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Numerical Analysis of Automobile Radiator

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Abstract*— Now a day, the demand of automobile vehicles is on peak. So, it is a great challenge for automotive industries to contribute a powerful and efficient engine. The performance of an engine affects by various systems like fuel supply system, transmission system, lubrication system, cooling system etc. So, it becomes essential to account them while model an engine for improved the engines performance. Cooling system is one of the important systems. It also increases heat transfer and fuel economy which indications to increases the performance of an engine. Most internal combustion engines are fluid cooled using either a liquid or air coolant run through a heat exchanger (radiator) cooled by air. Different research papers have applied different method has been studied and finalized that the various coolants (nanofluids), tubes, fan and core, change efficiency of radiator at different mass flow rate. From the literature study, it has been seen that the efficiency of the radiator has been increased through a variety of methods, out of which radiator fan is the most used one to improving the efficiency of radiator by modification of radiator fan and radiator tube. This review focuses on the various research papers regarding CFD analysis to improve automobile radiator efficiency. Different research papers have applied different methodology and different tools for modeling, meshing and numerical solution. Various results suggest that CFD have been proved very effective in reducing concept-to-production time and cost. CFD results have high correlation level with the actual experimental results.

***Keywords*— Radiator,Heat Transfer,CFD,Pressure,Temperature**

I. INTRODUCTION

Automobile radiator is used to cool down automotive engine. If it's not done various problems like knocking, piston deformation, cylinder deformation etc. can happen. If radiator works properly cooling system will work properly in turn engine performance will increase. Design of new radiator includes: air flow optimization as it's a very important criteria in convective heat transfer by designing various panels(radiator cover, fins, core, grills etc.) which come in between the path of air flow when air flow from atmosphere through the radiator assembly hence effect the amount of air which can be made to flow through it, design fan blades to suck more air through it by creating more suction, air flow Optimization by reducing air recirculation and air leakage through radiator core, design of radiator core in circular shape, overall size of radiator core, direction of flow of working fluid in vertical, horizontal or radially outward etc. wedge shaped frontal area of radiator, space between fins and space between tube, fin and tubes size, number of tubes ,shape of fins and tubes, coolant mass flow rate, material of fins, tube and panel on which their physical and thermal properties are depended, air inlet temperature which can be reduced by installing intercooler in front of radiator core, These are some possible design parameter which can be kept in mind to design a better automobile radiator. Role of CFD is very vital nowadays as a design tool. For CFD simulation various commercial software are available in market. Modeling is done by CAD then whole discretization model is resolved into small cells by discretization. Apply governing equation to discrete element and solve them by CFD solver.

II. LITERATURE REVIEW

[1]**Dr. Channankaiah, D. Arunpandiyan,** Different kinds of engine cooling system have been studied by researchers through experimental and numerical analysis. The Liquid and air cooling system are two important characteristics of the cooling process. In air cooling system by modifying the fins and radiator shape, the radiator cooling capacity can be improved. While in the liquid cooling system by modifying the radiator tubes, fins, core, fan and coolant (nanofluid), the radiator cooling capacity can be improved. Out of these the liquid cooling system transfers the heat at maximum level while comparing the air cooling system. From the literature it has been found that to improve the air flow distribution of radiator by changing the number of fan blades and blades angle.

[2]**Ramesh J. ladumor, Prof.V.Y.Gajjar, Prof.K.K.Araniya,** From the review of literature, it can be analyzed the Automobile radiator cooling system is very important in an internal combustion engine. From literature survey, different findings are concluded. The efficiency of radiator increase by inserting– heat pipe in radiator core. The heat capacity dissipation and the– efficiency factor (EF) of Nano coolant (NC) are higher than ethyl glycol-water (EG/W), and the TiO2 NC are higher than Al2O3 NC. The overall heat transfer coefficient increases with enhancing volumetric flow rate of the Nano fluid significantly. Cooling capacity and effectiveness increase– with increase in mass flow rate of air and coolant. Also increasing the inlet liquid temperature decreases the overall heat transfer coefficient. The overall heat

transfer coefficient decreases– with increasing inlet temperature of the Nano fluid. Nano fluid offer higher heat-transfer properties– compared to that of conventional automotive engine coolant. Requirement of pumping power reduce with– the use of Nano fluid in radiator. A blend of 50/50 mix of water and ethylene– glycol in which corrosion inhibitors have been incorporated is much more effective than using water and ethylene glycol alone. While water alone is good coolant but the enormous corrosion problems associated with it, is enough to discourage its use. The heat transfer behaviour of the Nano fluid– were highly depended on the particle concentration, the flow condition and depended on the temperature.

[3]**Devendra Vashist, Sunny Bhatia, Ashish Kalra,** A set of numerical data on automotive radiator using coolant operating at high temperature has been presented in the study. By the literature survey a number of recommendations have been provided for the development of a more effective and compact radiator. The same is elaborated in the section, future scope. In the performance evaluation of the radiator, a radiators installed into a test set up and parameter of mass flow rate of air is varied its effect on the effectiveness and cooling capacity is studied. The same parameters were presented graphically and the inferences made.

[4]**J. R. Patel, .A. M. Mavani,** After a comprehensive study of the existing literature it is observed that the geometric & operating parameters affects the heat transfer rate as well as performance of radiator. The fluid flow & heat transfer analysis of single tube fin Arrangement of automobile radiator is successfully carried out using numerical simulation built in commercial software FLUENT. Significant increases of the total heat transfer rates have been observed with the nano particles and its increases overall heat transfer rate. Optimizing the values of mass flow rates and the power rating of the vehicles by generating CFD codes. So many operational & geometric parameters plays an important role in the performance of radiator but the mass flow rate of air one of the operational parameter is play significant effect as the vehicle speed must be controlled by vehicle speed and it feasible to vary the parameter of mass flow rate of air. Pitch of tube for radiator is feasible to air – volume ratio constant. Coolants are easily available and coolants as nano fluids give much higher heat transfer rate than base fluid. It has fluid flow heat transfer characteristics. Most of researchers have investigated on the performance of radiator by different parameter study under CFD analysis for improves its efficiency.

[5]**Hardikkumar B. Patel Mr. Deepu Dinesan,** As per review of research papers, we can see that Such parameters like; Shape of radiator core, direction flow of working fluid, frontal area of radiator, Space between fins, space between tube, fin & tube size, coolant mass flow rate, material of fins, pitch of tube, velocity of fluid, air inlet temperature are kept in mind to design a better automobile radiator. Using CFD we were directed comparing the heat transfer & pressure drop of heat exchanger with different parameters for optimum performance And CFD analysis has also reduced the cost & time in design and development of radiator as compared to conventional methods.

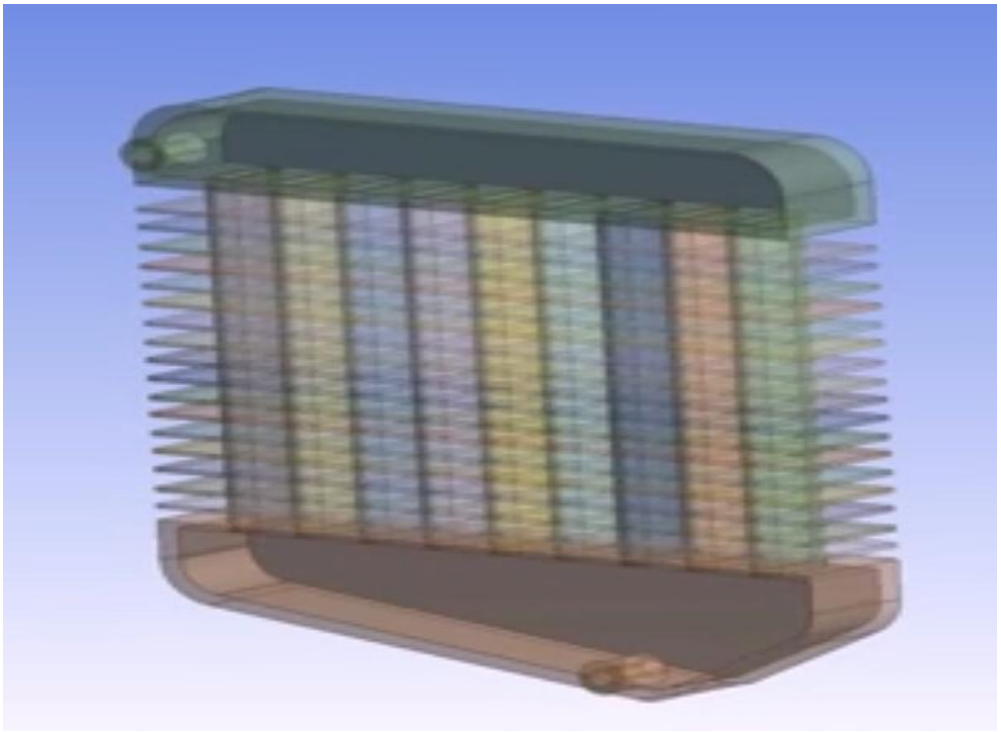
[6]**JP Yadav & Bharat Raj Singh,** A complete set of numerical parametric studies on automotive radiator has been presented in detail in this study. The modelling of radiator has been described by two methods, one is finite difference method & the other is thermal resistance concept. By a detailed literature survey a number of recommendations have been provided for the development of a more effective & compact radiator. All these recommendations are listed in the future scope section. These recommendations demand changes from the range of the geometrical parameters to the extent of coolant composition. In the performance evaluation of the radiator, a radiator is installed into a test-setup and the various parameters including mass flow rate of coolant, inlet coolant temperature etc. are varied. Then the corresponding value of the effectiveness and outlet coolant temperature are reversed. These values are then plotted in the 3-axis graphs and their behavior is studied. In the testing, a comparative analysis between different coolants has also been shown. Here, one of the coolants is used as water and other as mixture of water in propylene glycol in a ratio of 40:60. Here a big difference in the cooling capacity of the radiator is seen when the flowing coolant from water is changed to mixture. This is on the account of a very high value of specific heat of water in comparison to the mixture. It therefore can be concluded that the water is still the best coolant but its limitation are that it is corrosive and contains dissolved salts that degrade the coolant flow passage. By making a mixture with ethylene glycol its specific heat is decreased but its other properties are enhanced. It also increases the boiling temperature of water and decreases freezing temperature also. But if the mixture is to be as effective as that of the water then its mass flow rate should be increased. All the formulas used in the calculation are listed in the testing results and discussion section. Hence on the basis of the study it is concluded that:- The cooling capacity and the effectiveness are indirect relation with the inlet temperature of hot coolant i.e. with an increase in the value of inlet coolant temperature the cooling capacity & the effectiveness of the radiator increases respectively. The cooling capacity and the effectiveness are also in direct relation to the mass flow rate of the coolant. All these results have been calculated by taking the fan speed at 6000rpm. During our testing we have taken the maximum fluid inlet temperature at 80OC. So, the values of effectiveness are lower at this low temperature. Whereas in actual the inlet coolant temperature to the radiator is very much higher than experimented. Therefore, the nature of the graph needs to be concentrated on and not the specific values

[7]**Upendra Kulshrestha, Gaurav Kumar,Manu Augustine and Sanjay Mittal,** CFD analysis has reduced the cost, time in design and development of radiator as compared to conventional methods. It also reduces the need of prototype during design process while we do iterations to get optimized design. Now we need to make prototype of the optimized design only for physical testing. In past years we have seen very increasing trend in the use of CFD in many fields over worldwide and in India also. Its effect is reaching in Indian universities at very hopeful rate and scholars are showing

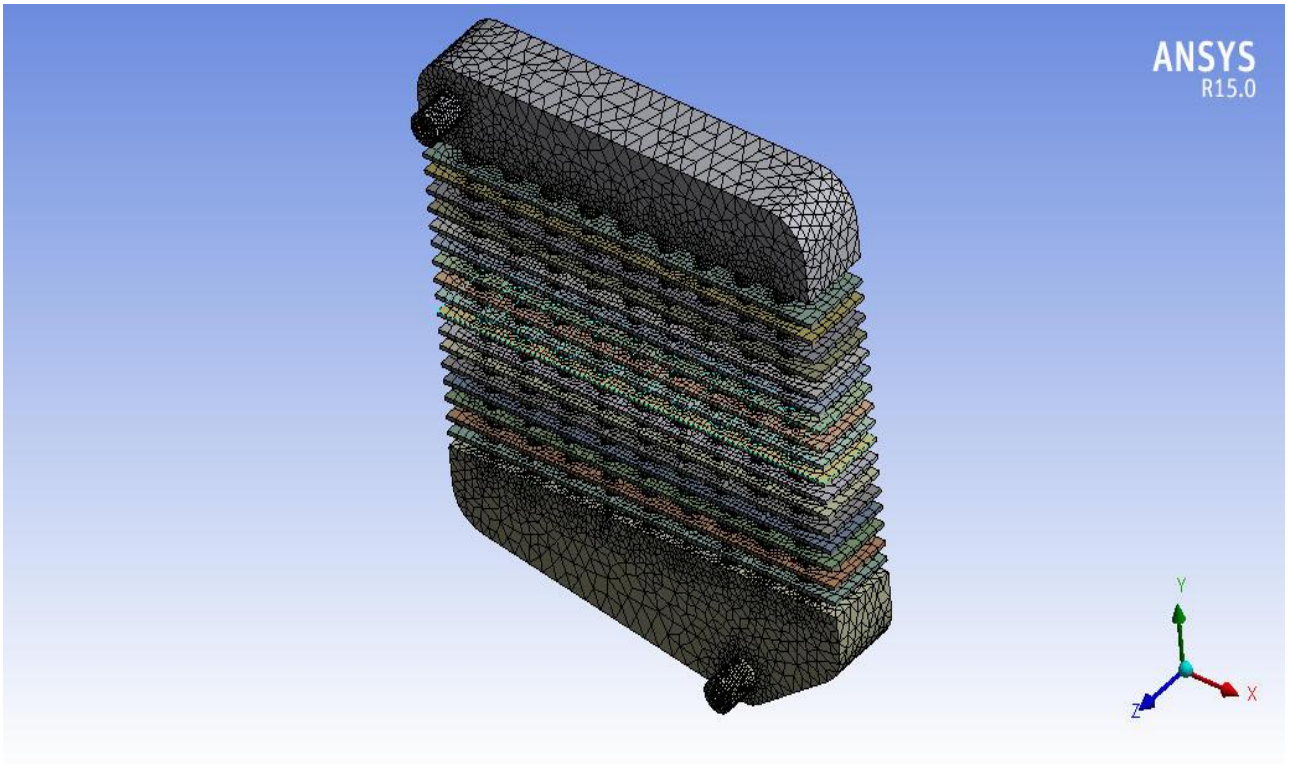
very interest in it. Today in India over 500 scholars are doing work regarding CFD and numbers are increasing. However the need of high processing capabilities computer and generation of codes is still a big problem in India. Students may have good grip on the required mathematics and fluid mechanics concepts but they lack knowledge regarding computer languages to generate codes. So we feel before increasing scope inCFD at graduation course, first we should focus on computer programming course in engineering colleges.

III. CFD ANALYSIS

3.1 Modeling of Radiator. After performing simple calculation, the modeling has been performed in Ansys Design Modeler and then after the analysis work has been performed on the ANSYS15.0 version

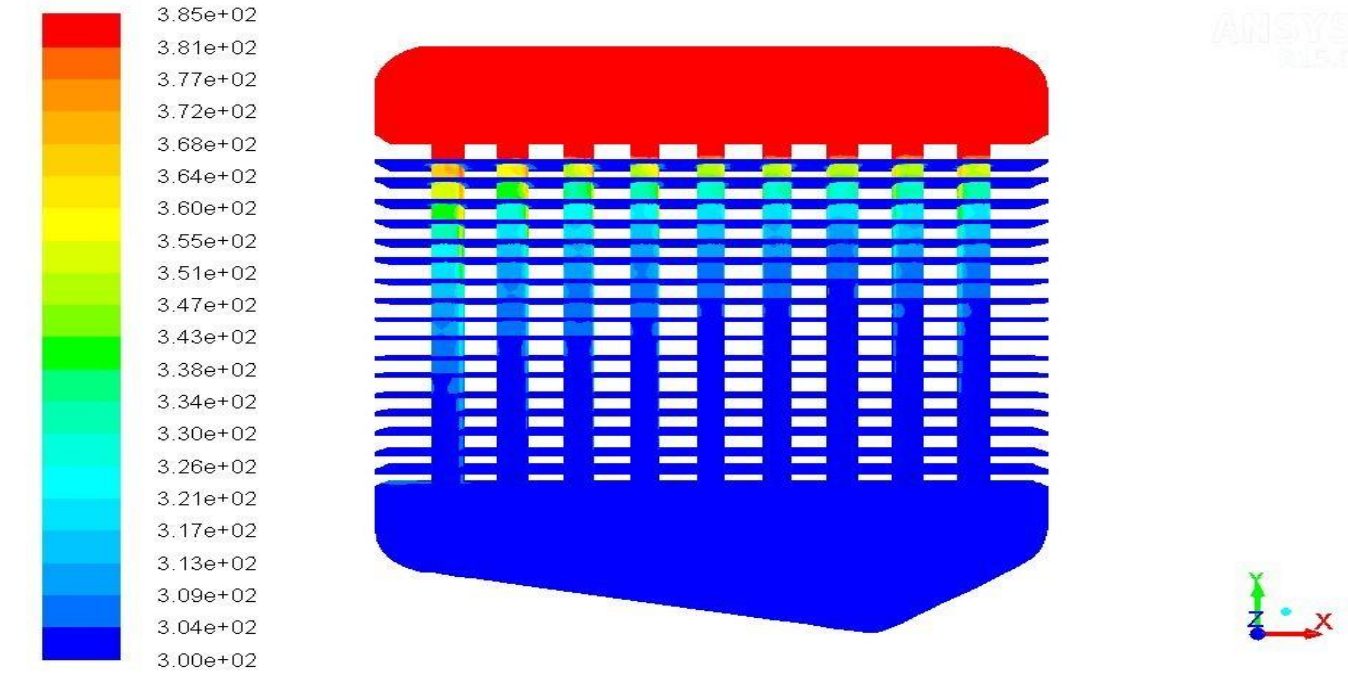


Figure(1) Model of Radiator

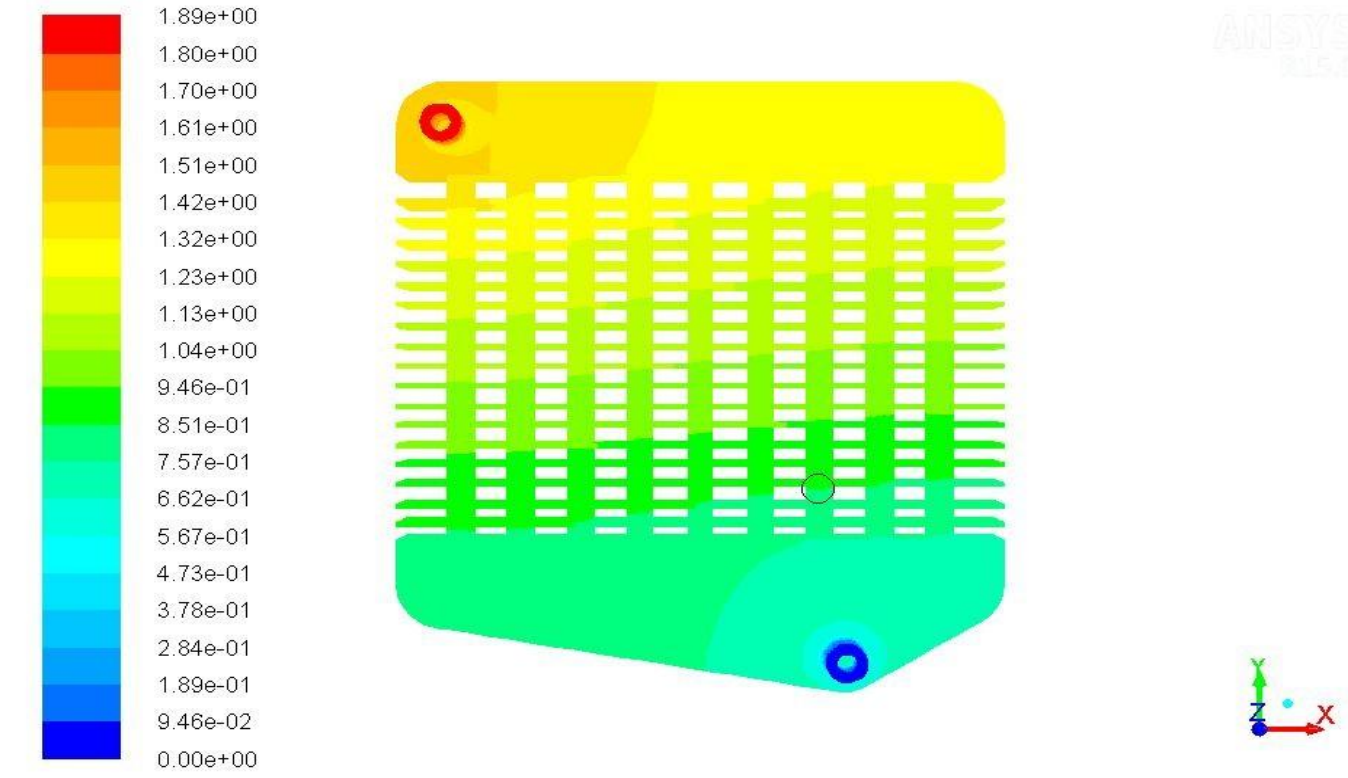


Fifure(2) Meshing Model of Radiator

3.2 CFD Analysis



Figure(3) Static Temperature



Figure(4) Static Pressure

Inlet	2.0031919
Outlet	-0.075086221
Wall-100	0
Wall-104	0
Wall-105	0
Wall-106	0
Wall-107	0
Wall-111	0
Wall-112	0
Wall-113	0
Wall-114	0
Wall-55	0
Wall-56	0
Wall-57	0
Wall-58	0
Wall-62	0
Wall-63	0
Wall-64	0
Wall-65	0
Wall-69	0
Wall-70	0
Wall-71	0
Wall-72	0
Wall-76	0
Wall-77	0
Wall-78	0
Wall-79	0
Wall-83	0
Wall-84	0
Wall-85	0
Wall-86	0
Wall-90	0
Wall-91	0
Wall-92	0
Wall-93	0
Wall-97	0
Wall-98	0
Wall-99	0
Wall-base	0
Wall-covection	-1.9109179
Wall-cubierta	0
Wall-tubo_recto	0
Total Heat Transfer Rate(w)	**0.017187849**

Figure(5) Heat Transfer Rate

IV. CONCLUSIONS

Cooling capacity increases with increase in mass flow rate of air and coolant. Reduction in cooling capacity with the increase in inlet air temperature while cooling capacity increases with the increase in inlet coolant temperature. The pressure drop also increases with the increase in air and coolant mass flow rate through radiator. Heat transfer rate increases with increase in surface are of radiator. Effectiveness of radiator increases with increase in the heat transfer rate.

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