Thermal Performance Optimization of Radiators with Nanofluid Heat Transfer

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ABSTRACT

Heat exchangers play an important part in the field of energy conservation, conversion and recovery. Numerous studies have focused on direct transfer type heat exchanger, where heat transfer between fluids occurs through a separating wall or into and out of a wall in a transient manner. There are two important phenomena happening in a heat exchanger: fluid flow in channels and heat transfer between fluids and channel walls. Thus, improvements to heat exchangers can be achieved by improving the processes occurring during those phenomena. Nano fluids, on the other hand, display much superior heat transfer characteristics compared to traditional heat transfer fluids. Nano fluids refer to engineered fluids that contain suspended Nano particles with average size below 100nm in traditional heat transfer fluids such as water, oil and ethylene glycol. An experimental system will be designed and constructed to investigate heat transfer behaviour of different type of Nano fluid a car-radiator heat exchanger. Heat transfer characteristics will be measured under the turbulent flow condition. The experiments is planned to be conducted for wide ranges of Peclet numbers, and volume concentrations of suspended Nano particles. The outcome expectation is to measure the significance of Peclet number on the heat transfer characteristics. The optimum volume concentrations in which the heat transfer characteristics become the maximum enhancement is also addressed. Finally, the structure of different Nano fluid is compared.

Keywords: *Nano Fluids, Heat Exchangers, Nano practices.*

I. INTRODUCTION

While in automotive applications the cooling system is designed for the majority of operational conditions and coolant temperatures are managed by actively controlling coolant flow and engine output in specific purpose applications, such as the case of locomotive engines, the trend is still to size the cooling package so that sufficient heat is rejected at extreme operating conditions (full engine power, high ambient temperature). Nevertheless, many of the technological practices matured in automotive thermal management are now being implemented in specific applications. Along with this, there is also an increasing demand to reduce product development times, to respond to market trends and to reduce investments. In this context, development engineers are encouraged to develop conceptual design strategies for the rapid assessment of the whole thermal management system at the component, system, and application levels, based on the use of CAE (Computer-aided engineering) tools, in order to achieve design objectives and specifications for different system aspects. The models have to be kept simple, especially compared with state of the art radiator calculation methods, if acceptable calculation times are to be achieved.

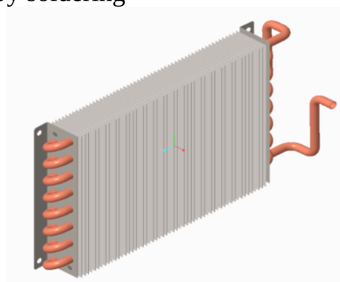
The computational cost of commercial 1D simulation programs is small when compared to complete system 3D simulations. Thus, 1D code is useful to conduct simulation of large systems; however, components and heat exchangers are considered only as momentum and energy sources or sinks, so that the detailed behavior of the heat exchanger must be studied in a 3D environment. This means that both 1D and 3D simulations are necessary in order to achieve both requirements (simulation of large systems and detailed evaluation of each component). The internal flow in a component, simulated in 3D, can be incorporated into a global 1D cooling system network. With this, the details of the internal flow are taken into account while conserving overall mass flow in the system, thus reducing uncertainties in boundary conditions prescribed in the 3D model and reducing the overall simulation time.

The radiator in a car is the part of the engine which is filled with water in order to cool the engine. It mainly consists of an upper tank and lower tank and between them is a core. The upper tank is connected to the water outlets from the engines jackets by a hose pipe and the lover tank is connected to the jacket inlet through water pump by means of hose pipes. There are 2-types of cores:

(a) Tubular

(b) Cellular

When the water is flowing down through the radiator core, it is cooled partially by the fan which blows air and partially by the air flow developed by the forward motion of the vehicle. As shown through water passages and air passages, water and air will be flowing for cooling purpose. It is to be noted that radiators are generally made out of copper and brass and their joints are made by soldering



NANO FLUIDS:

A Nano Fluid is a fluid containing nanometer-sized particles, called Nano particles.

These fluids are engineered colloidal suspensions of nanoparticles in a base fluid. The Nano particles used in Nanofluids are typically made of metals, oxides, carbides, or carbon Nano tubes. Common base fluids include water, ethylene glycol 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 behavior of Nanofluids is found to be very critical in deciding their suitability for convective heat transfer applications Nano fluids 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. In analysis such as computational fluid dynamics (CFD), Nano fluids can be assumed to be single phase fluids. However, almost all of new academic papers use two-phase assumption. Classical theory of single phase fluids can be applied, where physical properties of Nanofluids are taken as a function of properties of both constituents and their concentrations. An alternative approach simulates Nanofluids using a two-component model. The spreading of a Nanofluid droplet is enhanced by the solid-like ordering structure of nanoparticles assembled near the contact line by diffusion, which gives rise to a structural disjoining pressure in the vicinity of the contact line. However, such enhancement is not observed for small droplets with diameter of nanometer scale, because the wetting time scale is much smaller than the diffusion time scale.

II. RELATED WORK

The modelling of radiator is designed by using PTC Creo software

Fig 1: Final component of cooling plate

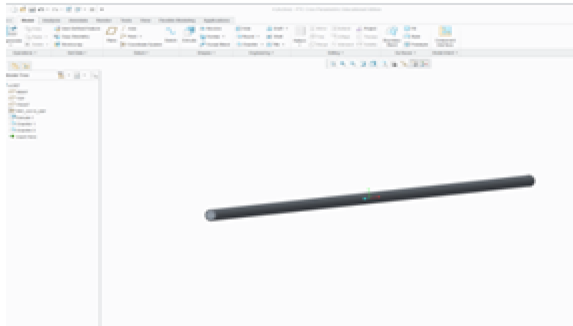


Fig 2: final component of supporting pipe

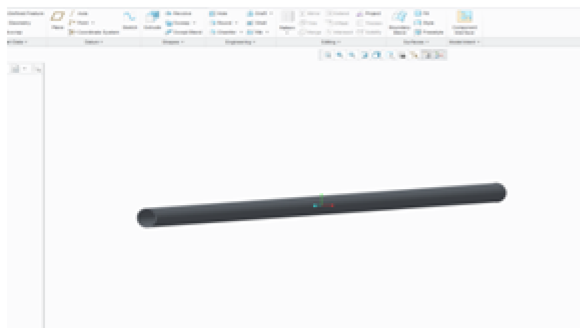


Fig 3: final product of pipe

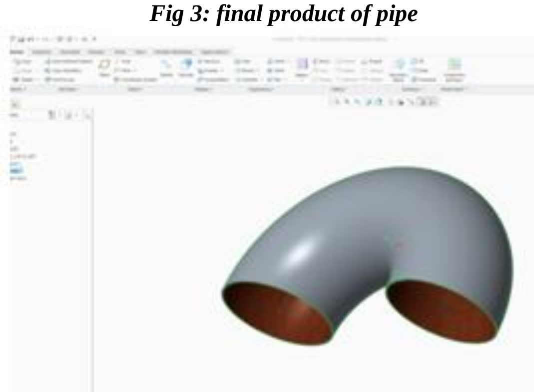


Fig 4: final product of C-Pipe

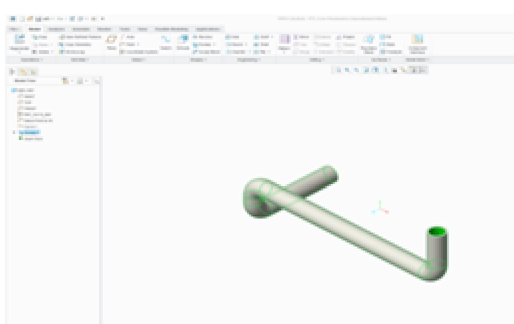


Fig 5: inlet and outlet pipe

The designed radiator model is analyzed by using ansys software & CFD analysis by using Nano particles

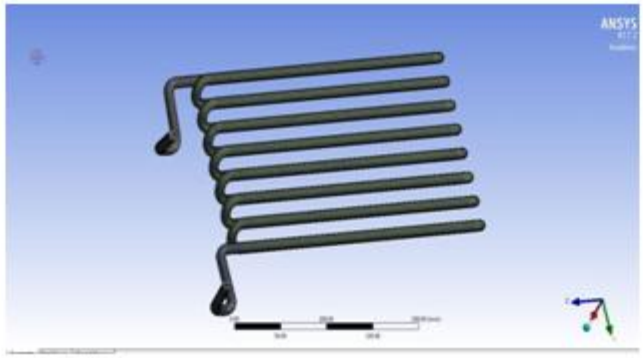


Fig 6: generated mesh of radiator

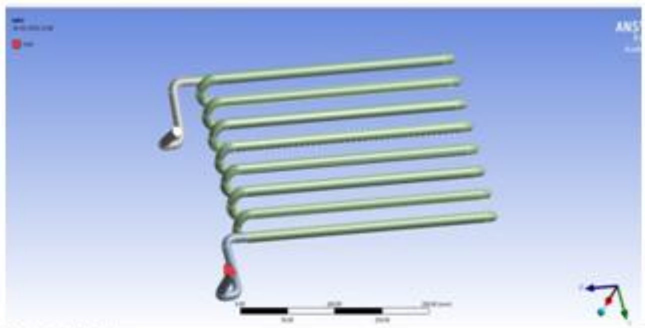


Fig 7: applied inlet boundary

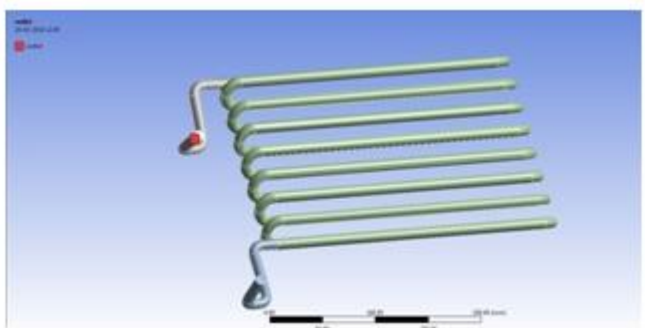


Fig 8: applied outlet boundary

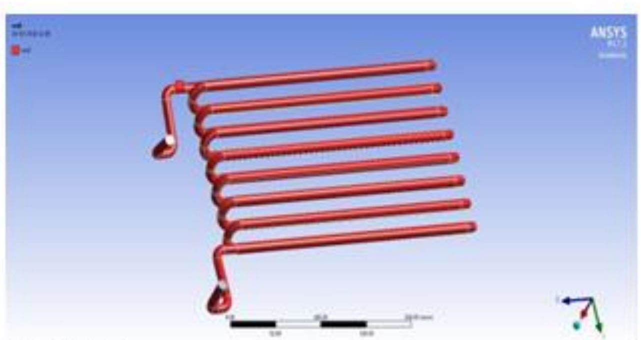


Fig 9: applied wall boundary

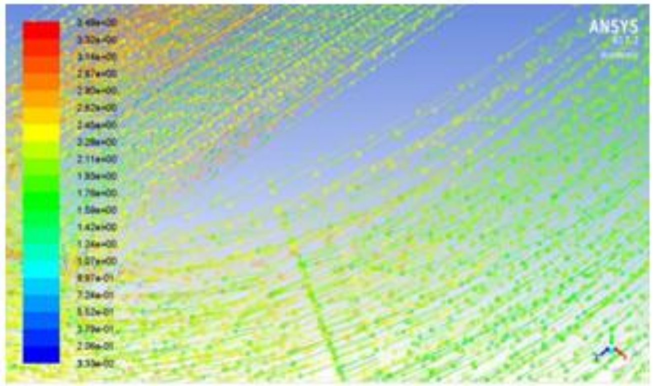


Fig 10: analysis of TiO_2 Nano fluid

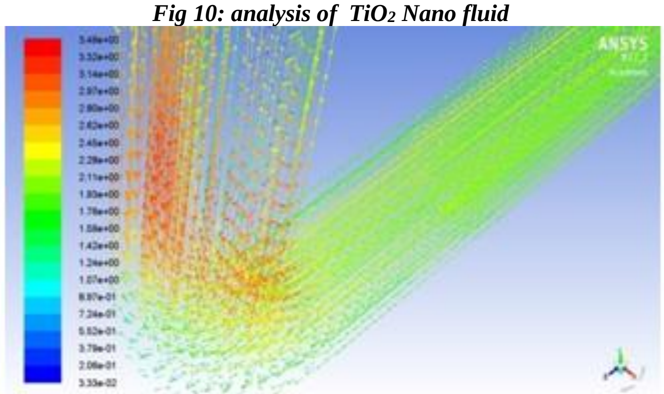


Fig 11: heat radiation of fluids

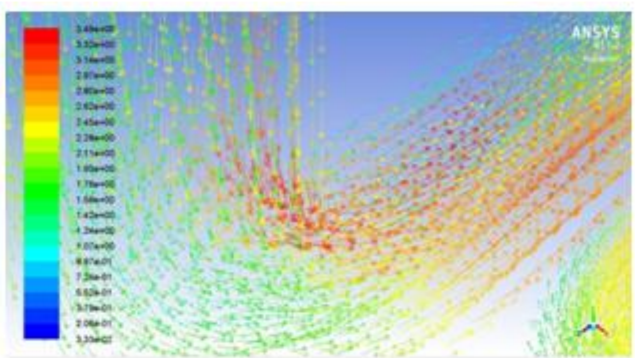


Fig 12: Maximum heat deflection at inlet flow

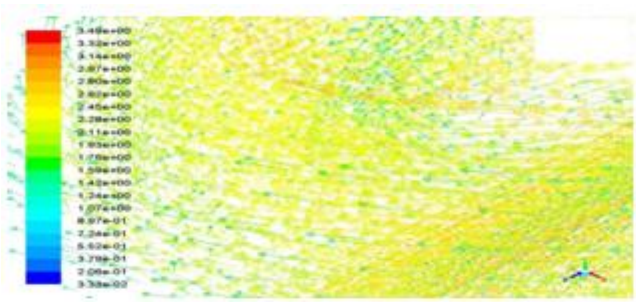


Fig 13: Mixing of Fluid and Nano particles

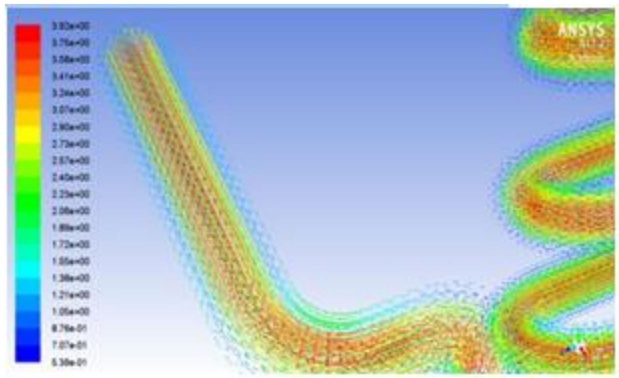
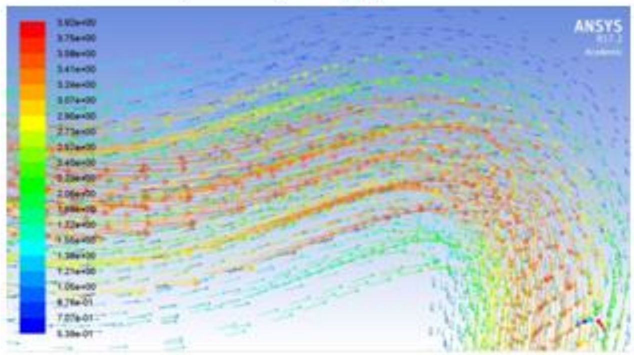


Fig 14: Analysis of CuO



Fi g 15: direction of fluid flow

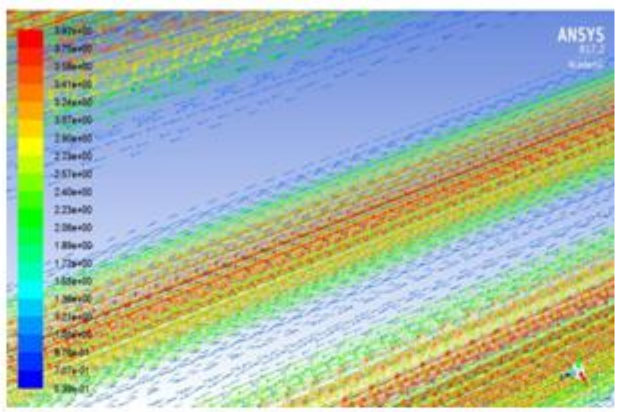


Fig 16: Heat displayed flow

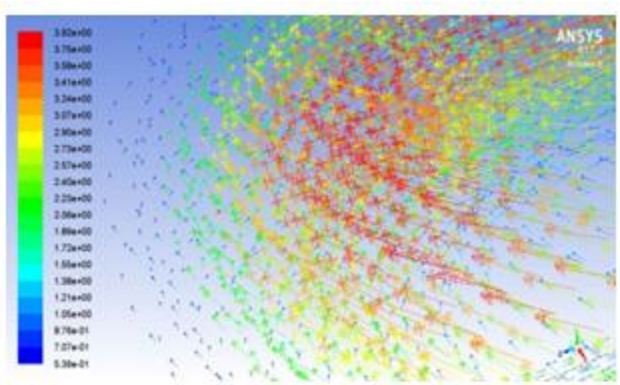


Fig 17: Nano particles in blue

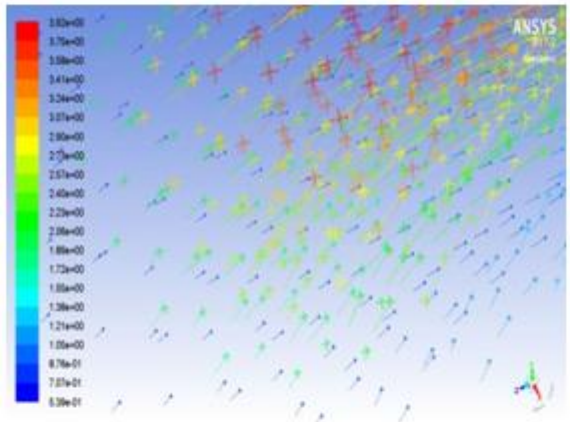


Fig 18: mixing of Nano particles

III. EXPERIMENTAL RESULTS

The radiator results are plot by graphs for nano fluids TiO_2 & CuO
RESULTS OF TiO_2 NANOFLUID:

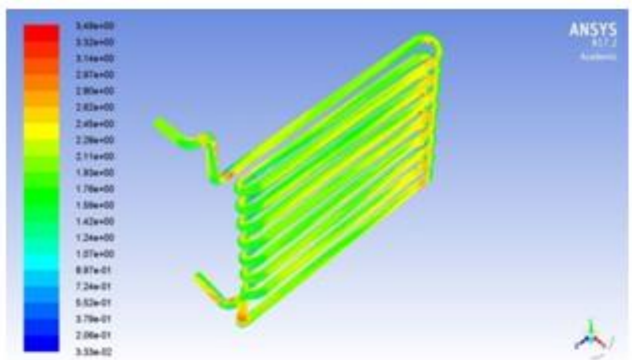
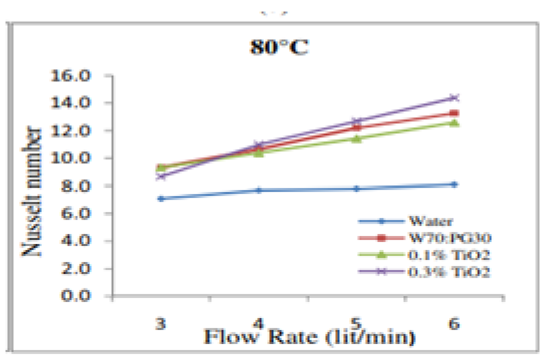
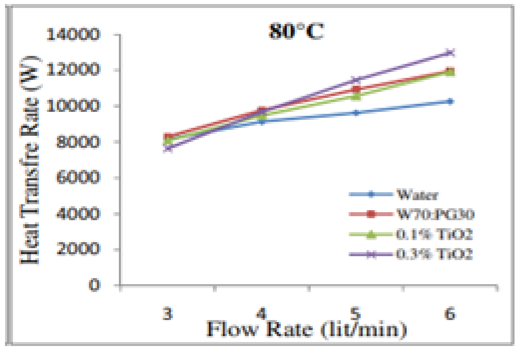


Fig 19: CFD Analysis of TiO_2

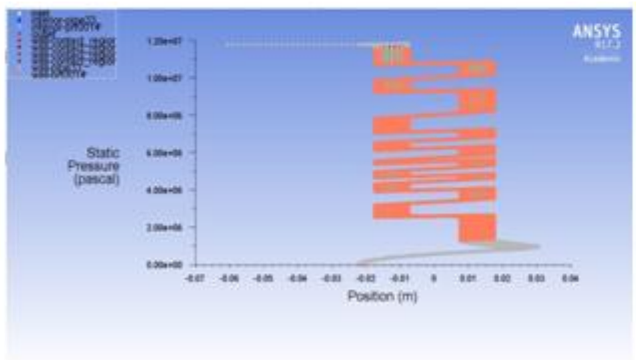
Inlet temp = 80°C
Outlet temp = 26.23°C



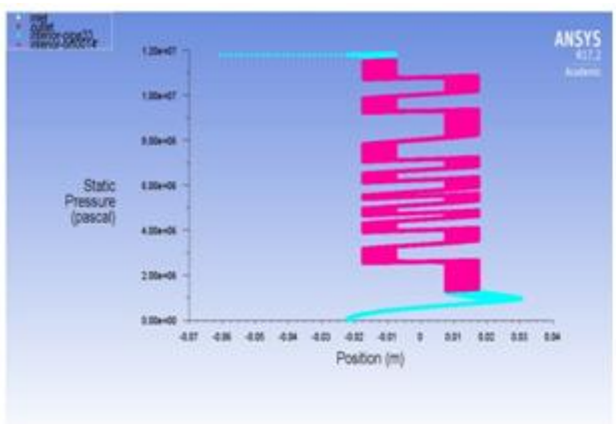
Graph 1: flow rate at 80°C



Graph 2: heat transfer rate at 80°C



Graph 3: static pressure rate at inlet of TiO_2



Graph 4: Static pressure rate at outlet of TiO_2

RESULTS OF CuO NANOFLUID:

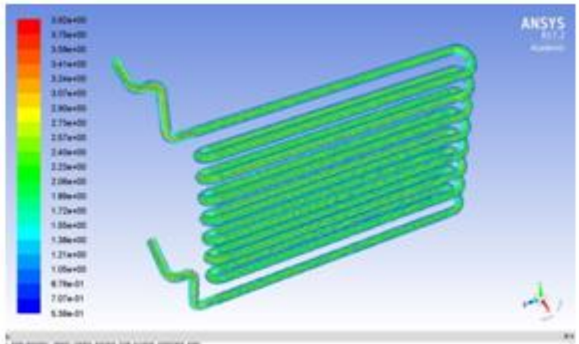
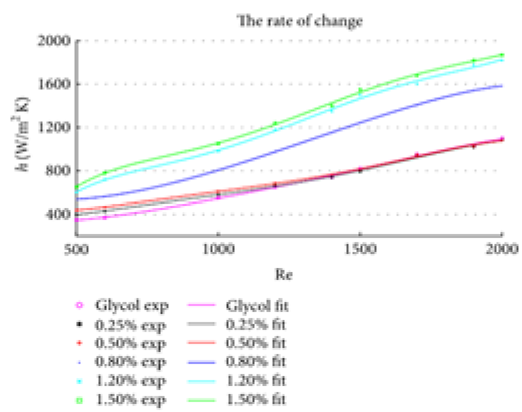
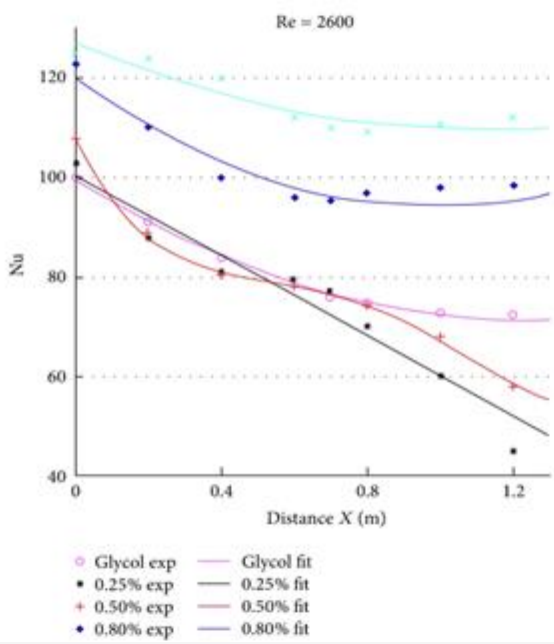


Fig 20: CFD Analysis of CuO

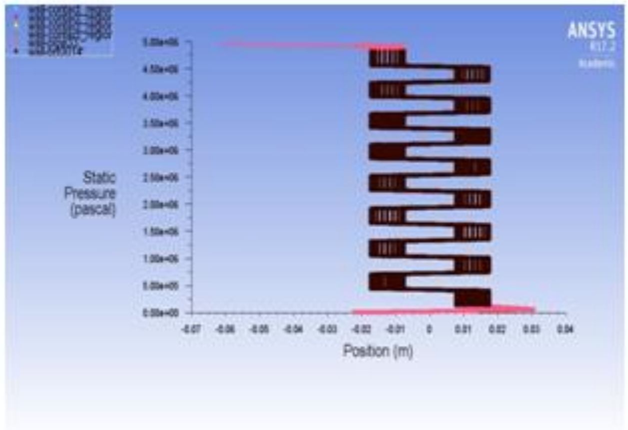
Inlet temp = 80ºC, Outlet temp = 18.56ºC



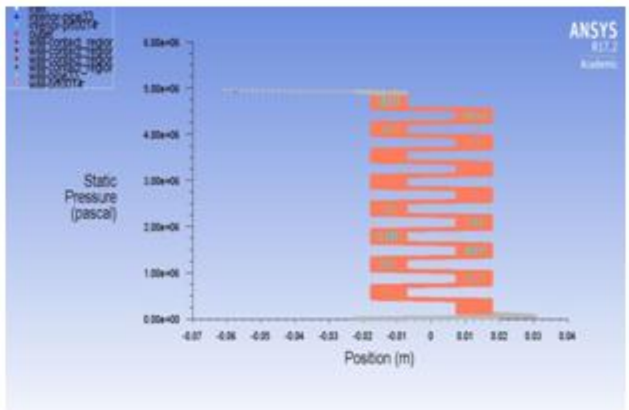
Graph 5: Convective heat transfer coefficient of CuO/glycol nanofluids with different mass fraction under laminar flow.



Graph 6: Tube axial local Nusselt number coefficient of CuO/glycol nanofluids with different mass fractions.



Graph 7: Pressure rate at inlet of CuO



Graph 8: Pressure rate at outlet of CuO

IV. CONCLUSION

The forced convective heat transfer experiment have been performed in an automobile radiator using pure water, TiO2nanofluid & CuO Nanofluid at two different concentrations and the following conclusions were obtained.

- The experimental results shows that the Nusselt number behavior of the Nanofluid was highly depend on the volume flow rate and a highest Nusselt number have been observed at 6 lit/min flow rate at 80°C inlet temperature.
- The Nusselt number enhancement of 8.3% was obtained by addition of 0.3% of TiO2 nanoparticles in the base coolant mixture.
- Heat transfer rate increases with increase in nanoparticles concentration at higher operating temperatures and coolant flow rate.
- The heat transfer enhancement of about 8.5% was achieved with addition 0.3% of TiO2 nanoparticles at 80°C coolant inlet temperature.
- The results shows that the Nanofluid coolants have tendency to remove heat from the engines at higher operating temperatures and flow rate effectively which makes it suitable for heavy duty engines.
- CuO nanoparticles make the heat transfer intensity of the fluid increase obviously in glycol fluid. It is observed that, by increasing Reynolds number, the heat transfer coefficient increases, especially the inlet which is very obvious. Adding moderate dispersant can ease nanoparticles aggregation effectively and enable it to be steady.
- For higher volume fractions of CuO nanoparticles, wall temperature decreases and heat transfer increases.
- For low concentration of CuO Nanofluid, there is no significant change in wall temperature, heat transfer coefficient, and Nusselt number. By increasing the mass fraction of CuO nanofluids, wall temperature decreases and heat transfer coefficient and Nusselt number increase.

- As nanofluids greatly increase the heat transfer coefficient of base liquid, compared to the defect taken by the volume of nanoparticles, its high heat transfer coefficient would bring more advantages. So increasing appropriately the particle volume fraction would be beneficial to the enhancement of heat transfer.

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