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Analytical and Experimental Study of Nano Particles Effect in Engine Cooling System

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Abstract:** Water is the conventional coolant in the IC engine cooling system. The most recent developments in nanotechnology have led to improvements in the original uses of Nanoparticles in car engine cooling systems. In this study, Nano fluids formed by using kinds of nanoparticles Al_2O_3 and TiO_2 were added to the four-stroke internal combustion engine radiator and compared with the conventional coolant (pure water). The purpose of adding these nanoparticles to base fluid is to improve thermal conductivity of the coolant. First base water is used as coolant and simulation is carried out. Then Al_2O_3 and TiO_2 nanoparticles had added in base fluid as coolant and CFD fluent simulation is carried out. The result shows that Nanoparticles of 2% Al_2O_3 is 15.04% enhancement of heat transfer than base fluid and 4% Al_2O_3 increases heat transfer rate to 21.28% while 2% of TiO_2 is 14.28%enhancement of heat transfer compared to base fluid and 4% TiO2 increases the rate of heat transfer to 18.69%. Al_2O_3 Nanoparticles shows better result than TiO_2 and concentration of nanoparticles has a positive effect on the heat transfer rate of the cooling system. The experimental investigation on stability Nanoparticles dispersion through visualization and UV. visible spectroscopy absorbance measurement is carried out on Al_2O_3 Nano fluid prepared by pH modification and pH~7.5 is relatively more stable. Experiments are performed with pure water and Nanoparticles in coolant separately and results showed that 0.02 concentration of Nanoparticles enhances heat transfer rate by 17.5%. Increases the concentration of nanoparticles and flowrate leads to increases heat transfer rate which leads to improved radiator performance.

***Keywords:** Cooling System, Heat Transfer Enhancement, Nanoparticles, Base Fluid, Metal Oxides.*

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1. INTRODUCTION

The primary goal of an engine's cooling system is to remove excess heat from the engine while maintaining the operating temperature. The temperature in the engine cylinder's combustion chamber rises to 1500–2000 °C. These temperatures are higher than the melting point of the materials used to make the engine's cylinder block and head. As a result, if the high temperatures generated by combustion gases are not evacuated, significant cylinder deformations will occur. Heat transfer enhancement using TiO_2 and Al_2O_3 Nanoparticles dispersed in clean water is provided in this paper to improve vehicle radiator heat transfer.
According to numerous researches, the exact mechanism of improved heat transmission for Nanofluid is yet unknown**.** Nanoparticles provide a number of obstacles that must be discovered and overcome before they can be used in automobile radiators. Nanoparticles' stability and production costs are major roadblocks to their commercialization. Nanoparticles are projected to have a significant influence as a coolant in heat exchanging devices if these problems are overcome(Bhogare and Kothawale 2013).(Choudhary et al. 2017) gives an investigation of the Al_2O_3 /water Nano fluid's stability. The zeta potential and visual inspection methods are used to investigate the stability. The effects of pH and sonication period on Nano fluid stability are investigated in depth. Past researchers' experimental and numerical analyses, as well as the amount of nanoparticles they recommended for maximum performance in automobile engine cooling systems. Finally, when compared to the original coolant, the heat transfer coefficient can be improved by up to 50%;(Sidiki et al., 2015)
Experimental and numerical analyses, as well as the amount of nanoparticles they recommended for maximum performance in automobile engine cooling systems. Finally, based on the information gathered, findings and important summaries were presented. They found that the percentage increment of the average heat transfer coefficient over the base fluid for 3 vol.% Al_2O_3 Nanoparticle was 36.6% and for 3 vol.% CuO Nanoparticle was 49.7%.(Sidik et al. 2015)
Five distinct concentrations of Al2O3 nanoparticles in the range of 0–1.0 vol. percent were formed when the nanoparticles were added to water. In an automobile radiator, the test fluid passes through 33 vertical tubes with elliptical cross sections, and air moves at a steady speed to provide a cross flow inside the tube bank. A fully turbulent regime has been achieved by varying the test fluid flow rate between 3 and 8 LPM. The obtained results show that heat transfer performance can be enhanced by increasing the fluid circulating rate. When compared to pure water, the use of low-concentration nanoparticles can increase heat transfer efficiency by 40–45%(Chavan and Pise 2013).

Because of the strong van der Waals interactions between nanoparticles, preparing a homogenous suspension remains a technological problem. Physical or chemical treatments, such as the addition of surfactant, surface modification of suspended particles, or placing significant force on suspended particle clusters, have all been used to create stable Nano fluid(Saidur, Leong, and Mohammed 2011). CATIA modeling software is used to create a radiator model, which is then meshed using GAMBIT pre-processing software. Using a Computational Fluid Dynamics (CFD)

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environment program, three volumes are created: coolant, radiator, and air, and overall pressure, temperature, and velocity distribution of coolant and air are studied and reported. According to the data, the rate of heat transfer is It performs better when Nano fluid (Al_2O_3/ Water) is used as a coolant. When using water as a coolant, the temperature drops from 373 to 356°C, or 17°C, and when using Nano fluid as a coolant, the temperature drops from 373 to 353°C, or 20°C. As a result, it has been demonstrated that Nano fluid heat transfer is superior to water as a radiator coolant. (Chintakayala and Rajamanickam 2013a)
For single and two-phase approaches, the current numerical work used computational fluid dynamics (CFD) to simulate turbulent and laminar flow heat transfer in Nanofluid (Al_2O_3 particles in water and ethylene glycol-based fluid) moving through a flat tube in 3D. The benefits of using pure base fluids were weighed. Empirical correlations were used to calculate Nano fluid viscosity and thermal conductivity as a function of the volumetric concentration of nanoparticles. The Nusselt numbers of pure water and pure ethylene glycol in flat tubes were first compared to the experimental results(Delavari and Hashemabadi 2014).
(Rabby et al. 2019) This research presented a computational study of laminar convective heat transfer in the developed zone of an aluminum oxide (Al_2O_3)-water Nano fluid over two parallel plates. The mass and momentum equations, as well as the second order single phase energy equation, are solved using the ANSYS FLUENT 16 program. For both water and Al_2O_3-H2O Nano fluid, the Nusselt number and heat transfer coefficient increase linearly as the Reynolds number increases in the developed zone, whereas the friction factor reduces linearly. Aluminum oxide (Al_2O_3) is a The flow of fluid in fixed and helical pipe radiators with rising rates of heat transfer and variable mass flow rates has been examined using computational fluid dynamics (CFD). The heat transfer rate of each design is calculated. For each design, aluminum oxide, air, and water are used as coolants at 2.8 and 1.5 kg/s mass flow rates. The purpose of this study is to develop a good model for increasing heat transfer at a specific coolant temperature. (Abhilash, Raghupathi, and Kumar 2020)
(Mia and Hossen 2019) presents a CFD analysis of a radiator tube with fin. ANSYS FLUENT 16.0 was used for this investigation. Computational Fluid Dynamics is used to investigate the flow properties in radiator tubes (CFD). Varied temperature and velocity contours for different Reynolds numbers with fixed volume fractions of Nanoparticles and for varying volume fractions of Nanoparticles with fixed Reynolds numbers are investigated in this work. As the Reynolds number and volume fraction increase, the temperature differential between the intake and outflow increases. (Aized and Hassaan 2019) A horizontal flat tube radiator is filled with four different
The great challenges in using Nano particles is stability problem because of Vander force in molecules which causes dissipation in solution of fluid. A combination of control of pH with minimum quantity surfactants can achieve stability of nanoparticles. So, the aim of this paper is to investigate the numerical and experimental analysis of stable TiO_2 and Al_2O_3 nanoparticles effect in cooling car radiator to enhance better heat transfer. The stability assessment of nanoparticles is accomplished through sedimentation photograph of different concentration and pH modification method.

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2. MATERIALS AND METHODS

Modeling of the Honda Civic horizontal type of car radiator will be done by solid work software and imported to ANSYS software to study temperature change, then analysis of thermal conductivity in the case of base fluid and Nano particles in the base fluid. Experimentally, Nano particles of Al2O3 and TiO2 are used to prepare Nano fluid to add to the base fluid in order to analyze the effect of Nano particles on the engine cooling system.

2.1 Thermal Conductivity

Maxwell (1881) was the first to calculate the electrical conductivity of a stationary mixture of two materials with different electrical conductivities. His final expression for a mixture of spheres, with thermal conductivity kp, in a matrix applied to the case of a stationary fluid of lower conductivity, kb, may be written as follows:

$$K_m = K_b \{1 + \frac{3(K_p - K_b)\varphi}{(K_p + 2K_b) - (K_p - K_b)\varphi}\} \quad (1)$$

Table 2-1 physical properties of base fluid and solid nanoparticles at normal tempreture(Aized and Hassaan 2019)

Materials	Physical properties			
	Specific Heat capacity $(J/kg.K)$	Density (kg/m^3)	Thermal conductivity $(W/m.K)$	Viscosity (kg/mK)
Base fluid (H_2O)	4182	998	0.6	0.001003
Aluminum oxide(Al_2O_3)	765	3980	38.5	-
Titanium oxide (TiO_2)	700	4150	8.4	-

2.2 Heat Flow Rate Equation

Heat flow rate is based on mass flow rate and temperature difference as Nano fluid used as a coolant. Mass flow rate is the function of density of the fluid and volume flow rate.

$$\dot{m}_m = \rho_m \times \dot{V} \quad (2)$$

Where, $\dot{m}_m$ is mass flow rate of fluid (kg/s), ρ_m is density of Nano fluid which is calculated based on equation (18) above and $\dot{V}$ is volume flow rate used for this simulation 3LPM. The heat transfers for radiator based on mass flow rate can be calculated as:

$$\dot{Q} = \dot{m}_m \times Cp_m \times (T_{in} - T_{out}) \quad (3)$$

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Where, Cp_m is the specific heat of mixture and Tin is initial temperature inlet to radiator and $Tout$ is radiator outlet temperature.

2.3 CFD Fluent Algorithm Diagram

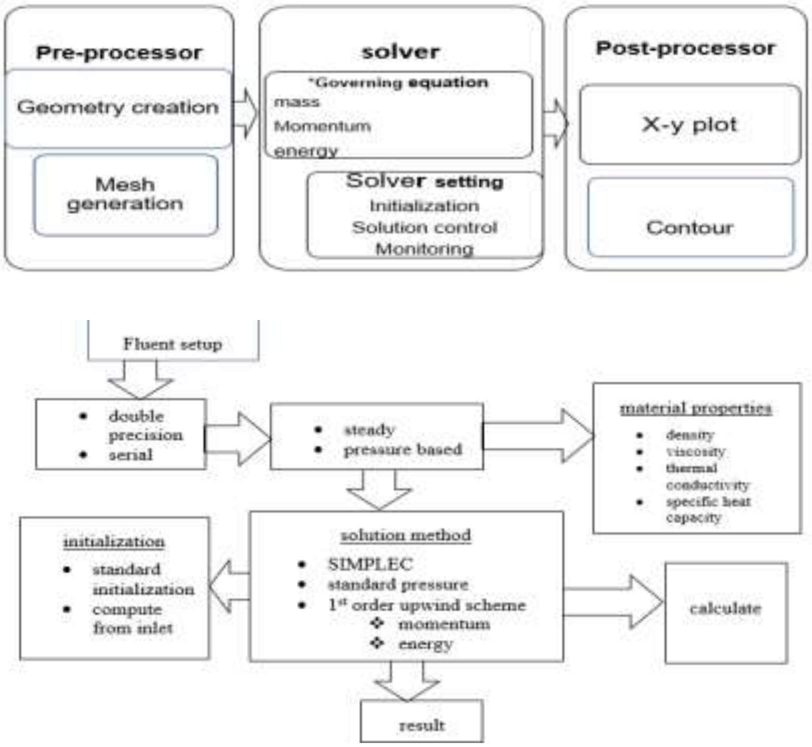

Diagram 2-1 CFD fluent and fluent setup algorithm diagram

2.4 Preparation of Nano fluid

There are mainly two techniques used to fabricate Nano fluid, namely, the bottom-up approach known as the one-step method and the top-down approach identified as the two-step method. Nevertheless, the drawback of employing the one-step method is the existence of contaminants that are challenging to remove. In contrast to the one-step method, the two-step method is more frequently employed to create Nano fluid since it has a cheaper processing cost and a large range of commercially available nanoparticles from several suppliers. This method involves creating or acquiring nanoparticles as a dry powder first, which is subsequently dissolved in the base fluid. For this thesis Nano particle of Al2O3 powder is purchased and fluid solution is prepared under two step method.

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Figure 2.1 aluminum oxide nanoparticles powder

Preparation of homogeneous suspension remains a technical challenge since the nanoparticles always form aggregates due to very strong Vander Waals interactions. To get stable Nano fluid, physical or chemical treatment have been conducted such as an addition of surfactant, surface modification, pH modification and ultra-sonication method. A combination of two or all these methods can be used to achieve stability. In this work, addition of surfactants and pH modification methods are used to prepare stable Nano fluid solution.

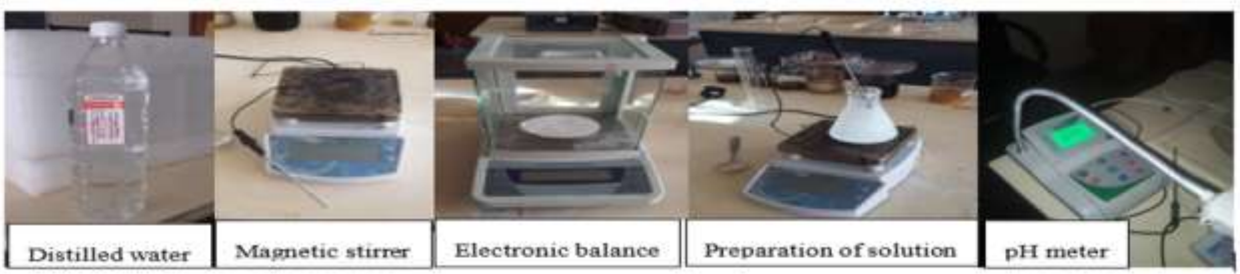

Figure 2.2 materials used for preparation of Nano fluid

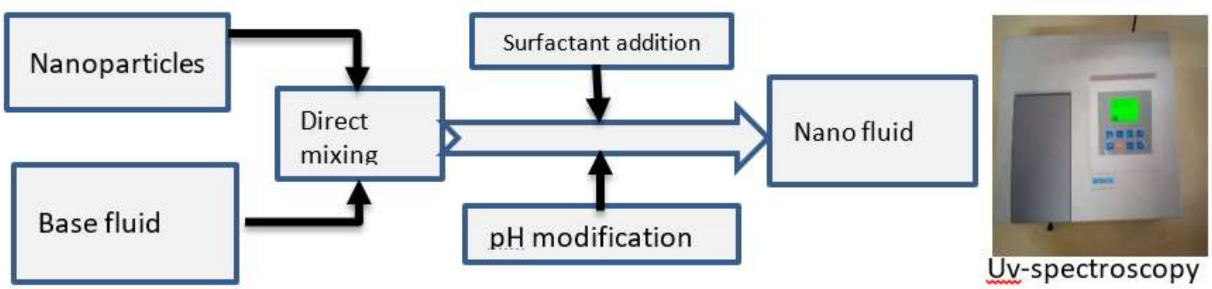

Figure 2.3 Two step-process preparation method of Nano fluid and apparatus

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3. MODELING AND EXPERIMENTAL SETUP

3.1 Modeling with Mesh generation

On Figure 0.1below, for the Radiator model, a mesh had been generated with 1963196 nodes and 1409338 elements. The mesh is structured type of mesh which is important because of its higher resolution and better convergence. This mesh was generated up body sizing. In order to simulate and work with low speed computers, the numbers of pipe in Honda civic passenger car's radiator are reduced from 72 pipes to 9 pipes which is carried out in the next mesh generation and fluent solver simulation.

The quality of mesh is a collective summary of quality of individual elements. Aspect ratio, skewness, orthogonality, determinant and Jacobian are some of the methods used to designate the quality of elements. One of the key quality metrics for mesh used in CFD simulations is skewness. A good rule of thumb is that the maximum skewness for tetrahedral cells should be less than 0.95.

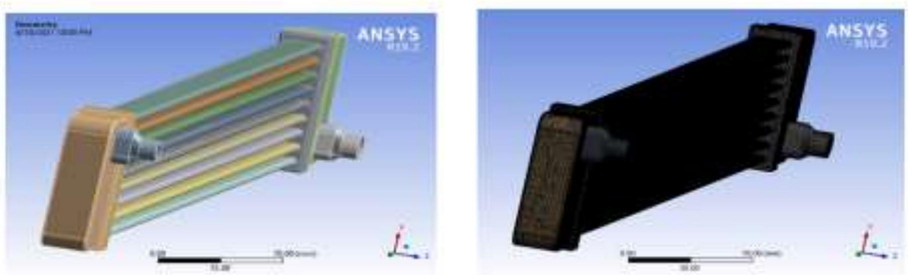

Figure 0.1 model and mesh of pipe reduced radiator

3.1.1 Boundary Condition

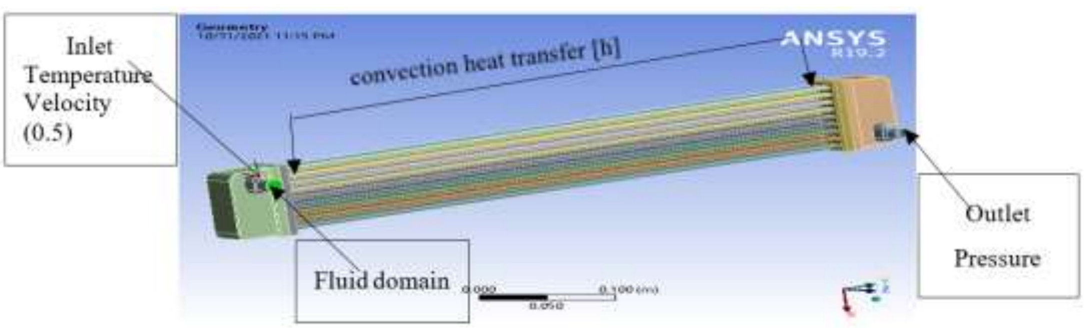

Figure 0.2 boundary condition of fluid domains for radiator model

The mesh consists of water flow domains. For the first simulation, the water domain was simulated using pure water and single-phase flow model. Then for the Nano fluids simulation, single-phase mixture model was again used in different concentration of Nano particles. The Nano fluid was considered as a homogeneous solution of nanoparticles and base liquid, which was the water.

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(Aized and Hassaan 2019) predict the homogenous behavior of Nano fluid. Different nanoparticles were added in the fluid to get the combination of Nano fluids. The velocity for working fluid inside to the inlet hose is 0.5 m/s and inside velocity of tube will be 0.055 m/s, and the temperature was defined as [343K, 358K, 370 K]. On the airside, the temperature at the inlet was selected as 300 K. Solution was let to run 500 iteration and was converged to 10^{-4} figure 4.5 shows that the plots of residuals with a number of iteration.

3.2 Experimental Set Up

The schematic diagram of an experimental setup is shown in Figure 0.3. The heat transfer coefficient of the car radiator has been measured by this setup. This experimental setup includes a car radiator, a fan, a combustion engine; 3 thermocouples for temperature measurement. A radiator consists of 18 horizontal tubes with a semicircular cross-section with a diameter of 5 mm and a 15mm depth of the rectangular area. Two thermocouples have been fixed on the flow line for determining inlet and outlet fluid temperatures. Two thermocouples have been fixed to the radiator surface to assure wall temperature. The speed of a fan was kept constant throughout the experiments. Tachometer used to measure the rpm of the engine and keeps constant to 1200rpm to see the effect of concentration and vary to see the effect of flowrate from [500-1100] rpm and calculate the volume flow rate based on the equation of (Lazim et al., 2016) which is $\dot{V} = 1e^{-7} * N$ is a linear equation of flowrate based on engine speed. Experimental set up description

1, thermocouple 2, surface temperatures switch(T1---T6) 3 coolant reservoir 4, radiator 5, engine 6, power supply for thermocouples 7, radiator upper hose 8, radiator lower hose 9, cooling fan 10, nanofluid 11, tachometer

Figure 0.3 Experimental set up of engine radiator Nano fluid cooling system

Table 0-2 Engine specification used in experiment

Engine type------------------I-4	**Engine model------------------VSG-413**
Net weight------------------108kg	Fuel type---------------gasoline

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Power @3000rpm--------38hp	Gross Torque @3000rpm------347Nm

4. RESULT AND DISCUSSION

4.1 Numerical results and discussion

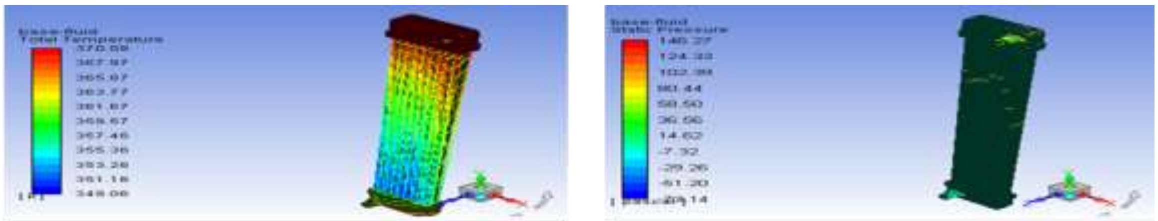
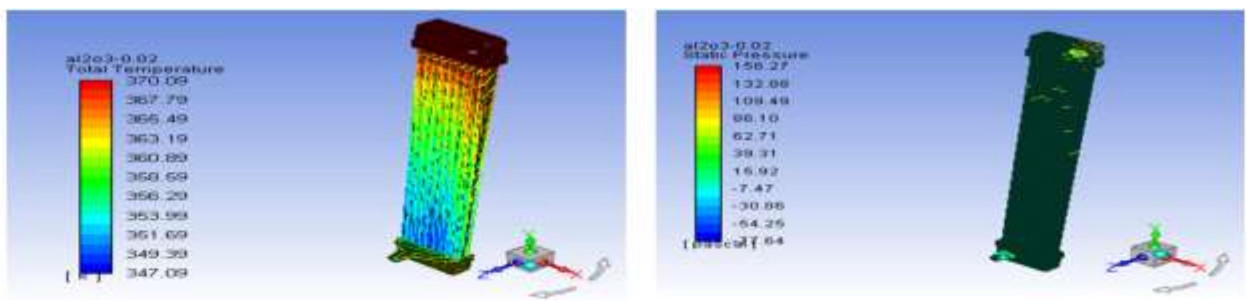
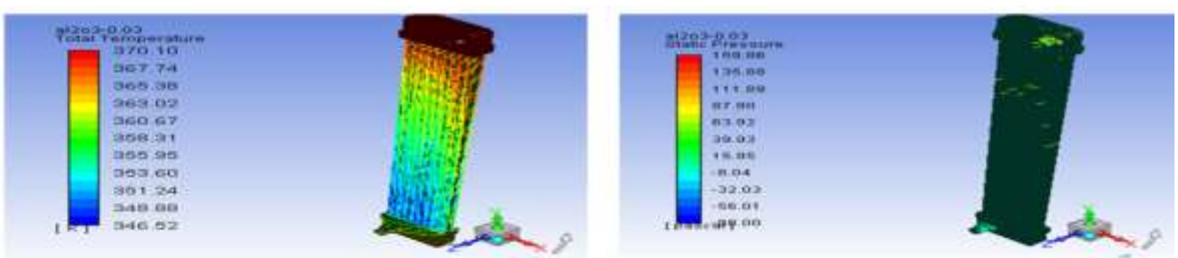


Figure 4.1 temperature and pressure contour plot of Phi=0 % base fluid

In the following plots, different concentration of Nanoparticles effect's result was shown in terms of temperature outlet and pressure drop for Al_2O_3 and TiO_2Nanoparticles



(**a**) Phi = 2% Al_2O_3



(**b**) Phi = 3% Al_2O_3

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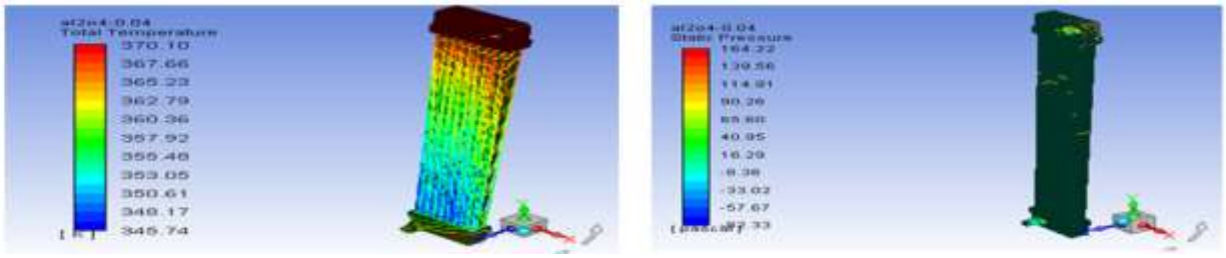

(c) Phi = 4% Al_2O_3

Figure 4.2 Temperature and pressure contour plot of (a) 0.02 Al_2O_3, (b) 0.03 Al_2O_3, and (c) 0.04 Al_2O_3 respectively.

4.1.1 Temperature Change Based on Concentration

The simulation results obtained from Figure 4.2 above show reasonable variation in the temperature as expected. A drop in temperature of the coolant (Nanoparticles) from 370K to 347.09K for 0.02 concentration of aluminum oxide and 347.21 for titanium oxide. The results indicate the temperature drops across the tube length also increase as concentration increases. As temperature drops from 370K to 345.74K for 0.04 concentration of Al_2O_3, the same effect is seen from titanium oxides Nanoparticles result as temperature drops from 370K to 346.21K.
Where the drop in temperature with water as a coolant is from 370 to 349.06 i.e., 20.94 °C, and with Nano fluid as coolant, it is 370 to 347.09 K for 2%Al_2O_3 and 370 K to 347.21 K for 2% TiO_2 i.e., 22.91 K for Al_2O_3 and 22.79K for TiO_2. So by this, it has been shown that heat transfer of Nanoparticles is better than that of water as coolant in the radiator. The following table shows that the effect of concentration on temperature drops and result validation based on previous work with graphical comparison.

Table 4-1Tempereture result Validation at phi=0.02 for Al_2O_3 and TiO_2 with base fluid

Fluid	**Temperature change (K)**		**Numerical**		**Numerical**		
	Present simulation		(Aized and Hassaan 2019)		(Chintakayala and Rajamanickam 2013b)		deviation
	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	(%)
Base fluid	370	349.06	370	-	373	356	1.12
0.02 $Al2O3$	370	347.090	370	352	373	353	1.39,0.83
0.02 $TiO2$	370	347.21	370	353			1.64

Graphical representation of value validation comparing to privies work as temperature drops across the length of pipes

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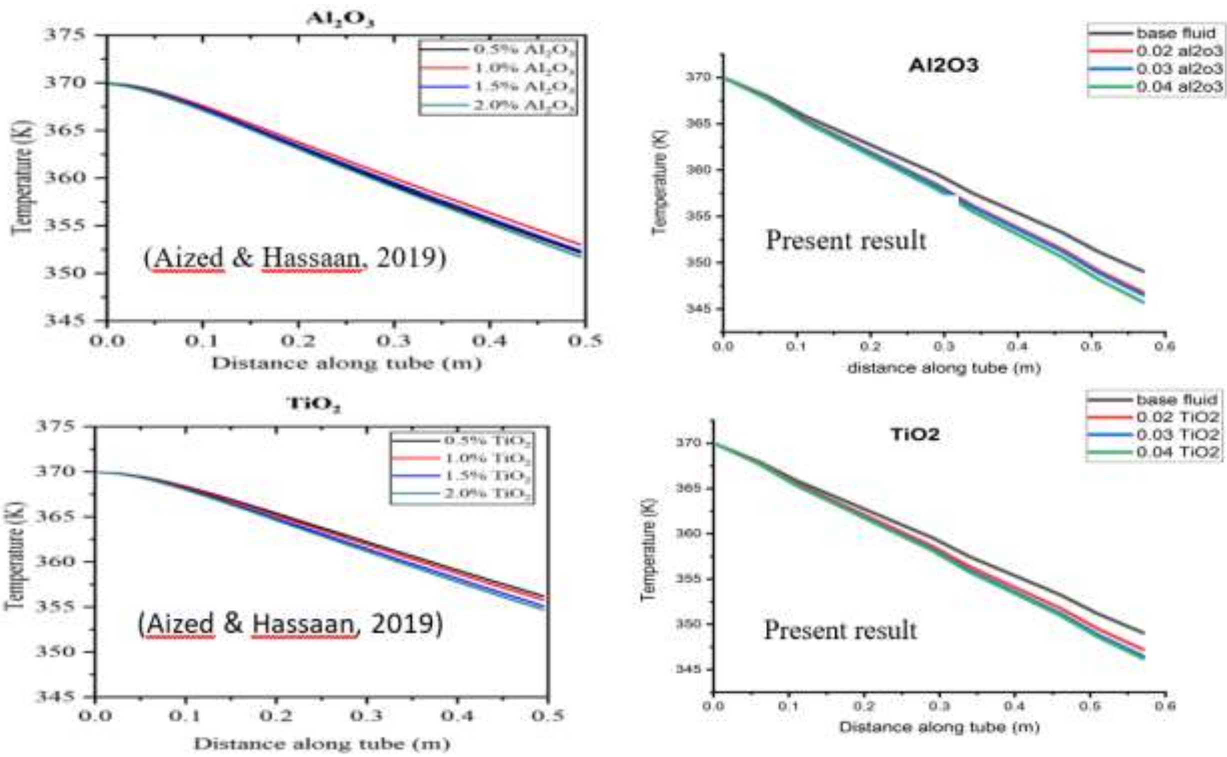

Figure 4.3 graphical representation of Nano fluid effect on temperature drops across pipe length

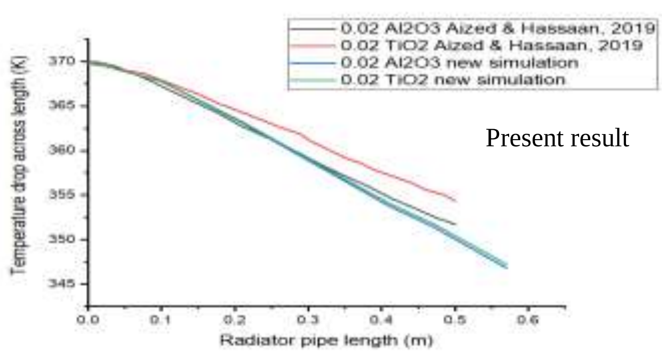

Figure 4.4 comparison of temperature drop across tube length with privies work

4.1.2 Heat Flow Rate Enhancement (W)

Based on simulation results and mass flow rate of the Nanoparticles, heat transfer in Nanoparticles equation (15) is better than that of normal coolant base water due to density and mass flow rate increase with Nanoparticles and temperature difference is also increasing. As observed from the result aluminum oxide Nanoparticles experiences better heat transfer rate enhancement. Based on equation (15);

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Heat transfer rate, base fluid $(Q) = 0.06 * 4191 * (370 - 349.06) = 5265 * 9/72 = 658w$ per 9 pipes.

Table 4-2 mass flowrate and heat flow rate based on volume concentration of Nano fluid

Base fluid and Nano fluid	**Mass flow rate (kg/s)**		**Heat flow rate (W)**				
			Present result		**(Aized and Hassaan 2019)**		
Base fluid (0%)	0.06		658		572.7		deviation
concentration (%)	Al_2O_3	TiO_2	Al_2O_3	TiO_2	Al_2O_3	TiO_2	percentage
2 3 4	0.0675 0.0695 0.0715	0.0677 0.0698 0.0719	757 774 798	752 773.7 781	648.8	619.8	8%TiO_2 13.8%for Al_2O_3
% improved at 2% concentration			15.04%	14.28	13.28	8.22	
deviation from privies improvement			1.76%	6.06%			

Based on the above simulation result as temperature is varying from 343k to 370k, it is observed that the temperature change is increases. This enhances rate of heat transfer and improves the radiator performance. Table 4.5 filled based on previous thermos physical properties equation at corresponding temperatures.

Table 4-3 Effect of varying inlet temperature with 0.02 nanoparticles and 3[LPM] flowrate

Fluid	Tin [K]	Tout [K]	ΔT [K]	ρ_m kg/m^3	K_m $w/m.k$	Cp_m $(J/Kg.K)$	Δp [pa]	Q watt	% increases of Q by T°C change
Base fluid	343	330	13	977.5	0.672	4195	189	2665	
	358	340.37	17.3	972	0.692	4203	186	3601	
	370	349.06	20.9	960	0.71	4209	219	5264	
0.02 Al2O3/water	343	328.9	14	1038	0.711	3930	197	2861	7.35
	358	339.02	18.9	1032	0.733	3938	197	3887	7.9
	370	347.09	22.9	1021.3	0.75	3916	234	6056	15.04
0.02 TiO2/water	343	328.8	14.2	1041	0.704	3916	198.3	2851	6.98
	358	338.86	19	1036	0.73	3921	198.3	3874	7.58
	370	347.21	22.8	1024.7	0.744	3900	234	6016	14.28

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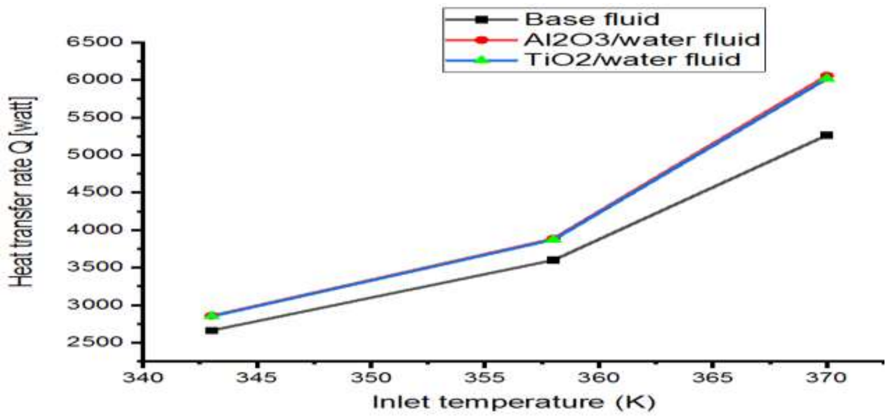

Figure 4.5 Rate of heat transfer rate at different inlet temperature

As seen from Figure 4.5, increases inlet temperature also increases the rate of heat transfer. This is because of thermal conductivity increases with increasing temperature. Temperature difference also increases as inlet temperature increases. Thus, inlet temperature enhances heat transfer and convective heat transfer as thermal conductivity increases.

4.2 Experimental Result Discussion

4.2.1 Stability Evaluation Techniques

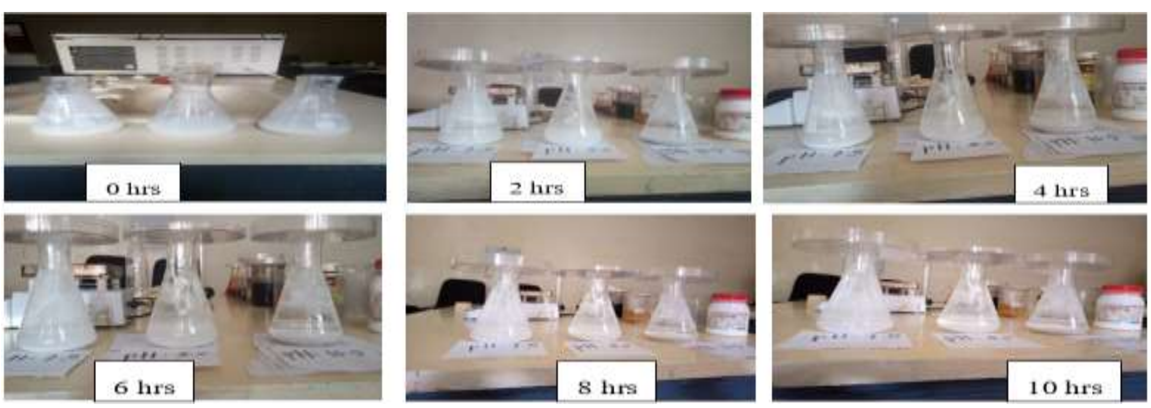

Figure 4.6 Observation for stability checking at different times

Stability or the repulsive force to the settlement of nanoparticles in suspension has dominant effects on the attributes of nanoparticles. This study conducts visual observation for 10 hrs for stability analysis of Al_2O_3 nanoparticles as seen from Figure 4.6. Visual inspection is also followed in previous investigations. Besides, absorbance value is found through Uv-vis spectral analysis for specifying the stability condition of nanoparticles. The UV-vis spectrophotometer analysis method is also used by other researchers. (Faraji, Poursalehi, and Aliofkhazraei 2015).

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The alumina suspensions at pH~ 7.5 showed a good dispersion of nanoparticles and the dispersion was maintained for a long period, which was attributed to the higher charge on the surface of Nano-particles. Therefore, the suspension at pH~ [7.5 - 9.5] was more stable compared to others which are far from this pH value. This result is in good agreement with zeta potential and absorbency testing. As seen from Figure 2.3, Al_2O_3 Nanoparticles are prepared by the same concentration at different values of pH which is 7.5, 8.5, and 11.5 for checking stability. Visual inspection shows that a solution with pH 8.5 seems stable. Spectral absorption is another efficient and effective technique used to analyze the stability of the suspension. Nanoparticles absorbency of incident light can be measure UV- vis spectroscopy. The absorption determines the number of particles suspended. Consequently, higher absorbency brings about stable nanoparticles.(Umar et al. 2018). As Uv.vis spectroscopy result, absorbance recorded as 0.33, 0.206 and 0.194 for pH 7.5, 8.5 and 11.5 respectively. So, the solution with pH 7.5 is more stable.

4.2.2 Experimental Calculation Based On Volume Flowrate

Table 4-4 Experimental result table for 0.02 concentration Nano particle at different engine speed

Engine speed (rpm)	ΔT ℃	$T_{s-}T_{\infty}$ ℃	Flowrate (LPM)	ρ_m $\frac{Kg}{m^3}$	$\dot{m}_m$ $\frac{kg}{s}$	Cp_m $\frac{Kj}{Kg.K}$	K_m $\frac{W}{m.K}$	$\dot{Q}$ watt	h_{exp} $\frac{w}{m^2.k}$	Nu
500	18	22	3	1038	0.052	3.932	0.709	3680	531	6.2
700	18	25.6	4.2	1034	0.072	3.934	0.719	5098	632	7.28
900	19	32	5.4	1030	0.093	3.937	0.730	6957	690	7.83
1100	19.3	35	6.6	1027	0.113	3.940	0.736	8593	779	8.77

Table 4-4above shows that the volume flow rate of coolant is linearly proportional to engine speed and heat transfer, heat transfer coefficient and nusselt number are varied with the engine rpm due to volume flowrate is varied.

Table 4-5 volume flowrate effect on different concentration nanoparticles

Volume flowrate (LPM)	Fluid	Heat transfer(w)	$h[\frac{w}{m^2k}]$	Nu
3	Base fluid	3131	452	5.57
	0.01 Al_2O_3/water	3423	504	6.09
	0.02 Al_2O_3/water	3680	531	6.2
4.2	Base fluid	4337	538	6.54
	0.01 Al_2O_3/water	4742	600	7.15
	0.02 Al_2O_3/water	5098	632	7.28
5.4	Base fluid	5919	586	7.03
	0.01 Al_2O_3/water	6472	654	7.69

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	0.02 Al_2O_3/water	6957	690	7.83
6.6	Base fluid	7311	663	7.88
	0.01 Al_2O_3/water	7994	739	8.62
	0.02 Al_2O_3/water	8593	779	8.77
7.2	Base fluid	8308	851	10.24
	0.01 Al_2O_3/water	9084	949	11.2
	0.02 Al_2O_3/water	9765	1000	11.4

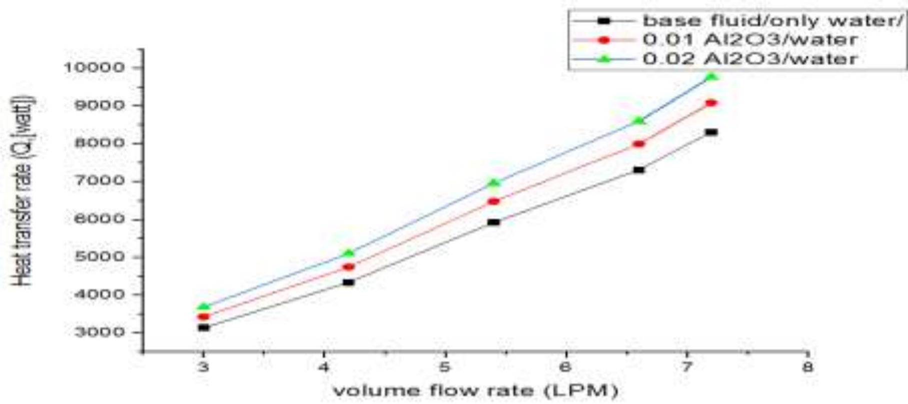

Figure 4.7 Heat transfer rate based on volume flowrate for different concentration nanoparticles

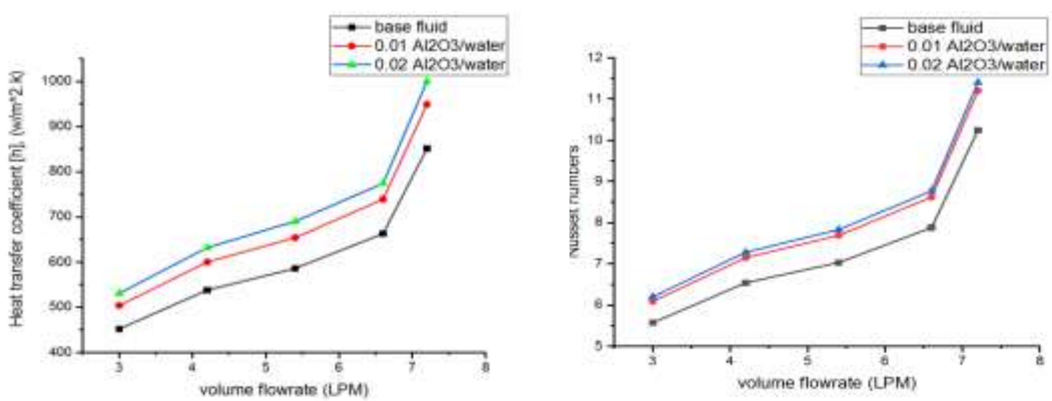

Figure 4.8 Nusselt number based on volume flowrate for different concentration nanoparticles

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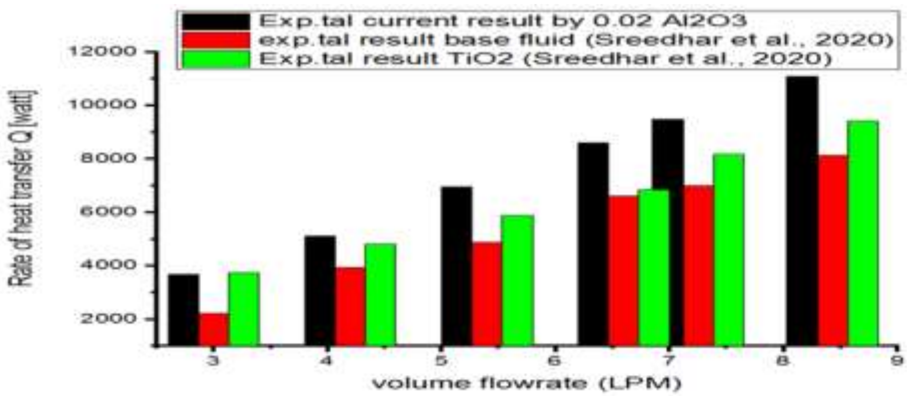

Figure 4.9 comparison of exp.tal result heat transfer with (Sreedhar, Rao, and Suresh 2020) at different

Figure 4.7 shows that volume flow rate and concentration of nanoparticles have positive influences on heat transfer rate which agrees with the results from the simulation result. As the volume flow rate increases, the rate of heat transfer also increases since the mass flow rate and density of the fluid is increase. The same is true for concentration increases in the sense the thermal conductivity is increased which leads to enhancing the rate of heat transfer. Figure 4.8 is another study of heat transfer coefficient and nusselt number under the effect of volume flow rate and the concentration of the nanoparticles. As seen from this figure volume flowrate affects the nusselt number essentially while the concentration of the nanoparticles slightly affects nusselt number. For the same volume flowrate, the heat transfer coefficient and heat transfer rate are maximum than base fluid coolant when small amount of nanoparticles added to the base fluid. These justification is improving that nanoparticles added in base fluid enhances rate of heat transfer. Figure 4.9 shows that comparison of new experimental with privies experimental work. The result shows some deviation from privies work is duo to geometrical differences and the current work is Al_2O_3 while privios work used TiO_2 nanoparticles.

5. CONCLUSION

The flow properties and heat transport of an automobile radiator tube were investigated using ANSYS FLUENT 19.2 and numerical computing. The research is carried out on different volume fractions of Nanoparticles and different types of Nano fluid. The data clearly illustrates that when the volume percent of Nanoparticles increases, the amount of heat transfer increases, and as a result, the output temperature decreases.

- As the concentration of nanoparticles increases from 0.02 concentration to 0.04 concentrations for Al_2O_3 Nanoparticles and TiO_2, the pipe's outlet temperature falls, enhancing heat transmission by increasing temperature differences between the outlet and output pipe.
- Based on ANSYS 19.2 CFD fluent simulation result, heat transfer under base fluid is 658 W and heat transfer 0.02 concentration of Al_2O_3 is 757 as seen from Table 4.3 above. According

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to this result, 15.04 % heat transfer is improved while 21.28% of heat transfer is improved when the concentration is raised to 0.04 which leads to having a heat transfer rate of 798W as seen from Table 4.3.

- From this, it is concluded that using Nanoparticles enhances heat transfer and it is possible to use a small radiator with Nanoparticles to minimize the frontal area of the vehicle to minimize aerodynamic resistance which intern improves the vehicle performance.
- Effect of the TiO_2 oxide nanoparticles on temperature outlet and heat transfer is showed that an increase the concentration of TiO_2 Nanoparticles is enhances the heat transfers as it drops the temperature outlet like that of Al_2O_3 nanoparticles.
- Based on ANSYS 19.2 CFD fluent simulation result, heat transfer under base fluid is 658 W and heat transfer 0.02 concentration of TiO_2 is 752 as seen from Table 4.3 above. According to this result, 14.28 % heat transfer is improved with 0.02 TiO_2 while 18.69% of heat transfer is improved when the concentration raised to 0.04 which leads to have heat transfer rate of 781 W as seen from Table 4.3
- From the above discussion, the same concentration of Al_2O_3 and TiO_2 leads to different temperature changes which enhance heat transfer at a different rate. From this simulation result, discussion Al_2O_3 Nanoparticles shows better heat transfer enhancement relative to the TiO_2 Nanoparticles.
- Experimental results are agreed with a numerical simulation which validates that increasing the concentration of Nanoparticles enhances heat transfer rate. using a 2% concentration of Nanoparticles enhanced the rate of heat transfer from 8308w to 9765W which is 17.5%.
- Volume flow rate is increased as engine rpm increases and which intern leads to increases heat transfer, heat transfer coefficient, and nusselt number.
- Stability analysis techniques using the addition of surfactants and pH modification shows that the solution with pH~7.5 is relatively more stable from the 24hrs observation and Uv.vis spectroscopy absorbance measurement results, as high absorbance is recorded 0.33 in pH 7.5 solution. high absorbance shows more stable.

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