

THERMAL PERFORMANCE ANALYSIS OF RADIATORS WITH NANO COATED MATERIAL

Submitted in partial fulfillment of the requirements for the award of the
Bachelor of Engineering Degree in
Automobile Engineering

By

HUBERT JOE.K (Reg. No. 37860012)

MOHAMED ABAITH .S (Reg. No. 37860018)



**DEPARTMENT OF AUTOMOBILE ENGINEERING
SCHOOL OF MECHANICAL ENGINEERING**

**SATHYABAMA
INSTITUTE OF SCIENCE, AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

**Accredited with Grade "A" by NAAC | 12b status by UGC | Approved by AICTE
JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI-600119**

MARCH –2021



SATHYABAMA

INSTITUTE OF SCIENCE, AND TECHNOLOGY

(DEEMED TO BE UNIVERSITY)

Accredited with A grade by NAAC | 12B status by UGC | Approved by AICTE

Jeppiar Nagar, Rajiv, Gandhi Salai, Chennai-119

www.sathyabama.ac.in

DEPARTMENT OF AUTOMOBILE ENGINEERING

BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of HUBERT JOE.K (Reg.No:37860012) and MOHAMED ABAITH.S (Reg.No:37860018), who carried out the project entitled “**THERMAL PERFORMANCE ANALYSIS OF RADIATORS WITH NANO COATED MATERIAL**” under our supervision from October 2020 to April 2021.

Internal Guide

Mr.P.KARTHIKEYAN, M.E.,

Head of the Department

Dr.V.K.BUPESH RAJA, ME.,PhD.,

Submitted for Viva-voce Examination held on

Internal Examiner

External Examiner

DECLARATION

We **HUBERT JOE.K (Reg.No.37860012)**, and **MOHAMED ABAITH.S (Reg.No.37860018)** hereby declare that the Project Report entitled **“THERMAL PERFORMANCE ANALYSIS OF RADIATORS WITH NANO COATED MATERIAL”** done by us under the guidance of Assistance professor. **Mr.P.KARTHIKEYAN, M.E.**, Department of Automobile Engineering at SATHYABAMA INSTITUTE OF SCIENCE, AND TECHNOLOGY, is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering in AUTOMOBILE ENGINEERING.

DATE:

PLACE: CHENNAI

SIGNATURE OF THE Candidate

ACKNOWLEDGEMENT

I am pleased to acknowledge my sincere thanks to the **Board of Management of SATHYABAMA** for their kind encouragement in doing this project and for completing it successfully. I am grateful to them.

I convey my thanks to **Dr.S.PRAKASH, M.E.,Ph.D.**, Dean, School of Mechanical Engineering, and **DR.V.K.BUPESH RAJA, M.E.,Ph.D.**, Head of Department, Dept of Automobile Engineering, for providing me necessary support and details at the right time during Progressive reviews.

I would like to express my sincere and deep sense of gratitude to my Project Guide Assistant professor **Mr.P.KARTHIKEYAN, M.E.**, Department of Automobile Engineering, for his valuable guidance, suggestions, and constant encouragement that pave the way for the successful completion of my project work.

I wish to express my thanks to all Teaching and Non-teaching staff members of the Department of Automobile Engineering who were help fulfilling many ways for the completion of the project.

ABSTRACT

Radiators are the type of heat exchanger used to transfer thermal energy from one medium to another for cooling and heating. The heat dissipation efficiency of the radiators is of great significance to the reliability of the power transformer system. However, traditional coatings on the radiators are designed to improve the corrosion resistance of radiators which usually have a lower thermal conductivity. In this project, the thermal properties of copper coating have been studied with 100micron coating thickness. The main objective of the work is about 15% improvement in the thermal conductivity compared to the traditional anticorrosive coatings. It provides a simple and effective way to accelerate the heat spread of radiators and thus lower the system temperature.

In this project, the coolant fluid will be transmitted at .04 kg/s mass flow rates, at 100-micron coating thicknesses, and coated on the top surface of the radiator tubes and fins. Flow analysis will be performed for 100c temperature as heat input conditioning for CFD. The optimal values of the parameters are obtained with the help of the graphs.

The radiators are made from an aluminum fin and tubes. Hot water is used for the tube side, while atmospheric air is used as a working fluid on the airside. The results are presented as contours of Velocity, Pressure, and Temperature with the fin length of the Radiators.

TABLE OF CONTENTS

CHAPTER NO	TITLE	PAGE NO
	ABSTRACT	V
	LIST OF CONTENT	VI
	LIST OF TABLE	IX
	LIST OF FIGURE	IX
	LIST OF SYMBOLS AND ABBREVIATIONS	XII
1	INTRODUCTION	
	1.1 TYPES OF RADIATORS	1
	1.1.1 TUBULAR TYPE CORE	1
	1.1.2 CELLULAR TYPE CORE	4
	1.2 CONSTRUCTION OF RADIATORS	5
	1.3 RADIATORS WORKING PRINCIPLE	6
	1.4 ADVANTAGE OF RADIATORS	8
	1.4.1 DISADVANTAGE OF RADIATORS	9
2	LITERATURE SURVEY	10

3	OBJECTIVE AND INNOVATION	14
	3.1 PROBLEM IDENTIFICATION	
	3.2 OBJECTIVE	
4	MATERIAL AND METHODS	15
	4.1 METHODOLOGY	15
	4.2 CAD	16
	4.3 3D DESIGNS (SOLID WORKS)	17
	4.3.1 BILL OF MATERIAL	17
	4.4 ANALYSIS	24
	4.4.1 FLOW SIMULATION	25
	4.5 MATERIAL TO BE USED	26
	4.5.1 ALUMINUM T6	26
	4.5.2 COPPER ALLOY	27
5	INPUT PARAMETERS OF THE ANALYSIS	28
	5.1 CFD SIMULATION WALL CONDITION	28
	5.1.1 WATER FLUID PROPERTIES	30
	5.1.2 SOLID ALUMINUM PROPERTIES	31
	5.1.3 COPPER ALLOY PROPERTIES	32
6	RESULT	33

	6.1 WITHOUT COATING	33
	6.1.1 WITHOUT COATING-INLET, OUTLET, FIN, PIPE	
	TEMPERATURE RESULTS.	35
	6.2 WITH COATING	40
	6.2.1 WITH COATING-INLET, OUTLET, FIN, PIPE	
	TEMPERATURE RESULTS	
7	CONCLUSION.	46
8	REFERENCES	47

LIST OF TABLES

S.NO	TABLE NO	TITLE	PAGE NO
1	4.3.1	Bill of material of radiators	17
2	4.4	property of Aluminum Al-6061 (T6)	26
3	4.5	Property of Copper Alloy	27

LIST OF DIAGRAMS

S.NO	FIGURE NO	TITLE	PAGE NO
1	Fig 1.1	Automobile radiators	1
2	Fig 1.1.1	Tubular type	3
3	Fig 1.1.2	Cellular type core	4
4.	Fig 1.2.1	Radiator and its working parts	5
5	Fig 1.3.1	Aluminum radiators	6
6	Fig 4.1	Radiators full view	17
7	Fig 4.2.1	Plate end	18
8	Fig 4.2.1	Dimension of plate end	19
9	Fig 4.2.2	Copper pipe C type	19
10	Fig 4.2.3	Dimension of copper C type	20
11	Fig 4.2.4	Dimension and Design of the copper tube	21
12	Fig 4.2.5	Cooling plate	22
13	Fig 4.2.6	Dimension of the cooling plate	22
14	Fig 4.2.7	Radiators pipe	23
15	Fig 4.2.8	Dimension of the Radiators pipe	23

16	Fig 5.1.1	Water fluid properties	30
17	Fig 5.1.2	Solid aluminum properties	31
18	Fig 5.1.3	Copper alloy properties	32
19	Fig 6.1.1	Without coating inlet, outlet, fin, pipe temp	33
20	Fig 6.1.2	Without coating convergence graph	34
21	Fig 6.1.3	Without coating outlet temp convergence	34
22	Fig 6.1.4	Without coating fin surface temp convergence	35
23	Fig 6.1.5	Without coating inlet, outlet, fin, pipe temp	37
24	Fig 6.1.6	Without coating pressure contour	38
25	Fig 6.1.7	Without coating fluid temp	38
26	Figs 6.1.8	Without coating velocity streamline flow	39
27	Fig 6.1.9	Without coating velocity vector flow	40
28	Fig 6.2.1	With coating outlet temp convergence graph	40
29	Fig 6.2.2	With coating fin surface temp convergence	41
30	Fig 6.2.3	With coating convergence graph	41
31	Fig 6.2.4	With coating inlet, outlet, fin, pipe temp result	43
32	Fig 6.2.5	With coating contour velocity result	44

LIST OF ABBREVIATIONS

CAD	Computer Aided Design
FEA	Element Analysis
CFD	Computational Fluid Dynamics
Al	Aluminum
Sn	Tin
Zn	Zinc
Cu	Copper
P	Phosphorus
FE	Finite Element
N	Newton

CHAPTER 1

INTRODUCTION

Radiators are used to convert thermal energy from one mode to another for cooling and heating. Radiators function in automobiles, buildings as well as in electronics. The radiators act as a source of heat to the surrounding, but it might be the purpose of heating the environment, and it acts as a coolant source for automotive engine cooling.

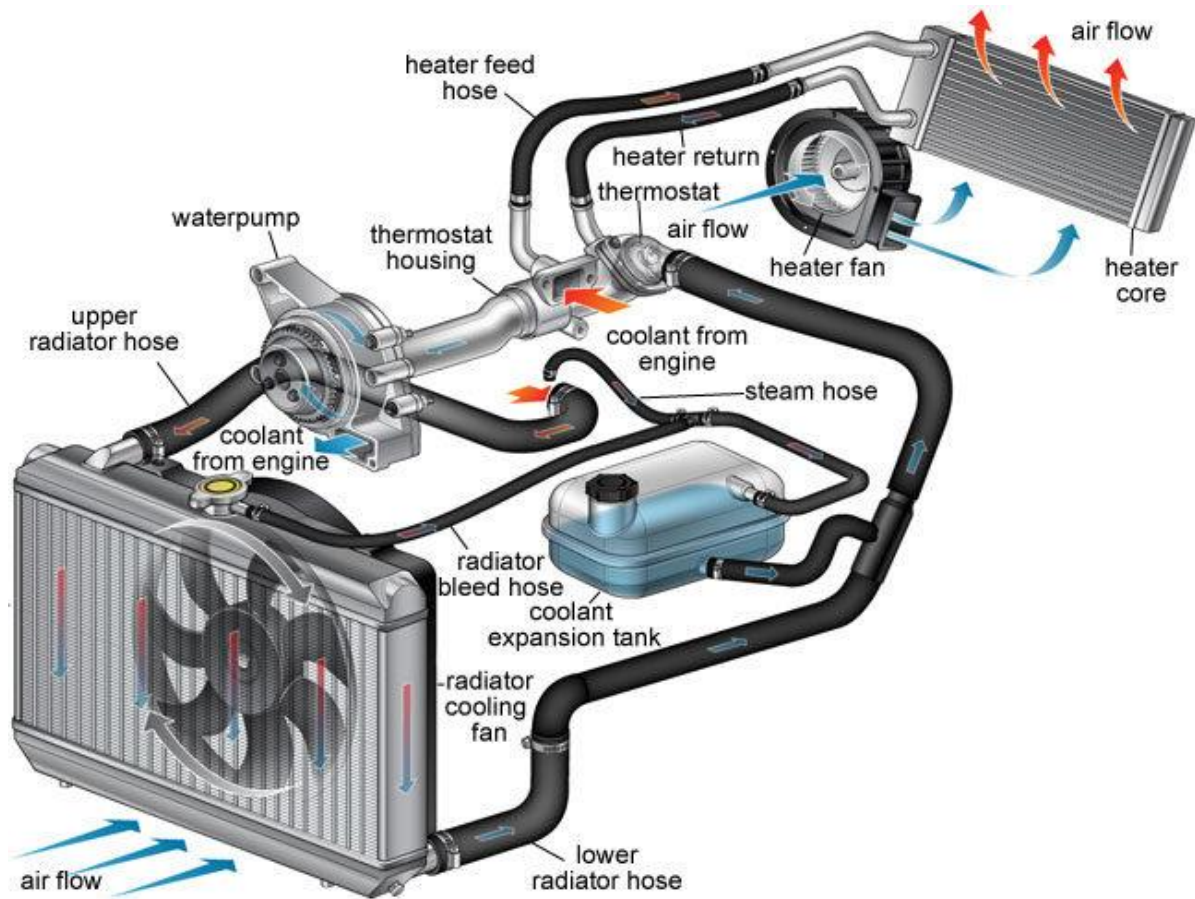


FIG:1.1 AUTOMOBILE RADIATORS

Radiators transfer most of their heat via convection rather than thermal radiation. If there are large temperature differences, it can distort the engine components. The radiators will do the cooling purposes because the temperature of the burning gases in the engine cylinder reaches up to 1500 to 2000°C.

The radiators have a wide range of application in automobile industries there are mainly used to cool the internal combustion engine in the automobile. They are also used in piston-engined aircraft, railways, locomotives, motorcycles, stationary generating plants, and other places where such engines are used.

The heat exchangers are made from aluminum plate finned copper tubes. Ambient air is used as a working fluid in the airside, while hot water is used for the tube side. The experimental results revealed that the fin pitch has an insignificant effect on the heat transfer characteristic

1.1: Types of Radiators

There are two basic types of radiators

1. Tubular type
2. Cellular type

1.1.1Tubular Type Core

In a tubular-type core, the upper and lower tanks are connected by a series of tubes through which water passes. Fins are placed around the tubes to improve heat transfer. Air passes around the outside of the tubes, between the fins, absorbing heat from the water in passing.

In a tubular radiators, because the water passes through all the tubes, if one tube becomes clogged, the cooling effect of the entire tube is lost.



Fig:1.1.1 Tubular Type Core

1.1.2: Cellular Type Core

In cellular type core, air passes through the tubes, and the water flows in the spaces between them. The core is composed of a large number of individual air cells which are surrounded by water. Because of its appearance, the cellular type usually is known as honeycomb radiators, especially when the cells in front are hexagonal.

In cellular radiators, the clogging of any passage results in a loss but of a small part of the total cooling surface.

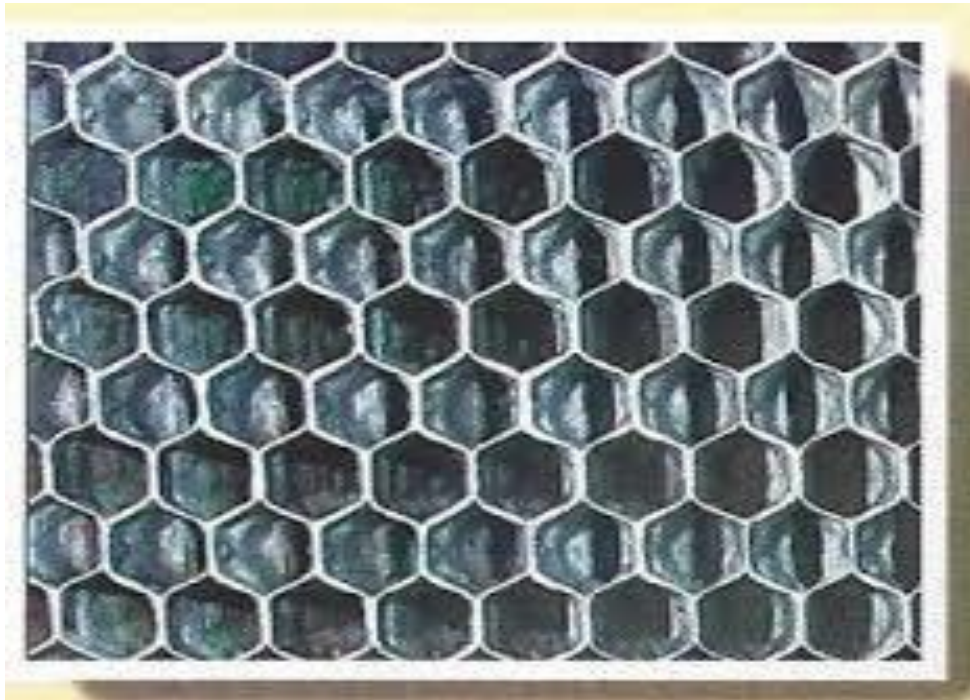


Fig:1.1.2 cellular type core

1.2: Construction of Radiators

It consists of an upper tank and a lower tank, and between them, a core.

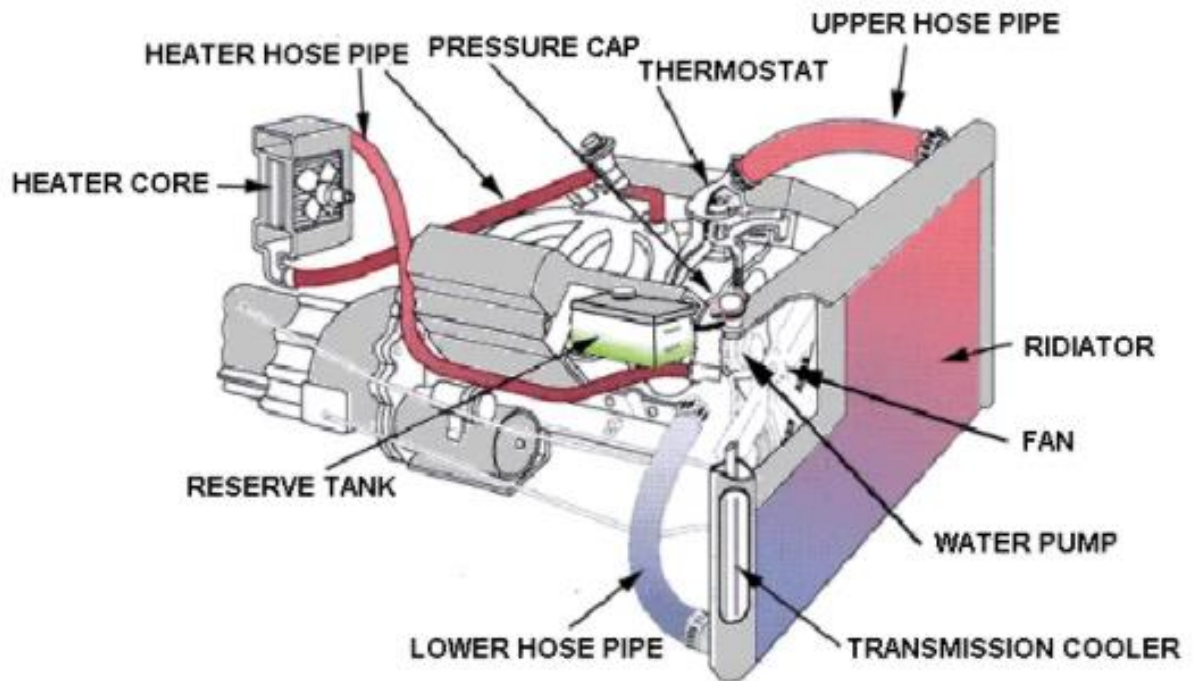


Fig 1.2.1 Radiators and their working parts

- The upper tank is connected to the water outlet or outlets from the engine jacket by a hosepipe and
- The lower tank is connected to the jacket inlet through the water pump.
- The core is a radiating element, which cools the water.

1.3: Radiators Working Principle

The radiators are a pretty simple device. Nowadays, **most modern cars use aluminum radiators**. Radiators usually have a tank on each side, and inside the tank is a transmission cooler.

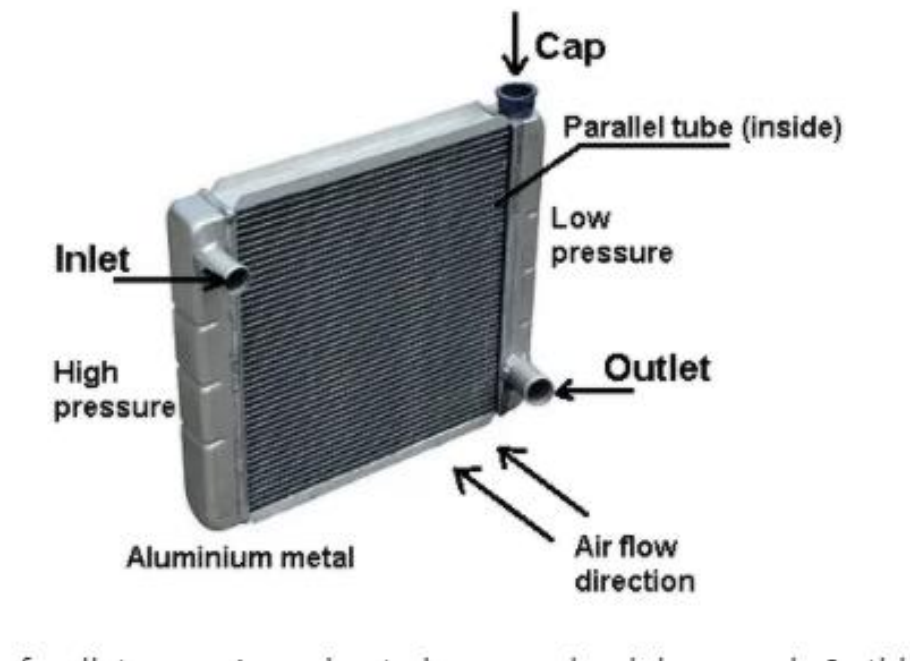


Fig 1.3.1 Aluminum radiators

In this type of radiator, you're going to have an aluminum mesh. This aluminum device consists of two ports inlet and outlet. Inside the radiators, there are tubes mounted in a parallel arrangement, and the aluminum fins are attached to all of the tubes.

The Radiators working is very simple. In the radiators, the coolant flows from the inlet to the outlet through many tubes mounted in a parallel arrangement.

The hot water enters the radiators through the inlet port, and a fan is attached behind the radiators to cool down the hot water in the tubes. The fan blows the air and cools down the water. So the water is going to come out cooler than it entered before and then go back to the engine.

Now how it does that air is going to be feeding through this.

The aluminum fins are attached to the tubes this called tubulator. Now the tubes are filled with hot coolant coming from the engine. So they're going to give off heat to this aluminum coat by passing air through the fan, it cools the aluminum coat. If the fluid flowed very smoothly through the tubes, only the fluid actually touching the tubes would be cooled directly. Now it is going to send out to the cooler and then go back to the engine.

Radiation and Convection One might expect the term “radiators” to apply to devices that transfer heat primarily by thermal radiation (see: infrared heating), while a device that relied primarily on natural or forced convection would be called a “convector.” In practice, the term “radiators” refers to any of a number of devices in which a liquid circulates through exposed pipes (often with fins or other means of increasing surface area), notwithstanding that such devices tend to transfer heat mainly by convection and might logically be called convectors. The term “convector” refers to a class of devices in which the source of heat is not directly exposed.

1.4: ADVANTAGES OF RADIATORS

- **Low maintenance:** While there are some instances where radiators will need to be serviced by a professional, they tend to be relatively low maintenance. This is because they are hooked up to your home's plumbing system and utilize your water heater to produce heat: they themselves have very few internal components that will need to be checked upon or replaced.
- **Reliable:** In a similar vein to the above point, radiators are extremely durable and reliable, usually being made out of porcelain, cast iron, or ceramic, which means that they can withstand a great deal of wear and tear without becoming damaged. In addition, due to the fact that they have very few moving parts and no dedicated heating element, they are unlikely to suffer mechanical breakdowns and stop functioning even after years of use.
- **Conductivity:** Another major advantage of radiators is the fact that ceramic, cast iron, and other materials used to construct them will hold on to heat for an extended period of time, which means that your radiators will continue to heat up the room that it is installed in even after they have been turned off.

1.4.1: DISADVANTAGES OF RADIATORS

- **Noise:** A key disadvantage associated with radiators is the fact that they can be noisy while operating, which is usually caused by some sort of air that is caught in the pipes. This can take the form of squealing, banging, or other knocking sounds.
- **Needs Ventilation:** In order for a radiator to properly work, it needs an adequate amount of airflow in the room that it is installed in. Otherwise, the heat from the unit will simply sit around the unit, which can reduce the comfort levels within your home and create drafts and cold spots.
- **Hot:** Another major downside of radiators, especially if you have small children or pets in the house, is the fact that they can grow extremely hot to the touch while working. This is an important safety consideration to keep in mind, as burnt hands or paws (or even drapes and blankets that catch fire) are an important safety consideration.

CHAPTER 2

LITERATURE SURVEY

- [1].I K E H Wiryanta, and I M A Adiaksa did “Experimental and numerical investigation of thermal radiators performances as a source of heat energy in the design of dryer simulation.”

The purpose of this research was to investigate the temperature performance of the tube and fin car radiators experimentally and numerically. The experiment research was carried out on a simulation design consists of a reservoir water tank, a heater, a pump to circulate hot water to the radiators, and a cooling fan. The geometry and meshing created using ANSYS Workbench and the post-processing using Fluent. The simulation result showed the similarity with the experimental research. From the results of experimental and numerical analysis of radiators performances in this study, it can be suggested several things to improving the performances. The first is an improvement on the system designs, optimizing the speed of the cooling fan and also optimizing the flow rate of the hot water from the reservoir to the radiators so that the radiators work rejecting heat can be more optimal.

- [2].P.Natarajan Performed “Heat Transfer Analysis in Light Passenger Car Radiators with Various Geometrical Configurations”

The research work was focused on the Design and analysis of various aspects of single-phase convective heat transfer. The Design and analysis of the effects of various geometrical configurations on the Performance of a staggered type fin and tube radiators are presented. The method is demonstrated on the fins-tube as elements for the heat transfer, but it can in principle be applied also to other

geometrical configuration forms. The study is conducted to investigate the effects of the tube performance of the radiators having various geometrical configurations. They concluded that the outlet temperature and maximum velocity for circular and oval tube-III are nearly the same as other oval tubes, oval tube-I, oval tube-II are less than oval tube-III. Pressure is high for oval tube-III than for the circular tube.

[3].Sudalai Suresh Pungaiah, and Chidambara Kuttalam Kailasanathan did “Thermal Analysis and Optimization of Nano Coated Radiators Tubes Using Computational Fluid Dynamics and Taguchi Method”

In this study, the coolant fluid was transmitted at three different mass flow rates, at three different coating thicknesses, and coated on the top surface of the radiators tubes. Thermal analysis is performed for three temperatures as heat input conditioning for CFD

The design parameters of the Taguchi method and the CFD analysis are found to provide a simple, systematic, and efficient methodology for optimizing process parameters. The findings of ANOVA showed 95% confidence and were confirmed in the most significant parameters. The heat transfer efficiency of the radiators increases primarily due to the copper nano-coating on the aluminum core of the radiators. By coating, the copper particles on the aluminum tubes, the heat transfer properties of copper are accomplished by the heater core. Therefore, we can minimize the front portion of the vehicle by using a copper-coated aluminum tube radiators instead of a traditional aluminum radiators to cool the engine that produces high power to achieve maximum performance. The inner layer of aluminum has the same traditional properties and the outer layer of copper coating is free from rust and has less weight than the true copper alloy radiators.

[4].C. Uma Maheswari, C. Suresh Reddy, C, Rajeshwara Reddy, A.T. KiranSai Naidu, C. Saradhi, A. Chenna kesavulu did” CFD ANALYSIS OF RADIATORS”

This paper deals with the thermal, and CFD analysis of automobile radiators. They did a theoretical calculation in MAT Lab by varying the mass flow rate of coolant. The temperature distribution, heat transfer rate for different velocities of coolant to has been done for different tube materials such as copper, aluminum, and stainless steel. The numerical results were compared and found that copper has the best heat transfer rate, and has better efficiency than the others.

Finally, they concluded that when the coolant mass flow rate increases the outlet temperature of the coolant increases. Their results show that copper has the highest, and aluminum is better than stainless steel. Due to corrosion-resistant copper is best used for tube materials

Research Gap: They discussed radiator tubes made of copper, aluminum, and stainless steel. They have not included the radiators fins in CFD Analysis.

[5].Sai Kiran.S, Dr.M.V.A.Raju did “Modeling& Analysis of Louvered Fin Radiators with Nanofluids Using CFD”

In this research work, the computational analysis tool ANSYS is used to perform a CFD analysis on a radiators at different mass flow rates, normally the radiators has no louvered fins The CFD analysis will be performed for the radiators with and without louvered fins. Modeling and Analysis are performed in CFD.

The results from the computations are found to be in good agreement with that of the experiments. In order to ensure improvement in heat transfer in nanofluid, The fluid flow and heat transfer analysis of the automotive radiators (louver fin) with Nanofluid is successfully carried out. The variations in the pressure, temperature, and velocity in

the direction of coolant flow and airflow are analyzed. Cooling capacity increases with an increase in the 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.

[6].Kola David, Abhishek Kumar did “CFD and Heat Transfer Analysis of Automobile Radiators Using Helical Tubes”

In this research work, different Nanofluids mixed with base fluid water are analyzed for their performance in the helical type tube and straight type tube radiators. The 3D model of the radiators is done in CREO parametric software. CFD analysis is done on the radiators for all fluids, and thermal analysis is done in Ansys.

In this project, different types of fluids are applied to the radiators. Finally, they concluded, by observing the CFD analysis the heat transfer coefficient values are increases by increasing the mass flow inlet. When they compare the fluids the aluminum oxide Nanofluid is the better fluid because the heat transfer rate value is more at fluid aluminum oxide Nanofluid. By observing thermal analysis results, heat flux is more when Copper is used than Aluminum alloy. When they compare the different geometries of the radiators the helical type tube is the better model because the heat transfer rate value is more for helical type tube radiators is the better model.

[7].Upendra K, CFD analysis of automobile radiators- A review In proceeding of the International Jornal of Engineering Research and Applications, International Conference on Emerging Trends in Mechanical and electrical engineering, Thai Nguyen, Vietnam, 13-14 March 2014

CHAPTER 3

OBJECTIVE AND INNOVATION

3.1 PROBLEM IDENTIFICATION

- Most of the articles show that they discussed radiators tubes made of copper, aluminum, and stainless steel. They have not included the radiators fins for CFD Analysis.
- They conducted CFD analysis with some coating materials for specific temperature and Mass flow rate.

3.2 OBJECTIVE

In this project, the coolant fluid will be transmitted at .04 kg/s mass flow rates, at 100-micron coating thicknesses, and coated on the top surface of the radiators tubes and fins.

Flow analysis will be performed for 100c temperature as heat input conditioning for CFD. The optimal values of the parameters are obtained with the help of the graphs. The main objective of the project is to compare and increase the heat dissipation rate of automobile radiators with and without coating material.

The results will be obtained by comparing the results of the computational fluid dynamics analysis with the copper nano-coating and without the copper nano coating.

CHAPTER 4

MATERIAL AND METHOD

4.1 METHODOLOGY

- Create a Radiators geometry using Solid works
- Export to ANSYS Workbench for preparing the model for Flow Analysis
- Meshing geometry using Tetra element with the Skewness value < 1
- Define the wall condition
- Export the meshed model to fluent
- Assigning fluid and Solid Domain
- Defining fluid and solid properties
- Fluid and Solid Boundary condition
- Run the iteration
- export the results to CFD Post -Postprocessor
- Post-process temperature results in the inlet, Fin Surface, Pipe outer surface, and outlet
- The same will be repeated with coating Material
- Compare the results between both coating and without coating

Software methodology was adopted for the progress of the work.

Here Modelling is done with Solid works and analysis done with ANSYS CFD.

DESIGN AND ANALYSIS

The radiators of a commercially existing vehicle are chosen for the analysis to bring practicality to the study. the details of the geometry of the radiators were obtained by the process of reverse engineering. The dimensions of individual components of the radiators were measured using suitable measuring instruments then used to generate the Gambit model. Discrediting the fluid domain, simulation of the fluid flow with heat transfer at steady-state, and post-processing the results, and drawing suitable conclusions.

4.2 COMPUTER AIDED DESIGN

Computer-aided Design (CAD) is defined as the application of computers and graphics software to aid or enhance product design from conceptualization to documentation. CAD is most commonly associated with the use of an interactive computer graphics system, referred to as a CAD system. Computer-aided design systems are powerful tools and in the mechanical Designand geometric modeling of products and components.

There are several good reasons for using a CAD system to support the engineering design function:

- To increase the productivity
- To improve the quality of the Design
- To uniform Design standards
- To create a manufacturing database.

In our project, we have used solid work 3d modeling software to design automobile radiators. with various parts of the radiators, and meshed together to get the complete radiators

4.3 3D DESIGNS (SOLID WORKS)

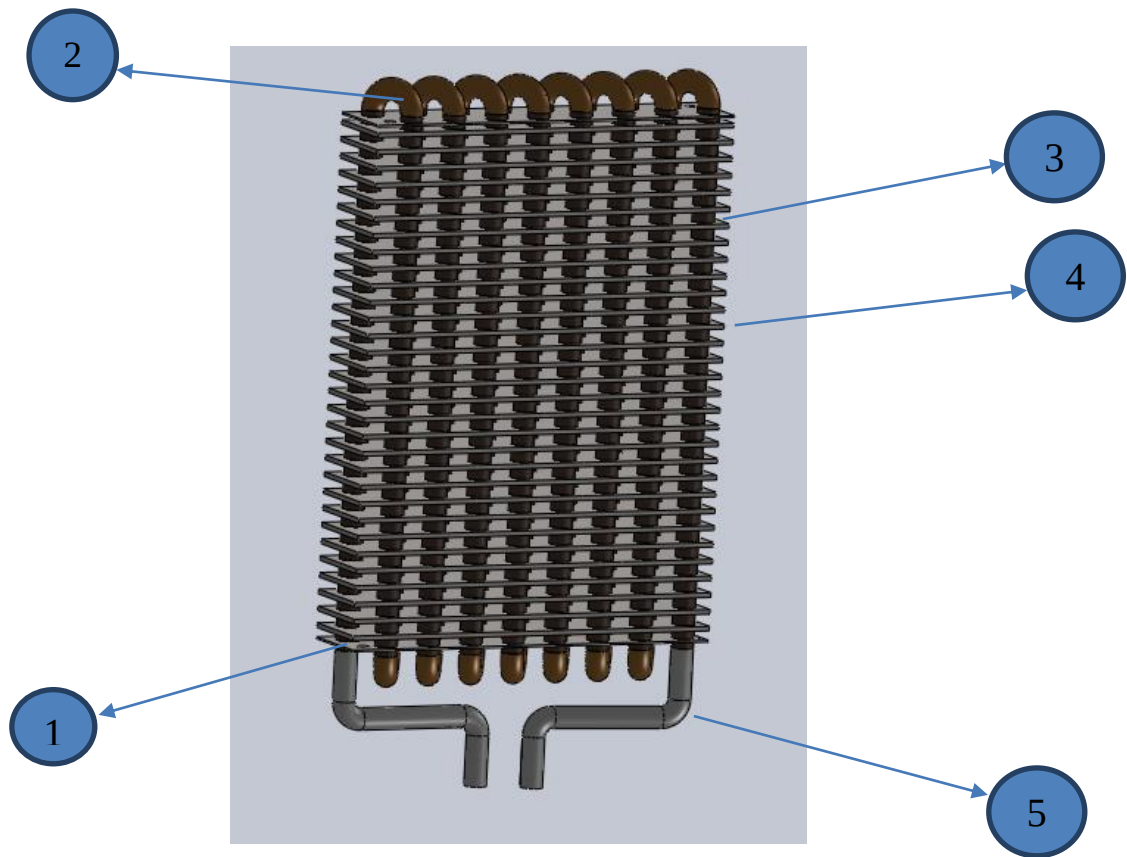


Fig 4.1 Radiators full view

4.3.1 BILL OF MATERIALS

S.NO	NAME	QUANTITY
1	PLATE END	2
2	COPPER PIPE C TYPE	15
3	RADIATORS TUBE	16
4	COOLING PLATE	31

5	RADIATORS PIPE	2
---	----------------	---

Table 4.3.1 Bill of material

PLATE END

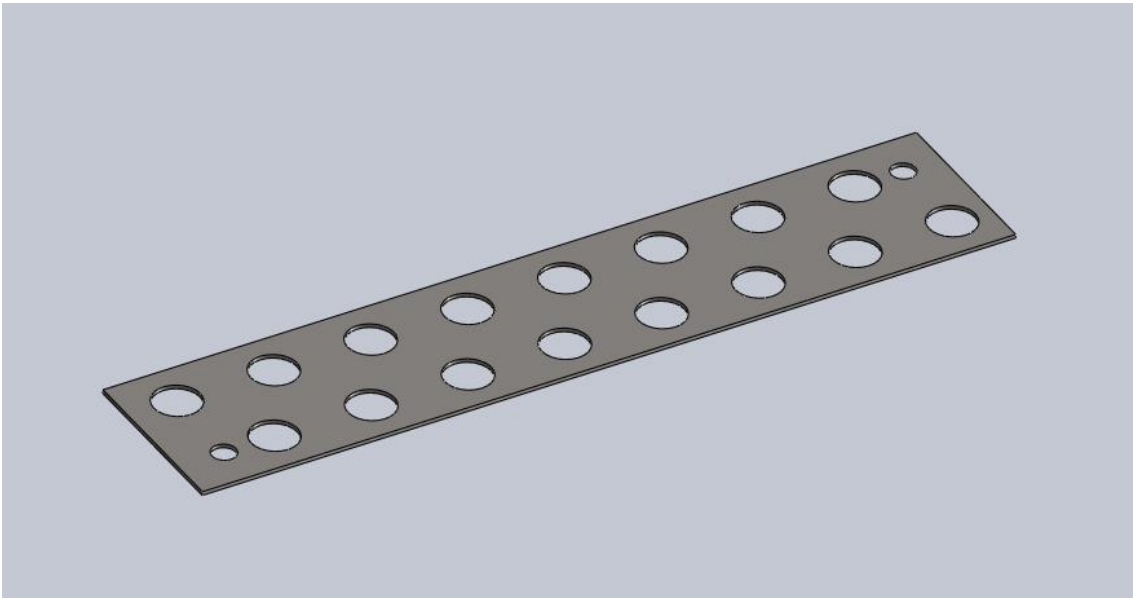


Fig 4.2 Plate end

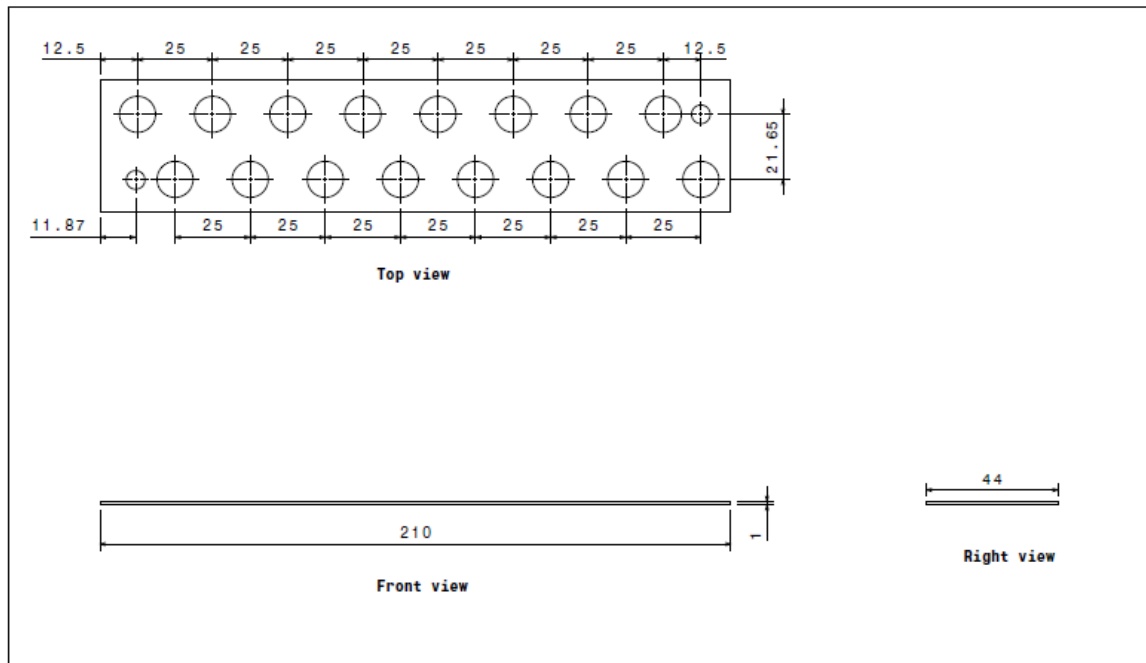


Fig 4.2.1 Dimension of plate end

COPPER PIPE C TYPE

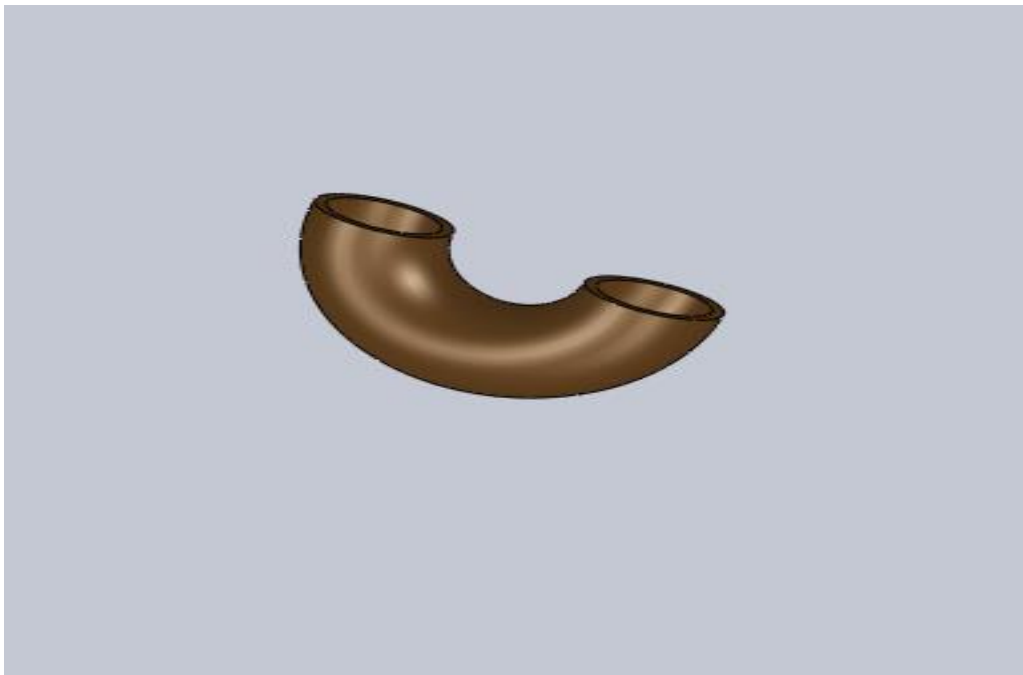


Fig 4.2.2 Copper pipe C type

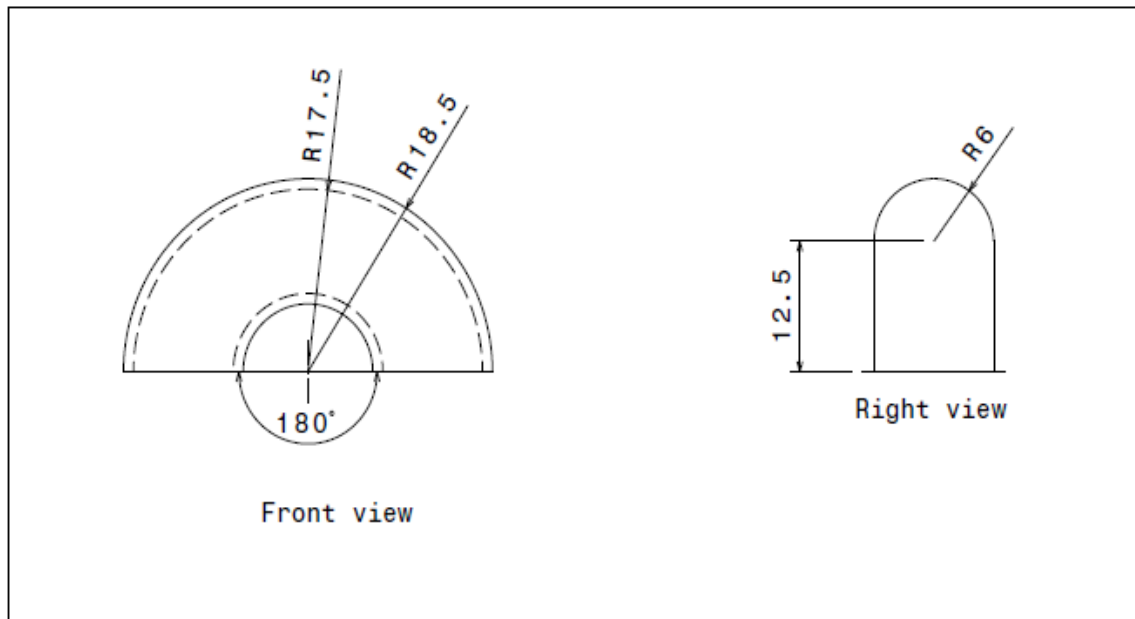


Fig 4.2.3 Dimension of copper end C type

RADIATORS TUBE

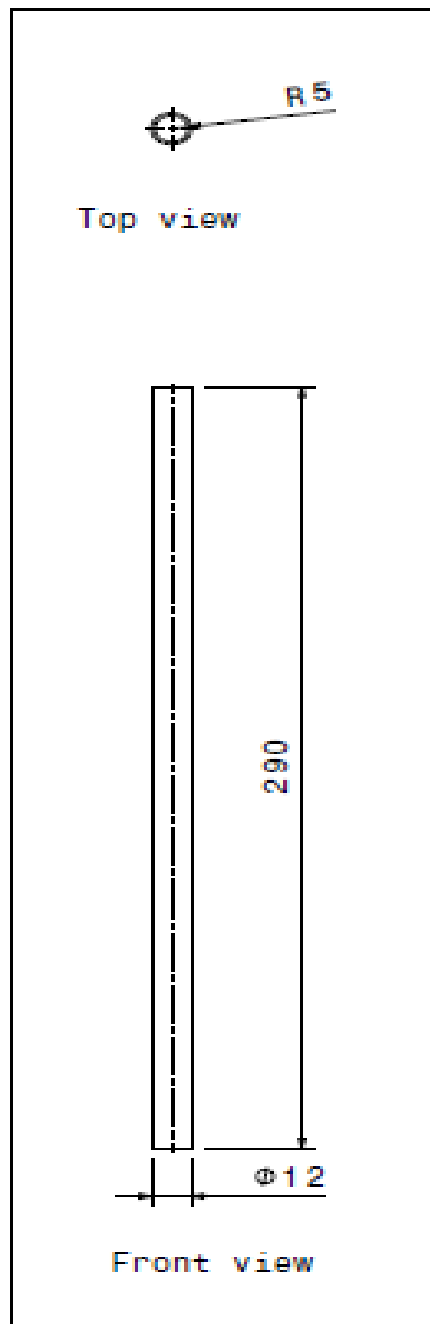


Fig 4.2.4 dimension and Design of the copper tube

COOLING PLATE

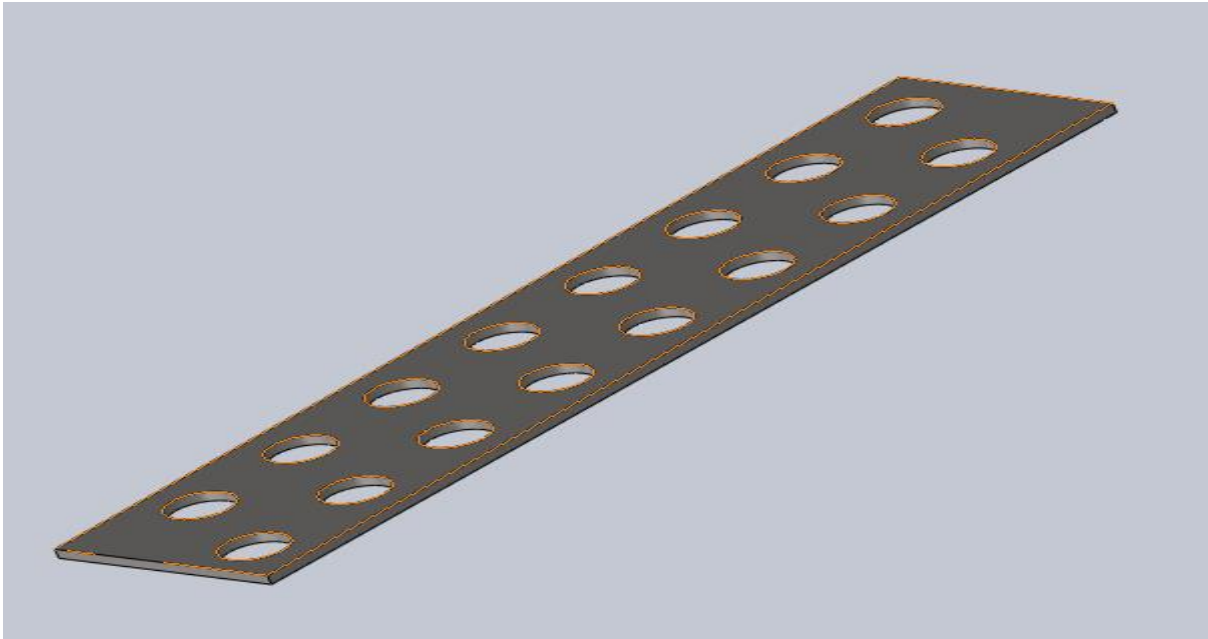


Fig 4.2.5 Cooling plate

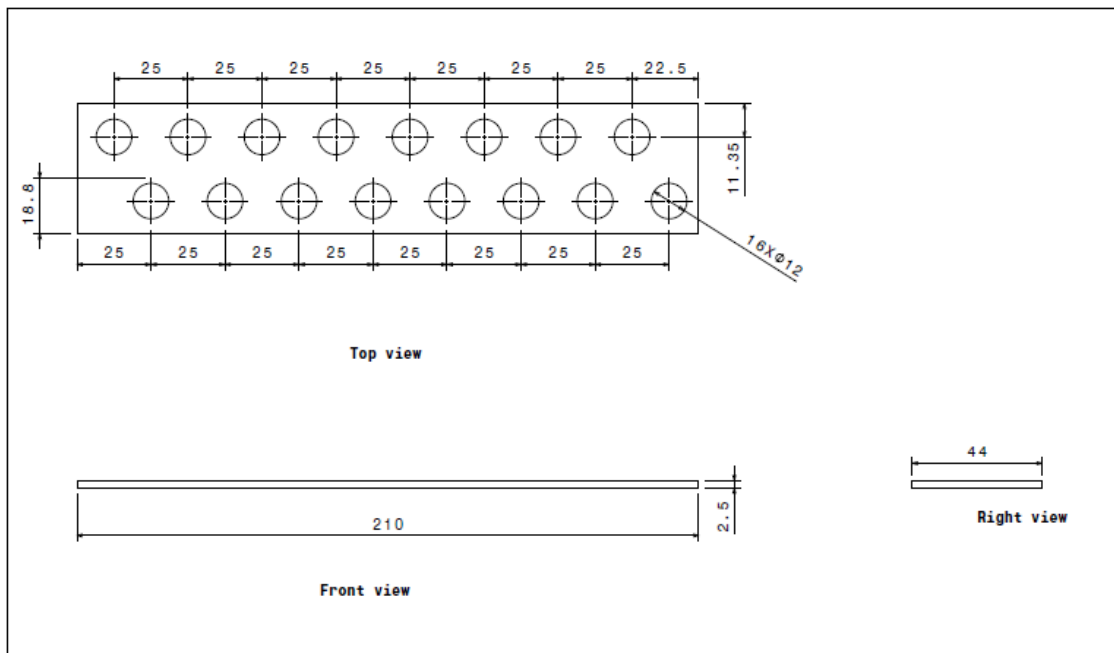


Fig 4.2.6 Dimension of the cooling plate

RADIATORS PIPE

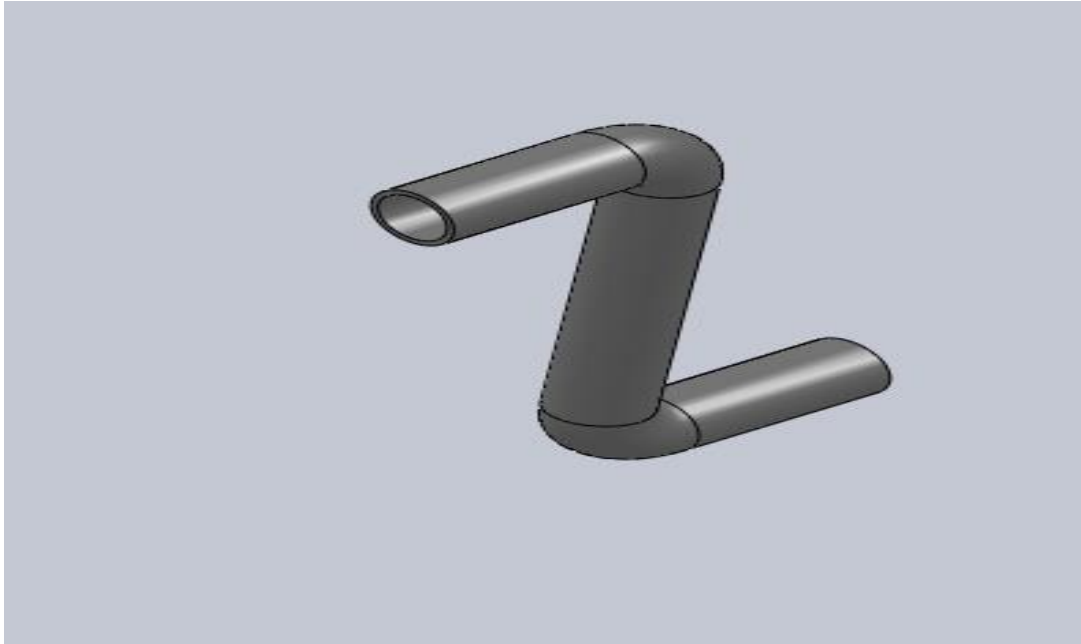


Fig 4.2.7 Radiators pipe

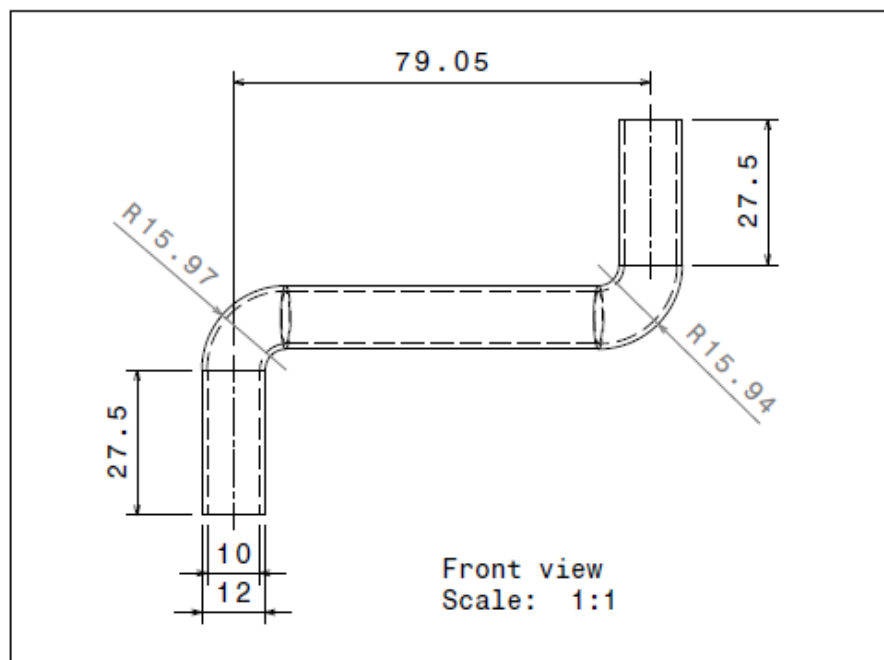


Fig 4.2.8 Dimension of radiators pipe

4.4 ANALYSIS

Computational Fluid Dynamics (CFD) is one of the branches of fluid mechanics that uses numerical methods, and algorithms to analyze, and solve problems that involve fluid flows. CFD has become an integral part of the engineering design cycle. CFD analysis reduces the development time and increases the reliability of the designs. It makes it possible to evaluate, and predict the working parameters such as velocity, pressure, and temperature throughout the solving process. The fundamental basis of any CFD problem is the Navier Stokes equations, which define any single-phase fluid flow. It works by solving the equations of the fluid flow over a region of interest, with the specified known conditions on the boundary of that region. Conservation of matter, momentum, and energy must be satisfied throughout the region of interest.

CFD Model Analysis In solid work, the three-dimensional model of the radiators was generated and exported to an IGS file as a single layer. The original designs have been modeled as one region, and characteristics not involved in internal flow have been eliminated. ANSYS CFD software was used in meshing and CFD analysis.

Mesh The core section of the geometric model was given a finer mesh (Figure 4) than the other geometry regions to reduce the time of the CPU and load on the computer. The basic dimensions for the core section were 0.64 m. The base size was set at 2.56 m for the air

ANSYS ICEM CFD meshing technologies provide physics preferences that help to automate the meshing process. For an initial design, a mesh (Tetrahedral) can often be generated in batch with an initial solution run to locate regions of interest. Further refinement can then be made to the mesh to improve the accuracy of the solution.

There are physics preferences for structural, fluid, explicit simulations. By setting physics preferences, the software adapts to more logical defaults in the meshing.

4.4.1 Flow simulation

Flow Simulation is capable of calculating the flow of fluids of different types in the same analysis, but fluids of different types must be separated by walls. Mixing of fluids may be considered, only if the fluids are of the same type. Flow Simulation has an integrated database containing the properties of several liquids, gases, and solids. Solids are used in conjugate heat conduction analysis. For each analysis maximum of ten liquids or gases can be chosen. It can analyze various types of flows namely turbulent flows, Laminar flows, and Laminar or Turbulent flows. The turbulent equations can be disregarded, only if the flow is entirely laminar. It will analyze, and simulate the effects of fluid flow, heat transfer, and related forces on immersed or surrounding components.

4.5 MATERIALS TO BE USED IN THE RADIATORS

Based on the requirements of radiators, materials are selected for this Design. Following materials are selected based on design criteria:

4.5.1 Aluminum (6061) T6

Aluminum 6000-series alloys (e.g.:- Al6061) have much better corrosion resistance and on further addition of T6 heat treatment, the toughness and resistance to fatigue crack growth can be improved, hence increasing its strength by as much as 30%. Thermal conductivity for aluminum 6061 is 180 W/ (m*K) and when the density is considered, the specific thermal conductivity of aluminum (thermal conductivity divided by specific gravity) is 54 W/(m*K).

Properties	Value
Tensile strength	170 MPa
Yield strength	83.0 MPa
Elongation at break (in 50 mm)	12%
Poisson's ratio	0.34
Elastic modulus	117 GPa
Compressive strength	250 MPa

Table 4.4 properties of Al 6061

4.5.2 Copper Alloy

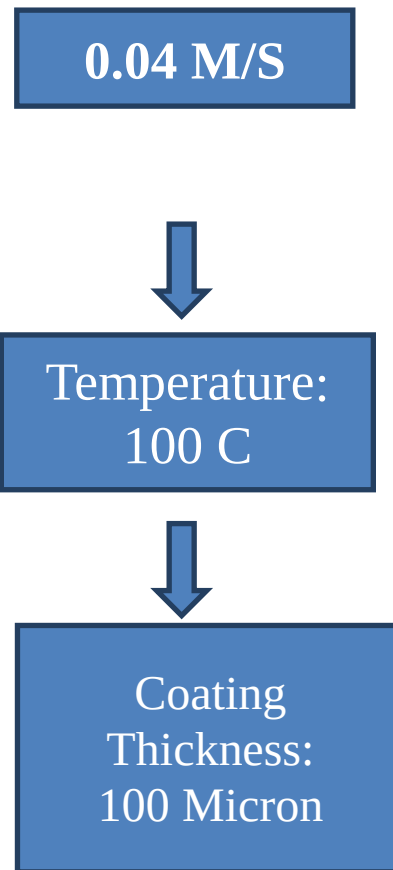
A copper alloy which is suitable for a heat exchanger contains 1 to 4.5 wt % of Zn, preferably contains 1.5 to 2.0 wt % of Sn, 0.01 to 0.04% of P, and the balance substantially Cu and inevitable impurities, and has grain size which is not greater than 0.015 mm and preferably below 0.01 mm. The alloy shows high resistance to corrosion which can be caused by the coolant or the external atmosphere. This also shows a good solder wettability which allows the solder joint to have proper conduction at its eutectic temperature. Brass shows a rather inferior corrosion resistance as compared to this alloy.

PHYSICAL PROPERTY	VALUE
Density	2.70g/cm ³
Melting point	650°C
Thermal expansion	23x10 ⁻⁶ /k
Modulus of elasticity	70 Gpa
Thermal conductivity	166 W/mk
Electrical resistivity	0.040x10 ⁻⁶ Ω.m

Table 4.5 properties of copper alloy

CHAPTER 5

INPUT PARAMETERS OF ANALYSIS



5.1 CFD SIMULATION WALL CONDITION

FLUID	=WATER
SOLID PIPE	= ALUMINUM
SOLID FIN	= ALUMINUM
SOLID FIN SURFACE CAOTING	= COPPER
SOLID PIPE SURFACE COATING	= COPPER

ANSYS CFD meshing technologies provide physics preferences that help to automate the meshing process. For an initial design, a mesh (Tetrahedral) can often be generated in batch with an initial solution run to locate regions of interest. Further refinement can then be made to the mesh to improve the accuracy of the solution. There are physics preferences for structural, fluid, explicit simulations. By setting physics preferences, the software adapts to more logical defaults in the meshing.

5.1.1 WATER- FLUID PROPERTIES

The screenshot shows the 'Create/Edit Materials' dialog box. The 'Name' field is 'water-liquid'. The 'Material Type' is 'fluid'. The 'Chemical Formula' is 'h2o<l>'. The 'Fluent Fluid Materials' dropdown is 'water-liquid (h2o<l>)'. The 'Mixture' dropdown is 'none'. The 'Order Materials by' section has 'Name' selected. There are buttons for 'Fluent Database...' and 'User-Defined Database...'. The 'Properties' section is expanded, showing four properties: Density (kg/m³), Cp (Specific Heat) (J/kg-K), Thermal Conductivity (W/m-K), and Viscosity (kg/m-s). Each property has a dropdown set to 'constant' and an 'Edit...' button. The values are: Density 998.2, Cp 4182, Thermal Conductivity 0.6, and Viscosity 0.001003. At the bottom are buttons for 'Change/Create', 'Delete', 'Close', and 'Help'.

Property	Unit	Value
Density	kg/m ³	998.2
Cp (Specific Heat)	J/kg-K	4182
Thermal Conductivity	W/m-K	0.6
Viscosity	kg/m-s	0.001003

Fig 5.1.1 water- fluid properties

5.1.2 SOLID-ALUMINUM PROPERTIES

The screenshot shows the 'Create/Edit Materials' dialog box. The 'Name' field is 'aluminum' and the 'Chemical Formula' is 'al'. The 'Material Type' is set to 'solid'. Under 'Fluent Solid Materials', 'aluminum (al)' is selected. The 'Mixture' is set to 'none'. The 'Order Materials by' section has 'Name' selected. The 'Properties' section shows three properties: Density (kg/m³) with a value of 2719, Cp (Specific Heat) (J/kg-K) with a value of 871, and Thermal Conductivity (W/m-K) with a value of 202.4. All three properties are set to 'constant'. The bottom of the dialog has buttons for 'Change/Create', 'Delete', 'Close', and 'Help'.

Property	Value
Density (kg/m ³)	2719
Cp (Specific Heat) (J/kg-K)	871
Thermal Conductivity (W/m-K)	202.4

Fig 5.1.2 solid-aluminum properties

The solid aluminum which should be used on the radiators have the above properties and the properties have to be chosen on the material selection part Density – 2719 kg/m³ , specific heat-871 J/kg-K, thermal conductivity- 202.4 W/m-K.

5.1.3 COPPER ALLOY PROPERTIES (COATING)

The screenshot shows the 'Create/Edit Materials' dialog box. The 'Name' field contains 'copper' and the 'Chemical Formula' field contains 'cu'. The 'Material Type' is set to 'solid'. Under 'Fluent Solid Materials', 'copper (cu)' is selected. The 'Mixture' is set to 'none'. In the 'Properties' section, 'Density (kg/m3)' is set to 'constant' with a value of 8978. 'Cp (Specific Heat) (J/kg-K)' is set to 'constant' with a value of 381. 'Thermal Conductivity (W/m-K)' is set to 'constant' with a value of 387.6. The 'Order Materials by' section has 'Name' selected. Buttons for 'Change/Create', 'Delete', 'Close', and 'Help' are at the bottom.

Fig 5.1.3 COPPER ALLOY PROPERTIES (COATING)

The copper alloy which is to be coated on the radiators tube have the above properties and the properties have to be chosen on the material selection part Density – 8978 kg/m³ , specific heat- 381 J/kg-k, thermal conductivity- 387.6 w/m-k.

CHAPTER 6

RESULT

6.1 WITHOUT COATING

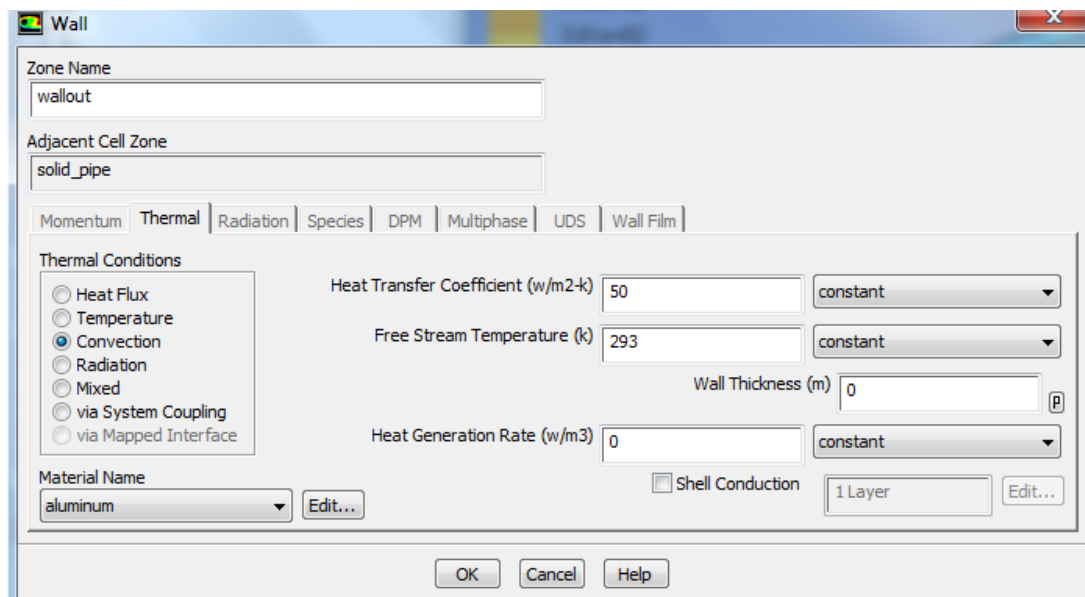


Fig 6.1.1 without coating – inlet, outlet, fin, pipe temp results

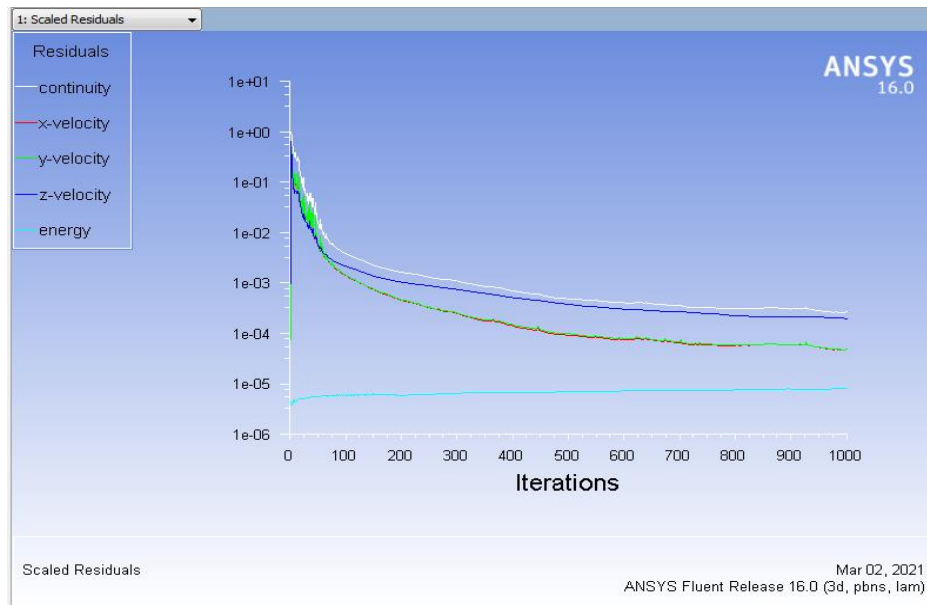


Fig 6.1.2 without coating – convergence history

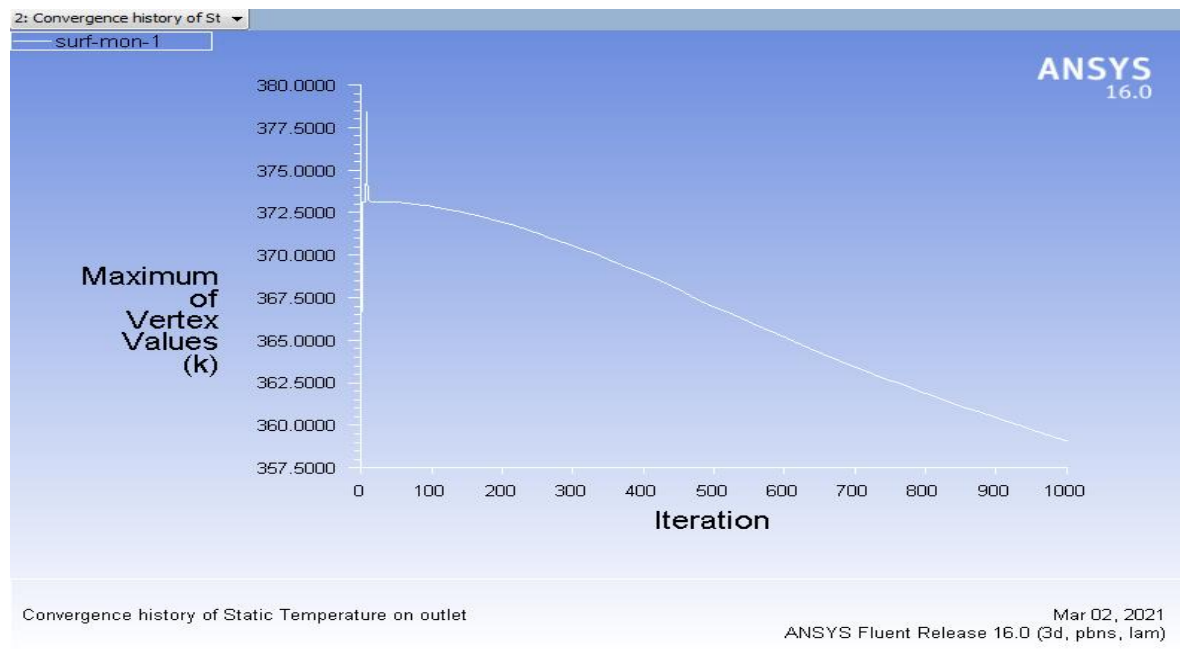


Fig 6.1.3 WITHOUT COATING OUTLET TEMP CONVERGENCE GRAPH

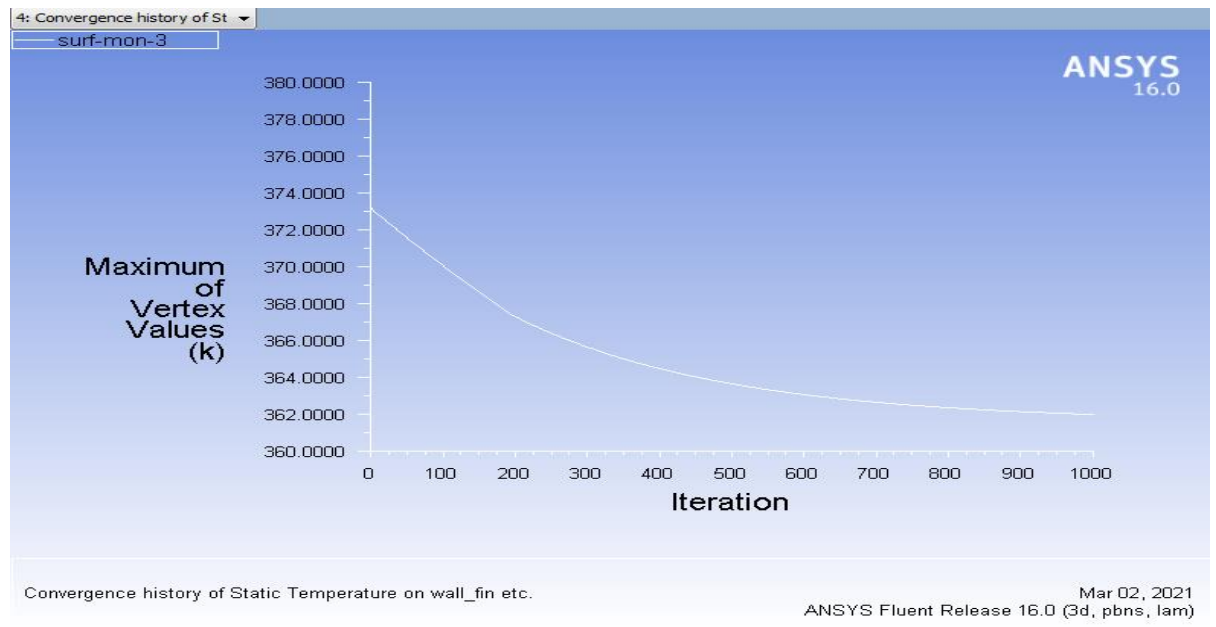
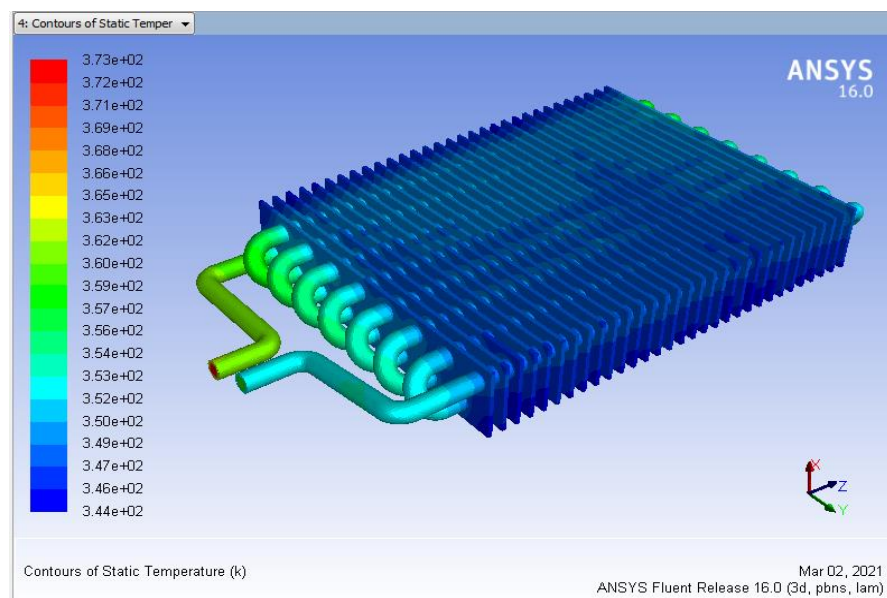


Fig 6.1.4 WITHOUT COATING – FIN SURFACE TEMP CONVERGENCE GRAPH



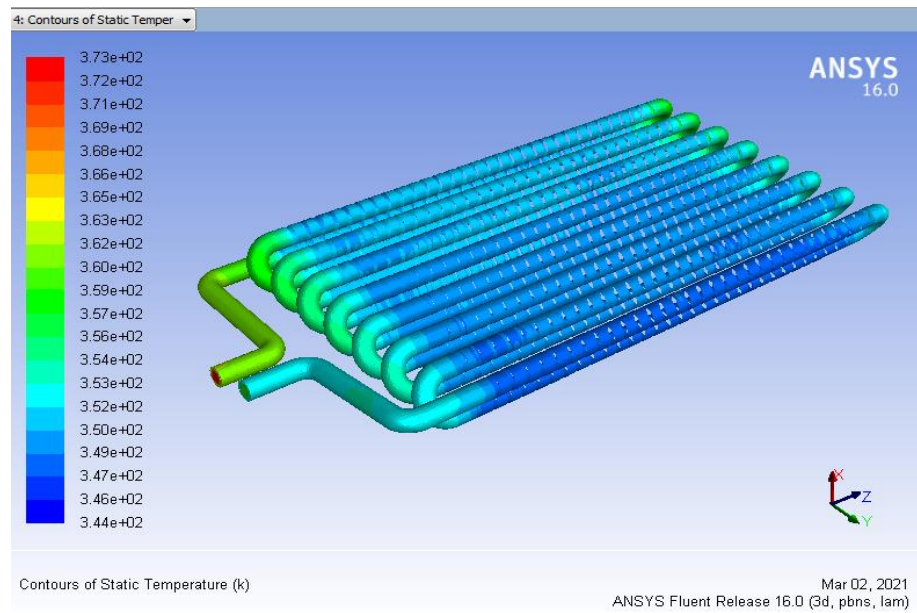
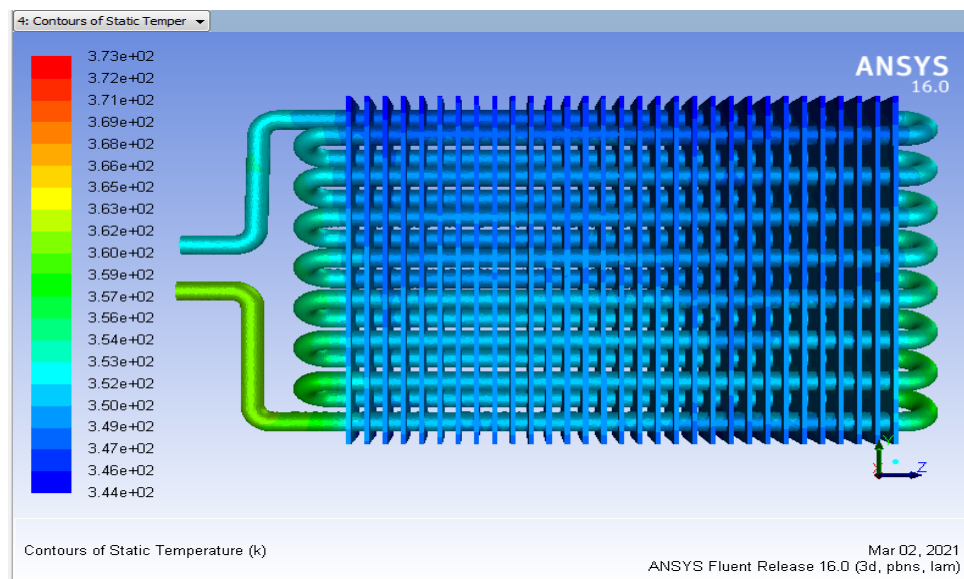


Fig 6.1.5 WITHOUT COATING – INLET, OUTLET, FIN, PIPE TEMP RESULTS



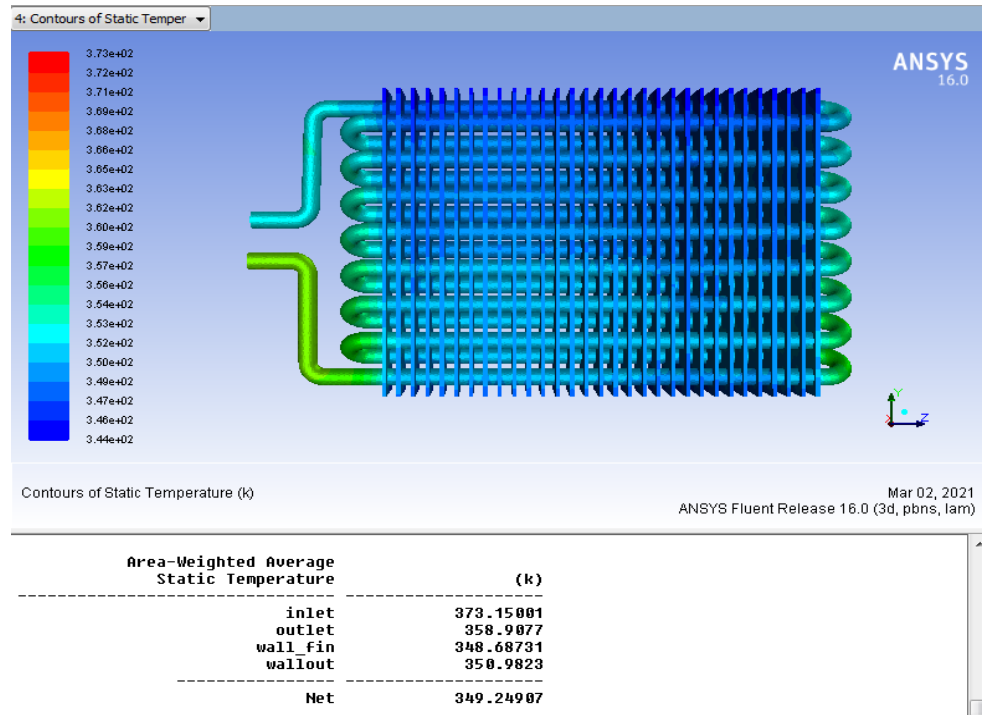


Fig 6.1.5 WITHOUT COATING – INLET, OUTLET, FIN, PIPE TEMP RESULT

Contours of static pressure

The flow across a cylinder when flow field can be divided into two regions. A boundary layer region near the surface and in viscous region away from the surface. The pressure gradient along the surface of the cylinder is not zero, and in fact this pressure gradient is responsible for the development of a separated flow region on the back side of the cylinder. The separation of flow affects the drag force on a curved surface to a great extent.

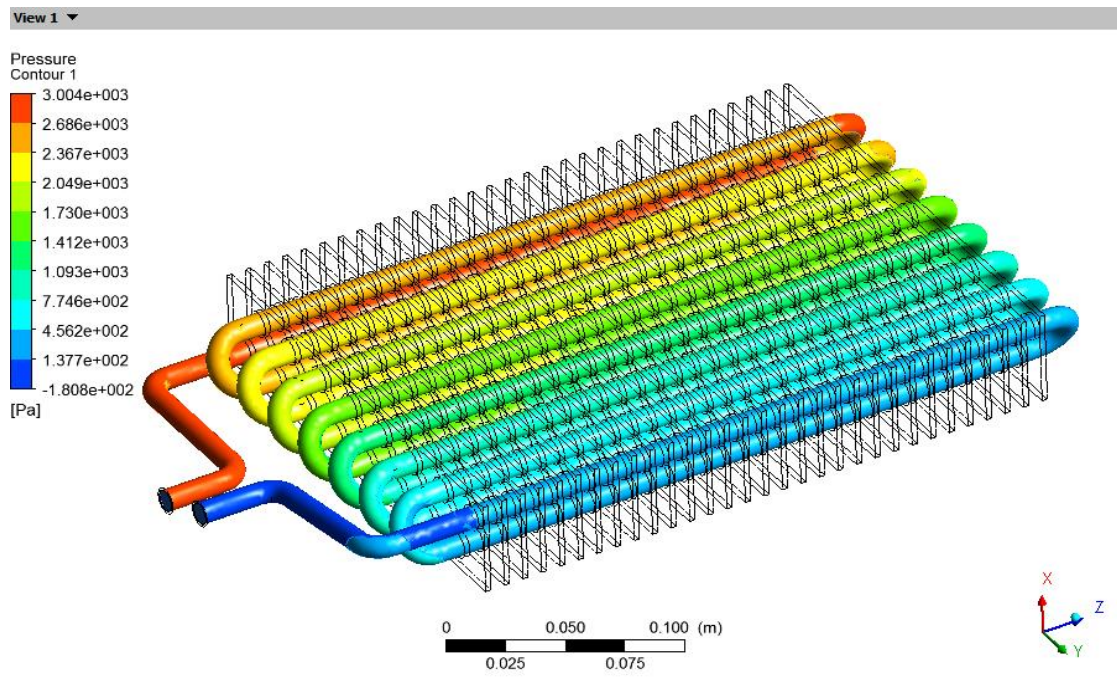


Fig 6.1.6 WITHOUT COATING – PRESSURE CONTOUR

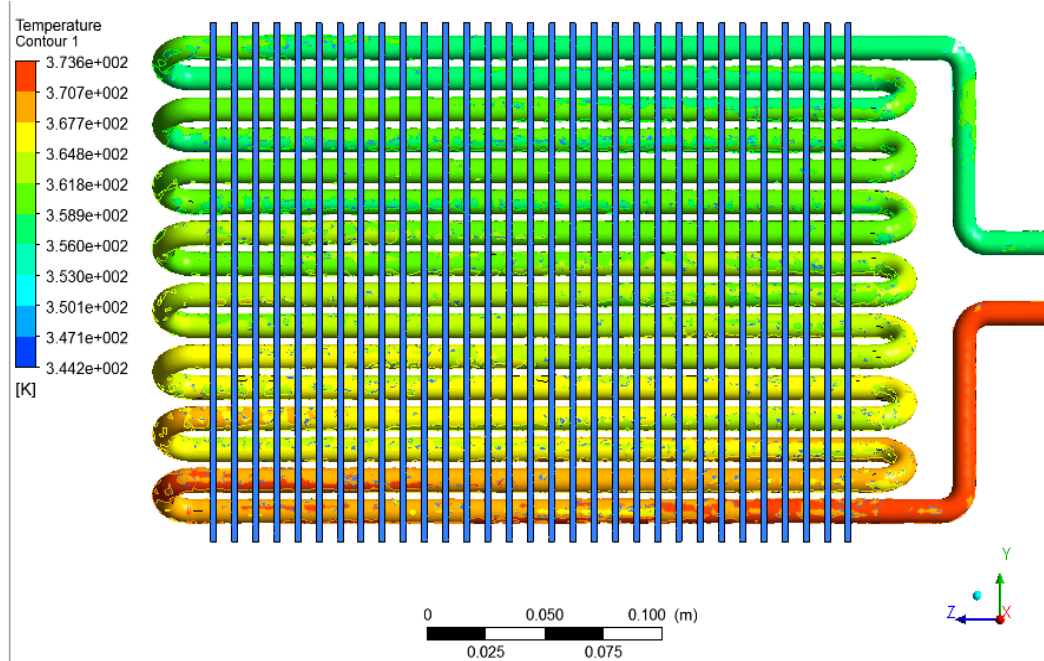


Fig 6.1.7 WITHOUT COATING FLUID – TEMPERATURE

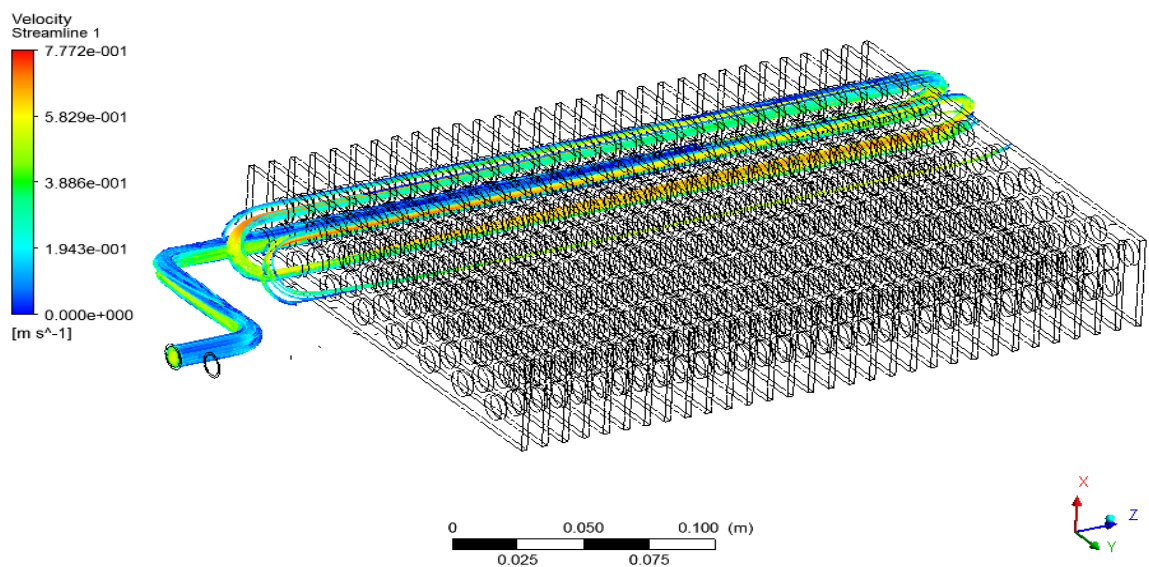


FIG 6.1.8 WITHOUT COATING VELOCITY STREAM LINE FLOW

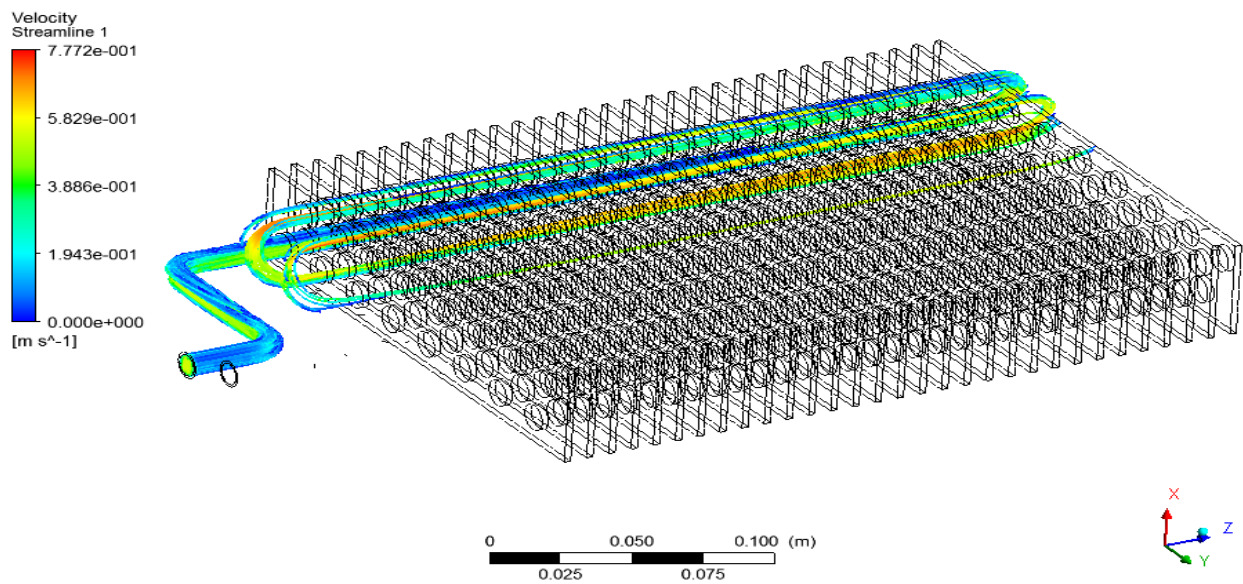


FIG 6.1.8 WITHOUT COATING VELOCITY STREAM LINE FLOW

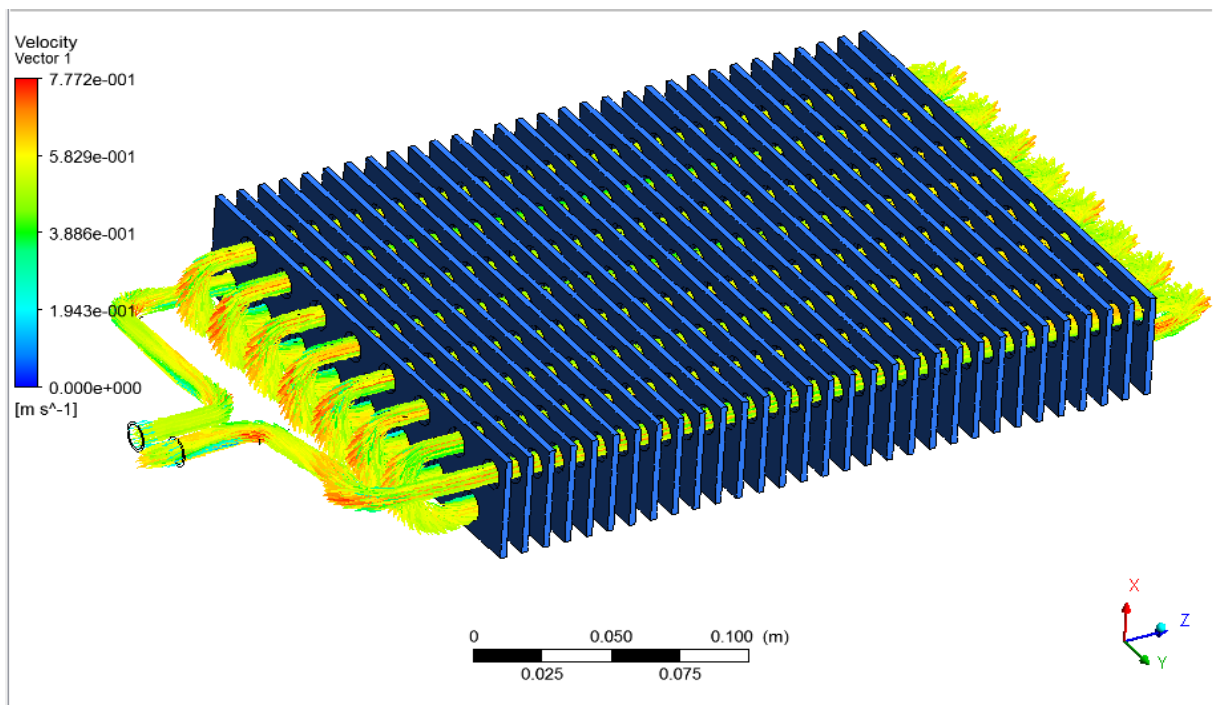


FIG 6.1.9 WITHOUT COATING VELOCITY VECTOR FLOW

6.2 WITH COATING

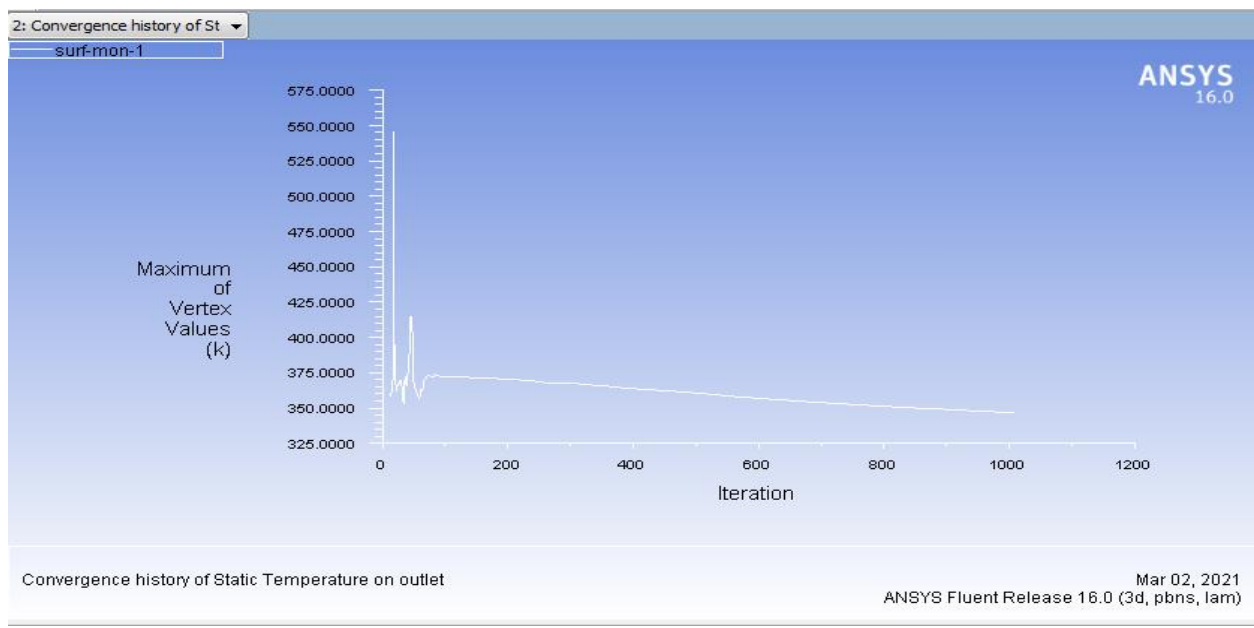


Fig 6.2.1 WITHCOATING – OUTLET TEMP CONVERGENCE GRAPH

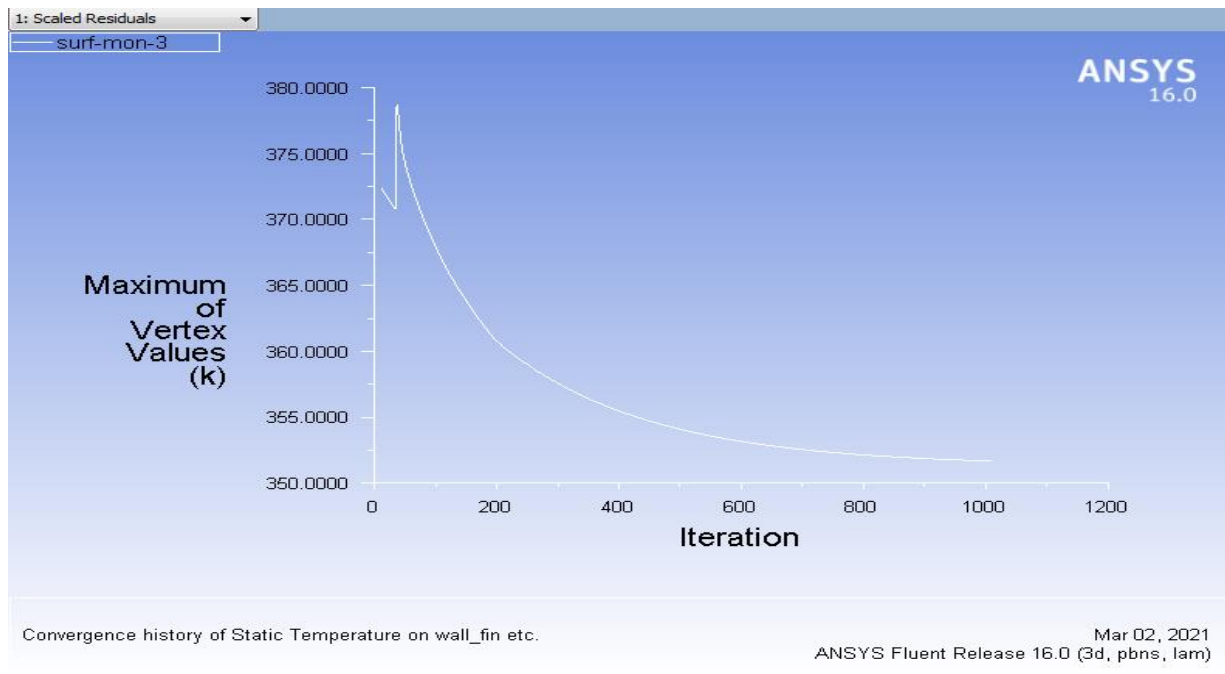


Fig 6.2.2 WITHCOATING – FIN SURF TEMP CONVERGENCE GRAPH

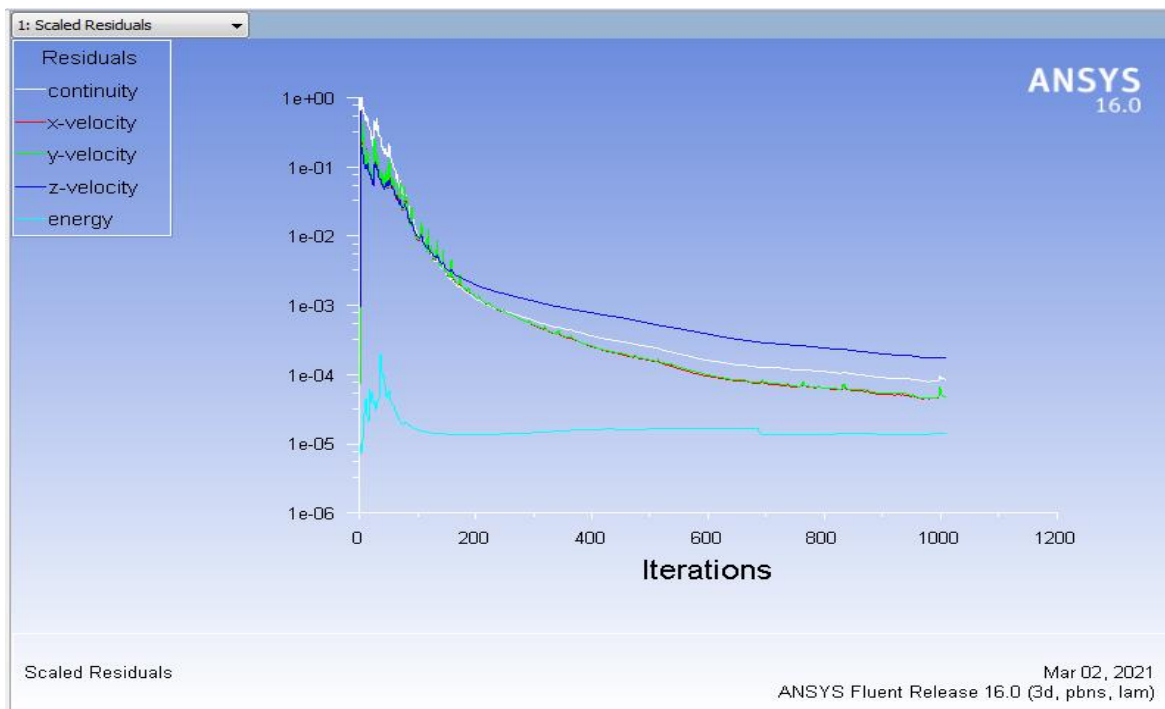


Fig 6.2.3 WITHCOATING – CONVERGENCE GRAPH

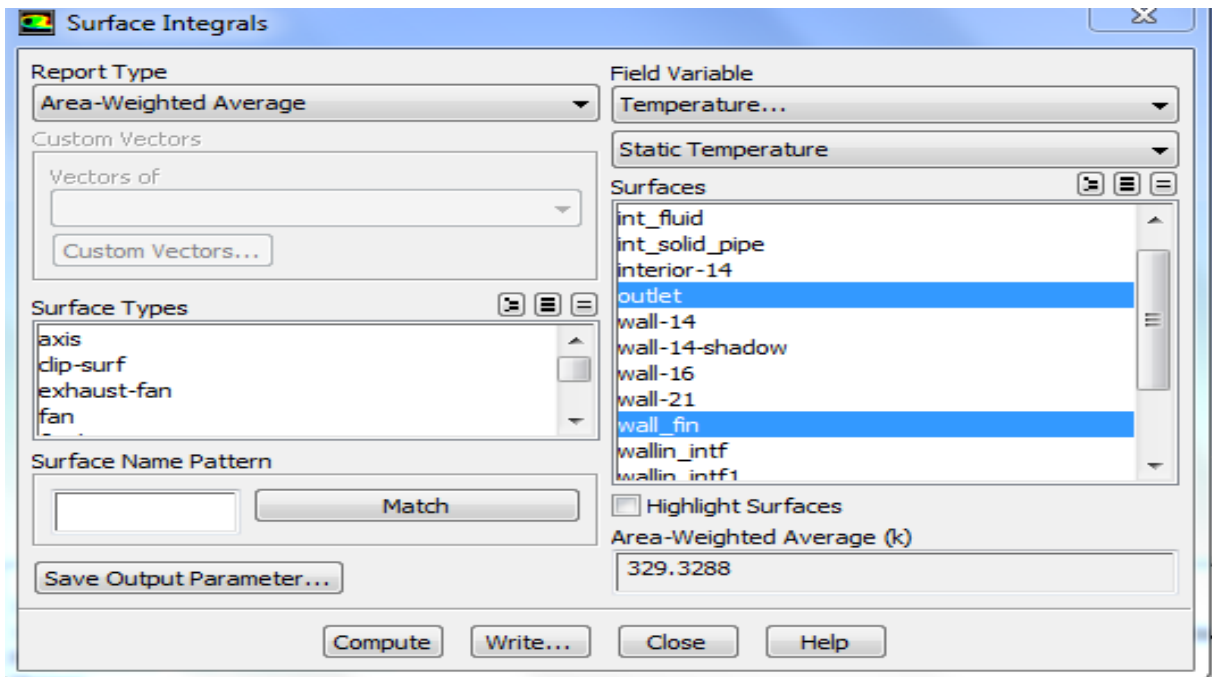
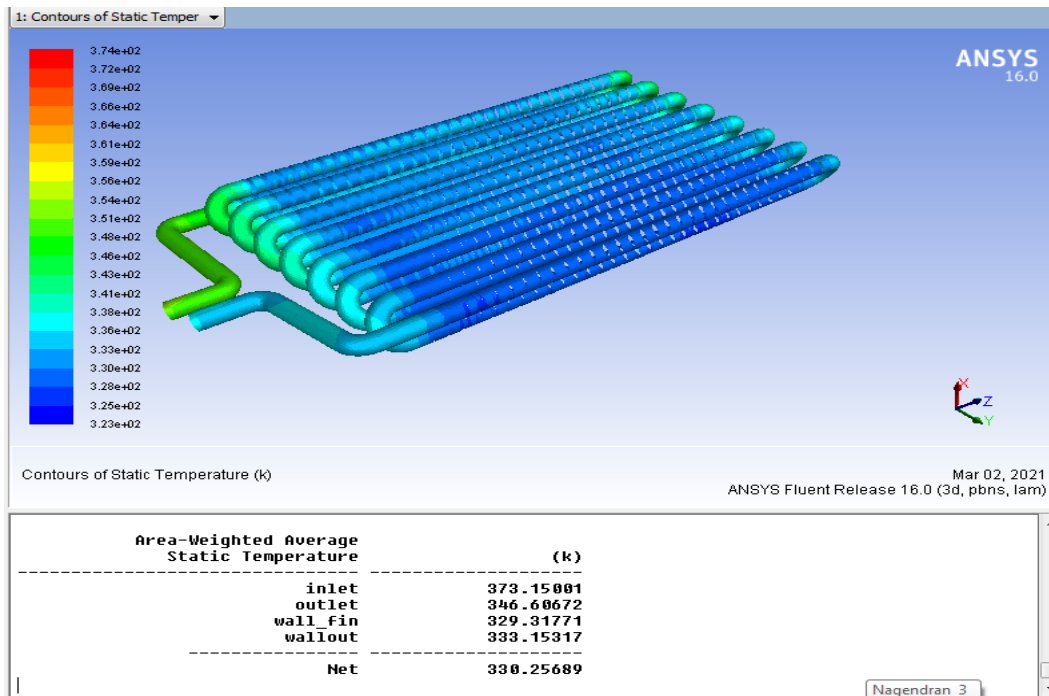


Fig 6.2.4 WITHCOATING – INLET, OUTLET, FIN, PIPE TEMP RESULTS



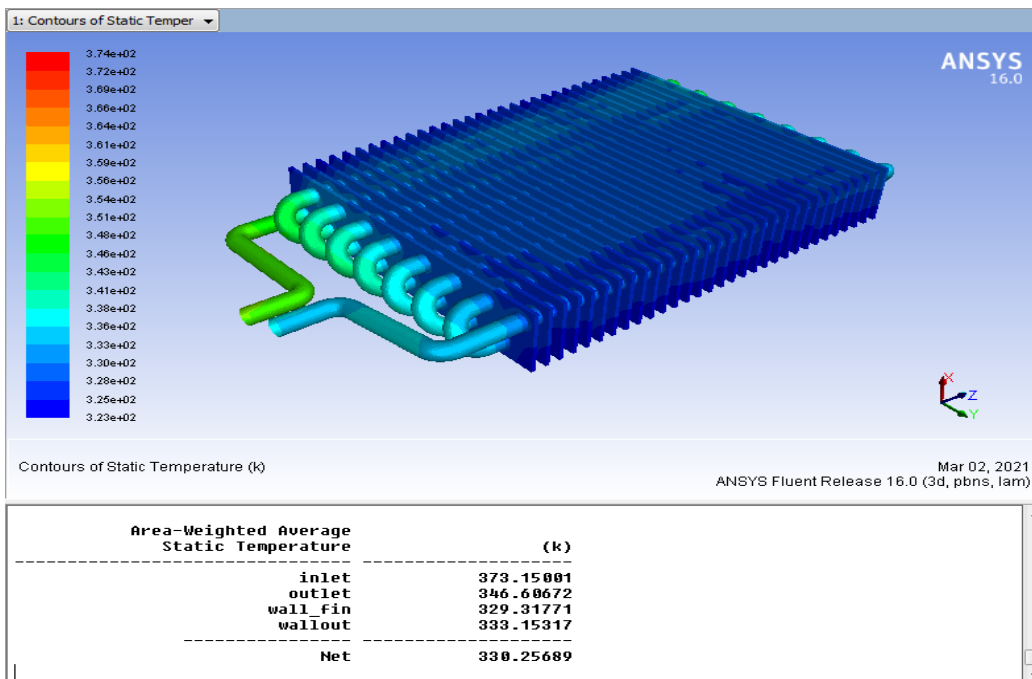
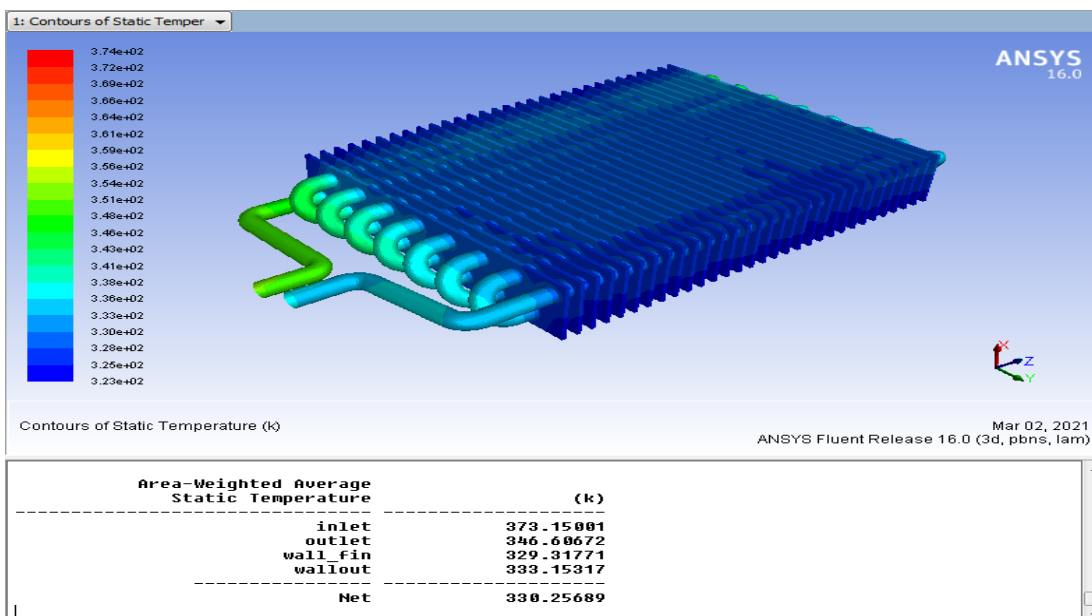


Fig 6.2.4 WITHCOATING – INLET, OUTLET, FIN, PIPE TEMP RESULTS



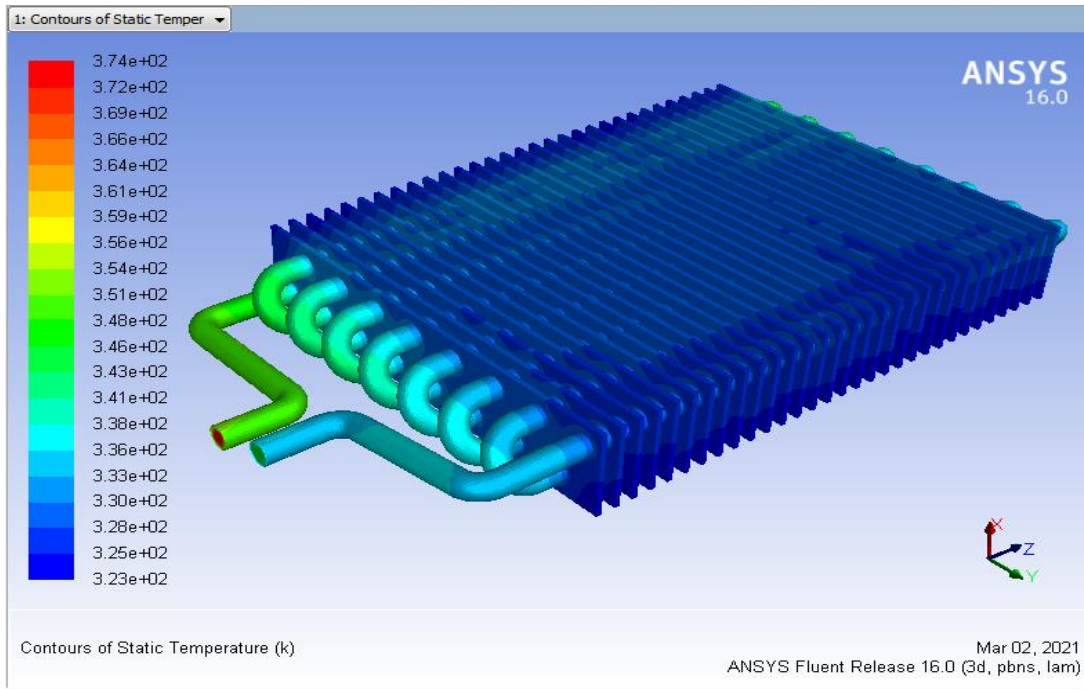


Fig 6.2.4 WITHCOATING – INLET, OUTLET, FIN, PIPE TEMP RESULTS

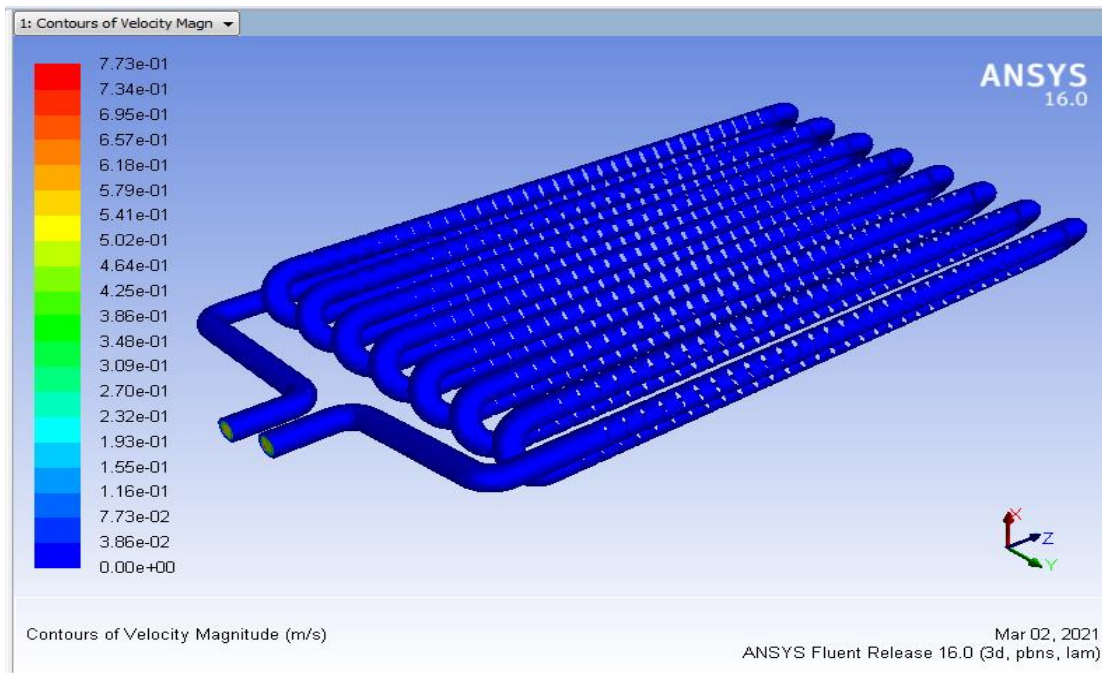


Fig 6.2.5 WITHCOATING – CONTOUR VELOCITY RESULTS

6.1.1 WITHOUT COATING – INLET, OUTLET, FIN, PIPE TEMP RESULTS

Area-Weighted Average Static Temperature		(k)
inlet		373.15001
outlet		358.9077
wall_fin		348.68731
wallout		350.9823
Net		349.24907

Hence the above results shows the final temperature loss occurs on the radiators before applying the nano coated material. Which the final net value is 349.24907 K.

6.2.1 WITH COATING – INLET, OUTLET, FIN, PIPE TEMP RESULTS

Contours of Static Temperature (k)		Mar 02, 2021 ANSYS Fluent Release 16.0 (3d, pbns, lam)
Area-Weighted Average Static Temperature		(k)
inlet		373.15001
outlet		346.60672
wall_fin		329.31771
wallout		333.15317
Net		330.25689

The above results shows the final temperature loss occurred on the radiators after copper alloy nano coated material. and the final net value is 330.25689K.

CHAPTER 7

CONCLUTION

TEMPERATURE (K)	BEFORE COATING (K)	PERCENTAGE OF TEMP LOSS	AFTER COATING(K)	PERCENTAGE OF TEMP LOSS
INLET	373.15	-	373.15	-
OUTLET	358.91	3.82%	346.61	7.11%
FIN SURFACE	348.68		329.32	
PIPE OUTER SURFACE	350.98		333.15	

Table 7.1 CONCLUTION

With and without coating on the pipe and pin surface of the radiators, CFD analysis has been carried out. From the table it clearly shows that coating material has play the vital role in increasing heat transfer rate in radiators. In this analysis, using copper coating over the pipe and fin surface, **7.11 %** heat has reduced in the radiators outlet.

CHAPTER 8

REFERENCES

- [1] I K E H Wiryanta and I M A Adiaksa, Doi: 10.1088/1742-6596/953/1/012060, Experimental and numerical investigation of thermal radiators performances as a source of heat energy in Design of dryer simulation.

- [2] P.Natarajan, Heat Transfer Analysis in Light Passenger Car Radiators with Various Geometrical Configurations, e-ISSN: 2395-0056MVolume: 05 Issue: 06 | June 2018.

- [3] Sudalai Suresh Pungaiah and Chidambara Kuttalam Kailasanathan, Doi: 10.3390/coatings10090804, Thermal Analysis and Optimization of Nano Coated Radiators Tubes Using Computational Fluid Dynamics and Taguchi Method.

- [4] C. Uma Maheswari, C. Suresh Reddy, C Rajeshwara Reddy,A.T. KiranSai Naidu , C.Saradhi,A. Chenna kesavulu, ISSN: 2455-3689, March. 2016, CFD Analysis of Radiators.

- [5] Sai Kiran.S, Dr.M.V.A.Raju Bahubalendruni, (SJIF): 4.72 e-ISSN (O): 2348-4470 p-ISSN (P): 2348-6406, September -2017,Modeling & Analysis of Louvered Fin Radiators with NanoFluids using CFD.

- [6] Kola David, Abhishek kumar, DOI:10.15680/IJIRSET.2019.0805138, CFD and Heat Transfer Analysis of Automobile Radiators Using Helical Tubes.

- [7] Upendra K,CFD analysis of automobile radiators- A review In proceeding of the International Jornal of Engineering Research and Applications, International conference on Emerging Trends in Mechanical and electrical engineering, Thai Nguyen,Vietnam, 13-14 march 2014

