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"EVALUATION OF THE PERFORMANCE OF VARIOUS COOLANTS USED IN CAR RADIATORS"

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Abstract : The automotive industry's demand for engines with the highest performance, efficiency, and design has steadily increased. Water is typically used as the coolant when using a radiator as an engine cooling component. The radiator's coolant mixing process removes heat from a liquid-cooled system. Coolant is circulated by pumps, and heat is removed by radiators. Radiator design and size optimization are required for an effective cooling rate.

Due to some limitations in the design optimization process, testing alternate coolants to water can increase efficiency. Thus, a car radiator's thermal performance was enhanced in this experiment utilising several coolants. To the base fluid, a mixture of water and water with differnt percent concentrations of Al_2O_3 and CuO particles were added, and the fluid's properties for heat transfer were then assessed. "To analyse the performance of the heat transfer characteristics of water/anti-freezing based fluid as a coolant for vehicle radiators," is the stated goal of the current paper. 698.84 was the highest Reynold's number. The lowest Nu Number calculated by Al_2O_3 contained fluid was 499.1. When comparing Al_2O_3 and CuO and Water only fluids, the highest Nu for H_2O is 10.79, the second highest for CuO fluid is 6.49, and the lowest value for Al_2O_3 contained fluid is 5.66.

IndexTerms – Car radiator, Nano fluid, performance analysis, etc.

I. INTRODUCTION

The cooling system of a car engine is important in maintaining its performance. The engine produces a lot of heat that must be removed in order for it to function optimally. The present cooling system that is available uses water and an anti-freezing agent as the coolant for the radiator to remove the heat from the engine via conduction and convection. The heat transfer performance of the coolant is not adequate to remove more heat that may be produced in the engine. With the use of nanoparticles, the surface area of heat transfer of coolant can be increased, thus increasing the heat transfer performance of the coolant. However, the concentration of the nanoparticles of Al2O3 and CuO that can optimally transfer heat must be determined. In the past decades, research efforts have been conducted to improve the performance of the cool system in cars, specifically the radiator and coolant fluid.

Nano Fluids

Cooling system is one of the important systems amongst all. It is responsible to carry large amount of heat waste to surroundings for efficient working of an engine. It also enhances heat transfer and fuel economy which leads to maximize the performance of an engine. Most internal combustion engines are fluid cooled using either air or a liquid coolant run through a heat exchanger (radiator) cooled by air. The heat transfer through radiator can be improved by maximizing the heat transfer area and increasing the heat transfer coefficient. The heat transfer coefficient can be increased either by using more efficient heat transfer methods or by improving the thermo physical properties of the heat transfer material i.e. coolant.
Earlier, Water was widely used in radiator as a coolant for its good ability to holding heat, transfer heat and can be readily obtained. Also the mixture of water & ethylene glycol later introduced as a coolant. Both of them having certain merits & demerits. With the advancement of nanotechnology, the new generation of heat transfer fluids called, "Nanofluids" have been developed and researchers found that these fluids offer higher thermal conductivity compared to that of conventional coolants. Nanofluids which consist of a carrier liquid, such as water, ethylene glycol dispersed with tiny nano-scale particles known as nanoparticles.

Types of Nanofluids

There are various metallic, non-metallic nanoparticles and multiwalled carbon nanotubes (MWCNT) which are currently used with base fluids to enhance the thermal performance of the cooling systems. Common base fluids are water, ethylene glycol and oil.

The metallic nanoparticles like Cu, Fe, Au, Ag etc. and non-metallic particles or compounds like Al2O3 (Alumina), CuO, SiC, TiO_2, Fe_3O_4 (Iron Oxide), ZrO_2 (Zirconia), WO_3 (Tungsten trioxide), ZnO, SiO_2 etc. are generally used with base fluids.

Challenges of Nanofluids

Many interesting properties of nanofluids have been reported in the review. In the studies, thermal conductivity of nanofluids has received the maximum attention by many researchers. Conversely, the use of nanofluids in a wide variety of applications appears promising. But the development of the field is hindered by

lack of agreement of results obtained by different researchers;

poor characterization of suspensions;

lack of theoretical understanding of the mechanisms responsible for changes in properties. Experimental studies in the convective heat transfer of nanofluids are needed. Many issues, such as thermal conductivity, the Brownian motion of particles, particle migration, and thermo physical property change with temperature, must be carefully considered with convective heat transfer in nanofluids.

Therefore, Bhogare et al. (2013) concludes several important issues that should receive greater attention in the near future as per following

- Long Term Stability of Nanoparticles Dispersion.
- Increased Pressure Drop & Pumping Power.
- Higher Viscosity
- Lower Specific Heat.
- Higher Cost.
- Difficulties in Production of Nanofluids

II LITERATURE REVIEW

The cooling effectiveness of radiators has been studied by numerous researchers, some of whom include:

Sandeep Kumar (2014) investigated the effect of CuO-distilled-based nano-fluids on heat transfer and pressure drop characteristics. They observed that at 30LPH flow rate of coolant as use of 0.5% CuO nano particles, pressure drop 30.7% higher than distilled water. Addition of 0.1 % CuO nano particles in base water pressure drop 6.2% higher than distilled water. So he concluded that as an increase nanoparticle, heat transfer increases but pressure drop also increased.

Dhananjaya (2015) studied corrugated and louvered fin and flat tube radiator. The use of 10% CuO nano particles in base water states that the overall heat transfer coefficient is higher than use of base water. But it increases the pumping power.

K.Y.Leong and R.Saidur (2010) studied the performance investigation of car radiator operated with nano-fluid based coolants. The observation of CuO nano fluid particles at constant heat flux 50 W/cm2 and Reynolds No 2000 heat transfer coefficient 1.35 times higher than base fluid of water and ethylene glycol. Leong investigated 3.8% heat enhancement could be archived by 2% Cu nano particles in base fluid at Reynolds 6000.The pressure drop 110.97kPa was obtained by adding 2% Cu particle compare to a pressure drop of 98.93 kPa for a base fluid. So nano-fluids increases 12.13% pressure drop compared to base fluid.

The virtual models reviewed by **Ruoyang Yuana et al (2020),** in this paper provide tools for component-level, system-level, and control design, analysis, and optimization. The study concerns the latest techniques for an overall vehicle model development and software integration of multi-domain subsystems from a thermal management view and discusses the challenges presented for future studies. In this paper, a wide variety of system designs for modeling vehicle thermal performance are reviewed, providing an overview of necessary considerations for developing a cost-effective tool to evaluate fuel consumption and emissions across dynamic drive-cycles and under a range of weather conditions.

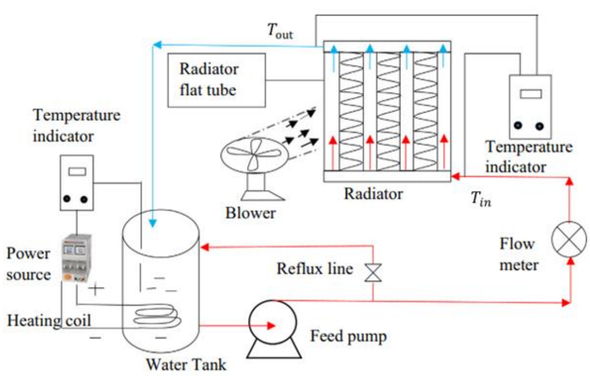


Figure 2.1 Schematic of the operating condition of the car radiator (Alhassan Salami Tijani et. al. 2018).

III Model Description

Using Ansys Workbench Geometry Modular, a three dimensional Radiator was produced. The fins affixed to the tube are made of aluminium. The Auto CADD software was used to create the model. Figure 3.1 depicts the geometry.

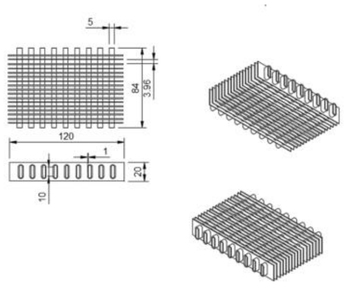


Figure 3.1 Geometry of Radiator

Meshing

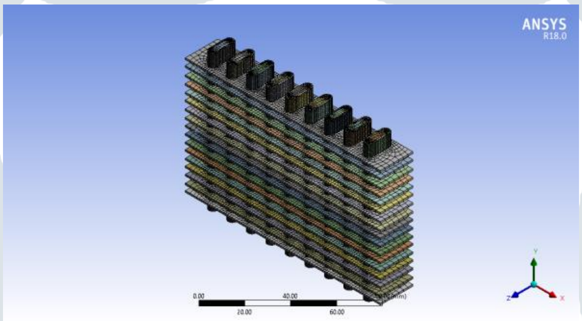


Figure 3.2 Mesh Model

IV SIMULATION RESULTS

The simulation has been carried out on the basis of CFD analysis using Ansys Fluent. The results can be subdivided in two different sections i.e. when fluid velocity constant and fluid inlet temperature varies and second is when the fluid inlet temperature is constant and fluid inlet velocity varies.

Results having constant fluid velocity (i.e. 0.5 m/s) and varying the fluid inlet temperature.

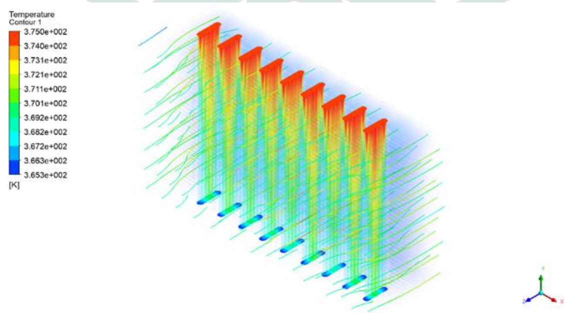


Figure 4.1 Temperature difference obtained having inlet temperature 375 K for Water as a Coolant

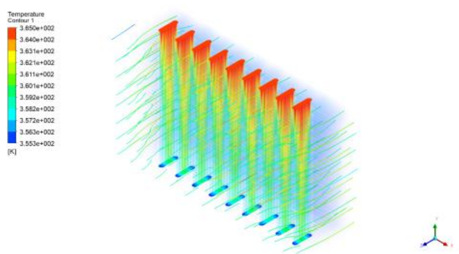


Figure 4.2 Temperature difference obtained having inlet temperature 365 K for Water as a Coolant

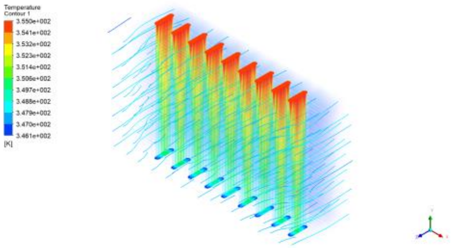


Figure 4.3 Temperature difference obtained having inlet temperature 355 K for Water as a Coolant

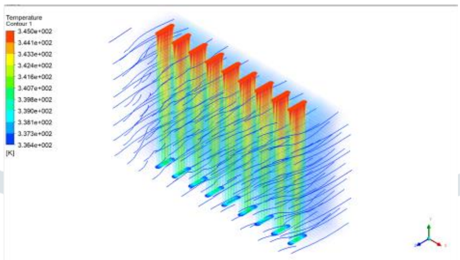


Figure 4.4 Temperature difference obtained having inlet temperature 345 K for Water as a Coolant

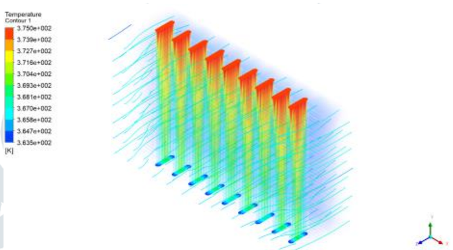
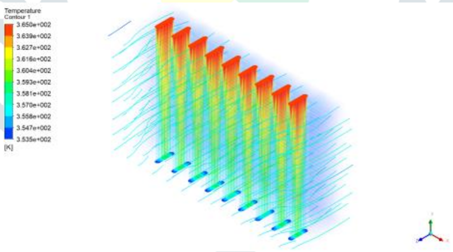


Figure 4.5 Temperature difference obtained having inlet temperature 375 K for Water+Al_2O_3 as a Coolant



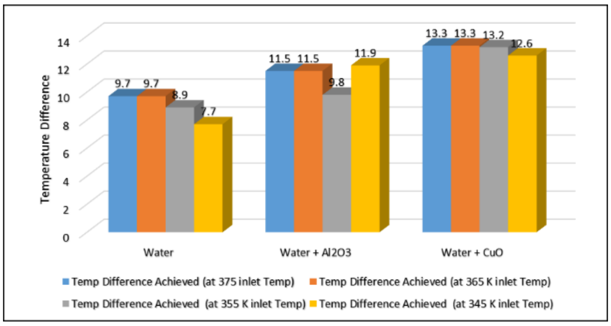


Figure 4.6 Temperature Difference obtained with varying inlet temperature at constant inlet velocity 0.5 m/s

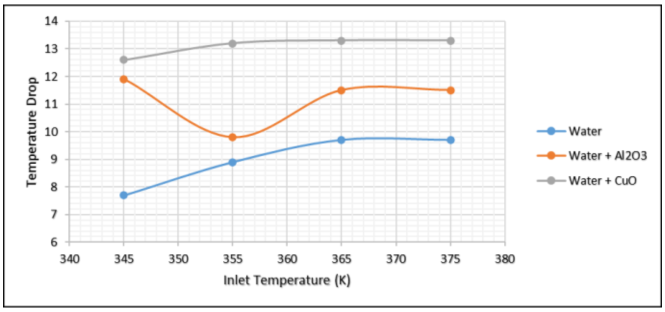


Figure 4.7 Temperature Difference variation trends with respect to inlet temperature for all the 3 fluids

Results having constant fluid inlet temperature (i.e. 375 ˚K) and varying the fluid inlet velocity.

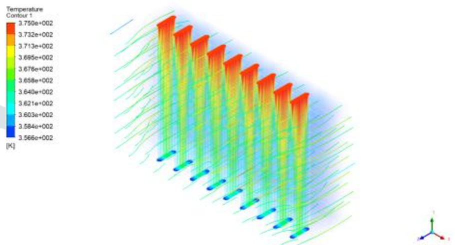


Figure 4.8 Temperature difference obtained having inlet velocity 0.1m/s for Water as a Coolant

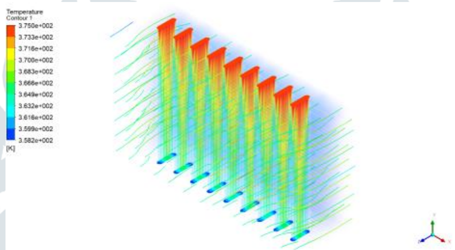


Figure 4.9 Temperature difference obtained having inlet velocity 0.2m/s for Water as a Coolant

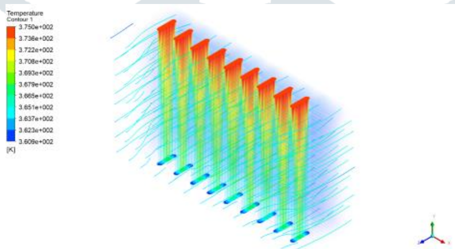


Figure 4.10 Temperature difference obtained having inlet velocity 0.3 m/s for Water as a Coolant

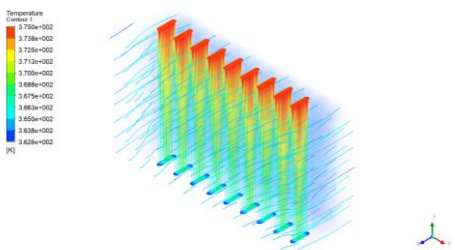


Figure 4.11 Temperature difference obtained having inlet velocity 0.4 m/s for Water as a Coolant

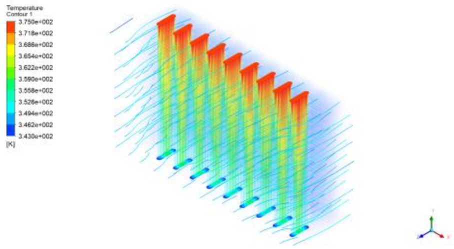
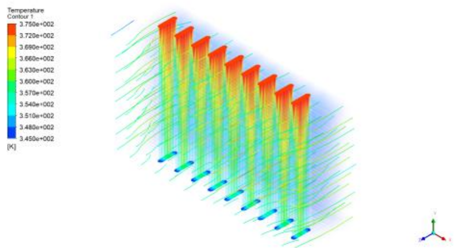


Figure 4.12 Temperature difference obtained having inlet velocity 0.1 m/s for Water + Al_2O_3 as a Coolant



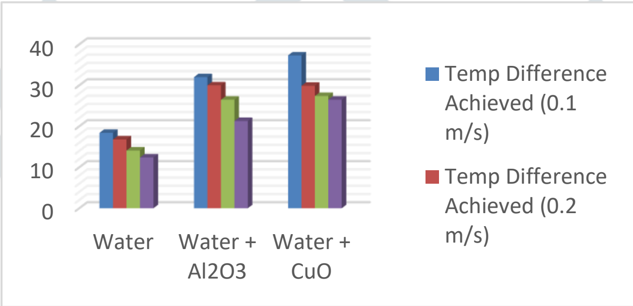


Figure 4.13 Temperature Difference obtained with varying inlet velocity at constant inlet temperature 375 K

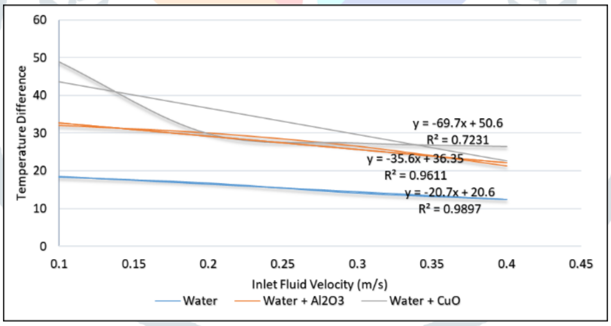


Figure 4.14 Temperature Difference variation trends with respect to inlet fluid velocity for all the 3 fluids

Surface Heat Transfer Coefficient

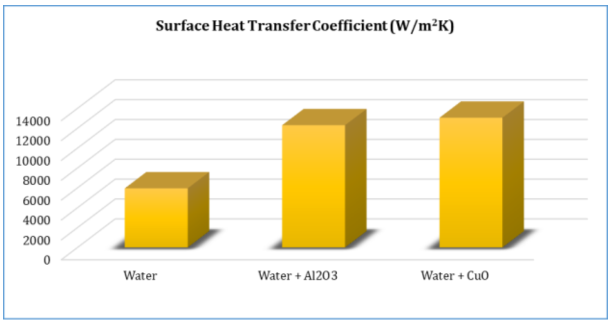


Figure 4.15 Comparison of Surface Heat Transfer for all the 3 Fluids

V Conclusion

The following results have been obtained after the study.

It is observed that the temperature difference lowers while increasing the coolant inlet temperature. This is due to the fact that higher velocity lowers the surface contact time and reduces the heat transfer. There is close relation in between temperature difference and fluid inlet temperature as maximum value of R^2 can be obtained and the curve varies linearly.

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