*International Journal for Modern Trends in Science and Technology*, 8(06): 74-80, 2022

ISSN: 2455-3778 online
DOI: https://doi.org/10.46501/IJMTST0806008
Available online at: http://www.ijmtst.com/vol8issue06.html

# Analysis of Automobile Radiator using Computational Fluid Dynamics

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**To Cite this Article**
B.Geeta Chandra Sekhar, K.Karthik Preetham Naidu, K.Harish, B Yeshwant Balavada, A Somanadh and G Manjit. . Analysis of Automobile Radiator using Computational Fluid Dynamics. International Journal for Modern Trends in Science and Technology 2022, 8(06), pp. 74-80. https://doi.org/10.46501/IJMTST0806008

**Article Info**
Received: 28 April 2022; Accepted: 28 May 2022; Published: 30 May 2022.

## ABSTRACT

***Radiators are a type of heat exchangers used to transfer thermal energy from one medium to another for the purpose of cooling and heating. Upwards of 33% of the energy generated by the engine through combustion is lost in heat. Insufficient heat dissipation can result in the overheating of the engine, which leads to the breakdown of the lubricating oil, metal weakening of engine parts, and significant wear between engine parts. To minimize the stress on the engine because of heat generation, automotive radiators must be redesigned to be more compact while still maintaining an elevated level of heat transfer components. This led to the increased demand for power-packed radiators, which can dissipate the maximum amount of heat or any given space. This project aims to do the analysis of a straight tube radiator for different velocities. The modeling is done using Creo Parametric, fluid flow analysis is done by using Ansys Fluent.***

*KEYWORDS:* ***ANSYS, CFD, Velocity, Heat Exchanger, Fluent, Radiator***

## INTRODUCTION

Heat exchanger is a type of system that is used to transfer heat between two or more fluids. In both the processes like heating and cooling the heat exchangers are used. To prevent the mixing of the fluids a solid wall is used that keeps the fluids from being directly in contact. Radiators are heat exchangers which transfer the thermal energy from one medium to another medium for the purpose of cooling and heating. Radiator is one such device that consists of large amount of cooling surface which contains coolant that transfers heat from the radiator to the surrounding atmosphere. Radiator has a wide range of applications in automobile industries there are used to cool the internal combustion engine. They also used in piston-engine aircraft, railways, locomotives, motorcycles, stationary generating plants and other places where such engines are used. In the present the car radiators are made up of aluminium, brass, and copper because of high heat conductivity. Radiators transfer most of the heat generated through convection. In 1901 the first car radiator was invented by German engineer Wilhelm Maybach. The radiator is classified based on the core structure of the radiator and the type of the coolant movement inside. In the radiator additional fins are added for the cooling effect where fins absorb most of the heat and dissipate it to the surroundings. Here, can say that the heat transfer is taking place conventionally from the fins to the air . Better coolant velocity determines the heat transfer which is performed by sending the coolant at a specified velocity and inlet temperature and observing the outlet temperature.

## 2. LITERATURE REVIEW

Study related to the Automobile radiator and analysis using CFD has been done by many authors portraying their ideas relating to their work on automobile radiator whose papers are used in review are listed below:

Chavan and Tasgaonkar [1], Low-lying areas and high temperature areas (regions with low heat transfer areas) are identified in the corners. We see that the velocity increases with the rpm of the radiator fan. For optimal performance, it eliminates corners and improves the radius of the Circular mode. The low power consumption of the fan works well because the cost savings of the equipment is 24%, the cost savings on the production of large scale will be about 20% when the operation is done. Radiator analysis was performed using CFD in ANSYS Fluent.

Hardik Kumar Patel and Deepu Dinesen [2],Using CFD were identified by comparing the heat transfer and pressure reduction of the heat exchanger with different performanceparameters. Reduction of Vishwa Deepak Dwivedi and Ranjeet Rai in the cooling capacity of the incoming air temperature while the cooling capacity rises with the rise of the incoming cooling temperature. Decreased pressure also increases with increasing air pressure and with a decrease in the ratio of weight to the radiator. Approximately 6% increase in cooling capacity using a hot-duty louver fin with Nanofluid compared to a standard cooler with the same model.

Jama et al[3], The air flow distribution and non-uniformity across the radiator of full-size Australian made ford falcon was evaluated in industrial wind tunnel. The cooling air intake of the vehicle were shielded by a quarter, one half and three quarter and fully blocked. The best method to shield front end is to employ horizontal method. This shielding method produces the more uniform cooling airflow distribution compared to other methods. Non uniformity index increased significantly as the front-end air intake area was shielded. It is reduced the cooling capacity of the vehicle. These shielding methods also produced higher average velocity across the radiator which is analogous to better cooling.

Oliet et al. [4], Studied varied factors which influences the radiator performance. It includes air, fin density, coolant flow and air inlet temperature. The radiator performance depends upon air and coolant mass flow rate. When air and coolant flow rates increase the efficiency of radiator also increases. When inlet air temperature increases the cooling capacity decreases. Smaller fin spacing and greater louver fin angle have higher heat transfer. Fin density may be increased till it blocks the air flow and heat transfer rate reduced.

## 3. MODELLING AND METHODOLOGY

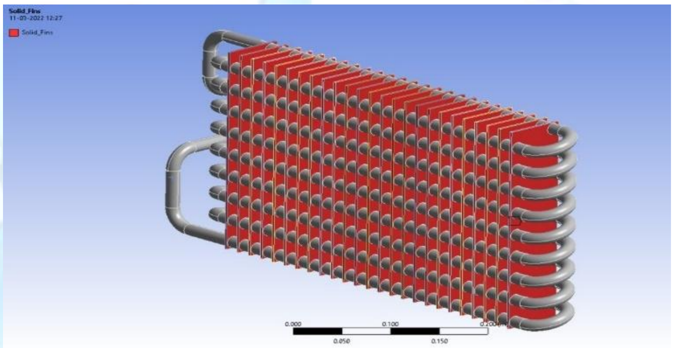

Fig 1 Radiator Fins and Tubes Model

### A. MODEL IMPORT INTO ANSYS

Modelis done in the Creo parametric software has beenimportedintotheANSYSworkbench.The geometry that is imported is showedbelow.

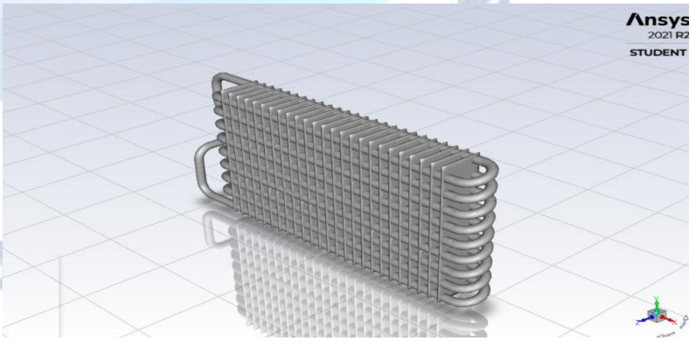


Fig 2 ANSYS Model

### B. MESHING

One oftheimportantfactorsintheANSYS is the Meshing. Themodel must be given a proper meshing to carry out the analysis in future. Meshing gives us the failure and errors in the analysis part and calculations. In the belowfigureshowsameshing done on the model in the black area.Proper meshing gives the accurate results as the nodes and elements are increased. The generated mesh have number of nodes is 58,882 and the number of elements is 1,97,973.

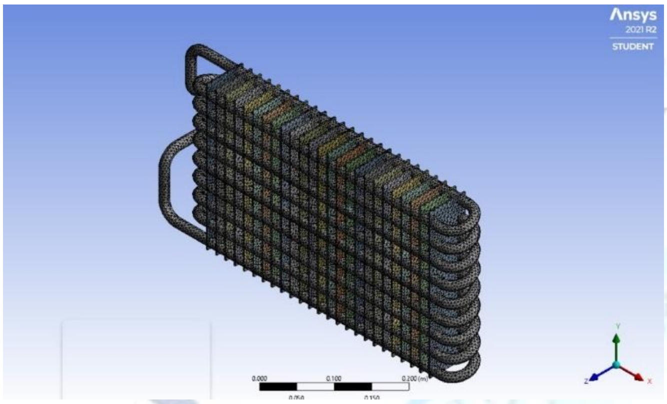


Fig 3 Meshing

### C. METHODOLOGY SETUP

Pre-set up of the solution s is very much important. These include giving inputs such as gravity, selecting the energy and the k-epsilon, giving the material, mentioning the velocity necessary for the analysis, room temperature and giving other reference values and starting the initialization. The graphs are monitored for the given number of iterations obtaining the temperature contours, scaled residuals and temperature outlet.

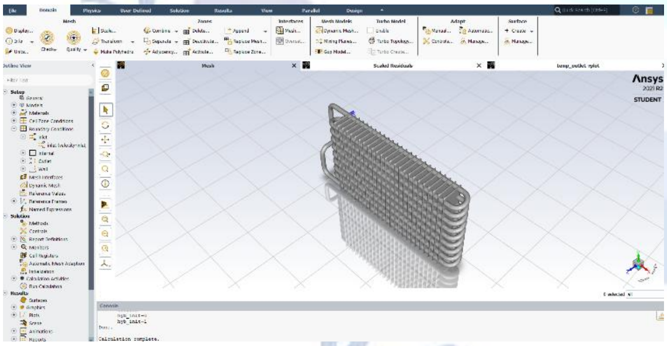

Fig 4 Set Up

### D. GEOMETRY

Specifications of the Car Radiator:

Length of the Fin plate - 0.21 meters
Width of the Fin plate - 0.044 meters
Length of the tube - 0.292 meters
Diameter of each tube - 0.005 meters
Total number of Tubes - 16
Inlet Diameter of Radiator tube - 0.01 meters
Outlet Diameter of Radiator tube - 0.01 meters

### E. ANALYSIS

**For Aluminium**: The Temperature contours for the car radiator with aluminium material upon subjecting to the coolant inlet velocity ranging from 1m/s to 10m/s with a temperature of 373K are shown in the below figures listed from 5 to 14.The Figures show the heat transfer taking place between the coolant water, tubes, and the fins of the car radiator.

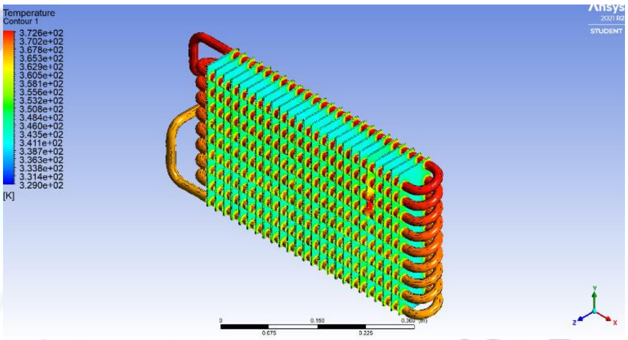


Fig 5 At 1m/s

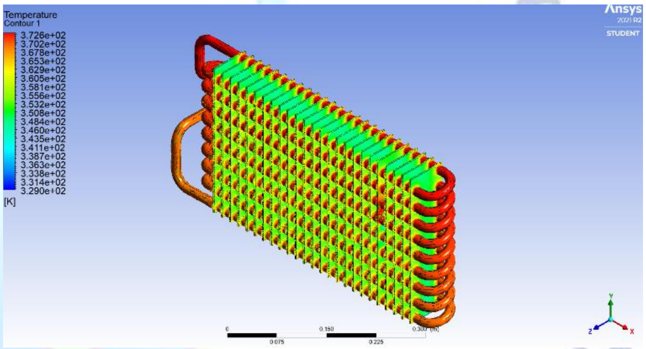


Fig 6 At 2m/s

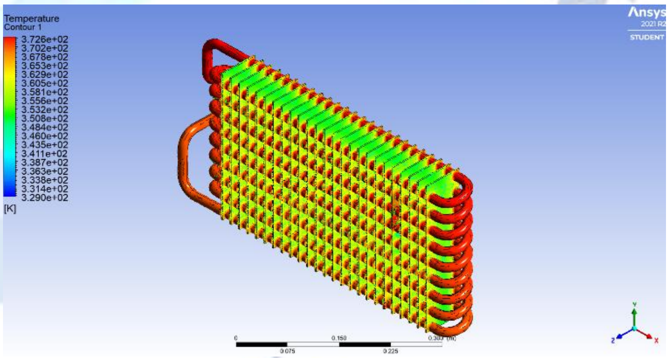


Fig 7 At 3m/s

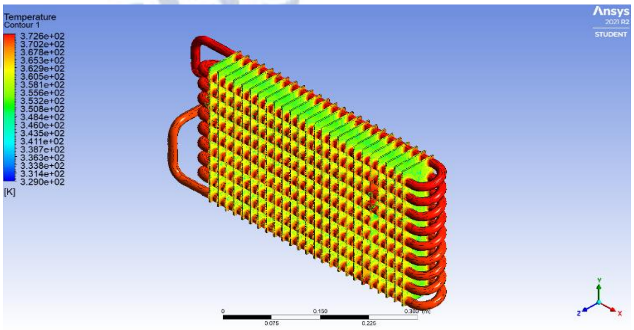


Fig 8 At 4m/s

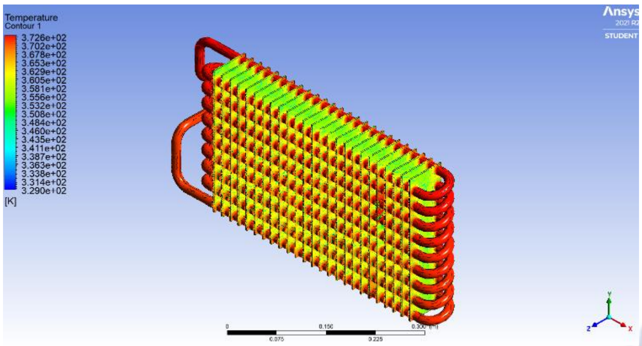


**Fig 9 At 5m/s**

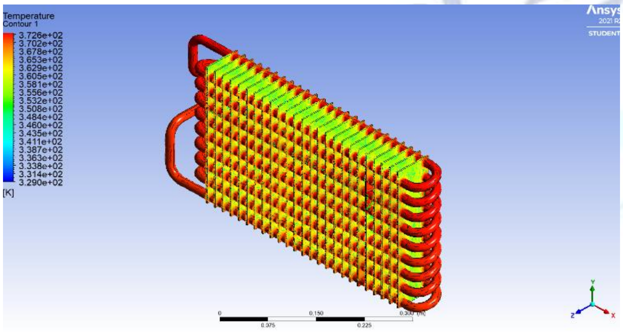


**Fig 10 At 6m/s**

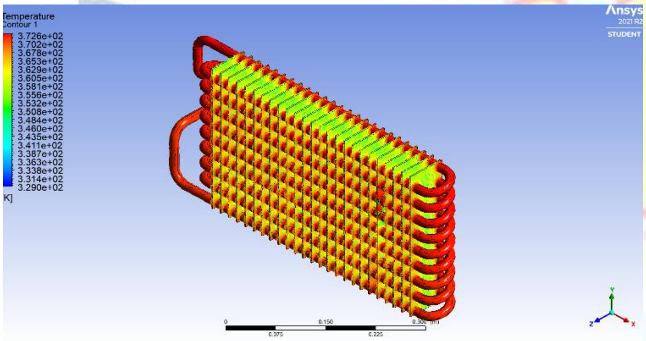


**Fig 11 At 7m/s**

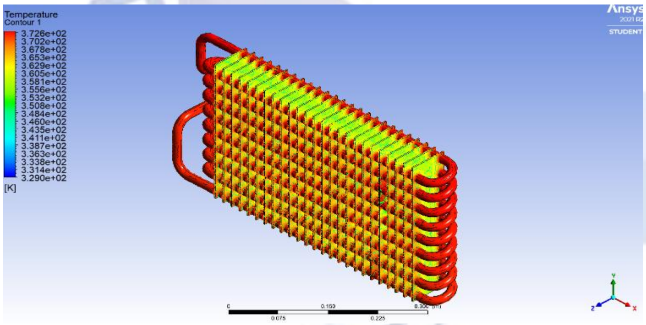


**Fig 12 At 8m/s**

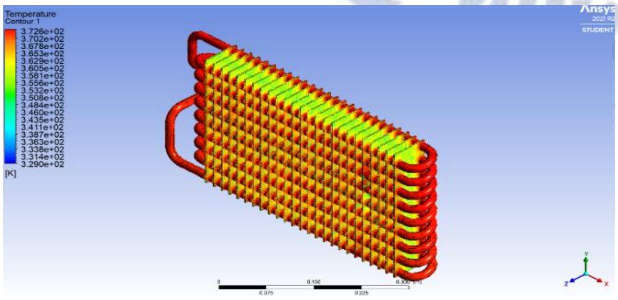


**Fig 13 At 9m/s**

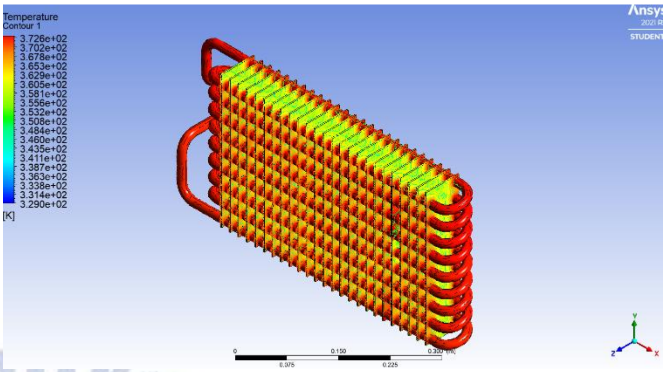


**Fig 14 At 10m/s**

**For Copper**: The Temperature contours for the car radiator with aluminium material upon subjecting to the coolant inlet velocity ranging from 1m/s to 10m/s with a temperature of 373K are shown in the below figures listed from 15 to 24. The Figures show the heat transfer taking place between the coolant water, tubes, and the fins of the car radiator.

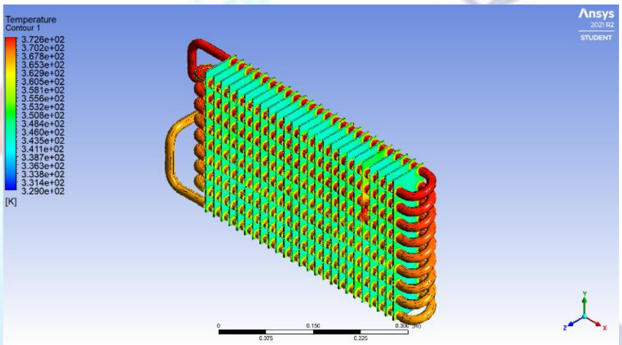


**Fig 15 At 1m/s**

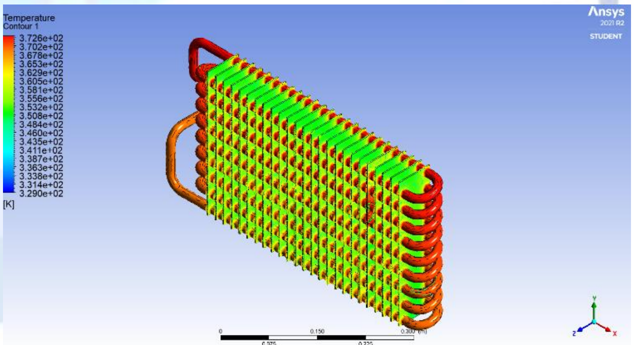


**Fig 16 At 2m/s**

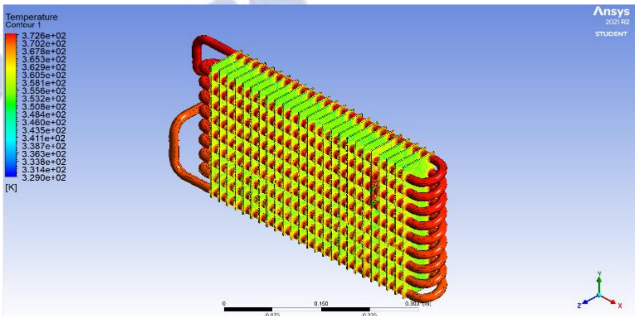


**Fig 17 At 3m/s**

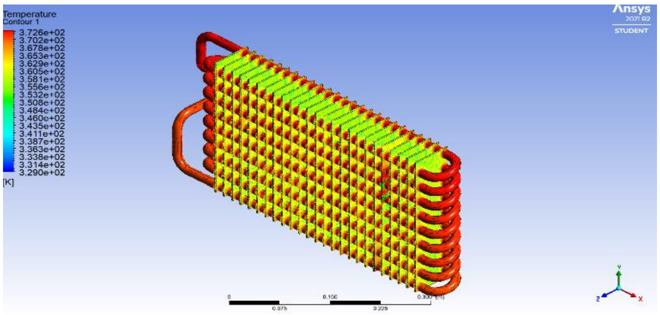


Fig 18 At 4m/s

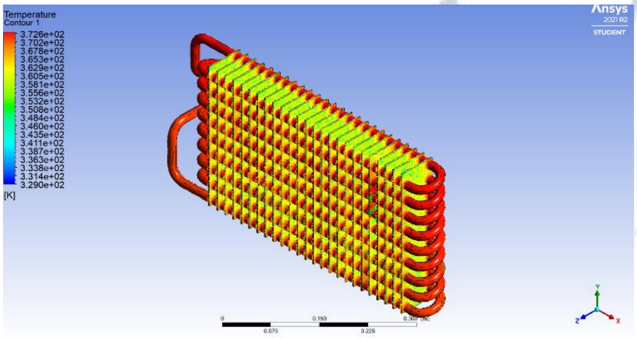


Fig 19 At 5m/s

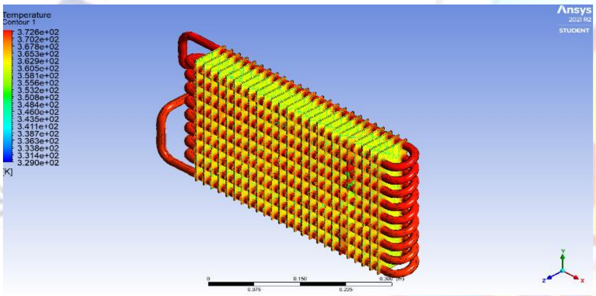


Fig 20At 6m/s

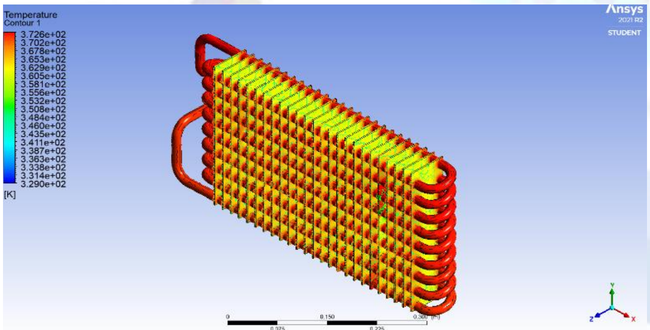


Fig 21 At 7m/s

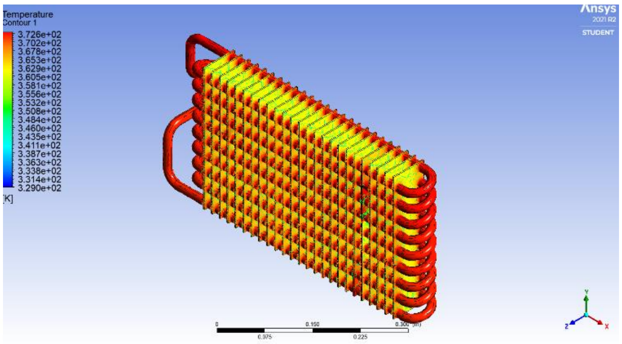


Fig 22 At 8m/s

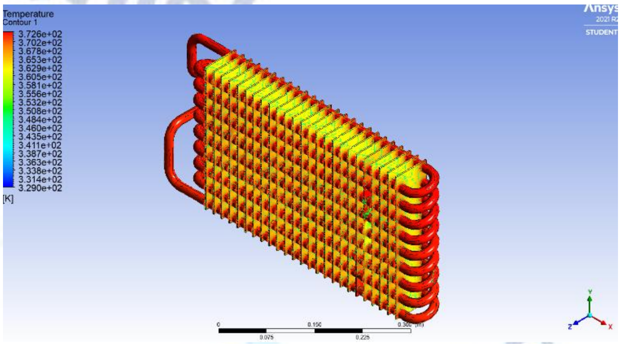


Fig 23 At 9m/s

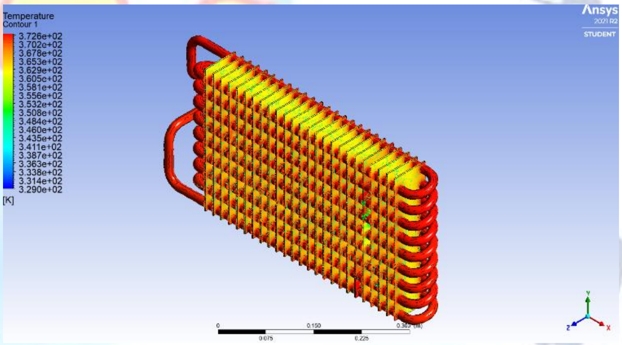


Fig 24 At 10m/s

## 4. RESULTS AND DISCUSSIONS

The Table 1.1 shows the outlet temperatures of the coolant from the car radiator at different velocities for Aluminiummaterial.

The Table 1.2 shows the outlet temperatures of the coolant from the car radiator at different velocities for Coppermaterial.The table values are increasing from 1m/s to 10m/s. The minimum temperature of the coolant for Aluminium material is 366.834K at a velocity of 1m/s and the minimum temperature of the coolant for Aluminium material is 366.684K at a velocity of 1m/s. The table values are increasing from 1m/s to 10m/s. We can concludethatincreaseinthe car radiator velocitywillleadto less time interaction of the coolant with the wall of the tubes. As there is less time interaction there is no heat transfer between the radiator tubes and between tubes and the fins. Hence, there is no heat loss in the coolant as the velocity increases. As the velocity decreases there is more contact between the coolant to the tubes and from tubes to the fins. So, there is more heatloss. As the process is going on at the room temperature the heat transfer rate is faster. Conduction takes place between the tube and the fins and convection takes place between the fins and the surrounding atmosphere. Comparing both the aluminum and copper materials, copper is the best suited material with the coolant inlet of 1m/s for the car radiator.

**Table 1 Table of Outlet temperature corresponding to the inlet velocity of the coolant for aluminium**

| VELOCITY (m/s) | OUTLET TEMPERATURE (K) |
|---|---|
| 1 | 366.834 |
| 2 | 369.318 |
| 3 | 370.360 |
| 4 | 370.962 |
| 5 | 371.312 |
| 6 | 371.582 |
| 7 | 371.777 |
| 8 | 371.914 |
| 9 | 372.033 |
| 10 | 372.101 |

**Table 2 Table of Outlet temperature corresponding to the inlet velocity of the coolant for copper**

| VELOCITY (m/s) | OUTLET TEMPERATURE (K) |
|---|---|
| 1 | 366.684 |
| 2 | 369.243 |
| 3 | 370.295 |
| 4 | 370.893 |
| 5 | 371.261 |
| 6 | 371.582 |
| 7 | 371.742 |
| 8 | 371.892 |
| 9 | 372.006 |
| 10 | 372.086 |

**Calculation:**

Coolant (C): Water

Velocity (V): 1m/s

Diameter of the cross section (d): 10mm = 0.01m

Area (A): $\pi d^2/4 = (3.14*(0.01^2))/4 = 7.85*10^{-5} m^2$

Discharge (Q): Q=AV $m^3/sec=(7.85*10^{-5})*1=7.85*10^{-5}$ $m^3/sec=7.85*10lit/sec$

Density of water ($\rho$): $kg/m^3 = 997\ kg/m^3$

Mass Flow rate (M): $\rho Q = (7.85*10^{-5}) * 997 = 0.078$ kg/s

## 5. CONCLUSION

In this present work ,CFD Analysis of Car Radiator is done for different velocities by using Aluminium and Copper and we have observed that as the velocity of the coolant increases the cooling capacity of the radiator decreases.

- In this present work, CFD Analysis of Car Radiator is done for different velocities by using Aluminium and Copper and we have observed that as velocity of the coolant increases the cooling capacity of the radiator decreases.
- It is observed that for Copper as radiator material, at a velocity of 1m/s it is preferable to entry the coolant when compared to the remaining values from 1m/s to 10m/s. Similarly, it is observed that for Aluminium as radiator material, at a velocity of 1m/s it is preferable to entry the coolant when compared to the remaining values from 1m/s to 10m/s.

When comparing the Copper and Aluminium as the materials of the radiator, the outlet temperature of coolant is less for copper at a Fluid velocity of 1m/s when compared to Aluminium material. For a velocity of 1m/s the calculated mass flow rate of the coolant is 0.078 kg/s and discharge is 7.85*10^-2 lit/sec. So, it is advisable to entry the fluid at a velocity as 1m/sec for copper material of the Radiator.

**Conflict of interest statement**

Authors declare that they do not have any conflict of interest.

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