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"EXPERIMENTAL INVESTIGATION OF DIESEL ENGINE PERFORMANCE, COMBUSTION AND EMISSION CHARACTERISTICS FUELLED WITH NANOPARTICLE BLENDED KARANJA BIODIESEL"

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ABSTRACT

Biodiesel is conceived as a renewable and environment-friendly fuel benignant to petro-diesel with benefits of lower level of smoke, unburned hydrocarbons and carbon monoxide than petro-diesel . It is easier to achieve clean combustion with biodiesel, resulting in reduced level of exhaust emission by using oxygenates as additives antioxidants as additives and nanoparticles as additives in biodiesel. In the present study, Experimental investigation were conducted with Normal Diesel, Biodiesel blends (B30 , B40 and B50 Karanjia oil) and their blends with Al2O3 Nanopartical at different concentration (30 ,40 , 50 PPM). The thermal performance, emission and combustion characteristics were studied in a 5.2 kW engine running at 1500 rpm at full load condition. Biodiesel (Karanjia oil) is an alternative fuel that is cleaner and used directly as fuel for a diesel engine without having to modify the engine system. It has the major advantages of having high biodegradability, excellent lubricity and no sulfur content. Hydrocarbon and carbon monoxide emission were lower with increase in saturation levels of Nanopartial with bends. The smoke emission was same for biodiesels blends. Higher Nanoparticle saturation with B50 blends which higher the cetane number and lesser the NOx emission. The hydrocarbon emissions reduced with increase in saturation percentage in biodiesel blends while the smoke emissions increased.

Key Words: Karanjia Bio Diesel , Thermal Performance , Smoke , Nanoparticle , Bio Diesel Blends , Exhaust emission

I. INTRODUCTION

The internal combustion engine is a heat engine that convert chemical energy in a fuel into mechanical energy, usually made available on a rotating output shaft. Chemical energy of the fuel is first converted to thermal energy by means of combustion or oxidation with air inside the engine. This thermal energy raises the temperature and pressure of the gases within the engine and the high-pressure gas then expands against the mechanical mechanisms of the engine. This expansion is converted by the mechanical linkages of the engine to a rotating crankshaft, which is the output of the engine. The crankshaft, in turn, is connected to a transmission and/or power train to transmit the rotating mechanical energy to the desired final use. For engines this will often be the propulsion of a vehicle.

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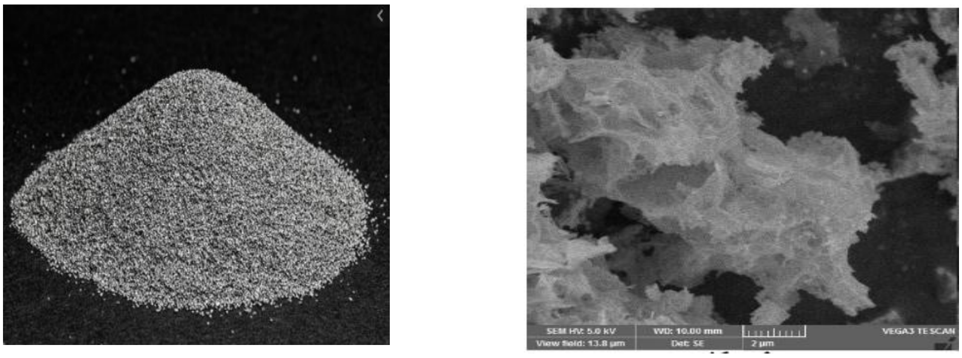
Aluminum Oxide Nanoparticles

Nanocrystalline ceramic materials are those with size smaller than 100 nm which have great importance in the field of nanotechnology. Nano-sized materials have properties superior to bulk materials, including improved surface area-to-volume ratio and high strength and toughness. Aluminum oxide has a chemical formula Al_2O_3. It is amphoteric in nature, and is used in various chemical, industrial and commercial applications. It is considered an indirect additive used in food contact substances by the FDA.

Heat transfer fluids increase the heat transfer coefficient without penalizing the pressure loss. This requires an accurate selection of particle shape, size, materials and concentrations. As it has been postulated, nanofluids must have low activation characteristic to avoid that high radiation doses occur. Particle size is a factor that must also be considered.



Aluminum oxide nanoparticles
Image Source:- [21] Hüseyin Aydin, Hasan Bayindir et. Al

Emission of Biodiesel And Its Blends

Improving the cold flow properties, evaporation and combustion characteristics as well as emission of biodiesel and their blends for potential use in engines as an additive or alternative to conventional fuels. The use of some additives seems to be restricted because of their slight influence on cloud point as it is more important for improving low temperature flow characteristics compared to pour point. Moreover, the use of different additives is quite costly which increases the cost of biodiesel. Blending biodiesel with vegetable oil is restricted because it is mainly applicable to biodiesel derived from certain feedstocks only. Blending with petroleum fuel is restricted to lower biodiesel blends (up to 30 vol%) with cloud point nearing up to around 10 0C [60] because mixing with fossil fuel do not change the chemical nature of the blends. On the other hand, very limited investigations are available regarding the use thermal cracking, urea complexation, epoxidation and alkoxylation for improving the low temperature properties of biodiesel. Although significant progress has been made on low-temperature flow problem of biodiesel, it is still an unresolved issue.

- ✓ NOX emission
- ✓ CO2 emission
- ✓ CO emission
- ✓ PM and smoke emissions

Diesel combustion is compression induced and depends to a major extent on successful vapourisation and mixing over an extremely short time, which is more complex and difficult than that of the spark ignition engine. The thermodynamic diesel cycle differs from the constant volume cycle of spark ignition engine as conceived by Otto. In reality, it tends to constant volume cycle but it is actually a combination of constant volume and constant pressure cycle.

[1] M.S. Gad (2020) Fuel demand rise coupled with its harmful emissions has contributed to the continuous search of substitute for diesel oil. Biodiesel properties were measured and agreed with ASTM standards. Biodiesel blend was obtained by blending of 20% volume respectively about B20. Biodiesel blend with CNTs and graphene nano sheet concentrations of 100 ppm achieved the highest decreases in smoke emissions by 28 and 54% but the maximum decreases in CO emission were 27 and 47%, respectively about B20

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[2] Nambaya Charyulu Tatikonda (2020), In a standard internal combustion engine, a large amount of heat energy is being wasted through the cooling and exhaust systems. So, to minimize these losses one advanced technology for coating applications grows rapidly. Hence, to improve engine performance and fuel economy one or more parts of the combustion chamber such as piston crown, inlet valves, exhaust valves and cylinder head are getting coated with ceramic materials without changing the original dimensions. The present work deals with the performance characteristics of a single-cylinder diesel engine with an eddy current dynamometer loading fuelled with Cymbopogon (Lemongrass) oil methyl ester (CME) when the piston crown was coated with yttria stabilized zirconia of thickness 350 microns equal to 0.35mm of thickness using plasma spray coating technique. Test samples were prepared and designated as CME10D90 (B10), CME20D80(B20), and CME30D70(B30).

[3] T. M. Yunus Khan (2020) The ever-increasing demand for transport is sustained by internal combustion (IC) engines.The demand for transport energy is large and continuously increasing across the globe. Though there are few alternative options emerging that may eliminate the IC engine, they are in a developing stage, meaning the burden of transportation has to be borne by IC engines until at least the near future. Hence, IC engines continue to be the prime mechanism to sustain transportation in general. However, the scarcity of fossil fuels and its rising prices have forced nations to look for alternate fuels. Biodiesel has been merged as the replacement of diesel as fuel for diesel engines.

[4] A. Prabu (2019) In this study, modernization of new fuel additives such as antioxidants, oxygenates and nanoparticles are mixed with jatropha biodiesel with the aim of diluting the level of pollutants from the engine exhaust and upgrading the performance of the engine. Most significant reduction of NO emission by 30 % is observed for antioxidants and nanoparticles blended test fuels and significant enhancement in the brake thermal efficiency almost equal to that of neat diesel is observed for oxygenates and nanoparticles blended test fuel, along with substantial reduction of smoke opacity by 43 %, carbon monoxide by 60 % and unburned hydrocarbon by 33 %.

[5] İsmet Sezer (2019), This study was compiled from the results of various researches performed on usage diethyl ether as a fuel or fuel additive in diesel engines. Three different methods have been used the reduction of the harmful exhaust emissions of die-sel engines. The first technique for the reduction of harmful emissions has im-proved the combustion by modification of engine design and fuel injection sys-tem, but this process is expensive and time-consuming. The second technique is the using various exhaust gas devices like catalytic converter and diesel particu-late filter. However, the use of these devices affects negatively diesel engine performance.

[6] M. Vijay Kumar (2018) Engine modification through reducing nozzle hole diameter (NHD) (i.e., from the base value of 0.28 to the modified value of 0.20 mm) has been shown as an effective strategy in improving engine performance, combustion, and emission parameters. However, it has also led to substantial increases in NOx emission as a major shortcoming. In light of that, the present study was aimed at overcoming this challenge through the application of a partially-cooled exhaust gas recirculation (EGR) system. More specifically, Mahua oil biodiesel-diesel blend (B20) and neat diesel were tested on a modified single cylinder diesel engine under five different engine loads (i.e., 2.46, 4.92, 7.38, 9.84, and 12.3 kg) and in the presence of varying EGR rates.

[7] Chandan Kumar (2018) The consumption of diesel fuel is increasing day by day due to its wide application in agriculture and transportation sectors which is also responsible for deteriorating condition of environment due to emissions i.e., smoke, CO, HC, NOx, etc. These emissions may be reduced by adding methanol in diesel fuel. As compared to diesel, lower value of viscosity and density of methanol-diesel lends helps in easy pumping. The lower boiling point of methanol helps in reducing the ignition delay and thereby avoiding knocking. Methanol with higher oxygen content also helps in easy vailability of more oxygen in the vicinity of the diesel for its quick and better combustion. To improve the working of diesel engine and control its emission level, blend diesel version definitely plays a very important role.

[8] A. Prabu (2018) This experimental work investigates the performance, combustion and emission characteristics of a single cylinder direct injection (DI) diesel engine with three fuel series: biodiesel–diesel (B20), biodiesel–diesel–nanoparticles (B20A30C30) and biodiesel–nanoparticles (B100A30C30). The nanoparticles such as Alumina (Al_2O_3) and Cerium oxide (CeO_2) of each 30ppm are mixed with the fuel blends by means of an ultrasonicator, to attain uniform suspension. Owing to the higher surface area/volume ratio characteristics of nanoparticles, the degree of mixing and chemical reactivity are enhanced during the combustion, attaining better performance, combustion and emission attributes of the diesel engine. The brake thermal e□ciency of the engine for the nanoparticles dispersed test fuel (B20A30C30) signi□cantly improved by 12%, succeeded by 30% reduction in NO emission, 60% reduction in carbon monoxide emission, 44% reduction in hydrocarbon emission and 38% reduction in smoke emission,

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compared to that of B100.

[9] Bhaskar Kathirvelu1 (2017) This paper is based on experiments conducted on a stationary, four stroke, naturally aspirated air cooled, single cylinder compression ignition engine coupled with an electrical swinging field dynamometer. Instead of 100% diesel, 20% Jatropha oil methyl ester with 80% diesel blend was injected directly in engine beside 25% pre-mixed charge of diesel in mixing chamber and with 20% exhaust gas recirculation. The performance and emission characteristics are compared with conventional 100% diesel injection in main chamber. The blend with diesel premixed charge with and without exhaust gas recirculation yields in reduction of oxides of nitrogen and particulate matter. Adverse effects are reduction of brake thermal efficiency.

[10] S. Jaichandar (2015) studied methyl ester derived from jatropha oil (JOME) and its blends of 20 and 50% on a volume basis with standard diesel as a source of fuel for a compression ignition engine. The engine tests were carried out at 0%, 25%, 50%, 75% and 100% load using a single-cylinder, four-stroke, constant speed diesel engine to study the performance, emission and combustion characteristics of these fuels. The results showed a 21% reduction in smoke, 17.9% reduction in HC emissions and 16% reduction in CO emissions for 20% JOME, with a 3.8% increase in NOx emission at full load.

[11] Dawody and Bhatti (2014) studied the performance of soyabean oil methyl esters in a single cylinder diesel engine and compared the results with diesel. The results showed that the brake thermal efficiency reduced by 3% with that of diesel. The increase in NOx emission was 35% and reduction in smoke emission was 48%. Marginal reduction in HC and carbon monoxide was observed in the tests. It was finally concluded that the performance of B20 was comparable with that of diesel.

[12] S. Jaichandar1 , K. Annamalai (2016), The use of jatropha oil as a fuel for diesel engines is gaining more interest. Biodiesel is defined as a transesterified alternative fuel obtained from vegetable oils or animal fats having properties comparable to those of diesel. In the present investigation a methyl ester derived from jatropha oil (JOME) was considered as fuel. This paper presents a comparative study on the use of JOME and its blends of 20 and 50% on a volume basis with standard diesel as a source of fuel for a compression ignition engine. The engine tests were carried out at 0%, 25%, 50%, 75% and 100% load using a single-cylinder, four-stroke, constant speed diesel engine to study the performance, emission and combustion characteristics of these fuels. The results showed a 21% reduction in smoke, 17.9% reduction in HC emissions and 16% reduction in CO emissions for 20% JOME, with a 3.8% increase in NOx emission at full load

[13] Obed Majeed Ali1, Rizalman Mamat, Nik R. Abdullah, Abdul Adam Abdullah (2016) , Biodiesel fuel can be used as an alternative to mineral diesel, its blend up to 20% used as a commercial fuel for the existing diesel engine in many countries. However, at high blending ratio, the fuel properties are worsening. The feasibility of pure biodiesel and blended fuel at high blending ratio using different chemical additives has been reviewed in this study. The results obtained by different researchers were analysed to evaluate the fuel properties trend and engine performance and emissions with different chemical additives. It found that, variety of chemical additives can be utilised with biodiesel fuel to improve the fuel properties. Furthermore, the chemical additives usage in biodiesel is inseparable both for improving the cold flow properties and for better engine performance and emission control. Therefore, research is needed to develop biodiesel specific additives that can be adopted to improve the fuel properties and achieve best engine performance at lower exhaust emission effects.

[14] Candan, F., et al. (2017) , In this study, methanol in ratios of 5-10-15% were incorporated into diesel fuel with the aim of reducing harmful exhaust gasses of Diesel engine, di-tertbutyl peroxide as cetane improver in a ratio of 1% was added into mixture fuels in order to reduce negative effects of methanol on engine performance parameters, and isobutanol of a ratio of 1% was used as additive for preventing phase sepa-ration of all mixtures. As results of experiments conducted on a single cylinder and direct injection Diesel engine, methanol caused the increase of NOx emission while reducing CO, HC, CO2, and smoke opacity emissions. It also reduced torque and power values, and increased brake specific fuel consumption values

[15] Gaurav paul et al (2014) carried out experimental and numerical investigation on the performance and emission tests on a diesel engine with blends of jatropha biodiesel. Experiments results showed that the thermal efficiency reduced by 8% and NOx emission increased by 24% for B100 when compared to diesel. Significant reduction in particulates and smoke emissions were observed. It was reported that the presence of oxygen in biodiesel increased the NOx emission and reduced the smoke emission.

[16] Ameya vilas Malvade et al (2013) investigated the effects of using palm oil biodiesel in a stationary single cylinder compression ignition engine. The properties of palm oil biodiesel were comparable with that of diesel. The

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results of the performance tests showed that the brake thermal efficiency and specific fuel consumption were comparable with diesel for blends up to B30.

[17] Boubhari chokri et al (2012) conducted performance and emission test on a compression ignition engine with blends of waste vegetable oil esters. The results showed that there is a decrease in power output by about 5% with every 10% increase in biodiesel by volume. The NOx emission decreased by 2.5% whereas the particulate emission decreased by 10% for increase in biodiesel blends.

[18]Dattatray bapu halwan et al (2011) investigated the effects of blends of biodiesel and ethanol with diesel in a multi cylinder diesel engine. It was reported that injection timing has to be changed to 18^o CA instead of the actual injection timing of 13^o CA before top dead centre. This was due to the displacement of 50% diesel by the blends. NOx emissions were doubled, while smoke emissions were reduced by 60-70% for all the blends. The carbon monoxide emission reduced significantly at lower loads.

[19] Rao (2011) studied the effects of 100% biodiesel in normal mode and preheated mode in a single cylinder diesel engine. A reduction in brake thermal efficiency and increase in NOx emission were observed for normal operation mode. In preheated mode of operation the efficiency and NOx emission were comparable with that of diesel. It was reported that high NOx emissions were due to the presence of unsaturated fatty acids and the advanced injection caused by higher density of jatropha biodiesel.

[20] Enweremadu et al (2010) carried out experiments with used cooking oil (UCO) biodiesel and its blends in a diesel engine. The blends of biodiesel reduced the engine performance marginally compared to diesel. BSFC increases with increase in percentage of UCO biodiesel in the blend and is due to the lower heating value of UCO biodiesel and its blends. NOx emissions were slightly higher while un-burnt hydrocarbon (UBHC) emissions were lower for UCO biodiesel when compared to diesel fuel due to the presence of oxygen. The ignition delay of UCO biodiesel decreases with increase in percentage of UCO in the blend and is less when compared to that of petroleum diesel. The peak pressure of UCO biodiesel and its blends is higher than that of diesel fuel. The rate of pressure rise and heat release for UCO biodiesel and diesel are similar. The exhaust gas temperature increase with increase in percentage of UCO in the blend. Increased oxygen content which improves combustion is a reason given for higher exhaust gas temperature.

[21] Aydin et al (2010) conducted the performance and emission tests of a diesel engine with cottonseed oil methyl ester. For the study, cottonseed oil methyl ester (CSOME) was added to diesel fuel by volume of 5% (B5), 20% (B20), 50% (B50) and 75% (B75) as well as pure CSOME (B100). The effects of CSOME diesel blends on engine performance and exhaust emissions were examined at various engine speed and load condition. Results showed that with the increase of CSOME in the blends, the torque was decreased due to higher viscosity and lower heating value of CSOME. At rated power output, brake specific fuel consumption of B20 was lower than those of other fuels including diesel fuel. It may be due to the fuel based oxygen and higher cetane number, leading to more complete combustion at low speeds.

II. EXPERIMENTAL SET-UP & METHODOLOGY

Experiment with engine often involves an energy balance on the engine. Energy is supplied to the engine as the chemical energy of the fuel and leave as energy in the cooling water, exhaust, brake work, and extraneous heat transfer, which is often termed „heat loss". But this usage is misleading as heat is energy in transit and First law of thermodynamics states that energy is conserved. The heat transfer to the cooling water is found from the temperature

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rise in coolant as it passes through the engine and the mass flow rate of the coolant
Where h is enthalpy, B.P is brake power, Q_{cool} is the heat transfer rate to the cooling medium and Q_{misc} is the heat rejected to the oil (if separately) plus convection and radiation from the engine external surface.
The indicated power is the sum of the brake power and friction power. A substantial part of the friction power (about half) is distributed between the piston and piston rings and cylinder wall and is transferred as thermal energy to the cooling medium. The remainder of the friction power is dissipated in the bearings, valve mechanisms, or derives auxiliary devices and is transferred as thermal energy to the oil or surrounding environment (in Q_{misc}) Fuel, air inlet, engine coolant inlet and outlet, lubricating oil temperatures will be measured by K type thermocouples. All the measurements will be collected and recorded by a high- speed data acquisition system.

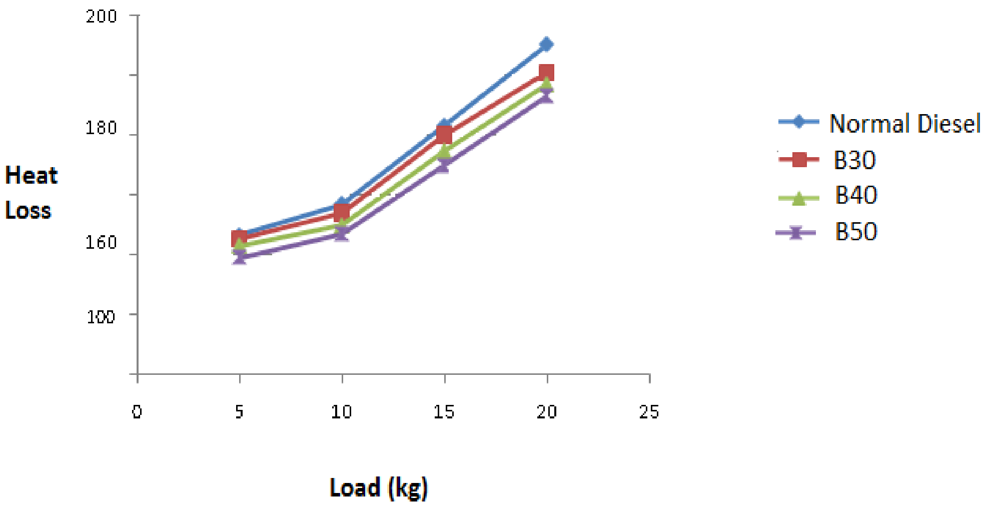
III. TEST SET-UP

Engine test rig Tachometer, stop watch, digital temperature indicator to measure different temperatures sensed by respective thermocouple. Manometer to measure the quantity of air drawn into the engine cylinder. Burette to measure the rate of fuel consumed.

IV. RESULTS AND DISCUSSION

The objective of this study is to investigate the performance, emission and combustion characteristics of a diesel engine fuelled with Karanja oil blends (B30, B40, and B50) compared with different concretion of nanopartical with standard diesel.

Performance analysis



Heat loss VS Load for Engine without nanopartical It has been found that there is no significant change in brake thermal efficiency up to 60% of load excepet of B50-40 PPM which shows changes after full load. We found that the B40-40 PPM case representing the efficient effective on brake thermal efficiency as load varies slightly.

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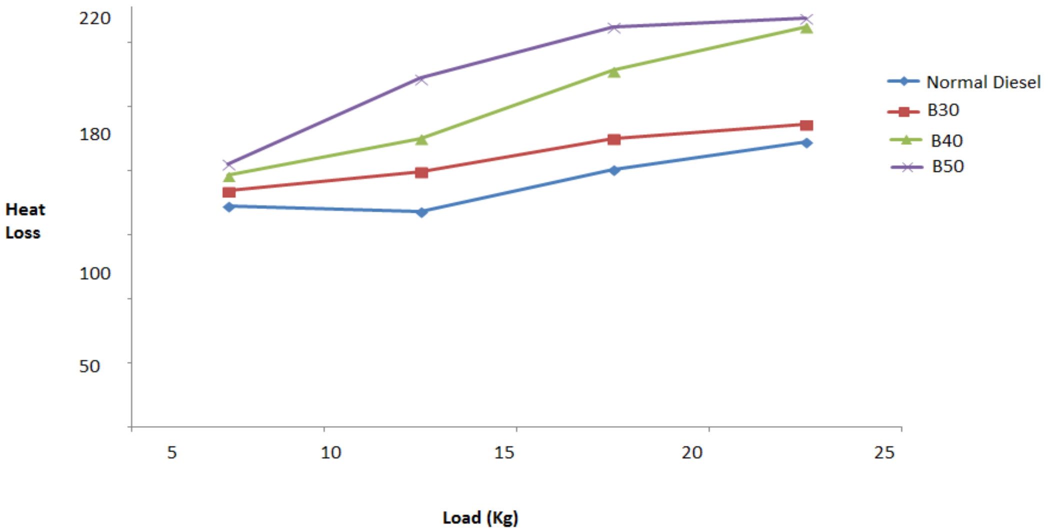
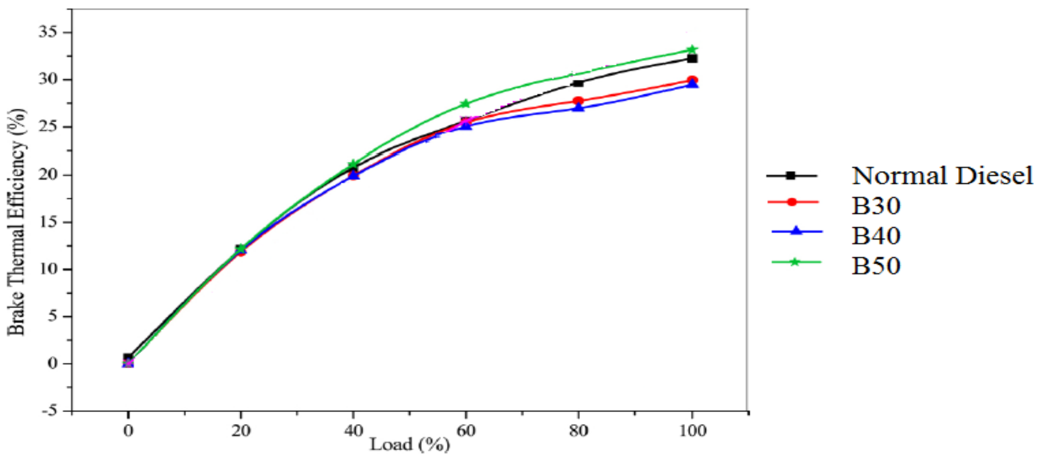


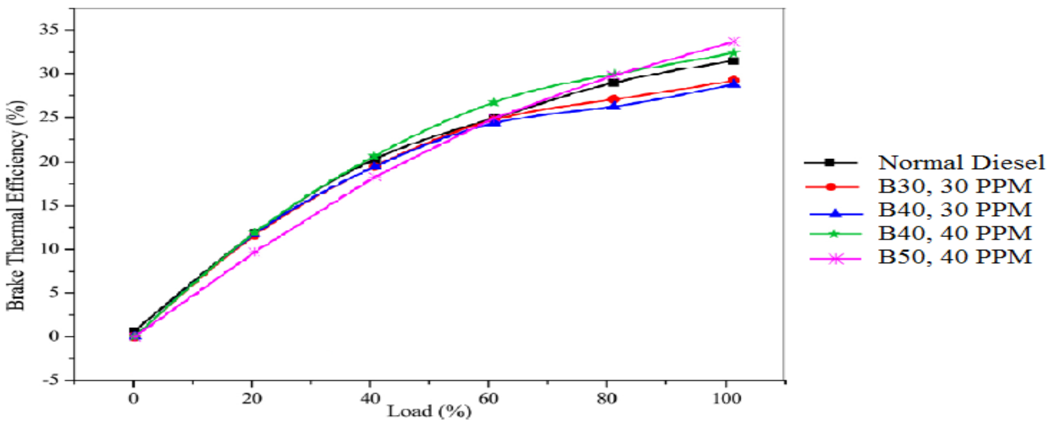
Heat loss VS Load for Engine with bio diesel with 30 PPM nanopartical

the variation of heat losses of pure diesel, B30, B40, B50 with load of different variation of load. It is evident from Figure that at lower load 5 kg, Heat loss is minimum for B30 blend and maximum for normal diesel. At higher load 20 kg, heat loss is minimum for B30 blend and maximum for normal diesel.



Brake Thermal Efficiency with normal Diesel, B30, B40 and B50

brake thermal efficiency of fuels used at different loads and blends with Normal Diesel & B30-30 PPM, B40-30 PPM, B40-40 PPM, B50-40 PPM and B50 with nanopartical concretion .



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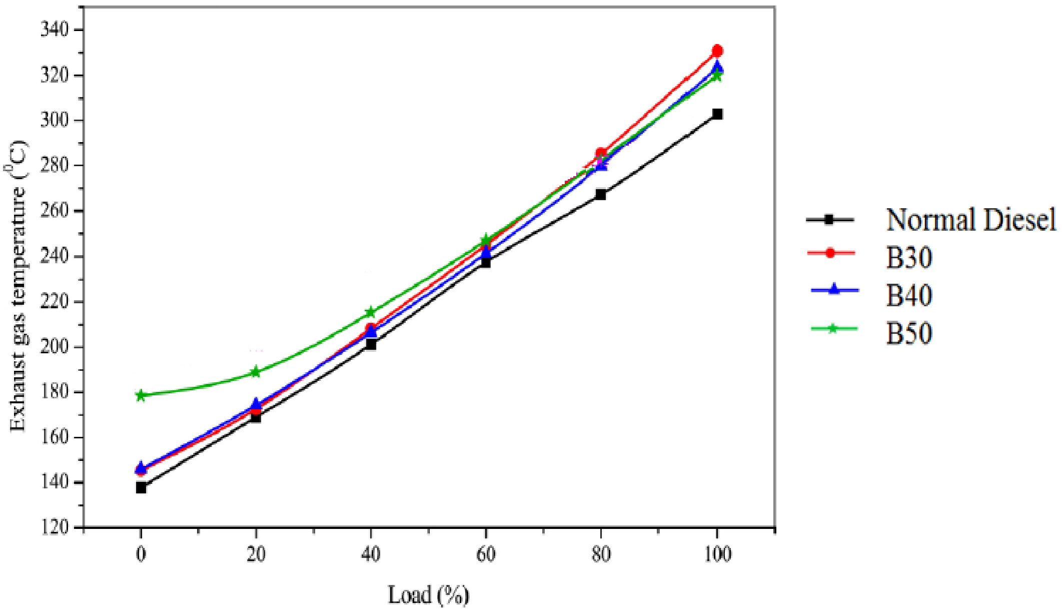
Exhaust Gas Temperature

the high viscosity of fuel leads to poor atomization and vaporizations of fuel droplets which results in late burning and higher exhaust temperature of biodiesel fuels. Shows that the exhaust gas temperature with respect to load for normal Diesel and B30, B40, B50. It is found that the exhaust temperature of reference diesel is lower than all the blends at all the load conditions. It is seen that the B30 blend gives 7% and 5.75% higher exhaust temperature than the diesel at 70% and 100% load respectiv1ely. This may be due to the breaking of molecular bonding which leads to rise the exhaust temperature.



Exhaust gas temperature at full load for Normal Diesel and B30 , B40, B50

V. CONCLUSION

In the present study, Experimental investigation were conducted with Normal Diesel , Biodiesel blends (B30 , B40 and B50 Karanjia oil) and their blends with Al_2O_3 Nanopartical at different concentration (30 ,40 , 50 PPM). The thermal performance, emission and combustion characteristics were studied in a 5.2 kW engine running at 1500 rpm at full load condition.

The main findings of the experimental investigation are summarized as follows:

1. Biodiesel (Karanjia oil) is an alternative fuel that is cleaner and used directly as fuel for a diesel engine without having to modify the engine system. It has the major advantages of having high biodegradability, excellent lubricity and no sulfur content.

2. An increase in thermal efficiency by about 3 % and reduction of NOx by about 4 to 7% were observed in B40+30 PPM as compare to Normal Diesel

For all the biodiesels, hydrocarbon and carbon monoxide emission were lower with increase in saturation levels of Nanopartial with bends. The smoke emission was same for biodiesels blends. Higher Nanoparticle saturation with B50 blends which higher the cetane number and lesser the NOx emission.

2. It was observed that the NOx and hydrocarbon emissions reduced with increase in saturation percentage in biodiesel blends while the smoke emissions increased.

3. As the B30, B30+30 and B30+40 produced significant reductions in the CO, HC, and smoke emissions compared with standard diesel and B50 But thermal performance decrease for the above.

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