DESIGN AND CFD ANALYSIS OF RADIATOR USING NANO-FLUIDS

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Abstract— Radiators are the heat exchangers used for cooling and heating purposes to transfer the thermal energy from one medium to another medium. Some radiators were designed to operate in vehicles, homes and electronics. The radiator is a source of heat for its environment, as it can either be used to heat this atmosphere or cool the supply of coolant. Most radiators use the convection to transfer the bulk of their heat.
An automotive radiator is the cornerstone of an automotive cooling system that plays a crucial role in transmitting the heat from engine components to the atmosphere through its complex operations. It is a form of heat exchanger designed to transfer heat from warm coolant of the engine to the fan's blown air. The cycles of heat transfer takes place from the coolant to pipes, then through fins from the tubes to the water. They are used to cool internal combustion engines, especially in vehicles, as well as in piston-engine aircraft, railway locomotives, power generating plants or any similar use of applications. The main function of this radiator is to cool the engine bypassing the coolant through the water jackets of the cylinder. The main objective of the project is to design a radiator and assign aluminium and nanofluids to find out the better material for heat transfer. CFD analysis is carried out to find the heat transfer through the radiator.
Designing of radiator is done in Catia V5R20 software. And, CFD analysis is performed in Ansys Fluent.

Index Terms— Radiators, Automobiles, Nanofluids, Cooling System, Catia V5R20, Ansys Fluent

1 INTRODUCTION

1.1 Radiators

A radiator is a type of heat exchanger. It is designed to transfer heat from the hot coolant that flows through it to the air blown through it by the fan. Most modern cars use aluminium radiators. These radiators are made by brazing thin aluminium fins to flattened aluminium tubes. The coolant flows from the inlet to the outlet through many tubes mounted in a parallel arrangement. The fins conduct the heat from the tubes and transfer it to the air flowing through the radiator. The tubes sometimes have a type of fin inserted into them called a turbulator, which increases the turbulence of the fluid flowing through the tubes. If the fluid flowed very smoothly through the tubes, only the fluid actually touching the tubes would be cooled directly. The amount of heat transferred to the tubes from the fluid running through them depends on the difference in temperature between the tube and the fluid touching it. So if the fluid that is in contact with the tube cools down quickly, less heat will be transferred. By creating turbulence inside the tube, all of the fluid mixes together, keeping the temperature of the fluid touching the tubes up so that more heat can be extracted, and all of the fluid inside the tube is used effectively. Radiators usually have a tank on each side, and inside the tank is a transmission cooler. In the picture above, you can see the inlet and outlet where the oil from the transmission enters the cooler. The transmission cooler is like a radiator within a radiator, except instead of exchanging heat with the air, the oil exchanges heat with the coolant in the radiator [1].

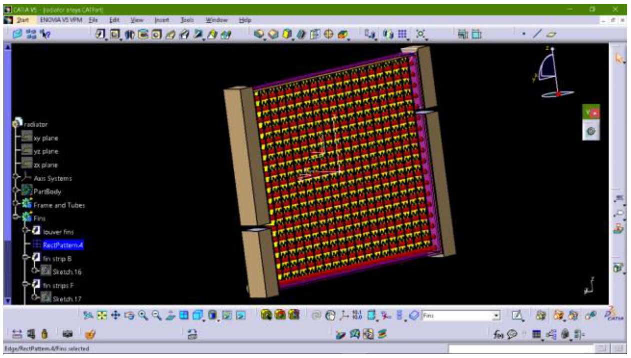
A **nanofluid** is a fluid containing nano meter-sized particles, called nanoparticles. These fluids are engineered colloidal suspensions of nanoparticles in a base fluid. The nanoparticles used in nanofluids are typically made of metals, oxides, carbides, or carbon nanotubes. Common base fluids include water, ethylene glycol[3] and oil. Nanofluids have novel properties that make them potentially useful in many applications in heat transfer, including microelectronics, fuel cells, pharmaceutical processes and hybrid-powered engines, engine cooling/vehicle thermal management, domestic refrigerator, chiller, heat exchanger, in grinding, machining and in boiler flue gas temperature reduction. They exhibit enhanced thermal conductivity and the convective heat transfer coefficient compared to the base fluid. Knowledge of the rheological behaviour of nanofluids is found to be critical in deciding their suitability for convective heat transfer applications. Nanofluids also have special acoustical properties and in ultrasonic fields display additional shear-wave reconversion of an incident compressional wave; the effect becomes more pronounced as concentration increases [2].

2 LITERATURE

Sandeep Patel and Dr. S.P. Deshmukh in their paper “Analytical Design and Verification of Automotive Radiator using 1-D Simulation” have concluded that The brief overview of this case study that has been given revealed several points as follows: Optimal design of cooling system leads to less fuel consumption & more cabin comfort but at the same time compactness needs to be ensured. Downsizing of engine and less under hood package space are the key challenges in designing engine cooling system. Analytical design procedure for industrial design of automotive radiator system is gives coarse estimations for core sizing but to make it more optimize we need to use simulation programs. Simulation of cooling system helps design engineers to ease the work of design by using different configurations. This work can be continued for studying NTU method for radiator design. In depth study of more simulation techniques are necessary. The Key design considerations to design optimal Radiator are, compactness, low pressure drop, Low cost, High volume, durability, requirement, heat transfer and fluid flow [3].

Rahul S Gupta and et.al in their paper “Thermal Analysis of Car Radiator by using Nano-fluid” have concluded that Therefore, at higher temperature, thermal conductivity and specific heat increased while viscosity and density decreased. Hence, MBNF exhibited better thermo–physical properties compared to pure methanol. From above analysis we can predict that ethanol will be found more effective than conventional base fluid rather than EG (Ethelyn glycogel), Water, Al2o3. After certain studied parameter we found that Cuo will be best dispersion capability and having larger heat dissipation capacity. By observing thermal analysis results, heat flux is more when Copper is used than Aluminium alloy [4].

3 DESIGN PROCEDURE FOR RADIATORS



3.1 Base Specifications for Radiators

Data we have for design of radiator

No of tubes per row = 18

No. of rows = 2

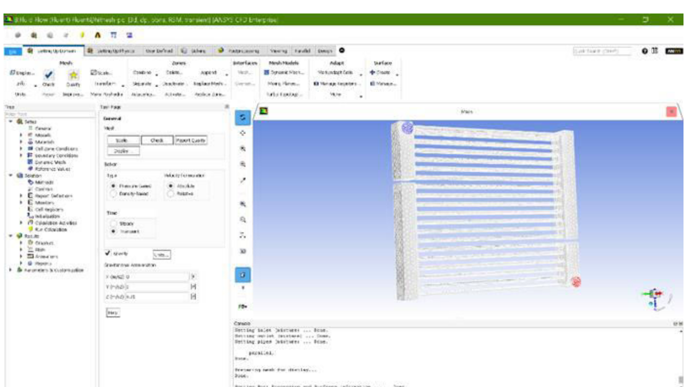
Length of the tubes = 500mm

Width of the radiator = 464mm

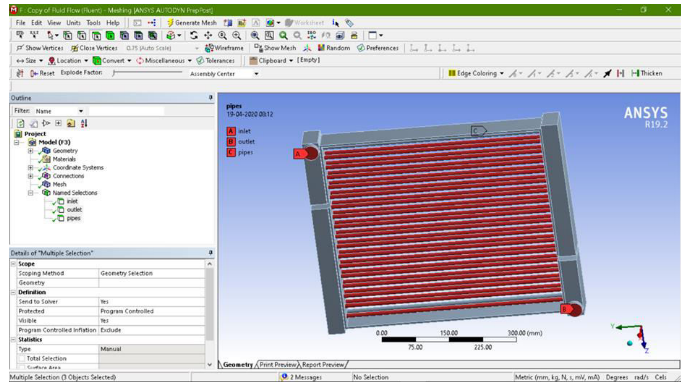
Diameter of the tube = 10mm

Thickness of the tube = 1mm

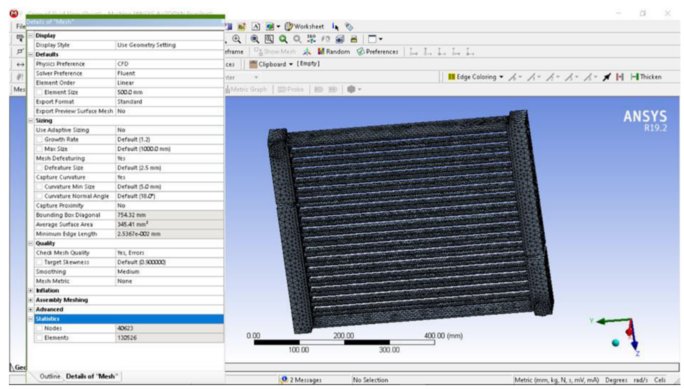
4.ANALYSIS OF RADIATOR



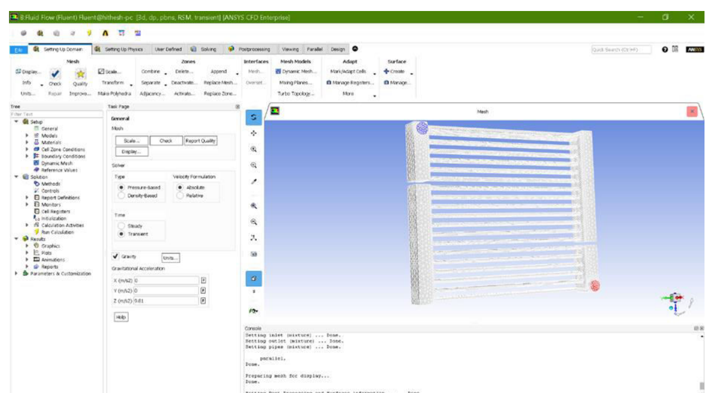
Importing of design from CATIA to ANSYS



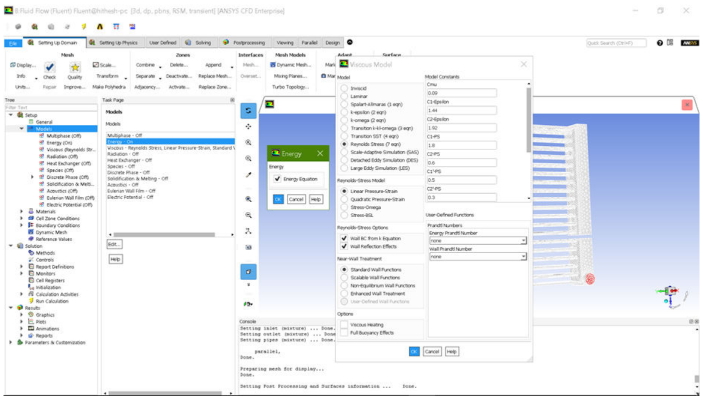
Generation of mesh to the radiator in ANSYS 16.0



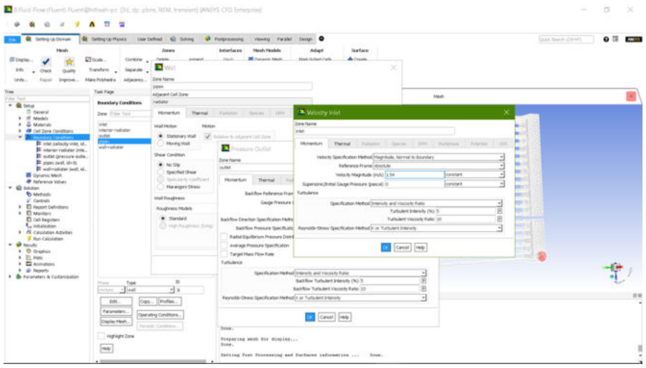
Details of the generated mesh of the radiator

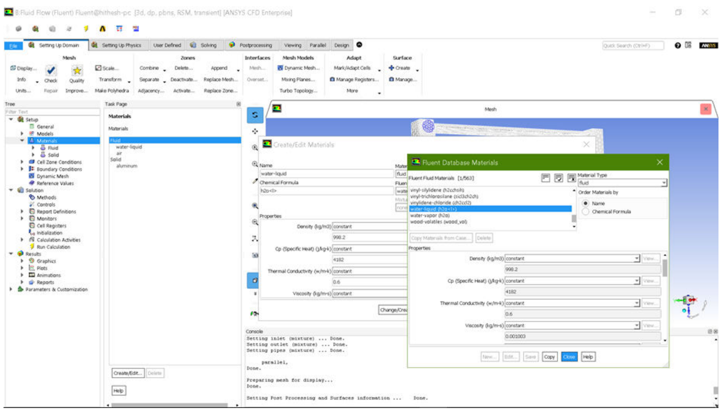


Displaying general Setup in ANSYS 16.0

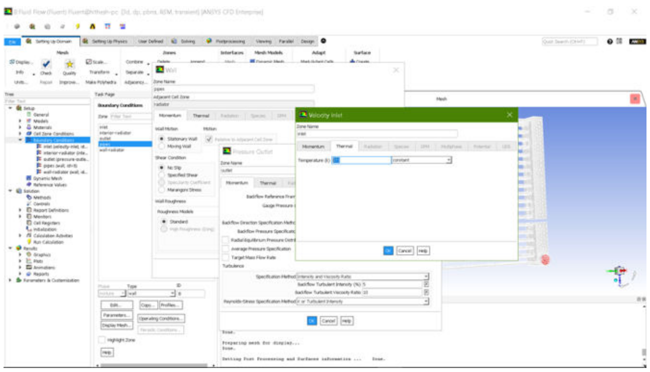


Model Setup in ANSYS 16.0

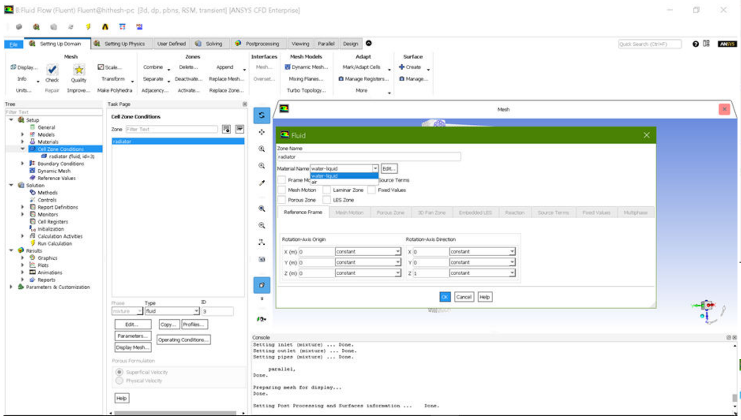




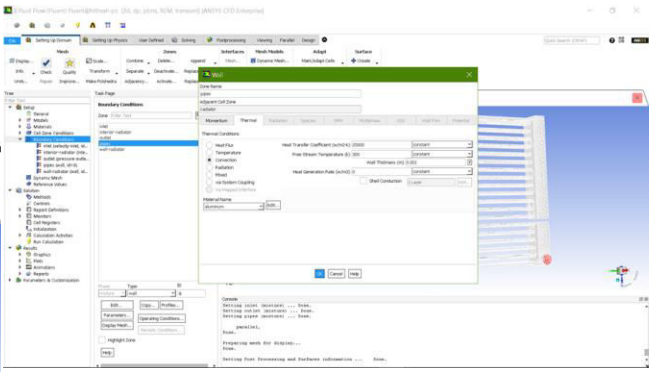
Applying materials in ANSYS 16.0



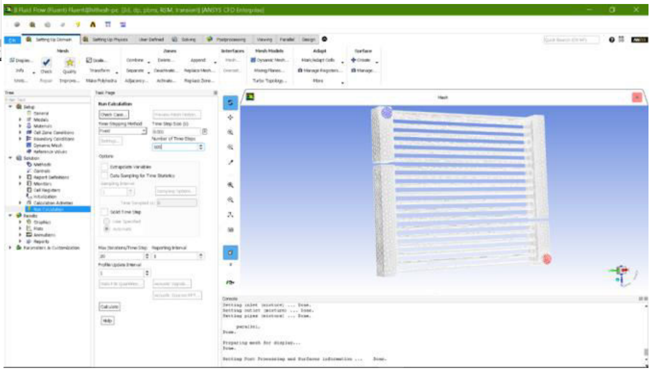
Applying inlet temperature



Cell zone conditions in ANSYS 16.0



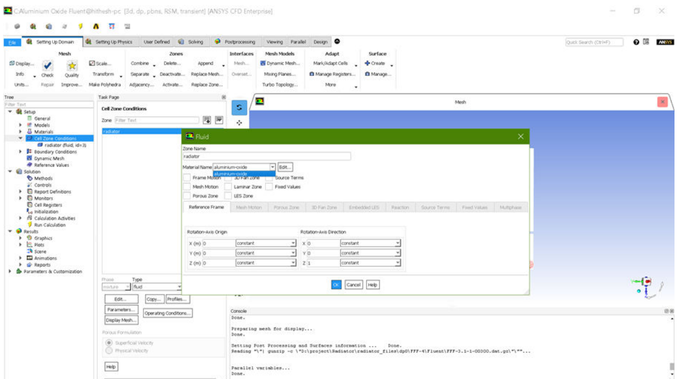
Applying wall in boundary conditions



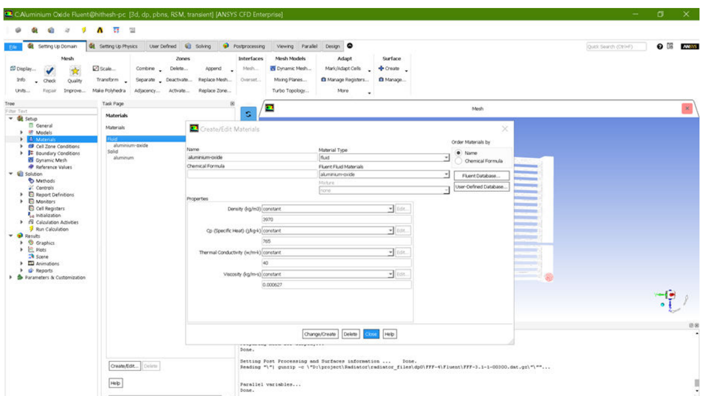
Run Calculations

4.1 NANO-FLUIDS ACTING ON RADIATOR

4.1.1 Aluminium Oxide acting on radiator

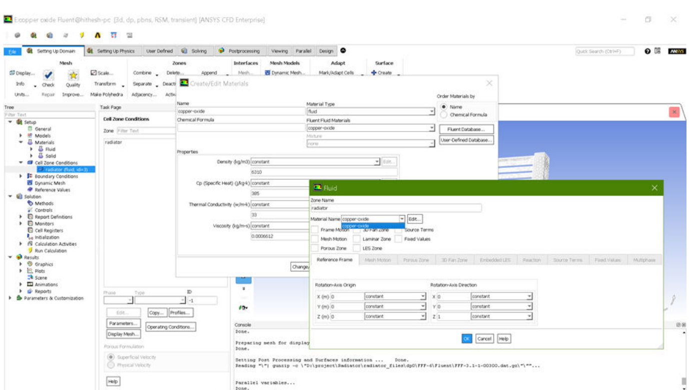


Applying Aluminium Oxide Fluid in Cell zone conditions

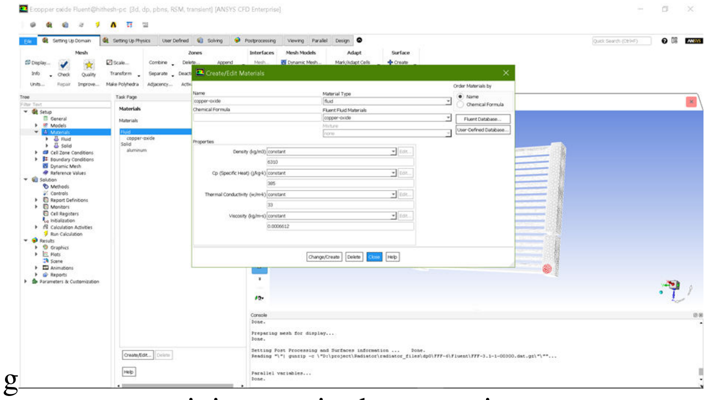


Applying materials by giving required properties

4.1.2 Copper Oxide acting on radiator

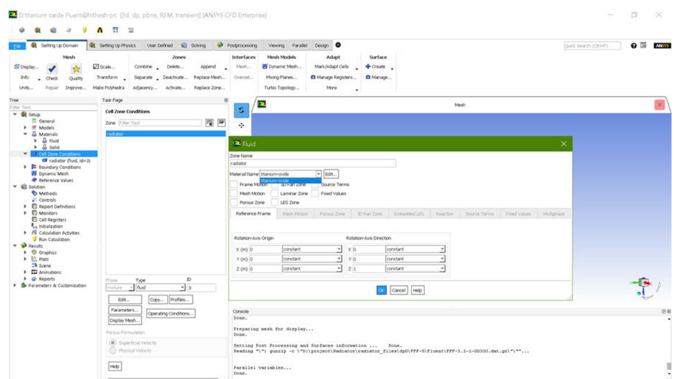


Applying Copper Oxide Fluid in Cell zone conditions

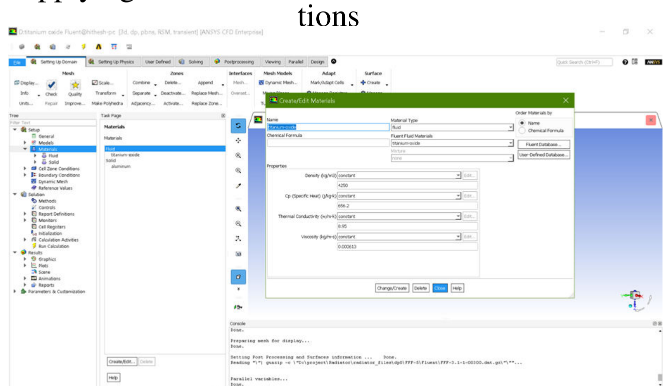


g iving required properties

4.1.3 Titanium Oxide acting on radiator



Applying Titanium Oxide Fluid in Cell zone conditions

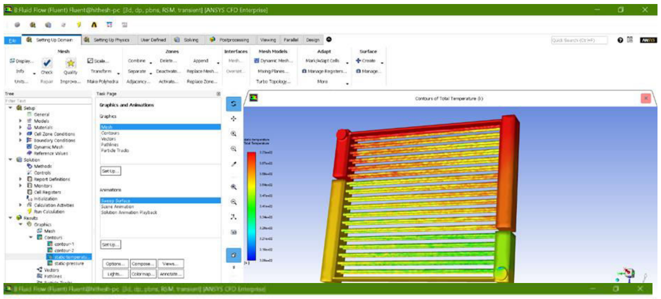


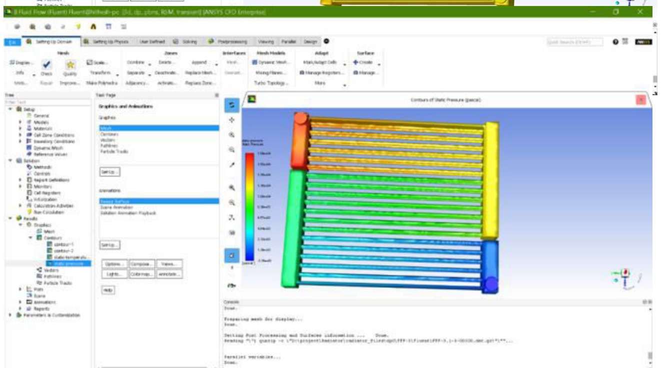
Applying materials by giving required properties

4.2 RESULTS

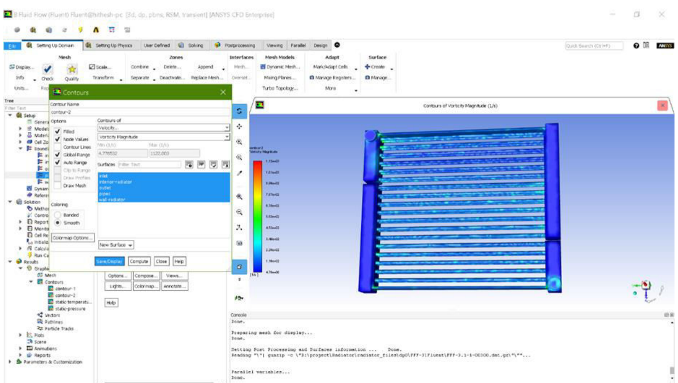
4.2.1 Analysis1- CFD Analysis

In this analysis1 we have taken the ethanol as base fluid for radiator. Then the results are





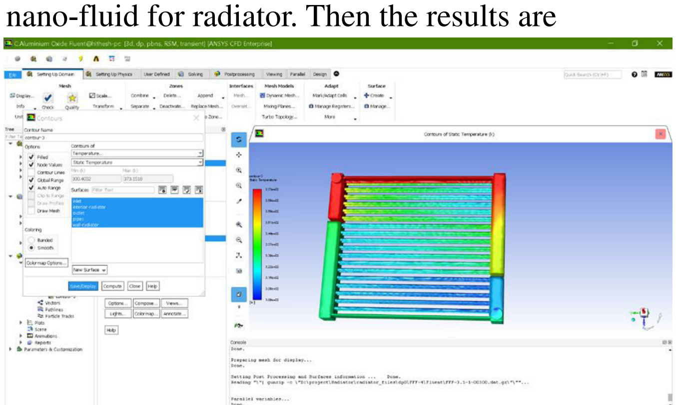
Analysis of static pressure of fluid ethanol



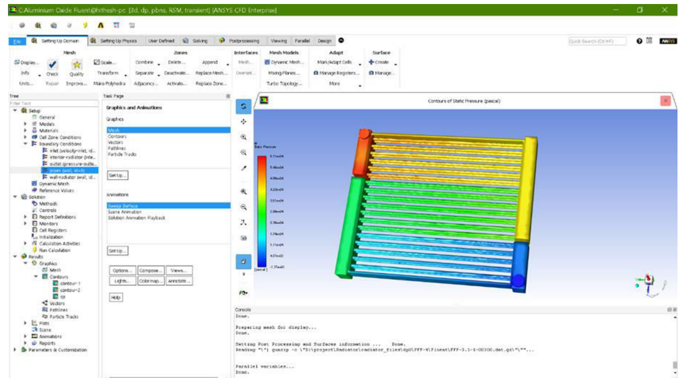
Analysis of velocity magnitude of fluid ethanol

4.2.2 Analysis2- CFD Analysis

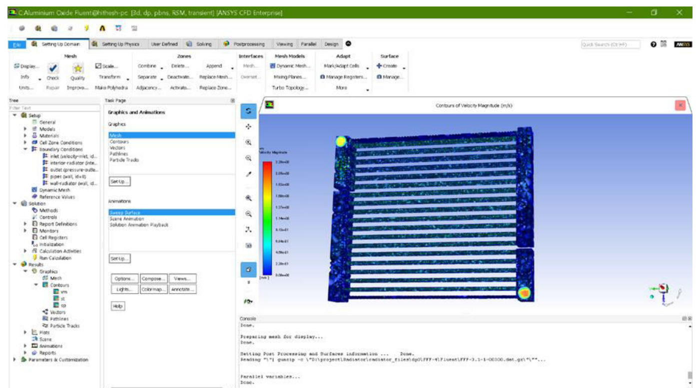
In this analysis2 we have taken the aluminium oxide as nano-fluid for radiator. Then the results are



Analysis of static temperature of fluid aluminium oxide



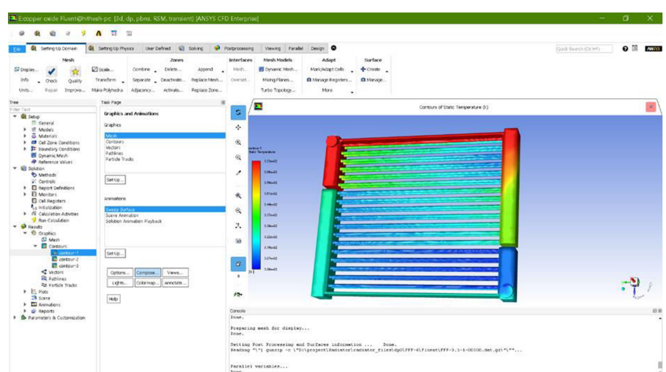
Analysis of static pressure of fluid aluminium oxide



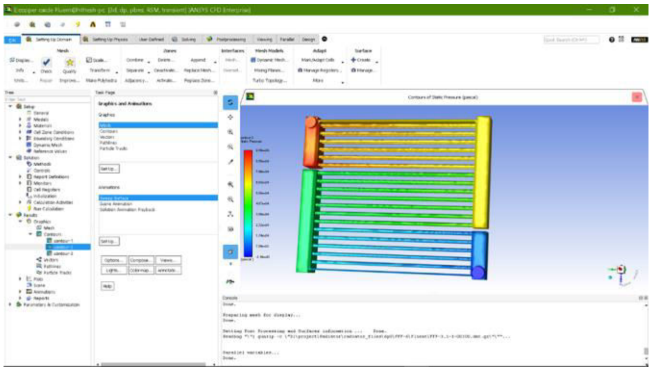
Analysis of velocity magnitude of fluid aluminium oxide

4.2.3 Analysis3- CFD Analysis

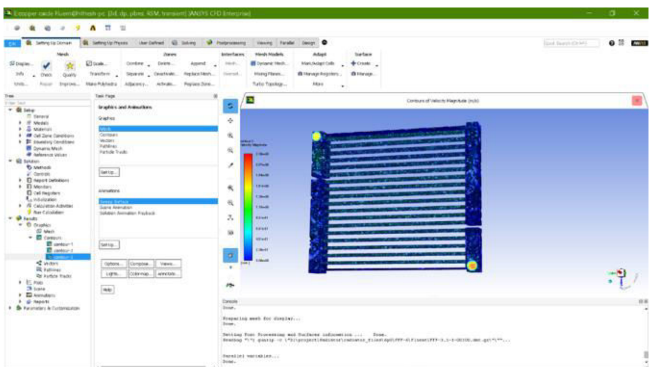
In this analysis3 we have taken the copper oxide as nano-fluid for radiator. Then the results are



Analysis of static temperature of fluid copper oxide



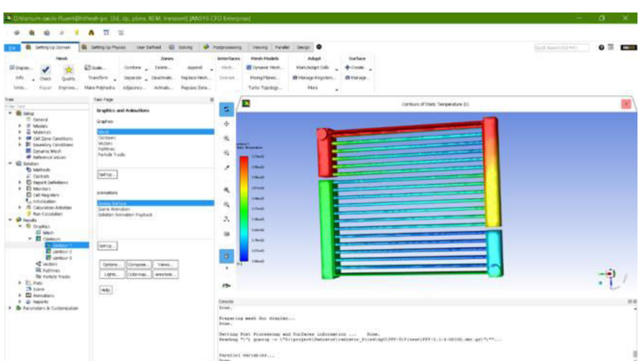
Analysis of static pressure of fluid copper oxide



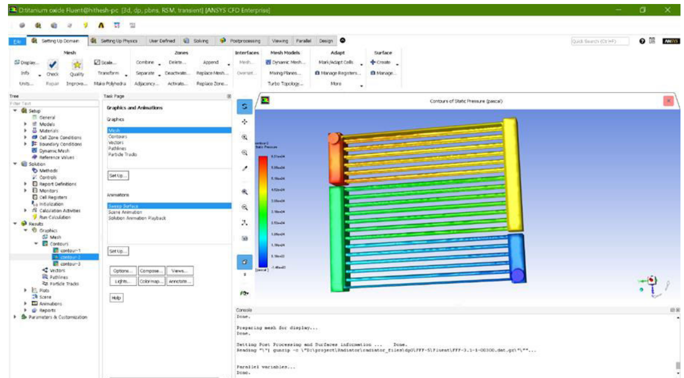
Analysis of velocity magnitude of fluid copper oxide

4.2.4 Analysis4- CFD Analysis

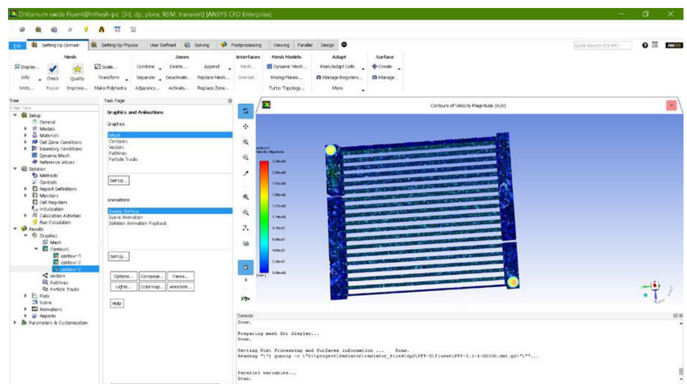
In this analysis4 we have taken the titanium oxide as nano-fluid for radiator. Then the results are



Analysis of static temperature of fluid titanium oxide



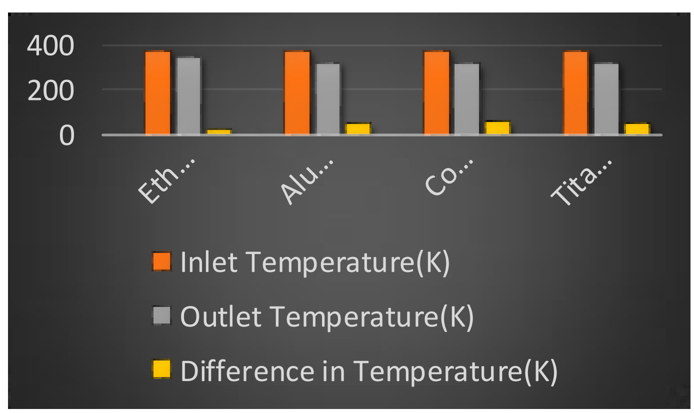
Analysis of static pressure of fluid titanium oxide



Analysis of velocity magnitude of fluid titanium oxide

5 RESULTS AND DISCUSSIONS

5.1 CFD ANALYSIS BASED ON STATIC TEMPERATURE



Graph: CFD Analysis based on static temperature

In CFD analysis the nano-fluid have the less outlet temperature with a value of 316K. By comparing the outlet temperatures of base fluid and nano-fluids, the fluid with less outlet temperature yields better results. Thus, Copper Oxide yields better results among the four fluids.

6 CONCLUSION

The present work relates to a radiator with applying of different nano-fluids. The following base fluid and nano-fluids are used Ethanol as base fluid, Aluminium oxide, Copper oxide, Titanium oxide as three nano-fluids, Copper oxide is found to be best suitable nano-fluid for the radiator with less outlet temperature. It is observed that least outlet temperature with the value of 316K respectively. By comparing the Analysis results it is observed that the copper oxide is selected as a best nano-fluid for radiator with the desired outlet temperature of 316K.

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