A COMPREHENSIVE REVIEW ON ENGINE COOLING SYSTEM USED IN AUTOMOTIVE SECTOR

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A B S T R A C T

With the increase in population and civilization the extreme demand of automotive sector has rapidly increased in present time. So, it is a incredible assignment for automobile industries to develop an effective and environment friendly engine. Cooling device is one of the vital structures of an car that influences the engine performance. Almost every IC engine utilizes theradiator as a heat exchanger to improve the overall heat transfer rate of the system. Radiator basically functions as the regulator for regulating the engine temperature for increasing the efficiency and cooling of the engine. Radiator enables the proper cooling system in automotive to maintain the excess temperature produced in the functioning of engine and its corresponding devices. In this work a survey based study is performed on an automotive radiator to study the affecting parameters and a simplified and improved solution can be presented for the improvement of radiator system in future.

Keywords: Automobile, Engine Radiator, Cooling System, ANSYS

1. Introduction

In today's scenario automotive sector is rapidly developing with very faster rate with the use of new and modern techniques. Most of researches have been prevailing to have the advancement in automotive performances and use of new technologies to incorporate in vehicle systems. Most of the researches are seen in the direction of improving the performance of cooling system used for cooling the engines. The trend these days is prevailing in the research towards the use of new green technologies in IC Engines to have low emissions and less environmental disasters. Use of green technologies in engine can help in less power consumption and more benefits to the customers. Most common problem is the passenger comfort which is affected with high heat producing engine systems. The engines used these days produces high amount of heat which results in heating of overall components used in the cooling system

Automotive these days comes with thermal energy management system which generally have different configurations and capacities of cooling the overall systems. These thermal energy management systems basically performs the function of cooling the engine and its components. Thermal Energy systems basically constitutes of a radiator system, radiator fan which is set up at the front of the radiator and coolant pump which circulates the coolant to the different components of the engine system. Coolant pump comes with a thermostat valve which work as a energy carrier or dissipater to carry the waste energy from the engine with the help of coolant fluid. This valve is a proportioning device which basically keep a track of temperature in the engine and regularly maintains it in the moderate condition. A better design also keeps the engine fluid i.e. ethylene glycol below its boiling point so as to maintain the engine heat load in the desired limit. Various researches and advancements have continuously contributed in the betterment of engine performance by implementing various electrically operated cooling systems which functions as the modulating device to maintain the thermal heat management in IC Engines. With the help of these electrical units overall temperature remains in the controlled range and efficiency is maintained.

Radiator present in most of the automotive vehicle are generally made of aluminum metal fins as it is has high heat transfer capacity and is also not too high in cost. Radiator have various fins and tubes on the surface of its body to have a high heat dissipation as they directory dissipates the heat to the outside surroundings. The coolant is made to flow from engines via radiators inlet port and with its function of absorbing the engines heat it dissipates the heat to the outside surroundings with heat transfer function. After circulating and complete dissipation process the coolant fluid and reaches the engine via outlet port.

Various techniques and procedures have been evolved for evaluating the architecture of cooling systems. It involves concise techniques to have the the proper evaluation of its functioning. Engine cooling systems is affected by varying engine load and flow of air from radiator system. In the figure below a testing procedure commonly used for the testing of engine energy is mentioned. The process consist of a dynamometerbasically dynamometer is a device used for detecting the variability of engines power and it's working. For having the proper environmental conditions at radiator a ram air system is installed which is used as adjustable source for air blowing. The System is evaluated depending upon the temperature response with respect to disturbance and is further analyzed in a steady state condition. The system shown below provides the knowledge of energy and load consumption with its effectiveness.

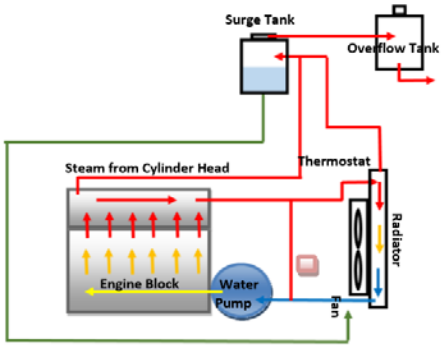

Figure 1 Layout of cooling system

Nomenclature
Q=quantity of heat convective heat transferred
H=coefficient of convective heat transfer
A=area of surface

1.1. Nanoparticle

Assuming the nanoparticles are perfect dispersed inside the base fluid, i. E. The particle concentration can be considered uniform all through the machine; the first-rate physical of the mixtures studied can be evaluated using a few classical formulations [c, d] as generally used for two segment flow. These family members had been used to expect nanofluids physical properties like density, Specific heat, dynamic viscosity and thermal conductivity at precise temperatures and concentrations.

$$\rho_{nf} = (1-\varphi)\rho_f + \varphi\rho_f \quad (1)$$

$$C_{nf} = \frac{(1-\varphi)C_f + \varphi\rho_p C_p}{\rho_{nf}} \quad (2)$$

$$\mu_{nf} = \mu_f \frac{1}{(1-\varphi)^{2.5}} \quad (3)$$

$$k_{nf} = \frac{k_p + (n-1)k_{bf} - \varphi(n-1)(k_{bf} - k_p)}{k_p + (n-1)k_{bf} + (k_{bf} - k_p)} k_{bf} \quad (4)$$

Calculate the overall heat transfer rate in convection process by given formula

$$Q=hA\ (t_1-t_2)$$

(t_1-t_2) =temperature difference between the fluid and the surface.

1.2. Components used in engine cooling

- Reservoir: it factors the coolant to the radiator. It serves the more quantity of coolant in it and provide it to radiator inside the case of coolant degree in radiator goes down.
- Fan: it is related behind the radiator to enlarge cooling ability. It drew fresh air via the radiator. It will increase the mass glide charge of air which will increase the effectiveness of the device.
- Radiator: the radiator is one of the types of heat exchanging system wherein the coolant permits the switch of heat with the aid of the phenomenon of conduction and convection to air surrounding. Its miles constituted with various fins connected to the several no. Of tubes which increase vicinity exposed to surrounding.
- Thermostat: it keeps the proper temperature through diverse the quantity of coolant flowing to radiator.

2. Literature review

(Subhedar, ramani, &gupta, 2018) worked with on the radiator system with the aid of nano particle incorporated with extremely-sonication. The setup used by the author was experimental

where various practical observations were recorded. In the experimental procedure fraction of nano particles, coolant waft charge, inlet temperature used inside the degrees of 0. 2–0. 8%, 4–9 l/m. In the results of this experimental it is explained that the fluid with nano material mixed have the high efficiency as compared to the fluid without nano particles. High amount of heat transfer is seen with the coolant fluid having nano particles mixed. With lowest 0.2% volume fraction there is rise of 30% heat transfer in the overall system.

(ali, ozkaymak, sözen, menlik, &fahed, 2018) worked on a experimental study where a coolant with nano particles is mixed to have the improvement in overall efficiency of the system. For the experimental work tio2 mixed with water nano- fluid is used as a coolant for the functioning in radiator of of car engine experimentally. For evaluating the results water and tio2 with water is used as working fluid or the coolant for the heat energy transfer. Both the fluids were used one after the other in the experimental setup. For the study fiat doblo 1.3 mjtdengine is used. The objective of this work was to check the heat transfer with different precent of nano particles with water. For the study purpose 0.1%, 0.2% and 0.3% of nano material is mixed with the water to have different results and comparision of their effectiveness. Among the three cases 0.3% showed the best results of heat transfer in the setup.

M. Hatami (2017) worked on a radiator of engine where four different nano materials were used which were 4 nanoparticles i.e. Copper oxide (cuo), TitanoiumOxide (tio2), aluminium oxide (al2o3) and iron oxide (fe3o4) in special shapes (platelet, brick, and cylindrical round) . For performing the analysis flat tube model of radiator is prepared for the analytical study. In the same analytical study different combination of Reynolds number are made in simulation process. Varied Reynolds number were 500, 1000, 1500 and 2000. Effect of change in design, nano material and Reynolds number were studied in this study.

Omkarbhatkar et. Al (2017)present a study of car radiator where the fuel was gasoline (ron 95). Study presented by the author was analytical study where coolant used for the heat transfer was 100% distilled water. Engine of KTM Duke was installed in this SAE Car model. The results showed that the mass drift price of air flowing through the radiator i.e. $\dot{m}$ = 2. 807 kg/sec and effectiveness of the radiator, ε = 0.4. In the complete analytical study effectiveness of radiator with mass flow rate characteristics was studied to have the overall performance of radiator used in engine systems.

(nagar&trivedi, 2017) conducted a survey based study where different engine cooling system were studied with the effect of radiator, cooling fan, coolant on engines working and performance were observed. Author in his study suggested that a round pass section can be used in radiators for the improvement its performance a further study can carried out in this direction. Author discussed various design changes and their effects on radiator performance in his study and suggested various outcomes and future scopes for future studies.

(jyothi, rajesh, &naidu, 2017) worked on changing the design of fin used in the surface of radiator. Fins basically works as a heat transfer surface medium with the help of surface contact. More the surface contact area of fin better will be the heat transfer. The present study presented by the author was an analytical study. In the study CATIA V5 is used for the modelling and ANSYS Fluent is used for the Analysis purpose. For the analysis purpose two different designs of fins were prepared i.e. rectangular fin model and trapezoidal fin model.

M. Hatami (2016) implemented response surface method in his study to identify the effect of wavy wall fins on an enclosure with a heated cylinder at the centre of the enclosure. For checking the effect of nano particle a convection based study is also implemented in the present study. For further identifying the effects 9 different wavywall profiles were also selected from the central composite design database wand wavywall and cylinderwall effect were studied.

Sandipkumarsonawane (2016) in his study worked on eulerian–lagrangian model which is further used for simulation of turbulent-pressured convection heat transfer in inner go with the flow the use of dilutes nanofluids. For evaluation, a single-phase mannequin of the nanofluid which describes a nanofluid as a single-segment fluid with accurately defined thermophysical residences is additionally applied. Simulations with the single-section mannequin show off particular prediction of the

heat transfer behavior of dilute nanofluids so long as the thermophysical residences are at once measured experimentally or those predicted from a brownian motion primarily based version.

(saradhi&chenna, 2016) worked on a radiator cooling system used in the modern cars. A computational fluid dynamics based study was presented in his study. Theoretical calculations were completed with the help of matlab software. From the CFD study mass flow rate and flow rate of coolant is studied. For the modelling of radiator model solidworks software was utilised and CFD analysis was performed by exporting the model of radiator into Ansys fluent. In the results temeperatur distribution, pressure profile and velocities were calculated. Different materials were used in the modelling process which were copper, aluminium and stainless steel. After the analysis procedure different results of temperature, velocities and pressure were compared to find the best result from the study.

(sathyan, 2016) stated that around 33% of energy produced by the engine is lost unnecessarily in overall combustion process. Inadequate amount of heat dissipation can result in over heating of the system which can further result in the overall performance of engine and vehicle working. Overheating in engines also results in breakdown of lubricant used in the engine finally resulting in breaking of engine parts. Pressure created in the engine also have the high effect in heat produced in the engine and in order to control these high heat production the radiators of the vehicles must be redesigned in such a that they have high heat dissipation to have optimum temperature of working inside the engines. Author in his study suggested various of controlling the amount of heat produced in the engine to have the high performance and efficiency.

M. Rahimi-gorji (2015) Worked on an analytical research where heat temperature transfer was the main consideration in the heat sinks. Heat sinks are basically the heat transferring devices which dissipates the heat to the surrounding with the air and contact surface area with the phenomenon of heat convection. For the present study a microchannel heat exchanger system is used for the analysis process where different nano fluids such as of cu, al2o3, ag, tio2 in water and ethylene glycol were used as the base fluid used for heat transfer and further the comparative study was performed. For comparing the results different temperature, pressure and velocity profile were generated to have the overall comparison of performance of the system.

İsmail durgun et al (2015) worked on a physical prototype of radiator which is used as a cooling system in automotive vehicle system. ethylene glycol is considered as the working fluid different temperature readings were recorded to identify the heat loss and savings. The engine coolant temperature of approximately 90 °c inside the vehicle with radiators become discovered to be 120 °c in radiator. Overall 13euro saving was depicted in the present study.

D i rathod (2015) Worked on a radiator tank where salt (sodium chloride) was used as a running fluid and water as a cooling agent. Complete study was performed experimentally and was found salt has higher melting factor of about 1400-1500^{o}c. Material used for the radiator tank was brass fabric. The results from the study stated that where sodium is used as running fluid soaks more heat from the engine and gives high cooling effect to the engine with the improvement in overall performance.

(tripathi&chandra, 2015) studied the effect of nano materials in the working fluid of radiator which is used as a cooling system in engine of automotives Radiator consist of various other parts also i.e. radiator fan, collent etc. with the increase of pollution in environment author also suggested that use of nano particles in working fluids of engine can result in reduction of pollution to the environment. In the present study nano particles such zinc primarily based nanofluids (znfe2o4) using chemical co-precipitation approach and its software is used in an vehicle cooling device alongside with combination of ethylene glycol and water (50:50).

Author also explained that nano materials have high thermal conductivity which can help the cooling systems to have easy and quick dissipation of heat further improving the engine efficiency. Present study was conducted analytically with the aid of software based program.

(hardikkumar b. Patel, 2014) empahised on a survey based study where different heat

exchangers and cooling devices were studied. Author also made high impact on the use of technologies to perform these experiments physically or analytically. For the reason various experimental as well analytical studies were studied. And in the end author also stated that the simulation with the use of softwares can save high cost of experiments and are also suitable for the prototyping stage.

(peyghambarzadeh, hashemabadi, sei, &hoseini, 2014) performed an experimental study on radiator of car engine where different concentration of nano fluids were used from the range of 0.1 to 1% volume. Nano fluid used in this study was al2o3 mixed with water. Different concentrations have different results and outcomes. The radiator used for the experimental work constituted of 34 verticles flow tubes with elliptical section for the air to pass through it. In the results and outcomes various temperature profile were created and temperature were recorded in the different intervals. Different flow rates i.e. 2-5l/min were used for the experimental procedure and finally the results were evaluated to find the best outcome of this experimental study.

(duangthongsuk&wongwises, 2014) conducted a study on nano fluids mixed with the traditional working fluid. Different properties such as thermal conductivity, viscosity were incorporated in the material preparation. An analytical method was conducted to find the overall performance of the radiator engine on behalf of temperature and velocity of the material.

3. Conclusion

After study literature review based observe diverse studies have been studied to have the right scope and knowledge of working with radiator machine. Radiator is cooling device used exactly for the cooling of heat produced for the duration of the functioning of engine. In this research paper, the overview study on car radiator is done. By using considering the factors which impacts the engine cooling gadget, the layout parameters of radiator are studied. The cooling device of an car performs a vital role in its performance, includes fundamental elements, diagnosed as radiator and fan. Improving thermal efficiency of engine leads to increase the engine's overall performance, decline the gas consumption and restrict the air pollutants emissions. Shape the literature survey it's been viewed that still there is lot of scope of work in this discipline through thinking about diverse parameters and acquiring their maximum dependable values to have excessive efficiency with limited resources.

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