Design and Analysis of an Automobile Radiator with and without Louvered Fins

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Abstract – Radiators are heat exchanging devices used to transfer thermal energy from one medium to another for the sole purpose of cooling and heating. The majority of radiators are constructed to be used in cars, buildings, and electronics. In this thesis, the present design of the automobile radiator was analyzed. Further, the design is modified by adding louvers and varying the pitch of louvers. The performance of the modified designs is validated by performing fluid flow analysis.

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1- INTRODUCTION

For cooling, radiators transfer thermal energy from one medium to another. Radiators are used to cool internal combustion engines, which are found mostly in automobiles but also in piston-engine aircraft, railway locomotives, motorbikes, and stationary power plants. The radiator distributes heat from the fluid inside to the air outside, cooling the fluid and cooling the engine as a result. The vast majority of radiators are designed for use in automobiles, buildings, and electronic devices. The radiator is always a source of heat to its surroundings, whether for the purpose of heating or cooling the fluid or coolant provided to it, as is the case with engine cooling. Radiators, despite their name, generally transport heat through convection rather than thermal radiation, however the term "convector" is used more narrowly.

Fig 1- Louvered fin radiator

II-METHODOLOGY

The following methodology is used to carry out the research work.

Conduct Literature survey
Study of present mechanisms used in radiator
Perform Calculation and Create a Model of Radiator
Perform a CFD analysis of Radiator
Compare the results of calculation and analysis

Fig 2-Research Methodology
III- CALCULATION OF HEAT TRANSFER RATE, AND AIR & COOLANT OUTLET TEMPERATURE

The heat transfer rate, air outlet & coolant outlet temperature are calculated and tabulated in the below table:

Table 1: Air Side calculations

| Sr. No. | Parameters                              | Value       |
|---------|-----------------------------------------|-------------|
| 1       | Coolant inlet Temperature               | 92 °C       |
| 2       | Air inlet Temperature                   | 27 °C       |
| 3       | Total surface area of fins (A_F)        | 3264464.3 mm² |
| 4       | Surface area of the tube between the fins (A_a) | 1178602.3 07 mm² |
| 5       | Area of the fins (A)                    | 4443066.6 07 mm² |
| 6       | Velocity of air, V_a                    | 17m/s       |
| 7       | Frontal area of the radiator through the air passes (A_FR) | 84815.5 mm² |
| 8       | Mass flow rate of air (m_a)             | 1.650934 kg/s |
| 9       | Reynolds no. for air Re_a               | 7005.3456 46 |
| 10      | Nusselt Numbers on Air Flow, Nua        | 66.288228 |
| 11      | Heat transfer coefficient, h_a          | 255.14163 9 w/m²k |
| 12      | Efficiency of the fins, η_f             | 0.999885    |
| 13      | Air-side heat transfer coefficient based on the total surface area, h_a' | 220.91623 9 w/m².k |

Table 2: Coolant Side Calculation

| Sr. No. | Parameters             | Value       |
|---------|------------------------|-------------|
| 1       | Coolant density, ρ_c   | 1070 3 kg/m |

Table 3: Air & Coolant Outlet Temperature

| Sr. No. | Parameters                              | Value       |
|---------|-----------------------------------------|-------------|
| 1       | Coolant outlet Temperatures (T_c,out)   | 77.53 °C   |
| 2       | Air outlet Temperature (T_a,o)          | 54.14416 °C |

IV-PARTS OF RADATOR

Radiator consist of several parts:

- Core
- Tanks
- Side Support
- Gasket
- Pressure Cap

Core:

A Heating Core is a Heat Exchanger that takes heat from the coolant as it passes through it in order to keep the engine temperature stable. This is commonly accomplished by transferring heat from heated coolant flowing through the tubes via the Inlet tank from the engine cooling jacket. The heat evacuated from the tube by the coolant is transferred to the ram air flowing over the fins.
Radiator core

Model of the radiator core

Parts of Core:

Tubes, fins, and header are all joined together mechanically using a hydraulic press to extend the tubes over the header, resulting in a locking. This mechanical locking is further secured by the use of epoxy resin, which forms a solid joint between the header and tubes.

- Header
- Tubes
- Fins
- Turbulators

Header:

Each radiator has two headers. Each tube protrudes through perforated plates known as headers. The header connects the fin and the tube, allowing the tanks to be mechanically attached to the aluminium core.

Round Tubes:

It is used to hold coolant: warm from the engine, bloodless again to the engine. The heat exchange is achieved via the tube wall and the fin, eliminated through the air passing via the radiator.

Fins:

Between each tube is a Fin, which is a flat strip of aluminium. It's a heat transfer medium that transfers heat from the coolant tubes to the air travelling through the radiator. The louvres are angular cuts on the fin surface that create turbulence in the air, increasing the amount of heat sucked up by the air and hence increasing the amount of heat rejected by the radiator. To enhance radiator efficiency, the louvres must be as large as feasible, but airsides pressure should be addressed because it rises with increasing louvre angle and might reduce radiator efficiency.

Turbulators:

The functions of turbulators are:

1. To enhance the turbulence inflow.
2. Increase the surface area inside the tube.
Turbulators

Tanks:
A coolant-filled radiator tank is a crucial structural component. It not only supports and links a radiator core to the car, but also the fan, motor, and shroud assembly (engine side), condenser, and perhaps transmission oil cooler, as well as power steering and hydraulic fan coolers. Each radiator contains two tanks: an inlet tank that receives hot coolant from the engine, and an outlet tank that receives cold coolant from the engine.

Side Support:
Two radiator side supports run parallel to the tubes, are crimped, and then brazed to the headers. The structure that keeps the fin tube matrix together is completed by side supports. It protects the radiator's first and last fins during handling prior to installation in a vehicle.

Gasket:
A radiator gasket helps in maintaining a leak-proof joint between tank and header. There are two gaskets per radiator.

Pressure Cap:
Pressure capes are placed on the radiator for multiple reasons.

The functions of the pressure cap are:
- Protect the radiator hoses
- Maintain the pressure in the cooling system
- Reduce cavitation
- Prevent or reduce surging.

It is very important to maintain constant pressure on the cooling system. The pressure should be near 103 kpa. In the case of Maruti 800 Pressure should not exceed 0.90 kgf/cm².

V- MODELLING OF RADIATOR

The modeling of the radiator is done by using Creo Parametric 8.0. The actual model of the Maruti 800 car radiator is measured and prepared in software.

VI- ANALYSIS OF RADIATOR

The heat transfer rates, thermal profiles, and overall efficiency of a Maruti 800 car's radiator are investigated and modelled. Creo Parametric 8.0 was used to create the model. To achieve the most accurate replica, all of the row's elements, including the hollow water tubes and fins, are recreated.

The goal is to do a CFD analysis of the radiator and replace the existing mechanism with a new one. The current mechanism is investigated first, and then the radiator design is adjusted to include louvred fins. The examination is done with air moving through the radiator at different speeds. The air velocity distribution over the radiator is calculated using ANSYS.
CONCLUSION

The following conclusions are marked from the above study:

- The geometric parameters of a louvred fin radiator, such as fin height, fin pitch, louvre angle, louvre pitch, and flow depth, have a significant impact on its performance.
- The flow regime over louvred fins is determined by frontal air velocity and louvre angle.
- With louver-directed flow, flow efficiency over louvred fins improves.
- Due to the lack of un-finned portions, 2D numerical models are insufficient to forecast the heat transfer coefficient. Both the heat transfer coefficient and the friction factor can be predicted using 3D numerical methods.
- As fin pitch increases, the friction factor (f) lowers.

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