Design and CFD Analysis of Car Radiator by Using Ansys

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Abstract - *During the planning and development of auto it absolutely was a bigger challenge to stop the engine & engine parts from excess heat generated within the engine cylinder. Thus, a cooling system is important to stop failure of the engine from melting and damages. The cooling system of equate degree automobile plays prime role in vehicle's performance. presently all automobile industries ar exploitation atomic number 13 based mostly Radiator. the quality radiator is partial temperature reduction and doesn't meet the need at high engine output. This study makes an attempt to analyze, convective heat transfer constant of automobile radiator exploitation completely different nano fluid. Ethylene glycol equate degree of water mixture is usually used as an engine fluid within the automobile radiator. These coolants have lower heat transfer rates owing to their lower thanks to its superior thermal physical phenomenon, the warmth transfer performance of f-MWCNT nanofluid was higher than DI water. The performance of warmth transfer of nanofluid was increased up to forty fifth compared to DI .*

1.INTRODUCTION

The thermal performance of a automobile radiator assumes a vital half within the execution of a car's cooling framework and every one alternative connected frameworks. For numerous years, this half has experienced very little} thought with little dynamic in its aggregation value, operation and pure mathematics. to boost effectiveness of a radiator, completely different studies are done on the additional gadgets, for instance, an oblong blade , a plate , a spherical tube , tier tube , Associate in Nursing elliptic tube and a spline balance . Among differing types of radiators, spline fin radiators area unit often utilised as a region of business vehicles. A spline fin radiator provides a high heat transfer rate nonetheless brings a couple of vital rubbing misfortune thanks to the unclear fluid section. The spline balance radiator is represented by 2 geometric elements: complicated stream sections to upgrade heat exchange and a huge distinction in geometric scales between the radiator and a balance component.

Sweetening in heat transfer is reliably wanted, because the operational rate of cars depends on upon the cooling rate. New innovation and propelled liquids with a lot of outstanding potential to boost the stream and warmth transfer area unit 2 selections to boost the warmth transfer rate and therefore the gift article manages the last different. Customary liquids, for instance, refrigerants, water, motor oil, ethanediol etc. have poor heat transfer execution and therefore high size and effectiveness of warmth transfer frameworks area unit necessary to accomplish the specified heat transfer. Among the efforts for improvement of warmth transfer the employment of extra substances to fluids is a lot of perceptible. Later advances in technology have permissible improvement of another classification of liquids termed nanofluids. Such liquids area unit fluid suspensions containing particles that area unit altogether smaller than a hundred nm, and have a bulk solids thermal conduction over the bottom fluids . Nanofluids area unit framed by suspending aluminous or non-metallic chemical compound nanoparticles in ancient heat transfer fluids. These reputed nanofluids show nice thermal properties contrasted and liquids unremarkably utilised for heat exchange and liquids containing particles on the micrometer scale . Pak Associate in Nursingd Cho displayed an exploratory examination of the convective turbulent heat transfer qualities of nanofluids ($Al2O3$-water) with 1-3 vol. %. The Nusselt variety for the nanofluids increments with the enlargement of volume fixation and Reynolds variety. Veeranna sridhara and Lakshmi Narayan Satapathy introduced Nanofluids area unit engineered by suspending nanoparticles with traditional sizes below a hundred nm in heat transfer liquids, for instance, water, oil, diesel, ethanediol, and so on. inventive heat transfer liquids area unit delivered by suspending aluminous or non-metallic nanometer-sized sturdy particles. the soundness of nanofluids, improvement of heat conductivities, thickness, and warmth transfer qualities of corundom ($Al2O3$)- based mostly nanofluids. The $Al2O3$ nanoparticles fluctuated within the scope of thirteen to 302 nm to urge prepared nanofluids, and therefore the watched improvement within the thermal conduction is a pair of to 12 months. Nanofluids have attracted attention as a brand new generation of warmth transfer fluids in building in automotive cooling applications, thanks to their glorious thermal performance. Recently, there are goodish analysis findings highlight superior heat transfer performances of nanofluids.

Therefore, this study an attempt to research the warmth transfer characteristics of an spline fin automobile radiator mistreatment mixture of water based mostly $Al2O3$ nanofluids as coolants. Thermal performance of associate degree automobile radiator operated with nanofluids is compared with a radiator mistreatment standard coolants. The impact of volume fraction of the Al2O3 nanoparticles with base fluids on the thermal performance and potential size reduction of a radiator were conjointly dole out.

2. MATERIAL AND METHOD

2.1 THERMOPHYSICAL PROPERTIES OF NANOFLUID

Al2O3 nanofluid solid particles and water (H2O) were used as nanofluid solid particles and base liquid fluid, severally. They were mixed at varied concentration to organize nanofluid material for radiator agent. In general, nanofluid has giant heat transfer characteristics when put next to standard fluids. many nanofluid properties were then evaluated and used for simulation processes.

Thermal conduction of nanofluid. Thermal conduction of nanofluids is calculated supported the empirical correlation given by Xuan et al as shown in Equation one.

$$Knf = \frac{kp + 2kb - 2\emptyset(kp - kb)}{kp + 2kb + \emptyset(kp - kb)}Kb + \frac{\rho p\emptyset Cpp}{2}\sqrt{\frac{kBT}{3\pi c\mu nf}}$$

where knf is thermal conductivity used in nanofluid (W/m.K), kp is thermal conduction of nano particle (W/m.K), computer memory unit is thermal conduction of basic fluid (W/m.K), computer memory unit is Boltzmann constant (1.381 x 10-23 J/K), and RC is radius cluster (10-8 m).

Specific heat. heat energy is that the quantitative relation of the quantity of warmth needed to extend 1°C temperature of a substance. the precise heat will be evaluated as follows .

$$Cp_{nf} = \frac{(1 - \varphi)\rho bcPb + \varphi(\rho PcPP)}{\rho nf}$$

where Cpnf is particular heat of nanofluid (J/kg.K), Cpb is particular heat of basic fluid (J/kg.K), and Cpp is particular heat of nano particle (J/kg.K).

2.2 MODEL CHARACTERISTICS

This analysis used procedure fluid dynamics (CFD) simulation technique, that in its application used ANSYS Fluid Flow Fluent software package. The initial procedure applied during this study was to conduct a literature study by collection theories associated with analysis on nanofluid. moreover, the creation of fluid pure mathematics is finished victimization Autodesk artificer 2020 software package. Radiator style refers to AN existing style. the planning was enclosed within the ANSYS software package and also the meshing method was applied, then modelling on the ANSYS Fluid Flow Fluent. the planning of radiator is given in Figure one

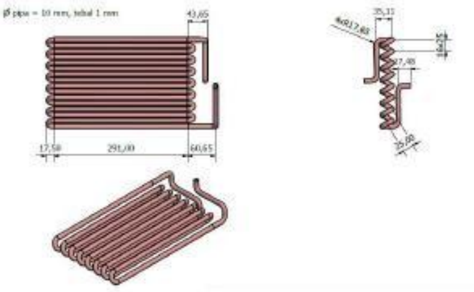

Figure 1. Radiator Design

2.3 BOUNDARY CONDITIONS

In this work, it is assumed that inlet velocity and temperature value is 0.4 m/s and 130°C, respectively.After calculating the Reynolds number, it can be seen that the fluid flow includes a transition because the Reynolds number is more than 3000 and less than 4000, then the assumption used in viscous is k- epsilon Realizable. The value of convective heat transfer coefficient for each concentration can be seenin Table

2.4 TABLE 1 Basic thermophysical properties of Al_2O_3 and H_2O

Thermophysical Properties	H_2O	Al_2O_3
Density (kg/m^3)	998.21	3970
Specific Heat (J/kg.K)	4182	525
Thermal Conductivity (W/m.K)	0.6024	17.65

2.5 NUMERICAL METHOD

Pre-Processing. Geometry was converted into an Ansys Fluid Flow Fluent workbench to define the flow plane to form a fluid body as illustrated in Figure 2

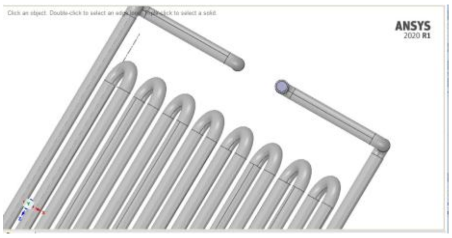

Figure 2. Geometry on Ansys

The next stage is the meshing process, where the meshing process can affect the accuracy value of the simulation results. The smaller meshing, the more accurate the simulation result, but it must also be adjusted to the specifications of the device used if perform calculations with a high level of accuracy. The parameters on meshing are presented in Table 4.

Table 2. Meshing Parameter

Parameter	Specification
Physics preference	CFD
Solver preference	Fluent
Element size	0.015 m
Smoothing	Medium
Mesh metric	Orthogonal quality
Use automatic inflation	Program controlled
Assembly mesh	None

3. RESULT AND DISCUSSION

3.1 FLUID FLOW

The fluid flow that flows in the radiator pipe starts from the inlet to the outlet and type of flow can be known based on the calculation of the Reynolds number. Reynolds Number is a dimensionless numberused to categorize fluid systems in which the effect of viscosity plays an important role in controlling the velocity or flow pattern of a fluid. Fluid flow includes laminar flow if it has the Re value of less than 2000 and if the Re value is more than 4000 then the flow includes turbulent flow [16]. The fluid flow flowing in the radiator pipe starts from the inlet up to the outlet and the type of flow can be known based on Reynolds number calculation. A transition flow is a flow regime between laminar flow and turbulent flow. Reynolds number for transition flow is between 2300 and 4000. Table 5 shows the results of Reynolds number values, while Figure 3 shows velocity streamline for each nanofluids concentration.

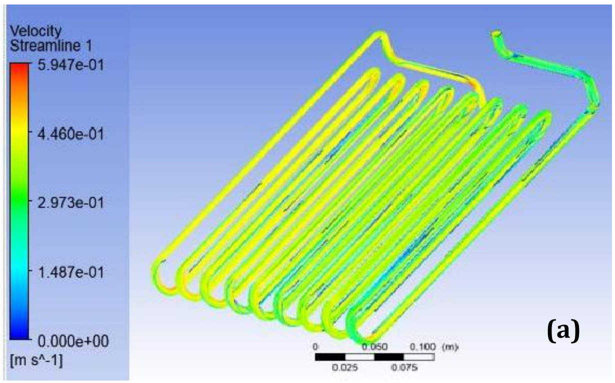

Figure 3 Streamline of velocity for concentration of: (a) 0% (water); (b) 0.3%; (c) 0.5%;and (d) 1%

Table 5. ReynoldsNumber Value

Concentration (%)	Reynolds Number
0.3	3926.1
0.5	3886.34
1	3777.2

Streamline of velocity for each concentration starts from the inlet side to the outlet side forming a flow pattern that is drawn through the lines that the fluid passes along the pipe. The 100% water has a maximum velocity of 0.5947 m/s with an average velocity of 0.411 m/s. The 0.3% concentration has a maximum velocity of 0.596 m/s with an average velocity of 0.497 m/s. The 0.5% concentration has a maximum velocity of 0.6003 m/s with an average velocity of 0.450 m/s. The 1% concentration variation has a maximum velocity of 0.6014 m/s with an average velocity of 0.451 m/s. This means that the fluid velocity increases with increasing nanoparticle concentration. In this case, nanoparticles play a role in transporting heat energy from one place to another. This phenomenon occurs because the total energy of the moving fluid element is the sum of its internal energy with kinetic energy. There is an exchange of changes in internal energy and kinetic energy to keep the total energy of the flow constant. Based on this, the amount of internal energy will decrease by the flow of heat from the hot nanofluid to the cool environment. Consequently, the kinetic energy will increase to maintain the total energy.

3.2 HEAT TRANSFER Rate AND OUTLET TEMPERATURE

Heat transfer is the process of energy movement due to temperature differences. The calculations we are interested in include determining the final temperature of the material and how long it will take for this material to reach that temperature. This can help inform the level of insulation required to ensure heat is not lost from the system. Lost heat is proportional to the temperature gradient (driving force or potential). The calculation result data is then exported on CFD-Post. This feature is used to display simulation results in the form of contours, streamlines, and fluid flow animations in more detail. Each variation has an inlet temperature of 130°C and has a different outlet temperature, according to the concentration of nanofluids. Figure 5 shows the contour of temperature for each nanofluids concentration.

The figures above indicate the temperature contour with the inlet side depicted in red colour and the outlet side depicted in blue colour. For nanofluids with concentration of Al_2O_3 of 0%, fluid temperature decreased from 130°C to 103°C. Nanofluids concentration of Al_2O_3 of 0.3% was able to reduce the temperature from 130°C to 89.7°C. Furthermore, nanofluids with 0.5% Al_2O_3 concentrationcould lower the temperature from 130°C to 87°C. Meanwhile, for nanofluids with 1% Al_2O_3 concentration, the temperature drop was quite high, from 130°C to 80°C. The simulation results showed that each concentration had a heat transfer rate varied according to the outlet temperature, as given in Figure 6. The rate of heat transfer is strongly influenced by the concentration of nanofluids.

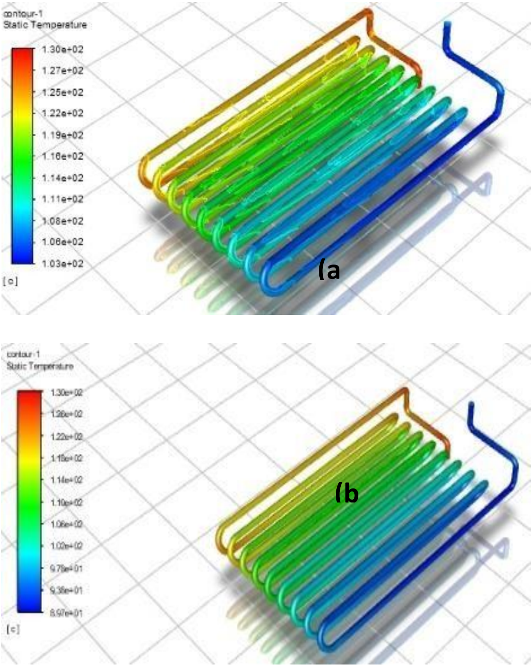

Figure 5. Contour of temperature along the radiator pipe for concentration of: (a) 0% (water);(b) 0.3%; (c) 0.5%; and (d) 1%

The result showed that the optimum outlet temperature of 80°C was obtained at a concentration of 1% with a temperature reduction of about 38.5%. This result is very close to the generally recommended working conditions. The change of temperature is inseparable from the thermophysical properties of nanofluid at various concentration. The results of the calculations prove that the greater the thermal conductivity of nanofluid, the more it can lower the outlet temperature. The increase in concentration is also accompanied by an increase in density, viscosity, thermal conductivity and convective heat transfer coefficient. However, the specific heat will decrease as the nanofluid concentration increases.

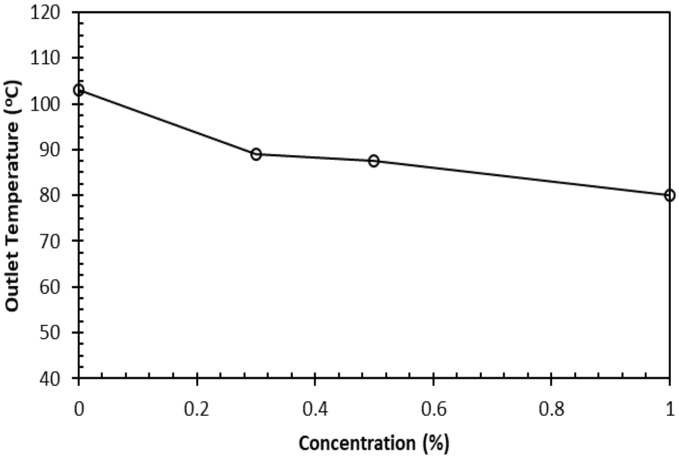

Figure 7. Effect of concentration of nanofluids on the outlet temperature

4. CONCLUSIONS

The use of nanofluid from a mixture of Al2O3 with water as a radiator coolant has been investigated through simulation studies by using computational fluid dynamics method. This study shows the effect of nanoparticle concentration on the rate of heat transfer and the outlet temperature of the working fluid from the radiator. Under the same conditions of velocity and inlet temperature of the working fluid, increasing the concentration of nanoparticles accelerates the rate of heat transfer released to the environment. As a consequence, the temperature of the working fluid decreased along the radiator pipe.

This is mainly due to the better thermal conductivity of the nanofluids compared to the base fluid of water. It was found that 1% of Al2O3 in the nanofluid was able to reduce the coolant outlet temperature close to the generally recommended working conditions.

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