Modeling Of Automotive Radiator by Varying Structure of Fin and Coolant

P.Sivashankari, K.R.Kavitha, J. Lilly Mercy, A.Krishnamoorthy, S.Prakash

Abstract: 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 designed to service in four wheeler and heavy duty vehicles. The radiator is always a origin of heat to its environment, although this may be for either the function for cooling the fluid or of heating this environment, or coolant supplied to it, as for engine cooling. In existing plain fins type radiator are commonly used, which are usually set up in a cross flow arrangement made up of aluminum and copper alloy. Powerful fan and water pump is accompanied in this to greatly improve heat dissipation rate. The addition of fins is one of the way to improve and increase the rate of radiator cooling. This method follow the principle of increasing contact surface. Contact surface can also be increased by varying fin geometrical structure. In this project simple modification has been carried out in the existing fin geometry with a view to improve its heat dissipated rate. Also comparison of conventional coolant with Nanofluids has been carried out by using PTC Creo 3.0 and analysis is carried out by using Ansys v16. The result are compared and optimum fin design is concluded.

I. INTRODUCTION

A huge amount of heat is generated from Modern automotive internal combustion engines. This heat is created[8-10], when the gasoline and air mixture is ignited in the combustion chamber. This outburst causes the piston to be forced from TDC to BDC in the combustion chamber, pulling the connecting rods, and spinning the crankshaft, generating the 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[16] and other components by these extreme temperatures, it is necessary to effectively dispose of the heat[11-13]. It has been proved that a ordinary averaged sized car can produce enough heat to manage a house of five room comfortably warm during zero degree on cold weather. Approximately 25% of the heat in combustion is converted into power to drive the vehicle and its accessories as shown figure 1.

II. LITERATURE SURVEY

The author explain about the usage of Al2O3 Nanofluids as the coolant in radiator. It improves the effectiveness of the cooling by 20% when compared to air and water cooling system.

The work explains about the usage of water and mono Ethylene Glycol with the ratio of 50:50 proportionality, the process of preparing the Nanofluids is done by Ultra- Sonication. It was observed that the heat transfer is about 30% rise.

The paper explains about the usage of the propylene Glycol Brine as the coolant for the radiators. It improves the cooling effect of radiator up to 25% when compared with water. By using propylene Glycol Brine as coolant, it improves the performance and minimise the fuel consumption and emission, which is economical and eco-friendly. The analysis is carried out in rectangular and Flat tube Fin.

The work explains about changing the dimension of the tube for liquid cooling system. By reducing the pressure, the corresponding temperature is also reduced which is effective in the performance of the cooling system in the radiator.

The plastic fibres are used as the radiator material to reduce the heat. The dimension has been reduced to obtain better cooling effect. The heat transfer performance and pressure drop are studied and proved to reduce the temperature from 60°C to 20°C.

III. METHODOLOGY

The methodology of the work are as follows and the flowchart of the work is mentioned.
in figure 3. Proposing new radiator fin design. Developing the radiator’s solid model using PTC Creo Software. Developing a finite-element model using Ansys software. Evaluate the radiator’s performance with convention and Nanofluids coolant.

### A. Radiator Fins Solid Model Development

Radiator is mounted on the present heavy vehicle diesel engine is cross flow compact heat exchanger. Radiator consist of 625 tube made of brass and 346 continues fins of 0.2mm thick made of aluminium alloy 6061. For the modelling and analysis purpose the 625 tube is reduced to 16 tubes and 346 fins is reduced to 8 fins which give same result in the specific ratio.

#### Fig. 3. Methodology

Existing model in figure 4, is dimensioned with tube inner and outer diameter of 10mm and 8mm respectively and the plain fin is of 2mm thick and 100mm in length and width. This model consist of 8 fin at 8mm apart. The model radiator plain fin are usually used in all automotive radiator for their easy construction.

#### Proposed model 1 in figure 5, is dimensioned with tube inner and outer diameter of 10mm and 8mm respectively and the fin is of 2mm thick and 100mm in length and width. It consist of hollow rectangular box shape structure in top of the plain fin of dimension 6mm length and 7.2mm height. This model consist of 8 fin at 8mm apart.

#### Proposed model 2 in figure 6, is dimensioned with tube inner and outer diameter of 10mm and 8mm respectively and the fin is of 2mm thick and 100mm in length and width. It consist of hollow triangular shape structure in top of the plain fin of dimension 6mm length and 7.2mm height. This model consist of 8 fin at 8mm apart.

#### Proposed model 3 in figure 7, is dimensioned with tube inner and outer diameter of 10mm and 8mm respectively and the fin is of 2mm thick and 100mm in length and width. It consist of hollow cylindrical shape structure in top of the plain fin of dimension 6mm length, 7.2mm height and radius of 3mm. This model consist of 8 fin at 8mm apart.

### B. Radiator Fins Solid Model Modelling

Modelling has been done using PTC Creo 3.0 in desktop environment with specification: i3 processor. Solid model of the existing model as shown in figure 8, is modelled using solid model software. The fin is modelled using extrude feature and the tube is modelled using sweep feature. The fin is patterned with 8 segments with 8mm apart in directional method. This model has less contact surface as compared to other proposed model but has more space in between for air to flow freely. The main advantage of existing model is it easy construction when compared to other types.
Solid model of the proposed model 1 as shown in figure 9, is modelled using solid model software. The fin is modelled using extrude feature and the tube is modelled using sweep feature. The fin is patterned with 8 segments with 8mm apart in directional method. This model has more contact surface as compared to previous existing type and less air flow region.

Solid model of the proposed model 2 as shown in figure 10, is modelled using solid model software. The fin is modelled using extrude feature and the tube is modelled using sweep feature. The fin is patterned with 8 segments with 8mm apart in directional method. Proposed model 2 as less contact surface than proposed model 1 but more space for air flow due to its geometrical structure.

Solid model of the proposed model 3 as shown in figure 3.8, is modelled using solid model software. The fin is modelled using extrude feature and the tube is modelled using sweep feature. The fin is patterned with 8 segments with 8mm apart in directional method.

C. Material Properties

Two material are used for radiator, Aluminium alloy 6061 for fins and Copper alloy brass for tube. As per ASTM(American Society For Testing and Materials) standards, the specification are tabulated below.

| Description       | Value For Al 6061 | Value For Brass |
|-------------------|------------------|-----------------|
| Density           | 2.7              | 8.70            |
| Specific Heat     | 0.896            | 0.380           |
| Capacitity (J/g-°C) | 167              | 111             |
| Thermal Conductivity | 582 - 652       | 900-940         |
| Melting Point     | 0.33             | 0.331           |
| Poisson ratio     | 70               | 110             |
| Modulus of Elasticity | 70             | 38              |
| Thermal Diffusivity | 32.4            | 20.8            |

D. Coolant Properties

Two coolant will be used for analysis purpose, conventional coolant(water) and SiC Nanofluids. The inlet temperature of the coolant is taken as 375K (101.85ºC) which is the temperature at which thermostat of the radiator fully opens.

| Description       | Air | Water | SiC |
|-------------------|-----|-------|-----|
| Inlet Temperature (°C) | 35  | 101.85 | 101.85 |
| Mass flow rate (kg/hr) | 525.35 | 100   | 100  |
| Specific Heat (kJ/kg-°C) | 1   | 4.187 | 2333.81 |
| Thermal Conductivity (W/mK) | 0.024 | 0.66 | 0.9769 |
| Density (kg/m3)    | 1.1 | 1000  | 1233.14 |

E. Mesh Generation

Solid mesh has been generated using Ansys 16.0 with configuration as relevance ce centre as fine, smoothing as high, as referred in Figure.12.

- Total number of Nodes (Normal type fin) = 94556
- Total number of Nodes (Box type fin) = 125140
- Total number of Nodes (Sharp type fin) = 135620
- Total number of Elements (Normal type fin) = 50485
- Total number of Elements (Box type fin) = 63493
- Total number of Elements (Sharp type fin) = 68453
- Total number of Elements (Round type fin) = 71789.
The analysis report of the work are as follows.

As illustrated in Figure 13, it can be interpreted that there is temperature drop from 375K to 368.07K i.e., 6.93K in the existing model fin. This model has less contact surface as compared to other proposed model but has more space in between for air to flow freely.

As referred in figure 14, it can be interpreted that there is temperature drop from 375K to 364.01K i.e., 12.9K in proposed model 3(Round type fin). Proposed model 3 has large contact surface than the existing and previous two proposed model as the result temperature is drop is high in proposed model 3.

As referred in figure. 16, it can be interpreted that there is temperature drop from 375K to 362.1K i.e., 12.9K in proposed model 3(Round type fin). Proposed model 3 has large contact surface than the existing and previous two proposed model as the result temperature is drop is high in proposed model 3.

As referred in Figure 15, it can be interpreted that there is temperature drop from 375K to 365.51K i.e., 9.5K in proposed model 2(Sharp type fin). Proposed model 2 as less contact surface than proposed model 1 but more space for air flow due to its geometrical structure. But the simulation result reports that temperature drop is slightly less when compared to proposed model 1.

As referred in figure. 17, it refers to the Nanofluids used as coolant for the normal type fin. It can interpreted that there is heat dissipation from 375K to 360.67K i.e., 14.33K in the existing model fin. This model has less contact surface as compared to other proposed model but has more space in between for air to flow freely. And use of nanofluid increased heat dissipation rate when compared to existing model using water as coolant.

F. Analysis With SiC Nanofluids As Coolant

The figure. 17, refers to the Nanofluids used as coolant for the normal type fin. It can interpreted that there is heat dissipation from 375K to 360.67K i.e., 14.33K in the existing model fin. This model has less contact surface as compared to other proposed model but has more space in between for air to flow freely. And use of nanofluid increased heat dissipation rate when compared to existing model using water as coolant.
Fig. 17. Variation Of Coolant(Nano fluid) Temperature In Normal Type Fin

The figure. 18, refers to the box type fin and the coolant used is SiC, it can be interpreted that there is heat dissipation from 375K to 353.64K i.e., 21.36K in proposed model 1(Box type fin). This model has more contact surface as compared to previous existing type and by use of nano fluid as coolant there is a significant temperature drop seen.

Fig. 18. Variation Of Coolant(Nanofluid) Temperature In Box Type Fin

In the figure. 19, the analysis is made for the sharp type fin using SiC as coolant, it can be interpreted that there is heat dissipation from 375K to 353.64K i.e., 21.36K in proposed model 1(Sharp type fin). Proposed model 2 as less contact surface than proposed model 1 but more space for air flow due to its geometrical structure and Nanofluids helps in having more heat drop than the previous two model.

Fig. 19 Variation Of Coolant(Nanofluids) Temperature In Sharp Type Fin

Figure. 20 refers to the round type fin, it can be interpreted that there is temperature drop from 375K to 349.44K i.e., 25.56K in proposed model 3(Round type fin). Proposed model 3 has large contact surface than the existing and previous two proposed model and with high heat transfer effect of Nanofluids there is a high temperature drop in proposed model 3.

Fig.20. Variation Of Coolant(Nanofluids) Temperature In Round Type Fin

IV. RESULT AND DISCUSSION

It is concluded that the simulation with different geometrical fin along with conventional coolant (water) shows that the structure with larger surface area has more heat dissipation rate than the other. Round type fin has 3.47% heat drop followed by box type fin with 2.94%, sharp type fin with 2.54% and normal type fin with 1.85%. Temperature drop in round type fin is 1.62% more than existing plain fin type, as mentioned in figure. 21.

Figure. 21 Temperature Variation Of Radiator With Water As Coolant

It is concluded that the simulation with different geometrical fin along with conventional coolant (water) shows that the structure with larger surface area has more heat dissipation rate than the other. Round type fin has 3.47% heat drop followed by box type fin with 2.94%, sharp type fin with 2.54% and normal type fin with 1.85%. Temperature drop in round type fin is 1.62% more than existing plain fin type, as referred in figure. 22.
It is concluded that the simulation with different geometrical fin along with Nanofluids coolant shows that the structure with larger surface area has more heat dissipation rate than the other. Round type fin has 6.82% heat drop followed by box type fin with 5.7%, sharp type fin with 5.44% and normal type fin with 3.83%. Temperature drop in round type fin is 2.99% more than existing plain fin type, as illustrated in figure. 23. Hence the temperature loss is across the water tube length and using coolant in the form of nano fluid.

Whenever the tubes experience friction, there will be pressure loss across the tubes. As there are number of tubes and in each tube input pressure and output pressure vary from each other, we get a graph of pressure variation along the tube length.

As referred in figure. 26, There is a regular drop in pressure along the length of the tube. Pressure drop start at 538 Pa.

### V. CONCLUSION

The analysis of the automotive radiator with Nanofluids and conventional coolant in different geometrical structure of fin is successfully carried out. The variations in the pressure, temperature is analysed.
From simulation of the radiator fins with conventional coolant (water) as coolant it is found that heat drop from 375K to 362.1K i.e. 3.47% for round type fin followed by box type fin from 375K to 364.01K i.e. 2.94%, sharp type fin from 375K to 365.1K i.e. 2.54% and normal type fin from 375K to 368.07K i.e. 1.85%. Round type fin show high temperature drop in the simulation.

From simulation of the radiator fins with SiC Nanofluids as coolant it is found that heat drop from 375K to 349.44K i.e. 6.82% for round type fin followed by box type fin from 375K to 353.64K i.e. 5.7%, sharp type fin from 375K to 354.59K 5.44% and normal type fin from 375K to 360.67K i.e. 3.83%. Round type fin show high temperature drop in the simulation.

From both the above simulation it is found out that temperature drop is high in radiator with large contact surface that is round type fin and further this heat dissipation can be increased by application of Nanofluids as coolant. In application of SiC Nanofluids the temperature drop is approximately twice the amount of conventional coolant (water). And pressure drop is at 538Pa. Use of different Nanofluids give result in different ratio. Increasing contact surface area largely also tends to reduce air contact surface which leads to poor cooling.

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### Modeling Of Automotive Radiator by varying structure of Fin and Coolant

**Professor Prakash Subramaniam** graduated from P.S.G.College of Technology in 1990 from Bharathiyar University and post graduated from Madras University in 2000. He received his Dr. Eng. degree from Sathyabama University in 2011. He has been with the Department of Mechanical & Production Engineering at the Sathyabama University of Chennai since 1998. His research interests include Machining of Composites, Modelling and Optimization in manufacturing process. He has received four times Best Faculty Award from Sathyabama University for Teaching and Key note speaker in various International Conferences, CII – Chennai. He is Chairman of Indian Institute of Production Engineers (IIPE) Chennai chapter. He has also visited Malaysia for attending CDIO meeting. He has authored more than 65 journal and conference papers. Currently, he is also a Dean –School of Mechanical Engineering in Sathyabama University. He also one of the member in Board of Management in Sathyabama University.

**Dr. Arunagiri Krishnamoorthy** is working as a Professor of Mechanical Engineering in Sathyabama Institute of Science and Technology, Chennai, India. He has around 17 years of industry experience and 23 years of teaching and research experience. His areas of interest are machining and analysis of composite materials, optimization and material characterization.