International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 05 Issue: 03 | Mar-2018 www.irjet.net p-ISSN: 2395-0072

Performance Evaluation of Automobile Radiator

Ramesh. T[1], Karthik. E[2], Venkatesan. T[3], Brightson George[4]

[1] *ME-Department of Mechanical Engineering, Bannari Amman Institute of Technology, Sathyamangalam, Erode*
[2, 3, 4] *BE – Department of Mechanical Engineering, Bannari Amman Institute of Technology, Sathyamangalam, Erode*

---***---

Abstract - *Today's automobiles are getting equipped with high powered engines. The process of equipping such automobiles with this has necessitated the need for improving the cooling efficiency of its radiators. The present work aims on studying and analyzing the thermal behavior of automobile radiators. Both LMTD and ε – NTU methods are widely used for design and performance analysis of radiators. The flow behavior of coolant fluids in radiator tubes is of great importance to the design of radiators. In addition to the concentration on flow behavior of coolants in radiators this work also focuses on the geometrical aspects which are used in the core of radiators. Finally case studies of radiator prototypes are proposed which provides the thermal behavior of radiator for the various mass flow rates of coolant and air and surface area parameters. Finally this work provides an overall behavior report of automobile radiators working at usual range of conclusions have also been reported with the presence of case studies.*

***Key Words*: Automobile radiators, Thermal behavior, LMTD and ε – NTU**

1. INTRODUCTION

In an automobile, fuel and air produce power within the engine through combustion. Only a portion of the total generated power actually supplies the automobile with power the rest is wasted in the form of exhaust and heat. If this waste heat is not removed , the engine will become more hot, that results in overheating and viscosity breakdown of the lubricating oil, metal weakening of the overheated engine parts, and stress between engine parts resulting in quick wear of piston rings, connecting rod etc.

2. RADIATOR

Radiator is a device which provides exchange of heat between two fluids is at different temperatures. The function of the radiator is to transfer heat from the hot water flowing through the radiator tubes to the air flowing through the closely spaced thin plates outside attached to the tubes. A radiator consists of an upper tank, core & the lower (Collector) tank. Hot coolant from the engine enters the radiator at the top & is cooled by the cross flow of the air , while flowing down the radiator .The coolant collects in the collector tank from where it is pumped to the engine for cooling.

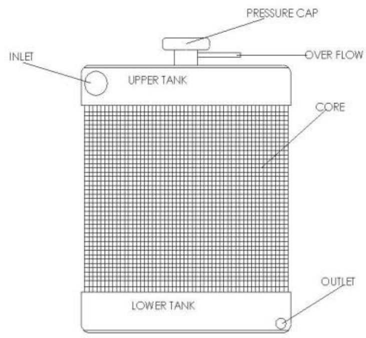

Fig. 1 TYPICAL RADIATOR

3. LITERATURE REVIEW

Trivedi and Vasava, illustrated the effect of Tube pitch for best configured radiator for optimum performance. Heat transfer increases as the surface area of the radiator assembly is increased.

P.K.Trivedi and N.B.Vasava in their study revealed that the velocity of the airflow through the radiator is a function of the vehicle speed and the "heat transferred by a radiator is a function of the airflow rate across the radiator" This paper presents a Computational Fluid Dynamics (CFD) modeling simulation of mass flow rate of air passing across the tubes of an automotive radiator. An introduction to mass flow rate and its significance was elaborated in order to understand the complications involved in the research and thereafter arrive at the objectives. Knowing the geometry of tube in radiator is the crucial application of CFD to numerically model and thereby analyze the simulation. The Air flow simulation is conducted using commercial software ANSYS

P. S. Amrutkar and S. R. Patil mentioned that the automotive radiator is key component of engine cooling system. Radiator thermal analysis consist sizing and rating of heat exchanger. Radiator size mainly depends on heat rejection requirement. Heat transfer calculations are important fundamentals to optimize radiator size. Automotive manufacturers use 1-D simulation software to decide radiator size. This paper focuses on thermal analysis of radiator theoretically using ε-NTU method and its validation by simulation approach.

Leong et al., described use of nano fluid based coolant in engine cooling system and its effect on cooling capacity. It is found that nano-fluid having higher thermal conductivity than base coolant like 50%/50% water and ethylene glycol.

Kishore, in his thesis dealt with enhancement of heat transfer for both laminar and turbulent flow conditions.

4. PROBLEM STATEMENT

Automotive engine cooling system takes care of excess heat produced during engine operation. It regulates engine surface temperature for engine optimum efficiency. Recent advancement in engine for power forced engine cooling system to develop new strategies to improve its performance efficiency. Also to reduce fuel consumption along with controlling engine emission to mitigate environmental pollution norms.

From the laws of thermodynamics, we know that heat transfer increases as we increase the surface area of the radiator assembly. That said, the demand for more powerful engines in smaller hood spaces has created a problem of insufficient rates of heat dissipation in automotive radiators. As a result, many radiators must be redesigned to be more compact while still having sufficient cooling power capabilities. This application proposes a new design for a smaller radiator assembly. The new design is capable of dissipating the same heat as the original, given a set of operating conditions.

The proposed work focuses on how to overcome the disadvantages of current radiator system which are related to size, weight, compactness, coolant flow arrangements and to achieve improvement. It consist study of geometric parameters of existing automobile radiator with its structure of tubes and core. Then development of prototypes of radiator based on existing tube structure. It includes the case studies of such prototypes which can form the basis to invent possible solutions on problems related to automotive engine cooling system.

5. EXPERIMENTAL SCHEME

The outlet of the radiator is connected to the oil storage tank. The oil storage tank is connected to the heater. This in turn is connected to the inlet of the radiator. For the flow purpose the centrifugal pump is used and for connection purpose the rubber hoses are used. The research work involves the analysis of cooling performance of radiator by introducing different nanoparticles and also by altering their usual design. This work follows the following layout.

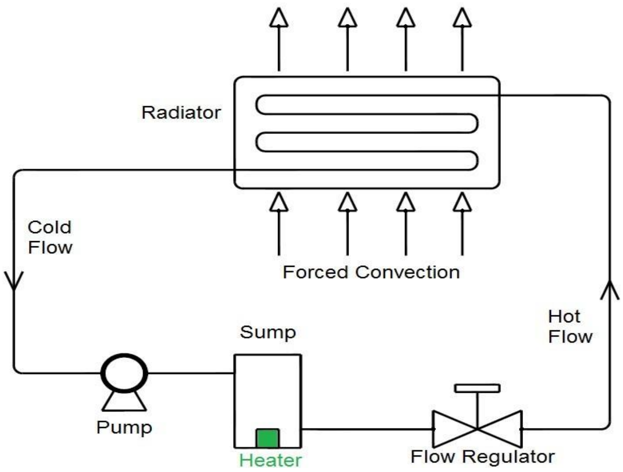

Fig. 2 Planned Experimental Layout [CAD Drawn]

The coolant enters the radiator in hot condition. The radiator distributes the hot coolant into its branched tubes where the coolant transfers its heat to the surroundings through the fins. The coolant leaves the radiator at a temperature just above the optimum temperature. This coolant is stored in the oil storage tank. From the storage tank the oil is taken through the engine's coolant jackets (here the engine is replaced by heater coils). As a result the coolant carries away the excess heat from the engine. This coolant in hot condition is taken to the radiator and the cycle continues.

6. DESIGN PARAMETERS

It is a simple method to use the Log Mean Temperature Difference (LMTD) method of heat exchanger analysis when the fluid inlet temperatures are known and the outlet temperatures are specified or readily determined from the energy balance expressions, as follows

$$q = \dot{m}_h c_{ph}(T_1 - T_2)$$

$$q = \dot{m}_c c_{pc}(t_2 - t_1)$$

$$=> t_2 = \frac{q}{\dot{m}_c c_{pc}} + t_1$$

$$q = UA\Delta T_{lm}$$

The value of ΔTlm for the exchanger may then be determined.

$$\Delta T_{lm} = \frac{(T_1 - t_2) - (T_2 - t_1)}{\ln[(T_1 - t_2)/(T_2 - t_1)]}$$

NTU METHOD

If only the inlet temperatures are known, use of the LMTD method requires a cumbersome iterative procedure.

$$NTU = \frac{UA}{C_{min}}$$

$$NTU = f\left(\varepsilon, \frac{C_{min}}{C_{max}}\right)$$

For cross flow with single pass and both fluids unmixed we have

$$\varepsilon = 1 - \exp\left[\left(\frac{1}{C_r}\right)(NTU)^{0.22}\{\exp[-C_r(NTU)^{0.78}] - 1\}\right]$$

Effectiveness of a single pass crossflow heat exchanger with both fluids unmixed

Generally,

$$C_h = \dot{m}_h C_{ph}$$

$$C_c = \dot{m}_c C_{pc}$$

To find Cmax and Cmin from Ch and Cc

qmax = Cmin(T1-t1)

$$\varepsilon = \frac{q}{q_{max}}$$

$$NTU = \frac{UA}{C_{min}}$$

Then the graph can be used to predict the value of 'U'

7. Research Work

T1	T2	t1	t2	mh (lpm)	kg/s	mc (lpm)	kg/s
72.5	57.7	36.4	67	1	0.017	0.5	0.008
65.7	56.1	35.4	64.9	1.5	0.025	0.5	0.008
52.6	50.8	37.8	52.2	2	0.033	0.5	0.008
67.4	49.1	38.8	56	0.5	0.008	1	0.017
70	52.1	36.6	52.2	0.5	0.008	1.5	0.025
70.9	54.2	36.8	49.2	0.5	0.008	2	0.033

The research work aims on evaluating the performance evaluation of automobile radiator after developing the radiator test rig. The methodology of the radiator performance evaluation is made through this project.

8. CONCLUSIONS

Thus this work has made a study and analysis of the thermal behavior of the automobile radiators using the LMTD and ε – NTU methods of designing radiators for various parameters of mass flow rates of coolant and air with its specific geometrical parameters. The performance enhancement of automobile radiators is found to be accomplished mainly by altering the convective heat transfer coefficient. The presence of case studies and comparing their results with the software generated results has proved an easier way of designing radiators which saves the time of the designer. In addition the case studies reveal that ε – NTU method is the most reliable method of designing radiators which are of cross flow type heat exchangers.

REFERENCES

[1] Ahmad Fakheri, (2014) "Heat Exchanger Efficiency", Journal of Heat Transfer, Vol.129

[2] Akhilnandh Ramesh et al., (2015) "Heat Transfer Studies on Air Cooled Spiral Radiator with Circumferential Fins", Procedia Engineering 127, 333 – 339

[3] Amrutkar PS and Patil SR, (2012)"Automotive Radiator Sizing and Rating – Simulation Approach", IOSR Journal of Mechanical and Civil Engineering

[4] Binit Kumar Jha et al., (2015) "Analysis of Automobile Radiator Test Rig Using Different Coolents", International Conference on Science, Technology and Management

[5] Incropera FP et al., (2007) "Fundamentals of Heat and Mass Transfer", John wiley & sons publications, 6th edition

[6] Devendra Vashist et al., (2014) "Some Studies on the Performance of Automotive Radiator at Higher Coolant Temperature", Journal of Basic and Applied Engineering Research, Volume 1, Number 3

[7] Chavan D. K and Tasgaonkar G. S, (2013) "Study, Analysis and Design of Automobile Radiator (Heat Exchanger) Proposed with Cad Drawings and Geometrical Model of the Fan", International Journal of Mechanical and Production Engineering Research and Development, Vol. 3, Issue 2