A Numerical Study of AL_2O_3-TIO2 Hybrid Nanofluid on Radiator Performance

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Abstract. Fluid cooler on system cooler machine automotive generally use coolant with mixture ethylene $_2$ glycol minimum 30 percent. Moment This use Nanoparticles can mixed on fluid cooler base between fluid And nanoparticles that have characteristic physique thermal more Good from fluid cooler pure. This is simulating genre fluid and displacement hot on radiators with using a hybrid nanofluid as fluid cooler. This research uses numeric use device ANSYS FLUENT computational fluid dynamics (CFD) software. Simulation process held start from 3D fluid domain modeling, meshing creation, physical model setup process nor condition limit and processing output data results. This study shows the radiator outlet temperature (Tout) and coefficient displacement hot whole radiator fin (U). The Tout and U values will be validated with Tout values and U results presented test _ in form error percentage. Results from CFD simulation, the smallest error of outlet temperature CFD simulation to experiment is 0.37 percent at Tin 70 Celsius, mass concentration of 0.2 percent at 20 LPM discharge and the highest error is 2.96 percent at Tin 90 Celsius pure coolant without nanoparticles with a discharge of 28 LPM. Minimum error of overall heat transfer coefficient is -0.39 percent Tin 70 Celsius, mass concentration 0.25 percent at 20 LPM discharge and maximum error is -2.45 percent at Tin 90 Celsius, pure coolant without nanoparticles with a discharge of 28 LPM.

Keywords: Hybrid nanofluid, heat transfer coefficient, radiator, temperature, CFD.

1 Introduction

Modern automotive internal combustion engine produces so much heat. This heat created when mixture fuel and air lit are burned. Radiators are used for heat exchange between engine to environment and the coolant fluid in radiator role is important in determining performance of heat transfer from engine to environment. The term of nanofluid for the first time is proposed by Choi [1] refer to mixture between fluid and nanoparticles that have better thermal physical characteristic than pure coolant fluid or conventional coolant fluid with suspended particle. Addition nanoparticles to fluid

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cooler can raise value of heat transfer coefficient so that radiator performance is risin. Example nanoparticles used is Al 2 O 3 and TiO2. Zafar, et al [2] use Al2 O3 which gain results maximum enhancement coefficient from hot that is 24.21 % use Al2O3. It is strengthened by results study by Permana [3] get results indicated research convection heat transfer coeficient nanofluid experience enhancement by 31-48% for concentration of 1% and enhancement by 52-79% for concentration of 4% of fluid , Based on from second study the nanoparticles Al2O3 increases coefficient displacement hot , then on nano particle TiO2 too obtained results increasing temperature nanofluid in a manner No significant as described on study by K. Abdul Hamid et al [4]. Studies displacement hot on radiators with nanofluids can be analyzed with CFD simulation. S Anis, et al. [5] used the ANSYS Fluent software to analyze radiators with nanofluid Al 2 O 3. From research the addition nanofluid Al 2 O 3 boost displacement hot from radiators. Vinod M. Angadi [6] also do analysis numeric on type the same nanofluid with using the STARCCM+ software. The conclusions reached from study This show same result with research by S Anis [5].

On studies This simulation CFD done for analyze radiator performance with hybrid nanofluid coolant Al2O3 and TiO2 uses software ANSYS Fluent. Results from analysis cfd form outlet temperature and coefficient transfer hot on validation with results testing experiment. With known accuracy simulation to experiment, it will help researcher in designing radiators with fluid hybrid nanofluid with more fast, efficient and economical.

2 Methods

2.1 CFD Simulation

Process flow diagram below show procedure performed for carry out CFD simulation of the start of the process end of the simulation process. Sort order step processing done in accordance order on the flowchart (see Fig. 1).

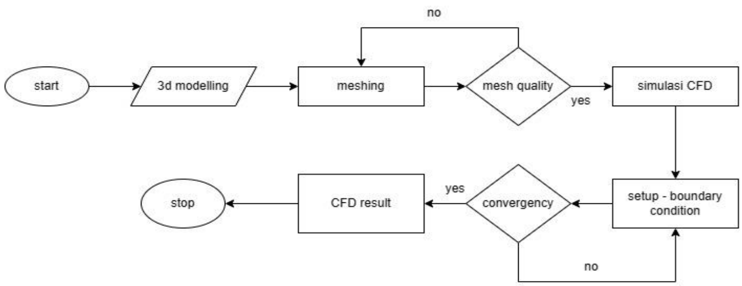

Fig. 1. Flowchart percent ANSYS Fluent CFD software simulation

2.2 Modeling Geometry

The 3-dimensional geometry model (Fig. 2) of the car radiator that will be investigated in this modeling is shown as shown below. The radiator used as a heat exchanger in this study is a car radiator with aluminum material. The type of radiator flow is cross flow using fins on the air side to increase the value of the convection coefficient. The radiator construction consists of an inlet manifold, outlet manifold, single row flat tube and corrugated fin.

Fig. 2. Radiator domain 3D model

2.3 Mesh Creation

Good quality mesh is very important when simulating CFD. The accuracy of the simulation results, the convergence of calculations and the duration of the simulation are determined by the quality of the mesh. Making the mesh is done using the automatic method (automatic method) contained in ANSYS. The mesh size is set constant at 0.001 m throughout the simulation domain area. The total number of mesh elements is 7.7 million. The entire simulation uses the same number of meshes. After the mesh is created (Fig. 3), the simulation boundary conditions such as inlets, outlets and walls are determined to be used when setting up ANSYS Fluent.

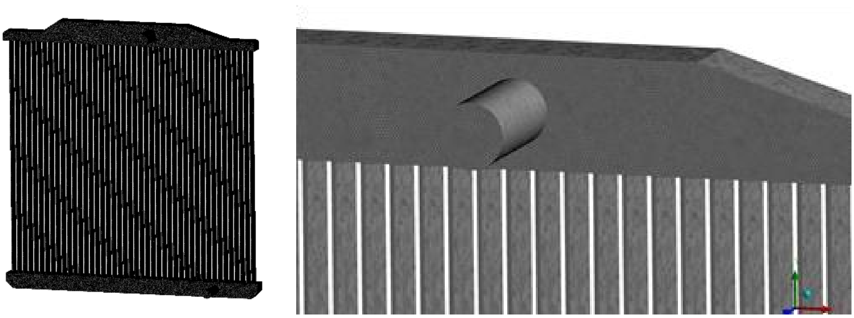

Fig. 3. Mesh of radiator domain

2.4 Settings Simulation

After the mesh is done made, next process is arrangement on CFD simulation in Fluent. The turbulence model used on simulation is standard k-epsilon with enhanced wall treatment. The fluid material used is a hybrid nanofluid Al 2 O 3 -TiO 2 where properties its thermophysical counted use equation:

1. Density Hybrid - Nanofluids

$$\rho_{nf} = \varphi \times \left(\frac{\rho_{p1} + \rho_{p2}}{2}\right) + (1 - \varphi)\rho_b$$

2. Viscosity Nanofluids Hybrid - Nanofluids

$$\mu_{nf} = \mu_f(1 + 7{,}3 \times \varphi + 123 \times \varphi^2)$$

3. Heat Specific Hybrid - Nanofluids

$$(\rho Cp)_{nf} = (1 - \varphi)(\rho Cp)_b + \varphi\left(\frac{(\rho Cp)_{p1} + (\rho Cp)_{p2}}{2}\right)$$

Condition limit at the inlet is speed axial uniform and the temperature at the radiator inlet according to the incoming discharge like results testing. On outlets using condition limit pressure static atmospheric relative pressure. On tube wall which is the transfer area hot between fluid cooling, wear condition limit total heat released to acquired environment from results experiment

3 Result and Discussion

From the CFD simulation you can is known outlet temperature value of each parameter. Result outlet temperature value simulation and experiment plotted on graph Fig. 4, so both of them can compared. From pictures chart, we can compare in a manner qualitative the resulting outlet temperature value simulation and experiment, where pattern tendency chart results simulation similar with pattern from chart result experiment. At the inlet temperature of 70 °C, 80 °C and 90 °C decrease Lowest on concentration mass 0.25 % at 20 LPM discharge at Tin 80°C.

From the chart on our Fig. 4 can compare in a manner qualitative the resulting outlet temperature value simulation and experiment, where pattern tendency chart results simulation similar with pattern from chart result experiment. At the inlet temperature of 70 °C, 80 °C and 90 °C.

Table 1 is a table of outlet temperature error values from simulations and experiments. The maximum error value is 2.7% at 20 lpm discharge and Tin 90 °C for coolant without hybrid-nanofluid, while the smallest error value is 0.3% at 20 lpm discharge. Tin 70oC at 0.25 % hybrid-nanofluid concentration.

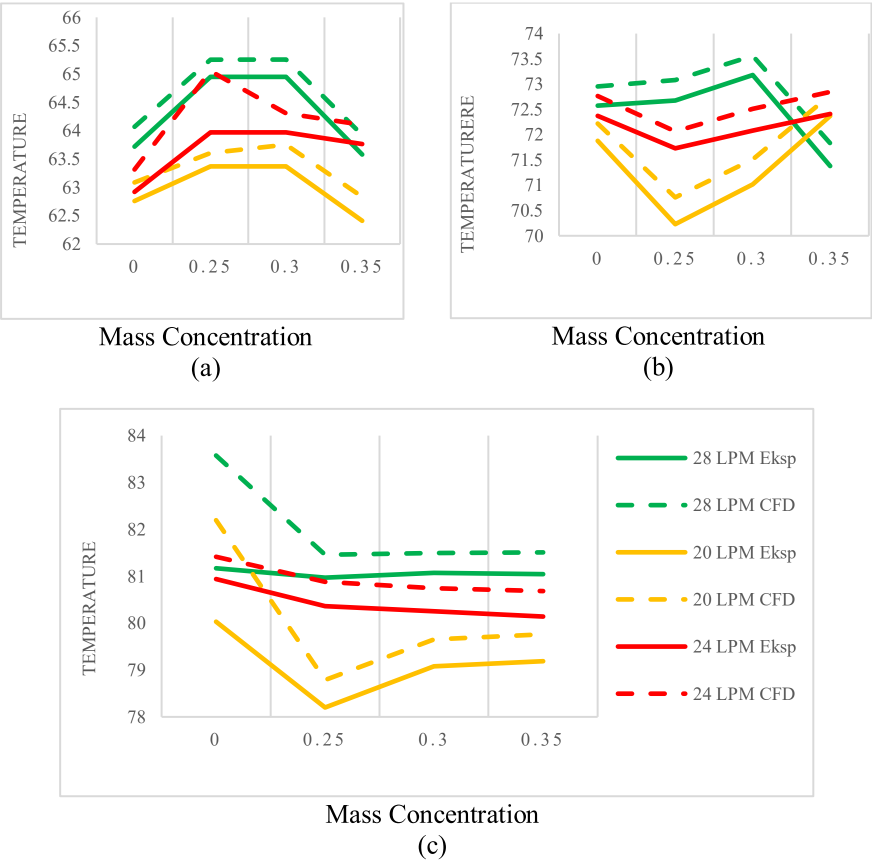

Fig. 4. Graph Comparison of CFD Results Tout vs Exp at (a) Tin 70 °C, (b) 80°C, (c) 90°C

Table 1. Table of Error Tout CFD vc Tout Exp on Tin 70 ,80,90 ° C

No	Concentration (%)	debit (Lpm)	CFD Vs Exp Error (%)		
			T_{in} 70 (°C)	T_{in} 80 (°C)	T_{in} 90 (°C)
1		20	0,528999	0,474402	2,705236
2	0	24	0,629371	0,537516	0,586854
3		28	0,547709	0,509782	2,962917
4		20	0,378728	0,754663	0,750639
5	0,25	24	1,691418	0,467029	0,648333
6		28	0,466513	0,569699	0,602692
7		20	0,604387	0,698395	0,71826
8	0,3	24	0,525246	0,593785	0,618069
9		28	0,461894	0,519268	0,518071
10		20	0.677776	0.567915	0.715999
11	0,35	24	0.537955	0.602127	0.677564
12		28	0.542623	0.63183	0.55768

Based on the graph of Fig. 5, the U value obtained from the experimental results at a discharge of 20 Lpm and an inlet temperature of 70 °C yields a result of 455.74W/m^2.°C for radiator coolant without the addition of hybrid-nanofluid (pure RC, 0%), at a concentration of 0.25% it increased by 460.95W/m^2.°C , at a concentration of 0.30% there was an increase of 462.09W/m^2.°C , and at a concentration of 0.35% there was an increase of 521.72W/m^2.°C . The result of CFD at pure RC concentration (0%) was 453.19 W/m^2.°C, at a concentration of 0.25% it increased to 459.11W/m^2.°C , at a concentration of 0.30% there was an increase of 459.16W/m^2.°C, and at a concentration of 0.35% there was an increase of 518.08W/m^2.°C . If we compare the results from the experiment and CFD, the pattern of changes in U with the nanofluid hybrid concentration has a relatively similar trend with a maximum error of -0.69% (Table 2).

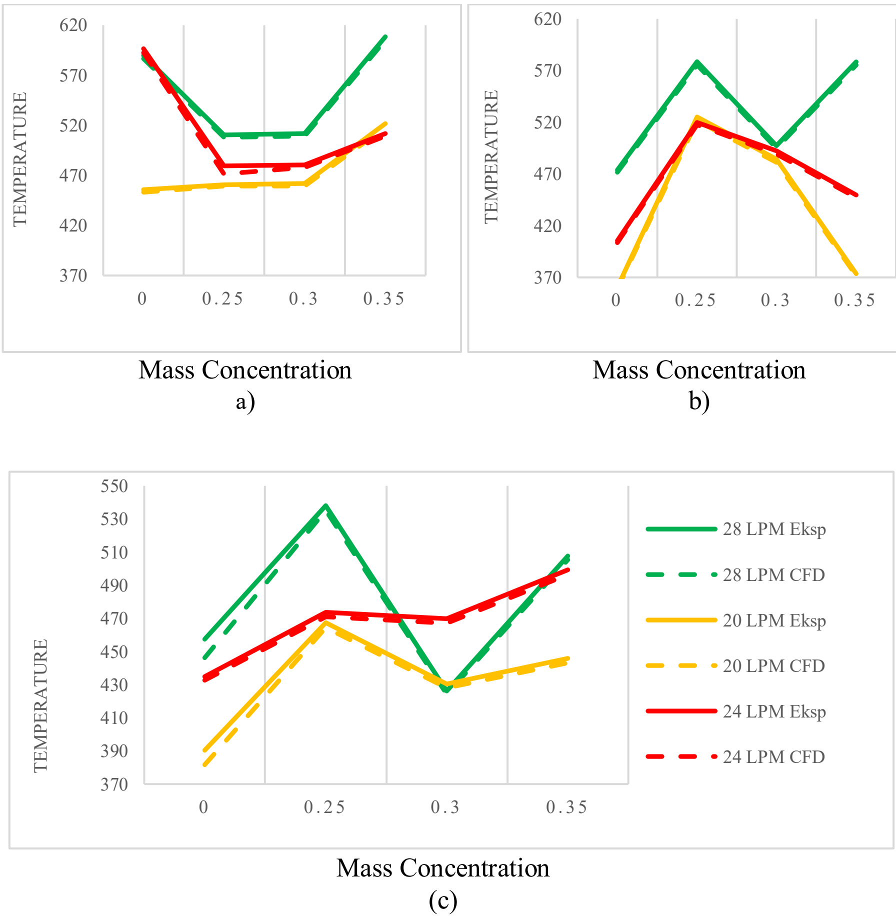

Fig. 5. Graph comparison U CFD Results vs Exp at (a) Tin 70°C, (b) 80°C, (c) 90°C

Table 2. Table of Error Utot CFD vc Tout Exp on on Tin 70 ,80,90 ° C

No	Concentration (%)	Debit (Lpm)	CFD Error vs Exp (%)		
			T_{in} 70 (° C)	T_{in} 80 (° C)	T_{in} 90 (°C)
1	0	20	-0,55992	-0,42553	-2,24116
2	0	24	-0,67978	-0,48219	-0,5057
3	0	28	-0,56563	-0,46291	-2,45062
4	0,25	20	-0,39918	-0,7095	-0,64556
5	0,25	24	-1,68457	-0,43774	-0,55262
6	0,25	28	-0,47421	-0,53408	-0,52673
7	0,3	20	-0,63511	-0,64921	-0,61741
8	0,3	24	-0,53088	-0,54108	-0,53522
9	0,3	28	-0,46954	-0,47195	-0,44004
10	0,35	20	-0,69592	-0,52091	-0,61872
11	0,35	24	-0,5532	-0,53792	-0,58185
12	0,35	28	-0,55397	-0,57523	-0,48043

4 Conclusion

In general, results from CFD simulation are agree with experiment in predict the radiator outlet temperature as well value of heat transfer coefficient thorough radiator qualitative and quantitative. Qualitatively, outlet temperature value as well heat transfer coefficient has same tendency with pattern from experiment results, if plotted on chart with condition mixtures concentration for different hybrid nanofluids. From the results simulation use ANSYS FLUENT software can increase the highest temperature at T inlite 90 ° C of 87.99 ° C on concentration 0% mass and 28 LPM discharge, for pressure inlet the water that enters the radiator with the CFD process can be different highest pressure _ at T inlite 70 ° C which is 5.93 kPa on concentration of 0.35% and discharge of 28 lpm , and on speed inlite the water entering the radiator with the CFD process looks relatively the same at every Tinlite 70.80, and 90 ° C which is equal to 0.44 m/s at concentration mass of 0.35% and discharge of 28 LPM. Quantitatively, maximum value of outlet temperature from CFD has error value 2.9% and minimum 0.4% if compared with experiment. For overall heat transfer coefficient, biggest and lowest error are -2.45% and -0.4%. CFD analysis predicts outlet temperature value is higher dan experiment results. On the other hand, the value of overall heat transfer coefficient lower than experiment.

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