

INVESTIGATION ON PERFORMANCE OF DIESEL ENGINE USING Al_2O_3 NANOFLUID AS COOLANT

V. Rambabu¹, P. Sai Chaitanya¹, K. Prasad Rao¹

¹ GMR Institute of Engineering and Technology, Mechanical Engineering Department, GMRIT Gmrnagar, 532127 Rajam, Andhra Pradesh, India, e-mail: nandu.343@gmail.com

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ABSTRACT

Water and ethylene glycol as ordinary coolants have been broadly utilized as a part of a car radiator for a long time. These heat exchange liquids offer low thermal conductivity. With the progression of nanotechnology, the new era of heat transfer fluids called, “nanofluids” have been developed and analysts found that these liquids offer higher thermal conductivity contrasted with that of routine coolants. This study concentrated on the utilization of a mixture of water and ethylene glycol based Al_2O_3 nanofluids in a cooling framework. Pertinent information, nanofluid properties and exact connections were obtained from literature review to examine the performance of a twin cylinder Diesel engine under various blends of nanofluid based coolants, furthermore, to research heat exchange improvement of a car radiator worked with nanofluid-based coolants. It was observed that, the performance of Diesel engine and heat transfer rate in cooling system framework enhanced with the utilization of nanofluids (with water and ethylene glycol the basefluid) contrasted with water and ethylene glycol (i.e. base liquid) alone. In the wake of leading the series of tests on Twin cylinder Diesel engine at 2%, 1% and 0.5% of nanofluid in basefluid, it was observed that performance of Diesel engine and heat exchange is upgraded better at 0.5% of Al_2O_3 nanofluid coolant.

Keywords: coolants, ethylene glycol, nanofluids, thermal conductivity, water.

INTRODUCTION

Constant innovative improvement in car enterprises has expanded the interest for high productivity engines. High engine productivity influences its performance as well as for better mileage and lower emissions. Reducing a vehicle weight by upgrading configuration and size of a radiator is a need for making the world green. Addition of fins is one of the ways to deal with increment of cooling rate of the radiator. It provides better heat exchange and improves the air convective heat exchange coefficient. Be that as it may, conventional methodology of increasing the cooling rate by utilizing fins and small scale channel has as of now come to as far as possible [1, 13, 14, 4]. Also, heat exchange liquids at air and

liquid side, for example, water and ethylene glycol show low thermal conductivity. Subsequently, there is a requirement for new and creative heat exchange liquids for enhancing heat transfer rate in a car radiator.

Nanofluids appear to be a potential substitution of customary coolants in engine cooling framework. As for the latter, there have been impressive exploration discoveries highlighting predominant heat exchange exhibitions of nanofluids. Yu et al. reported that around 15 to 40% of heat exchange improvement can be accomplished by utilizing different sorts of nanofluids. With these prevalent qualities, the size and weight of a car auto radiator can be diminished without influencing its heat exchange performance. This deciphers into a superior streamlined element for

outline of a car frontal area. Coefficient of drag can be minimized and fuel utilization proficiency can be enhanced [5, 6, 7].

Along these lines, this study endeavors to examine the heat exchange qualities of car radiator and performance of Diesel engine by utilizing water and ethylene glycol based alumina nanofluids as coolants. Heat performance of a radiator working with nanofluids is contrasted and a radiator utilizing traditional coolants. The impact of volume division of the alumina nanoparticles with base liquids on the heat performance and potential size diminishment of a radiator were additionally completed. Alumina nanoparticles were picked in this study, since they have higher heat conductivity contrasted with different nanoparticles, for example, copper [8, 9, 15].

Performance of engine is significantly a subject to the cooling arrangement of the engine. Expansion of nanoparticles to the coolant changes the physical and concoction properties of any coolant. Thus, dormant heat and enhancing the heat conductivity of the engine prompts diminish in group-

ing of discharges in the fumes. Nanoparticles enhance the cooling rate when they are alongside the coolant as base liquid in cooling frameworks. The rising interest for capable and proficient engine requires the utilization of a coolant with better heat exchange attributes [11, 12].

Car radiator is utilized for the cooling reason for the engine. The cooling arrangement of an engine assumes a vital part in its performance for these reason, analysts are utilizing diverse sorts of Nanofluids as a coolant, which builds the viability of a radiator, increases the performance of an engine and decreases fuel consumption. In this study 1.2% volume convergence of Al_2O_3 nanoparticles water based nanofluid is utilized and watches that viability of a car radiator upgrade up to 23% at steady mass stream rate [16, 18].

Performance of engine is estimated by considering different parameters, such as brake power, brake thermal efficiency, specific fuel consumption etc. Using appropriate coolant affects the above said parameters. Comparative study was done with different biodiesels to estimate

Table 1. List of Thermal conductivity and Heat transfer enhancement for various nanoparticles mixed with base fluids [19, 24]

SI No	Nanoparticles	Base Fluid	Volume Fraction of particles	Thermal conductivity Enhancement	Heat Transfer Enhancement
1	Al_2O_3	Water	1%	3	45
2	Al_2O_3	Water	-	15	40
3	Fe_2O_3	Water	0.65%		9
4	Cu	Ethylene Glycol	0.30%	40	-
5	CuO	Water	0.40%	17	8
6	Cu	Glycol	0.55%	21	-
7	Fe	Water	0.0010%	17	-
8	Al_2O_3	Water	4.30%	30	-
9	Al_2O_3	Engine Coolant (HP KOOLGARD)	3.50%	10.41	-
10	Sic	Water	4.20%	16	-
11	TiO_2	Water	5%	30	-
12	ZnO	Ethylene Glycol	5%	26.5	-
13	Cu	Ethylene Glycol	2%	-	3.8%
14	CuO, Al_2O_3	Ethylene Glycol and Water	-	-	Improvement in convective heat transfer coefficient
15	Al_2O_3	HP KOOLGARD	3.5%	10.41	-
16	CuO, Al_2O_3	Water	-	Enhance with increase in volume fraction	-
17	Sic	-	3.7%	-	50-60%
18	Al_2O_3	-	-	-	15-20%
19	Al_2O_3	Water	6.8%	-	40% enhancement in heat transfer coefficient

the performance of the engine which has lead to improvement in efficiency of the engine. Therefore, same parameters are considered in present paper to estimate the effect of coolant on engine performance [2, 3, 10, 17].

This study on the constrained convective heat exchange and stream attributes of a nanofluid comprising of water and distinctive volume convergences of Al_2O_3 nanofluid (0.3–2)% streaming in a flat shell and tube heat exchanger counter stream under turbulent stream conditions are researched. The Al_2O_3 nanoparticles of around 30 nm distance across are utilized as a part of the present study. The outcomes demonstrate that the convective heat exchange coefficient of nanofluid is somewhat higher than that of the base fluid at the same mass stream rate and at same gulf temperature [21, 22]. The heat exchange coefficient of the nanofluid increments with an expansion in the mass stream rate, additionally, the heat exchange coefficient increments with the increment of the volume convergence of the Al_2O_3 nanofluid, however increasing the volume focus cause increment in the consistency of the nanofluid prompting an increment in erosion factor [20, 23].

EXPERIMENTAL SETUP DESCRIPTION

Experimental setup consists of the following components:

- Twin cylinder diesel engine
- Radiator

- Battery
- Sump of 15 lts capacity
- Motor of 1/30 hp
- Electric loading setup
- Flexible pipes
- Thermometers
- Alumina nanofluid of 2%

Radiator assembly with the engine

- Radiator is the one major component f our experiment it is coupled to the engine.
- Radiator has one inlet and an outlet engine has one coolant inlet and coolant outlet.
- Radiator inlet and the engines outlet is connected with an pipe.
- Radiator outlet is allowed free and the outlet water from the radiator is collected at the sump.
- By means of the motor of 1/30 hp the sump water is lifted and connected to the diesel engine input.

Hence this way the radiator connects with the diesel engine and flow also takes place in such away.

Nanofluid coolant preparation for different mixtures

- **Stage 1:** Measuring the required volume of nanofluid to be added to the base fluid.
- **Stage 2:** Preparing the base fluid containing 70% distilled water and 30% ethylene glycol.



Fig. 1. Experimental setup

Table 2. Weights of nanoparticles corresponding to their volume concentration

Sl. No	Volume concentration (%)	Weight concentration (gm)
1	0.25	0.9555
2	0.5	1.91595
3	1	3.8512
4	2	7.78110

- **Stage 3:** Add the nanofluid to the base fluid and use Sonication process to obtain nano-fluid coolant.

EXPERIMENTAL PROCEDURE

Engine along with radiator setup was used for present study. Experiments were conducted on diesel engine at different concentration of nano fluid as coolant. Load on Engine was applied using a dynamometer. Data was recorded and using empirical formula performance characteristics of diesel engine were evaluated.

RESULTS AND DISCUSSION

Experimental investigations was carried out on a Twin-cylinder Diesel engine adopting Al_2O_3 nanofluid mixing coolant with basefluid at different proportions such as 0.5%, 1% and 2%. Performance of the engine was evaluated and these

results with the basefluids such as Water and Ethylene Glycol were compared. The graphs are plotted for each case to finally optimize results and improve the performance of engine and heat transfer enhancement.

Brake Thermal Efficiency Variation

The above graph shows the variation of Brake Thermal Efficiency with the loading with different coolants used. When 0.5% mixture coolant used, the brake thermal efficiency is increased is due to decreasing the heat input given to engine. As heat input is inversely proportion to brake thermal efficiency, the heat input decreases which results in increasing the brake thermal efficiency. The results in 1% nanofluid mixture coolant are also better compare to other coolants. In 2% mixture coolant, the brake thermal efficiency is decreased due to increasing the heat input given to engine.

Brake specific fuel consumption variation

The above graph shows the variation of Brake specific fuel consumption with the Brake power when we use different coolants. When we use water and 0.5% mixture coolant are used as coolants the result are much better than others in all three loading conditions. When we use 1% and 2% mixture coolants as coolants to engine, the mass of the fuel consumed is increased and also there is a sudden change in the graph with the increasing brake power.

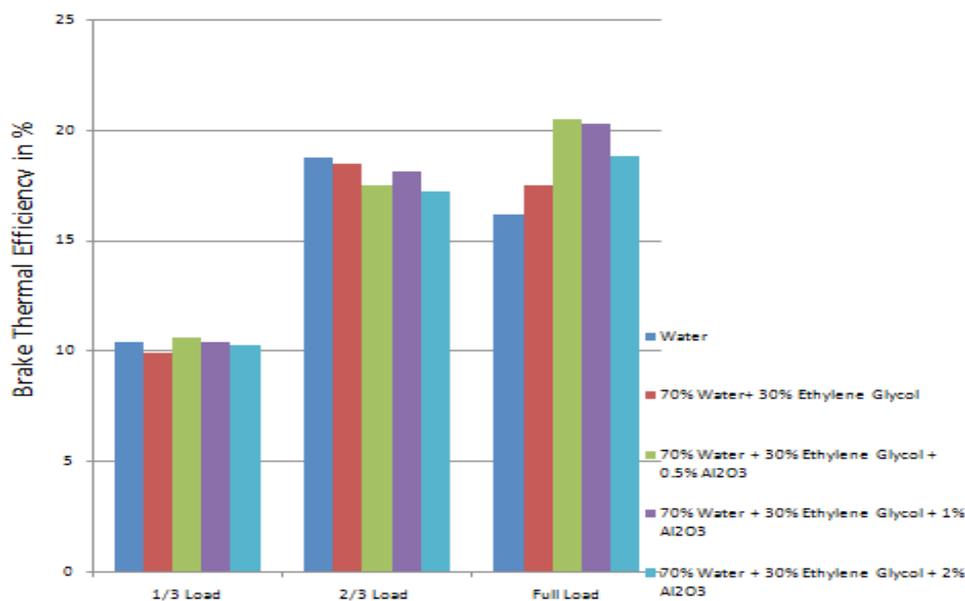


Fig. 2. Brake Thermal Efficiency versus Load

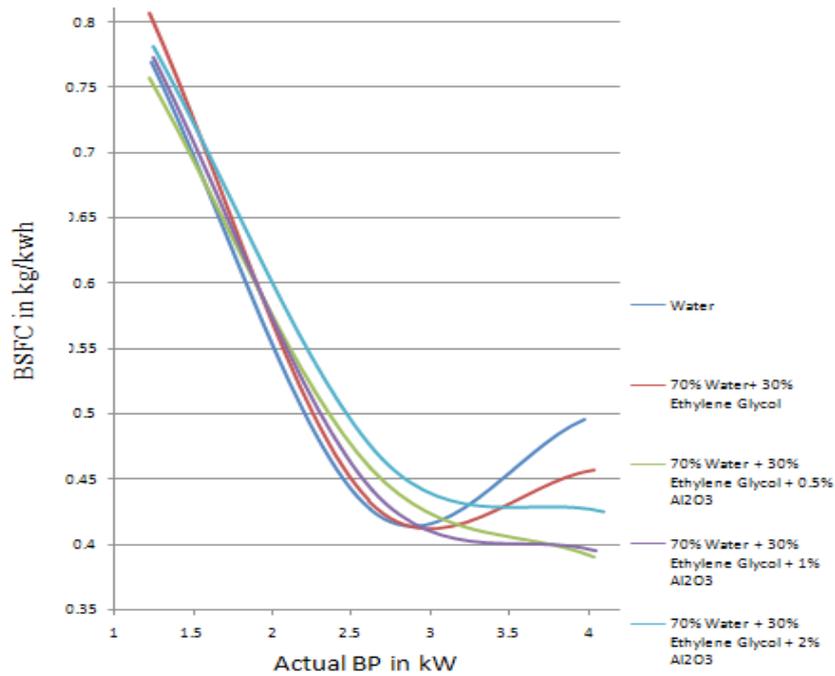


Fig. 3. Brake specific fuel consumption versus Brake power

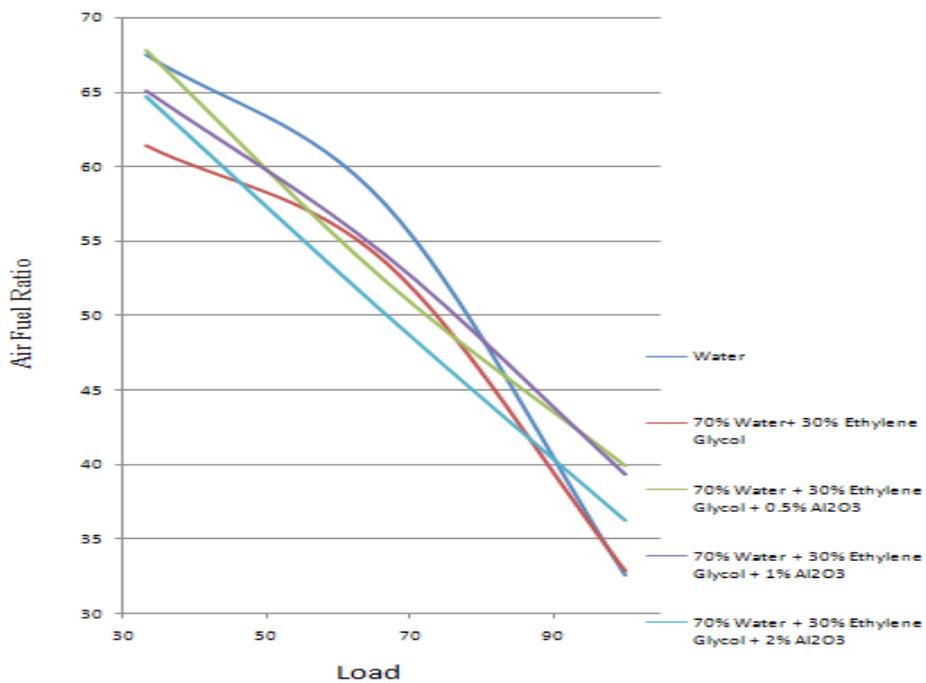


Fig. 4. Air Fuel Ratio versus Load

Air fuel ratio variation with Loading

The above graph shows the variation of the Air fuel ratio with the Loading. In above graph, results of water coolant and 70% Water + 30% Ethylene Glycol are fluctuated a lot. This is because of supply more amount of fuel to engine. While in 2% mixture coolant the graph is linear

and Air fuel ratio is low compare to 0.5% and 1% mixtures, this is due to increasing the heat absorption of coolant.

Heat input variation with Load

The above graph is plotted between the Heat input and Loading. This graph explains the vari-

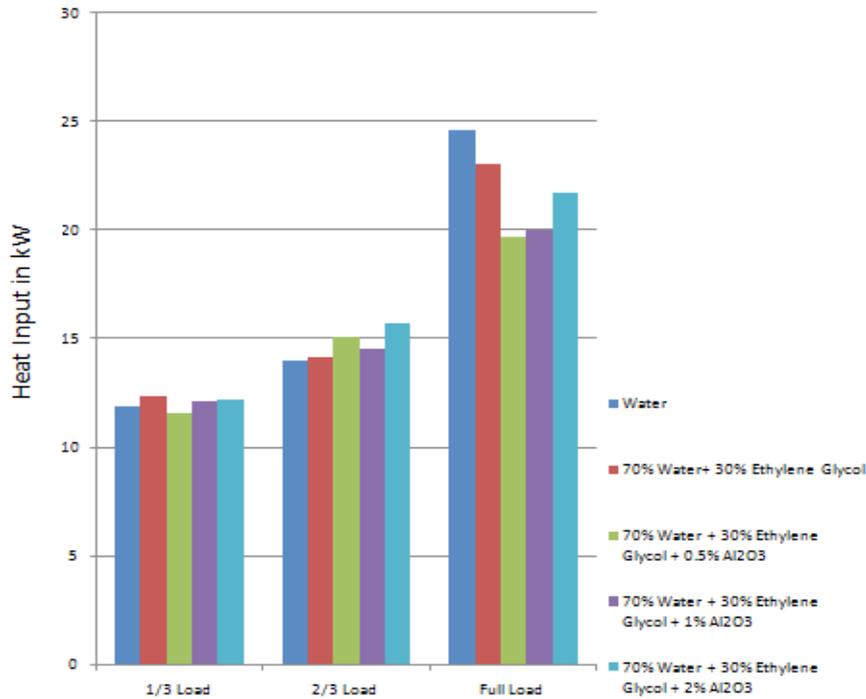


Fig. 5. Heat input versus Load

ation of Heat input with loading and with changing the coolants. When we use water as coolant Heat input given to engine increases rapidly at 100% loading compare to other coolants. This is due to overheating of the engine which draws the fuel as much as other cases. When we use 70% Water + 30% Ethylene Glycol + 0.5% Al₂O₃ mixture as coolant, the engine draws small amount of fuel because of enough condition to operate the engine in all three loadings while in 2% mixture, the engine is cooling so fast due to increasing the heat absorption capacity of the coolant. This is why engine consumes more fuel, which results in increasing the Heat input given to the engine.

CONCLUSIONS

The following conclusions are arrived from above experimentations:

- At 0.5% Al₂O₃ Nanofluid coolant, we have observed that Brake Power is Increased by 20.073% at maximum loading condition, in comparison to base fluids. Also decreasing of the brake power at 2% nanofluid coolant compare to 0.5% Al₂O₃ nanofluid coolant was observed.
- At 0.5% Al₂O₃ Nanofluid coolant, we have observed that Air fuel ratio increased by 22.51% at maximum loading condition, comparing to base fluids.

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- At 0.5% Al₂O₃ Nanofluid coolant, we have observed that Unaccounted Losses decreased by 9.81% at maximum loading condition when comparing to base fluids.
- At 0.5% Al₂O₃ Nanofluid coolant, the heat transfer capacity of coolant increased up to 40% when comparing to base fluids.
- We have also observed that increasing of percentage of Al₂O₃ in base fluid, it will result in poor performance of the engine due to fast cooling of engine.
- We have also observed that the coolant starts evaporating at maximum loading conditions when we use water as coolant.
- We observed that Twin cylinder Diesel engine gets overheating under water coolant; this will decrease the life time of engine and exhibits poor engine performance .
- From the above results and discussions, we can conclude that 70% Water + 30% Ethylene Glycol + 0.5% Al₂O₃ mixture nanofluid coolant exhibits better performance of the engine when comparing to all the remaining mixture coolants and basefluids.

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