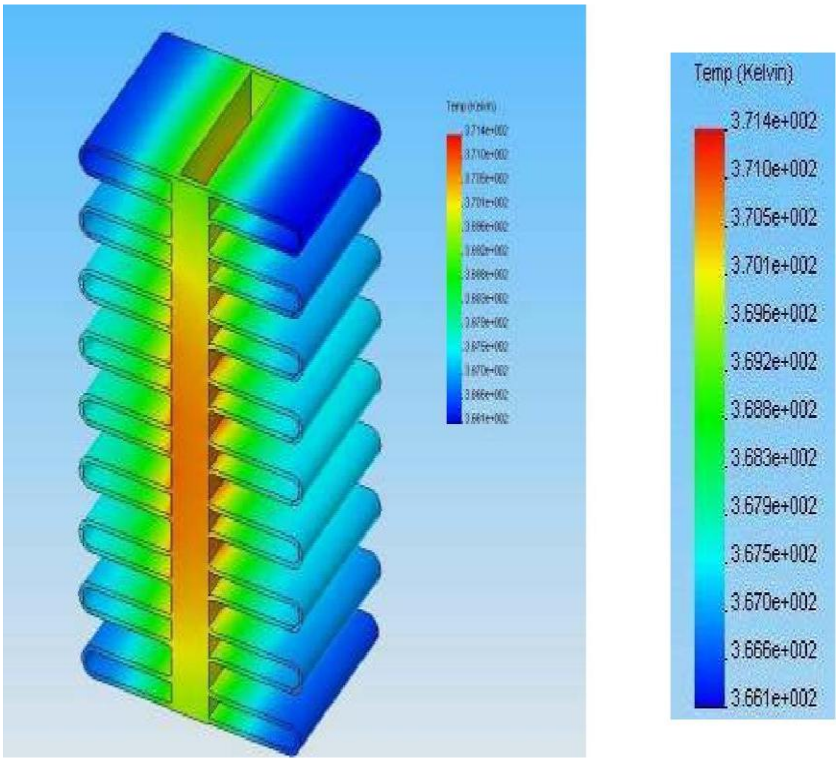


Fig.9 Copper Temp Distribution

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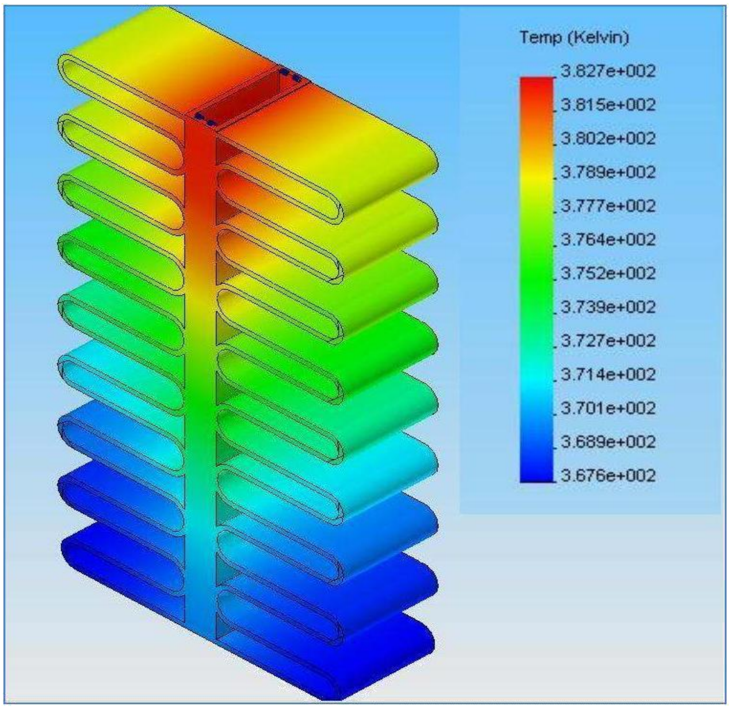

X. IMPROVING THE RADIATOR ALUMINUM MODEL

In current investigation, the depth of radiator tube is increased from 20 mm to 40 mm to increase the area which will increase the rate of heat transfer to the air as well .The dimensions are shown in figure (30).

Material: Aluminum Alloy

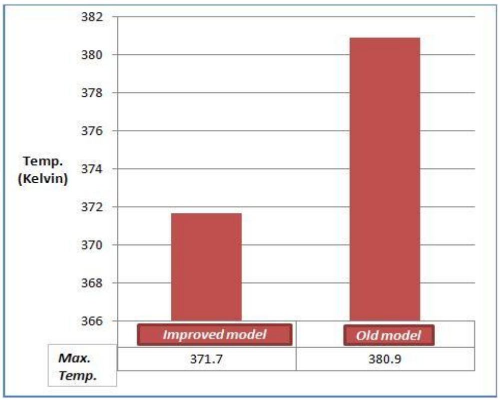

Fig.10 improve model heat distribution

The improved design has reduced the maximum temperature by 3.9 % as shown in fig.(31)

XI. RESULTS AND DISCUSION

The reverse engineering has been implemented throughout the present work, in order to achieve design analysis and improvement for the car radiator element.

A comparison has been carried out in chapter three between Aluminum and Copper alloy radiator models.

It is found that Copper radiator is more efficient when compared with the Aluminum radiator due to higher temperature drop (3.56 %.). However, The Aluminum radiator is much cheaper.

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A new design of the radiator has been proposed. The radiator dimensions were changed by increasing the width from 20 mm to 40 mm. And this change has reduced in reducing the maximum temperature by 3.9 %.

XII. CONCLUSION AND RECOMMENDATION

The efficiency of the internal combustion engine cooling system depends mainly on the performance of its units. The main unit in this system is the radiator.

It is reported that Copper radiator is more efficient when compared with the Aluminum radiator due to higher temperature drop. However, The Aluminum radiator is much cheaper.

It's recommended to use Copper radiator rather than Aluminum radiator due to higher temperature drop .Aluminum radiator is recommended due to lower cost.

Also the modified design is preferred due to low temperature where as the old model is preferred due to low cost and low weight.

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