A REVIEW ON EXPERIMENTAL INVESTIGATION AND TEMPERATURE DISTRIBUTION OF AUTOMOBILE RADIATOR USING NANO FLUIDS

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ABSTRACT

In internal combustion engine as piston moves inside the cylinder at very faster rate s it is very necessary to keep the temperature inside the engine at the moderate level so that the engine performance should not get affected. In order to achieve this task we required the continuous cooling surrounding the engine through water jacket and as the water surrounding the IC engine is get heated up very rapidly so a system should be required to keep this water circulated through a medium which controls the heating of water upto a desired level to do so radiator in an automobile is accomplished the desired objective. The system of radiator is consist of storage tank, supply pipe line, tubes with n number of passes, fins, inlet and outlet system, thermostat, pressure control unit etc.

Keywords*:* *Radiator, mass flow rate, temperature distribution, Nano fluid.*

INTRODUCTION

In order to achieve the day to day goals one cannot live rely only on what got gifted us from nature. So we must use gadgets such as mobile phones, computers, printers, vehicles etc. to get that work done with very low amount of energy to do and with a higher rate of accuracy, punctuality and simplicity. Automobile is a new form of vehicle which moves not only on wheels but using the automated systems like motors, accelerators, lighting system, air conditioner embedded with them and even some of them have calibre to save nature by using green fuels. So as we see from day to day automobiles are getting loaded to achieve the human desire up to that level of mark that never is think by our ancestors.

From the above summary it is necessary to have preventive as well as breakdown maintenance of the automobiles in a very quality manner so that the customer satisfaction can be meet and the companies have greater sells year after year.

In order to improve the vehicle performance and durability it is necessary that one should keep as much as preventive maintenance breakdown must be minimise with the lowest possible price and preventive maintenance should also be done in such a fashion that vehicle while running can always run in a moderate zone which is unaffected to their performance.

Components of automobile used for optimum performance:

The number of parameters to enhance the performance and effectiveness of an automobile some of them are listed here as follows

Cooling system- cooling system broadly classified in two manners called water cooling system and air cooling system.

Overall weight- to improve the acceleration and mileage overall weight reduction is considered in most of the LCVs

Fuel quality- the quality of fuel is not only improves the vehicle performance but also affect the environmental balance.

Material- weight of the engine is also associated with material, so material effect the performance of the engine. The advance material will also use to give the great Dependent Suspension System:

Definition and Types of Radiator

To cool down the water received from the engine radiator is used. It mainly have three parts: (i) upper tank, (ii) lower tank and (iii) tubes.

The upper tank contains hot water, coming from the engine, and circulates through tubes on downward direction. The fins are mounted around the tubes to dissipate the heat inside the tubes more effectively. An overflow pipe is mounted on the upper tank that departs the excess hot water or heated steam gets collected in the collection tank.

There are three types of radiators:

1. Gilled tube radiator: the grilled tube radiator was used in some decade ago, in some of the automobile it still be seen. Gilled tube radiator is one in which water flows inside the tubes. Each tube has some extended surface called fins which is used for transfer the heat of hot fluid to the surroundings.
2. Tubular radiator: separate fins are used in case of gilled radiator but tubular is one of the most simple construction radiators without separate fins for individual tubes. Vertical tubes of the radiator pass through thin fine copper sheets which run horizontally.
3. Honey comb or cellular radiator: honeycomb structure is a very latest trend in radiator which is used at a large extent. It has a higher effectiveness than other type of arrangement. This type of radiator consists of a large number of individual air cells which are surrounded by water. The one of the most important advantage of cellular style is that on clogging one tube or one side the whole surface, it is unaffected and cooling of the surface is not so much altered. However, in the tubular radiator, if one tube becomes clogged, the cooling effect of the entire tube is lost.

Advantages and limitations of cooling systems:

Advantages of water cooling system

-Because of even cooling of cylinder barrel and head (due to jacketing) makes it possible to reduce the cylinder head and valve seat temperatures.

-The volumetric efficiency of water cooled engines is higher than that of air-cooled engines.

-Compact design of engines with appreciably smaller frontal area is possible.

-In case of water cooled engines, installation is not necessarily at the front of the mobile vehicles, aircraft etc. as the cooling system can be conveniently located.

Disadvantages of water cooling system

-The system requires more maintenance.

-The engine performance becomes sensitive to climatic conditions.

-The power absorbed by the pump is considerable and affects the power output of the engine.

LITERATURE REVIEW

Dwivedi, V. D., &Rai, R.,[1]In modern gas turbines, the operating temperature of the turbine blades is higher than the melting point of the blade material. For the safe and continuous operation of high-performance gas turbines, a sophisticated cooling system must be developed. Various methods have been proposed for blade cooling, and such technique involves drilling radial holes to allow cooling air to flow at high velocity over the entire blade span. In the present wormathk, the analysis of the heat transfer of a gas turbine with four different models was analyzed, including a morning without holes and blades with a variable number of holes (5, 9 and 13) Model k-real (feasible with improved wall treatment) was used. In evaluating the graphs of total heat transfer rate and temperature distribution, the 13-hole blade is considered optimal.

Amrutkar, P. S., &Patil, S. R.,[2] The proposed work deals with the development of an Excel spreadsheet for the calculation of heat output. Only a few input parameters give a precise idea of the heat output. The blade helps to estimate the influence of variations in pipe and fin density, coolant flow, etc. on heat output. Theoretical calculation of the size of the cooler core and the heat output for a given engine power.Validation of the core size by a simulation software and comparison of the theoretical heat release with the results of the simulation. Optimize kernel size based on heat dissipation requirements. 3D modeling of the collector, tubes, fins and tanks of the radiator components. Finite element analysis of the radiator to test its robustness against thermal and pressure loads. Development of a prototype for the validation of the cooler performance

Yadav, J. P., & Singh, B. R.,[3] In this paper, forced convective heat transfer in a water based nanofluid has experimentally been compared to that of pure water in an automobile radiator. Five different concentrations of nanofluids in the range of 0.1-1 vol. % have been prepared by the addition of TiO2 nanoparticles into thewater. The test liquid flows through the radiator consisted of34 vertical tubes with elliptical cross section and air makes across flow inside the tube bank with constant speed. Liquidflow rate has been changed in the range of 90-120 l/min tohave the fully turbulent regime. Results demonstrate thatincreasing the fluid circulating rate can improve the heat transfer performance. Meanwhile, application of nanofluid with low concentrations can enhance heat transfer efficiency up to 45% in comparison with pure water.

Bhimani, V. L., Rathod, P. P., &Sorathiya, A. S.,[4] In this article, experimental heat transfer coefficients in the automobile radiator have been measured with two distinct working liquids: pure water and water based nanofluid (small amount of TiO2 nanoparticle in water) at different concentrations and temperatures and the following conclusions were made.
1. The presence of TiO2 nano particle in water can enhance the heat transfer rate of the automobile radiator. The degree of the heat transfer enhancement depends on the amount of nano particle added to pure water. Ultimately, at the concentration of 1 vol. %, the heat transfer enhancement of 40-45% compared to pure water was recorded.
2. Increasing the flow rate of working fluid (or equally Re) enhances the heat transfer coefficient for both pure water and nanofluid considerably.
3. It seems that the increase in the effective thermal conductivity and the variations of the other physical properties are not responsible for the large heat transfer enhancement. Brownian motion of nanoparticles maybe one of the factors in the enhancement of heat transfers. Although there are recent advances in the study of heat transfer with nanofluids, more experimental results and theoretical understanding of the mechanisms of the particle movements are needed to explain heat transfer behavior of nanofluids.

Ali, H. M., Azhar, M. D., Saleem, M., Saeed, Q. S., &Saieed, A.,[5] The focus of this research paper is on the application of water based MgOnanofluids for thermal management of a car radiator. Nanofluids of different volumetric concentrations (i. e. 0.06%, 0.09%, and 0.12%) were prepared and then experimentally tested for their heat transfer performance in a car radiator. All concentrations showed enhancement in heat transfer compared to the pure base fluid. A peak heat transfer enhancement of 31% was obtained at 0.12% volumetric concentration of MgO in basefluid. The fluid flow rate was kept in a range of 8-16 liter per minute. Lower flow rates resulted in greater heat transfer rates as compared to heat transfer rates at higher flow rates for the same volumetric concentration. Heat transfer rates were found weakly dependent on the inlet fluid temperature. An increase of 8 °C in inlet temperature showed only a 6%increase in heat transfer rate. In this paper, the convective heat transfer enhancement of automobile car radiator has been experimentally studied by using MgO water based nanofluids at different flow rates and at various volumetric concentrations to study their behavior. The following major conclusions are obtained.

Pendyala, R., Chong, J. L., &Ilyas, S. U.,[6] Nanofluids are the new developed thermal fluids with enhanced thermophysical properties which can improve heat transfer performance of various applications. By introducing nanoparticles with high thermal conductivity in the car radiator coolant can enhance the effective thermal conductivity of coolant which improves the performance of cooling system. Alumina, silica and copper oxide nanoparticles with ethylene glycol-water mixture (60:40) have been used in 3-dimentional car radiator simulations to study fluid flow patterns and heat transfer performance. Heat transfer performance for ethylene glycol-water mixture based nanofluids at different nanoparticle concentrations has been studied. Heat transfer coefficients are determined by numerical simulations with varying coolant velocities. Overall heat transfer performance is found to be improved using nanofluids with high effective thermal conductivity. Results display significant increase in heat transfer performance of coolant in car radiator with an increase in the particle loading.

Vasu, V., Krishna, K. R., & Kumar, A. C. S.,[7] Compact heat exchangers have been widely used in various applications in thermal fluid systems including automotive thermal fluid systems. Radiators for engine cooling systems, evaporators and condensers for HVAC systems, oil coolers and inter coolers are typical examples that can be found in ground vehicles. Recent development of Nanotechnology brings out a new heat transfer coolant called ‘Nanofluids’ these fluids exhibit larger thermal
properties than conventional coolants (water, Ethylene glycol, Engine oil etc.) due to the presence of suspended nanosized particles in then such as Al2O3, Cu,CuO,TiO2 etc. In this paper a theoretical analysis was carried with ε –

NTU rating method by using Al2O3 + H2O Nanofluid as coolant on automobile flat tube plain fin compact heat exchanger and different characteristics are graphically presented.

MATHEMATICAL MODELLING

In this module we will model the radiator of a heavy duty vehicle called truck engine. For the mentioned purpose we have taken a matador truck engine for mathematical calculation of the problem. The concern engine is coolant by a mixture of ethylene glycol and water. This coolant is flow in the tubes of the radiator. The specification for the mathematical analysis of the radiator is being taken by problem of internal combustion engine textbook by John B. Heywood. The inlet outlet conditions and other important parameter of the radiator is given below-

Inlet temperature of the coolant = 180 ^{0}C

Exit temperature of the coolant = 110 ^{0}C

Mass flow rate of the coolant = 1 kg/s

Density of the coolant = 1090 kg/m^3

Diameter of the tube = 20mm

Thermal conductivity of the tube (aluminium) = 120 W/mk

Thickness of the tube = 2 mm

Number of tubes in the radiator = 17

Length of the tube = 1200 mm

As the coolant enters into the tube and rejects the heat to the surrounding by the phenomenon of conduction and convection and decreases the temperature of the coolant at the exit of the tube. According to the principle of energy conservation heat rejected by the coolant will be equal to the heat gained by the air.

Heat rejected by the coolant is given by Q = Mc×Cpc×dT

Where Mc is the mass flow rate of the coolant

Cpc is the specific heat of the coolant

dT is the temperature difference of the coolant from inlet to exit.

Q= 1 kg/s×2.42 kj/kg-k×70 ^{0}C

Q = 169.4kw

This is the heat transfer for a single tube, we have to calculate the heat transfer for n number of tubes which is taken as 17 for our case

Q= n×169.4

Q = 16×169.4

Q = 2710.4kw

As the extended surface are attached with radiator tube, that increase the surface area and in turn heat transfer. The following dimensions are chosen for extended surface which is pointed below:

Surface temperature of the fin = 60 ^{0}C

Temperature of the surrounding = 25 ^{0}C

Temperature difference ϴ = 70^{0}C

Thermal conductivity of the material (Aluminium) = 190 W/m-k

Heat transfer coefficient = 150 W/m^2-k

Thickness of the fin = 2 mm

Length of the fin = 80 cm

Width of the fin = 120 cm

Heat transfer through the extended surface can be given by Q= $(PhkAc)^{1/2}$×ϴo×tanh(ml)

Where P- perimeter of the fin = 2(l+b) = 4m

h- Heat transfer coefficient

k- Thermal conductivity of the fin

Ac- Cross sectional area of the fin = l×b = 80×120 =0.96 m^2

ϴo- Temperature difference of the fin

m- fin constant

l- length of the fin = 0.8m

Fin constant m= $(hp/kAc)^{1/2}$ = $(150×4/190×0.96)^{1/2}$ = 2.19089

Heat transfer Q = $(150×4×190×0.96)^{1/2}$×35×tanh (2.19089×0.8)

Q = 330.80×70×0.989643914

The above value shows the value of heat flux for single fin geometry, the total heat flux for our case with multiple fins is calculated as follows:

Q = 72851.55969kW.

Now total heat transfer through radiator tubes is given by = 16.95+10.36 = 27.31

And the effectiveness of the radiator is given by

$\varepsilon = Q_{with\ fin}/ Q_{withot\ fin}$

ε= 2.025566

It has been clearly seen from the mathematical analysis and formulation that with extended surface radiator provides good effectiveness.

Now the mathematical results will be valided by the simulation software in terms of temperature and heat flux.

Conclusion

1. The effectiveness of the radiator are obtained from the results are greater than unity that is 2.025566 in our case, which implies that the use of fin with radiator tube is effective and helpful to transfer the heat of cooling fluid.
2. It has been seen that with the use of Cu-O as Nano fluid the heat flux will increases in both the cases. In our case the value of heat flux without fin will increase up to 3%. And if the same is used with fin then it will also increase up to around 2%.
3. The minimum possible temperature in case of without fin geometry considering ethylene glycol as coolant is 373 k while the temperature goes to decrease up to 374 k when we use the Nano fluid (Cu-O) as coolant.
4. The minimum possible temperature with fin geometry considering ethylene glycol as coolant is 330 k while the temperature goes to decrease up to 315 k when we use the Nano fluid (Cu-O) as coolant.

Future Scope:

After investigation and analysis of the radiator by use of simulation and mathematical modelling we satisfy with the results obtained from the ANSYS, there are some more scope is also present for future perspective from the research point of view and one can extend these work under the following points of consideration, out of which some important points are mentioned below:

1. One can iterate the material of the radiator and investigate the thermodynamic parameter of the radiator.
2. One can change the types of coolant used in the radiator and get the optimised results by investigation.
3. Some additional techniques like extended surface and moderation of the geometry in the fins can also be possible for get desired heat transfer in optimised way.
4. One can also use these exergy (rejected heat or unavailable energy) from the radiator tube and do some useful work.

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