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COMPARITIVE ANALYSIS OF NO_X AND SMOKE EMISSIONS OF BINARY DIESEL/ JME BLENDS DOPED WITH Al_2O_3 NANOPARTICLES STABILISED BY DEE AS SOLVENT AND TRITON-X100 and BRIJ58 SURFACTANTS

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ABSTRACT

According to this study, nanosized fuel carried additions to the tri-fuel blends on the engine performance and vibrations are investigated in detail. The tri-fuel mix, which is classified as DEE5BD25-Al_2O_3 np, is composed of diethyl ether (DEE) in the proportion of 5 percent, biodiesel Jatropha methyl ester (JME) in the proportion of 25 percent, and diesel in the proportion of 75 percent. DEE is a well-known high-cetane ignition improver and nanoparticle suspension stabilizer. To achieve the required results, the Al_2O_3 nanoparticles were sized at 25nm and concentrated from 25ppm to 50ppm in a binary diesel/JME mix. In order to suspend the nanoparticles in this fuel mix, the surfactants Trtion-X100 and Brij58 were selected independently and used in an ultrasonic liquid processor. The introduction of DEE into the binary diesel/JME mix has also changed it with nanoparticles and non-ionic surfactants, resulting in an improvement in the physicochemical characteristics. According to the findings of the testing, TFB with Al_2O_3 np had a 1.25 % greater brake thermal efficiency than clean diesel. The use of a higher percentage of Al_2O_3 np is not advised owing to the inactive heat dissipation in the fuel mix, as well as the possibility of a reduction in the chemical activity of the fuel catalyst. The addition of Al_2O_3 np to this fuel mix decreased NOx emissions by 200ppm compared to the use of straight diesel fuel alone. The results indicate that Brij58 outperformed the Trition-X100 surfactant in TFB, and that the amount of smoke produced is mostly dependent on the surfactant used. Triton-X100 produced less smoke when compared to the Brij surfactant, while Al_2O_3-B emitted 69.1 HSU compared to 57.7 HSU for Triton-X100. Triton-X100 released less smoke when compared to the Brij surfactant.

Keywords: Jatropa, Al_2O_3Nano particles, DEE, Surfactants, NHRR, CHRR, NOx, Smoke.

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INTRODUCTION

Compression ignition engines may benefit from the use of diethyl ether (DEE), which has certain appealing characteristics. Using DEE in combination with vegetable oil/diesel fuel may provide diesel engine owners with a new alternative for diesel engine fuel.[1] Bioethanol, a sustainable fuel, may be used to make jatropha oil via the process of dehydration. Because of its low autoignition temperature and high volatility, it is an excellent cold starting additive in both diesel and gasoline engines.[2] Compression ignition engines may run on DEE straight or in a mixture with diesel. In comparison to diesel, DEE's autoignition temperature is lower. The high flammability and low storage stability are also issues to be aware of. Due to the anesthetic effect, it may cause harm to human health.[3,4] However, there is a scarcity of data on the use of DEE as a major component of a biodiesel blend.[5] The optimum ETOH content is between 40 and 60 percent, with 50 percent DEE and 50 percent ETOH injection time for the two methods.[6] In view of the improved thermal efficiency and improved injection time, it was determined that 10% of DEE was the optimum quantity. According to the results of the tests, the mix significantly

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reduced smoke and CO levels across the loads.[7] Performance and emission parameters show that a DEE-Diesel mix of 5 percent is the most efficient. Diesel fuel interferes with the ignition process, and adding DEE lowers the Cetane number of diesel fuel significantly.[8,9] Antioxidants may help keep things from becoming oxidized.[10] DEE can be manufactured at a reasonable cost.[11] This was done by keeping the methanol-to-Jatropha oil volume ratio at a constant 3:7. A similar quantity of methanol is required to produce the ester from Jatropha oil, which is comparable.[12] The thermal efficiency of the brakes was higher in the case of the dual-fuel experiment. The ignition delay was longer while using plain Jatropha oil. The maximum pressure and the rate at which the pressure increased were higher with all of the methods. The estimated smoke discharge is 4.4 Bosch Smoke Units (BSU) with Jatropha oil neat, 4:1 BSU with the blend, and 4 BSU with the mixture.[13] Ceria has a fluorite structure (a generally open structure with easy oxygen transport). It is a crucial ionic oxide that has a large surface area and nano-size particles.[14] As an additional component in a diesel-biodiesel-ethanol mix, cerium oxide nanoparticles may be employed to enable complete fuel burning and emission reduction.[15] Adding cerium to diesel reduces dispersion and light-off temperatures by a significant margin. The rate of oxidation was increased.[16] The unexpected nature of ethanol interactions on metal/cerium oxide surfaces is an impetus for further investigation.[17] Aluminium oxide serves as an oxygen-giving catalyst, allowing CO to be oxidized while ingesting oxygen to reduce NOx. According to the results of the experiments, aluminium oxide nanoparticles may be used as an additive in diesel and diesel-biodiesel-ethanol blends.[18,19] While only a small amount of research has been done on nanoparticles as an additive to biodiesel, experimental investigations into the engine performance and emission characteristics of DEE and nanoparticles as additives in Jatropha biodiesel blends with non-ionic surfactants have been carried out in a small number of research studies. As a result, the primary focus of the present research is on a comparison of the performance and emission characteristics of Al_2O_3 nanoparticles dispersed in biodiesel and utilized in a single-cylinder direct injection diesel engine—the nano-additions to biodiesel act as a catalyst for the combustion process. When the amount of net heat generated inside the combustion chamber grows, the BTE rises, but the BSFC decreases. With the exception of NOx, these nanoparticles also help to reduce CO_2, HC, and other pollutants in the atmosphere. The duration of suspension of nanoparticles in biodiesel blends is referred to as their "stability" in the biodiesel blends.[20] Sufficient surfactant is needed for successful coating because it neutralizes electrostatic repulsive forces and balances Van der Waals attraction forces.[21] Significant reductions in BTE were seen when the surfactant content of the produced diesel fuel nanoemulsions was increased to 10% wt.[22] The type of surfactant used has a significant impact on the viscosity of nanofluids.[23]

EXPERIMENTAL

The world's use of fossil fuels has increased steadily in recent years as a result of increased energy demand, resulting in a reduction in the world's fossil fuel reserves.[24] The rising expense of fossil fuels, along with environmental degradation, has prompted the quest for alternate sources of energy.[25] Many researchers have transesterified vegetable oils using solid acid heterogeneous catalysts such as Zeolites, sulphonic acid groups, mixed metal oxides, polyoxometalates, and heteropoly acids, among other things.[26] Biomass is now the most advantageous renewable source of energy, and this trend is expected to continue in the foreseeable future.[27]

Kinematic Viscosity of the Al_2O_3 -np

Figure-1 shows that adding nanoparticles increases the kinematic viscosity of the diesel/JME binary blends. A lack of lubrication is caused by the use of fuel injection pumps or injector plungers with low viscosities, which leads to increased wear. The surfactants Triton-X100 and Brij58 were examined individually and added to the binary diesel-JME blends to produce a stable suspension of nanoparticles. Sonication utilizing an ultrasound liquid technique at a 20 kHz frequency and keeping it at a steady room temperature for two seconds can stabilize TFB with Al_2O_3 nanoparticles. TFB with Al_2O_3 nanoparticles in a stable solution with Triton-X100 and Brij58 surfactants may be observed in Fig.-2 (right).

Uncertainty Analysis

Uncertainty analysis is crucial to the precision of experimental findings. Observation, environment, and instrument type are all variables that contribute to experimentation-related uncertainty. A minimum of 30 minutes of running the engine is recommended before performing a test with any load since this helps keep the water's cooling temperature stable during the trial. Graphs are created by averaging engine data collected over three runs under various loads. The Uncertainty Analysis for engine efficiency, emission and smoke parameters has revealed that the uncertainties observed and calculated experimental values with the 95% confidence levels range from 58 to 1.97 percent at injector pressure 210bar. Sample calculation of total uncertainty in the measurement of SFC was found to be at 0.7864 %.

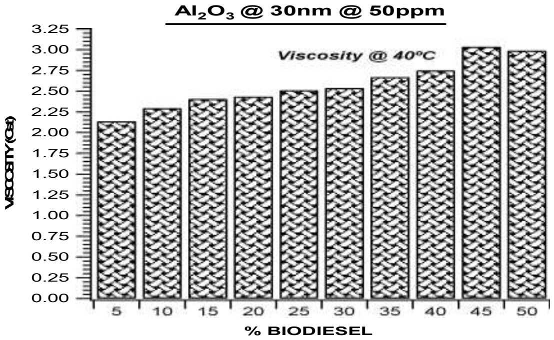

Fig.-1: Kinematic Viscosity of TFB with NP

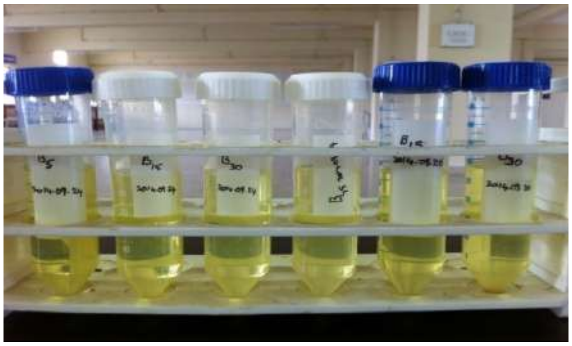

Fig.-2: Stability of TFB with NP

Procedure

A water-cooled engine having 3.5 kW as the rated power and a speed of 1500rpm was used to test the various fuel samples. The fuel supply system for high-pressure injections includes a high-pressure pump powered by an electric motor. Diesel, Biodiesel, and Diethyl Ether are the fuels tested in the single-cylinder diesel engine, together with nano metallic Aluminium Oxide. The particle size was normalized to 25nm using a ball milling machine, and the concentrations of Triton-X100 and Brij58 surfactants were 1000ppm and 250ppm, respectively. Dosing levels for microparticles in TFB range from 25 ppm to 50 ppm. In order to collect data, the engine is operated under various operating circumstances over a lengthy period of time (around 2-3 hours). The fuel sample came from a vehicle engine with a computerized single cylinder variable compression engine and an eddy current dynamometer for changing engine loads. The engine is driven for 30-40 minutes until there is no noticeable change in the water line temperature. The fuel consumption of a 10cc engine was measured three times, with the average used in the rest of the computations.

Fig.-3: Computerized Multifuel High-pressure Engine Test Rig

The amount of smoke produced was assessed using a Diesel Tune 114 smoke meter from Indus Instruments Pvt. Ltd., Bangalore, which was approved by India's Automotive Research Authority. The following are the different parts of the experimental setup: 1. Data logging software installed on a computer 2. Internet Protocol (Ethernet) 3. Sensor unit for calculating fuel consumption 4. Smoke meter 5 gas exhaust analyzer 6. Tank for fuel 7 and 8. Diesel injectors and exhaust silencers 9. Tank for incoming air 10. The Pruftechnik Vibration Measurement 11Instrument Cell with a load 12. Governor of fuel flow a high-pressure fuel injection pump Control system for a computer Throttle control 16. Load indication 19.

Angle encoder for the crankshaft 19. Speed dag 20. AC-to-DC converter Eddy current dynamometer with an air-cooling system. The experimental setup is shown in Fig.-3.

RESULTS AND DISCUSSION

Brake-specific fuel usage varies for various np concentrations in Triton-X100 and Brij58 surfactant, as shown in Figs.-4 and 5. A trifuel mix including nanosized Al_2O_3 particles reduces its specific fuel consumption as the load on the engine rises. Figures-4 and 5 demonstrate that Al_2O_3 has a superior SFC at 25 ppm and 50 ppm concentrations when using Triton or Brig 58 surfactant, respectively. This is because Al_2O_3 has a greater thermal conductivity and burns more quickly, as well as better premixed combustion. B25DEE-Brig58 for Al_2O_3 nanoparticles has the lowest specific fuel consumption of 0.31kg/kWhr at full load, while diesel has 0.34kg/kWhr. Fuel mix JME25 has been modified with 5% DEE and nanoparticles, resulting in a decrease in SFC. Tiny quantities of nanoparticles may have a significant impact on SFC[28,29]. When added in small amounts. Of particular, the greater combustion efficiency is to thank for the advancement in SFC technology. An improvement in combustion efficiency from more oxygen and the beneficial effects of aluminium nanoparticles on the physical characteristics of diesel fuel lowers the BSFC. When tiny quantities of DEE are added to butanol fuel blends, the viscosity improves, and the SFC decreases when compared to plain diesel fuel.[30] This was also observed by S. Imtenan et.al. The thermal efficiency of the brakes is dependent on the engine parameter, which shows how well fuel energy is transformed into mechanical output. Brake thermal efficiency improves with increasing load, as seen in figures 6and7. The greatest brake thermal efficiency is achieved with a B25DEE mix including Al_2O_3 – B25ppm, whereas plain diesel only achieves a brake thermal efficiency of 27.78 percent.[31,32] The test fuel's evaporation time is reduced because of the nano-Al_2O_3 addition, which lowers the physical delay. As the dose of Al_2O_3 nanoparticles is increased, no improvement in thermal brake performance is s seen.

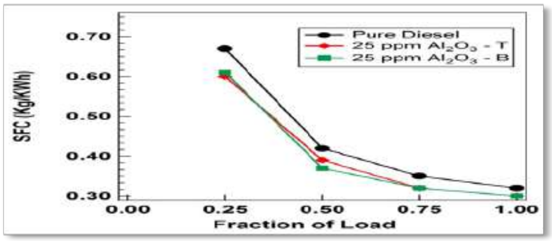

Fig.-4: SFC against Fraction of load for 25ppm Al_2O_3-T and 25ppm Al_2O_3-B and pure diesel

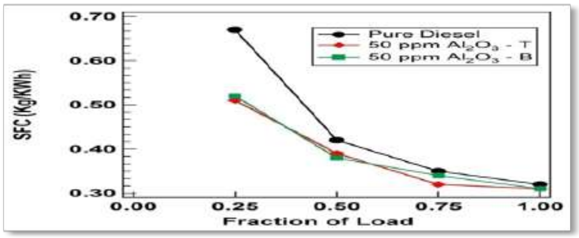

Fig.-5: SFC against Fraction of load for 50ppm Al_2O_3-T and 50ppm Al_2O_3-B and pure diesel

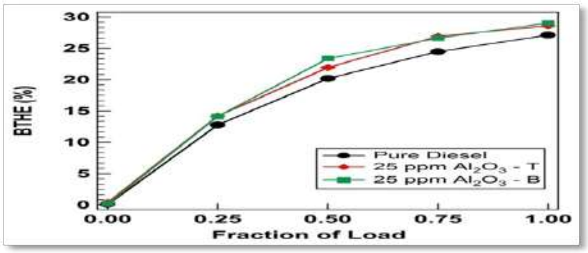

Fig.-6: BTHE against Fraction of load for 25ppm Al_2O_3-T and 25ppm Al_2O_3-B and pure diesel

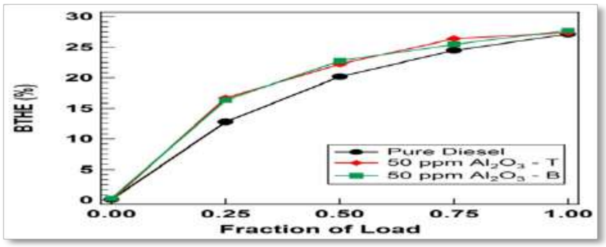

Fig.-7: BTHE against Fraction of load for 50ppm Al_2O_3-T and 50ppm Al_2O_3-B and pure diesel

This may be due to the fuel mix not being able to disperse heat as well owing to the higher concentration of nano particles.[33,34] Similar results have been reported for J20 biodiesel blends containing 5% DEE, which improved brake thermal efficiency by 2.8%, and for 10% DEE, which raised brake thermal efficiency by 5.3%[35]. However, owing to the flash point temperature, the quantity of DEE in the binary Jatropa-diesel mix of J25 is restricted to 5% in our current study. As a consequence, the current findings indicate that adding Al_2O_3 –B25ppm with 5% DEE improved brake thermal efficiency by 1.25 percent, in line with previously published findings as stated. Figures-8 and 9 illustrate how the air-to-fuel ratio changes when np concentration changes while the engine is running under various loads. When the engine speed was set at 1500 rpm and the engine load was changed, the air-to-fuel equivalency ratio rose. This can be seen in Figs.-9 and 10. Al_2O_3 nanoparticles at greater concentrations show an increase in the equivalent ratio, suggesting that adding more of the nanoparticles may improve leaner combustion.[36] In an oxygen-rich atmosphere, Al_2O_3-np participates in combustion owing to its high surface area. Figures 9 and 10 show that diesel and TFB-np have an equivalency ratio that is comparable at ¾ and full load operating circumstances, suggesting that TFB-np promotes lean combustion at these settings. TFB-np achieves this low Al_2O_3-np concentration lean combustion with less Al_2O_3-np. When the Al_2O_3-np concentration is raised to 50 ppm, the equivalence ratio decreases, suggesting aggregation of Al_2O_3-np particles that are not actively involved in the combustion process, resulting in rich mixture burning. Figures-14 and 15 show a similar trend in HC emissions. With an increasing load, CO_2 percentage drops concurrently, as shown by figures 10 and 11. Trifuel mixes include oxygenated fuel Diethyl ether and biodiesel, which oxidizes carbon monoxide into carbon dioxide. The reduction of CO emissions was made possible by using nanoparticles made of metal oxide. Nanoparticles with improved ignitability. Figures-10 and 11 show that CO and CO_2 emissions are mostly dependent on the kind of nanoparticles being used because the trends are the same for Triton and Brij surfactant.[37,38] Figures-10 and 11 show that Triton-X100 and Brij58 surfactant make a trade-off when it comes to CO and CO_2.

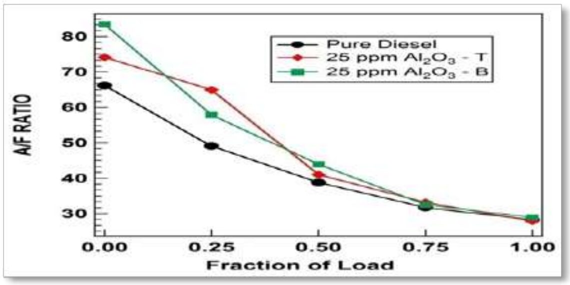

Fig.-8: A/F ratio vs Fraction of load for pure diesel, 25ppm Al_2O_3-T and 25ppm Al_2O_3-B

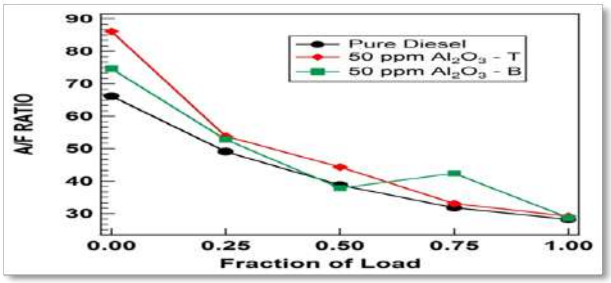

Fig.-9: A/F ratio vs Fraction of load for pure diesel, 50ppm Al_2O_3-T and 50ppm Al_2O_3-B

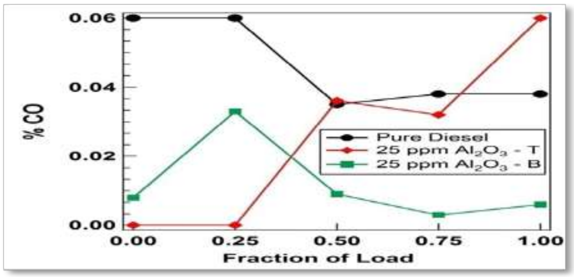

Fig.-10: %CO Vs Fraction of Load for pure diesel, 25ppm Al_2O_3-T and 25ppm Al_2O_3 -B

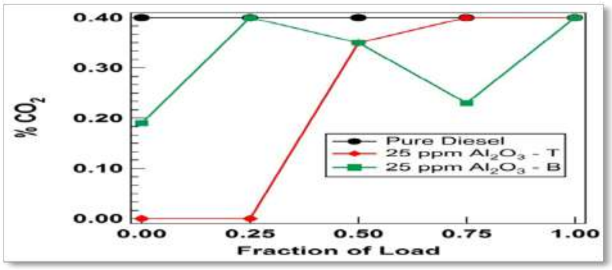

Fig.-11: $\%CO_2$ Vs Fraction of Load for pure diesel, 25ppm Al_2O_3-T and 25ppm Al_2O_3-B

At full load, Triton-X100 emits 0.06 percent more CO than the industry standard of 0.01 percent. Similar to Triton-X100, the CO percent rises steadily with increased engine load for Brij58. However, the quantity of CO percent emitted falls as the engine load rises for Brij58. Brij58 has the same CO_2 trade-off behavior. A tri-fuel mixture including Al_2O_3-np and both Triton-X100 and Brij58 surfactants produces less CO_2 and less particulate matter than pure diesel. The CO emissions were decreased as a result of the enhanced combustion associated with the use of Alumina nano-additive diesel fuels. The amount of gasoline provided was smaller when the loads were low (i.e., the mixture remains lean, which produced lesser heat resulting in lower flame temperature). Sadhik Basha et al. found similar outcomes using cerium oxide nanoparticles in binary diesel blends.[39] Sharma et al. found that a mix of Jatropha biodiesel and Carbon nanotube showed improved combustion owing to shorter for 100 ppm dosed carbon nanotubes in jatropha biodiesel[40], ignition delay results in the greatest decrease of CO emission. Figures-12 and 13 demonstrate that when the load rises, the NOx emissions rise as a result of the higher combustion temperatures. Increases in nanoparticle concentration for Triton –X100 and Brij58 surfactants result in lower NOx emissions.[41] This is because the SOC has been slowed down. For Al_2O_3–B25, the SOC is -12CAD, whereas, for plain diesel, it is -9CAD. Nanoparticles of metal oxide help the process of full combustion because they accelerate oxidation and conserve oxygen in the combustion chamber. Triton-X100 lowers NOx emissions more than Brij58 surfactant, according to the findings.

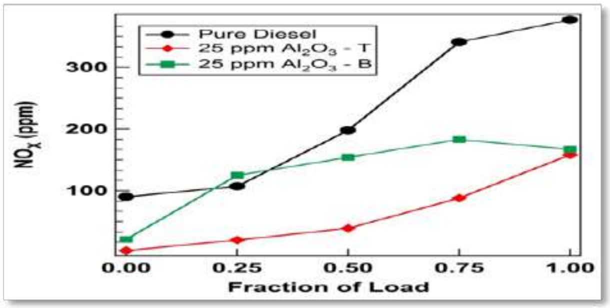

Fig.-12: NOx Vs Fraction of Load for pure diesel, 25ppm Al_2O_3-T and 25ppm Al_2O_3 -B

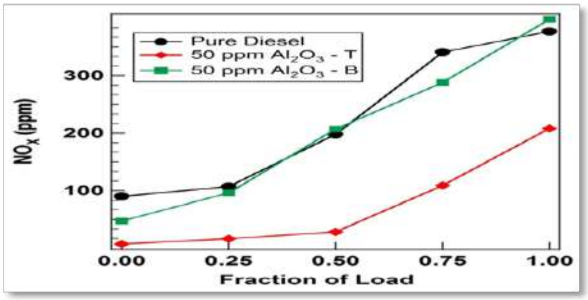

Fig.-13: NOx Vs Fraction of Load for pure diesel, 50ppm Al_2O_3-T and 50ppm Al_2O_3-B

The Al_2O_3 –T50ppm and Al_2O_3 –B25ppm complying with Euro3 standards provide the highest NOx reduction up to 200ppm.[42] The NOx reduction efficiency of nanoparticle doped additive binary diesel/JME fuel is higher. Triton-X100 reduces NOx emissions at all engine loading situations more efficiently than plain diesel, as seen in Figs.-23 and 24. When the Al_2O_3 -NP concentration is restricted to 50ppm, both Brij58 and neat diesel fuel emit the same amount of NOx. In reducing NOx emissions, lower concentrations of 25ppm Al_2O_3-np for both Triton-X100 and Brij58 surfactant are very effective, as shown in Figs.-12 and 13. When the number of nano particles in TFB blends rises, NOx emissions rise in lockstep. Selvan et al. reported similar results using multiwalled carbon nanotubes (MWCT).[43] Despite this, Sadhik basha et al found that when Alumina nanoparticles were added to plain diesel, the amount of NOx emissions was somewhat reduced.[44] Since no ignition improver was employed to regulate the combustion effectively, the reduction in NOx was minimal. As demonstrated in the current study, the addition of DEE and Al_2O_3-np to the binary Diesel/JME mix significantly reduced NOx emissions compared to plain diesel (Figs.-12 and 13). Figures-14 and 15 illustrate the changes in HC emissions due to engine load. Biodiesel emits fewer hydrocarbon compounds (HC) than diesel because of improved combustion of the test fuel and its additive mix owing to the presence of oxygen. The release of HC gas indicates an incomplete combustion process. Since the cylinder pressure and temperature are both low, this results in a relatively low burning rate (as seen in Fig.-14); as load increases, the amount of HC emissions increases. When Triton-X100 and Brij58surfactants are used in the tri-fuel mix, the HC emissions are substantially decreased thanks to Al_2O_3 nanoparticles. Both Al_2O_3 nanoparticles and surfactants at 25 ppm concentration decreased HC emissions, although the reduction was smaller than with plain diesel. This is because of the full burning of the fuel owing to DEE and metal oxide nanoparticles, which have a higher oxygen content.[45] Alumina nano-additive diesel fuels were shown to have a slightly lower carbon footprint than plain diesel, according to Idris et.al. The enhanced combustion properties of diesel fuel's nanoparticles were to blame. At greater loads, the Alumina nanoparticle acts as an oxidation catalyst, resulting in a minor decrease in HC emissions owing to the hydrocarbon oxidation effect. They also found that the magnitude of the HC emission did not vary much at low or moderate loads.[46] Figures-25 and 26 show substantial reductions in HC emissions both at half loads and full loads in the current study. The regulated dosing of Al_2O_3–np and the selection of appropriate non-ionic surfactants like Brij58 and Trtion-X100 enable this substantial decrease in HC emissions. Figures-16 and 17 illustrates the change in O_2 with increasing load, showing that O_2 declines with increasing load. Figure-10 shows the findings obtained, which are in agreement with those obtained using CO. Since nanoparticles are metallic oxides, which produce more oxygen during oxidation, a rise in their O_2 percent also occurs with increased nanoparticle concentration. Blends with higher oxygen concentration will burn cleaner, resulting in higher BTE, as seen in Figs.-4 and 5. The presence of smoke in the diesel engine exhaust is a sign of inefficient fuel combustion[47]. Lower smoke opacity is a result of higher mix oxygen concentration, as seen in Fig.-17. When the engine is operating on a binary diesel/JME fuel blend-np with DEE and surfactants as indicated in Figs.-18 to 21 under various engine loading circumstances, smoke measurements are performed using an Indus Diesel smoke meter.

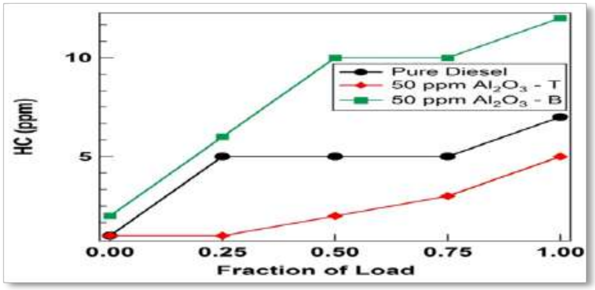

Fig.-14: HC Vs Fraction of Load for pure diesel, 50ppm Al_2O_3-T and 50ppm Al_2O_3 -B

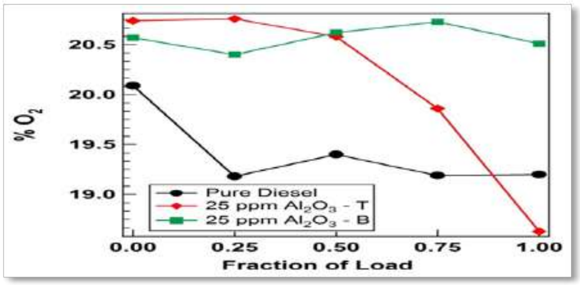

Fig.-15: %O_2 Vs Fraction of Load for pure diesel, 25ppm Al_2O_3-T and 25ppm Al_2O_3-B

In addition to conductivity "K', the device measures smoke in Hatridge smoke units (HSU) and standard deviation (SD). Figures 18-21 illustrate the changes in smoke emission for engines operating at a constant speed under various loading circumstances, and the test results are shown for nanoparticles of varying sizes. For all circumstances of engine loading, this tri-fuel mix with Al_2O_3 nanoparticles combined with Triton-X100 and Brij58 surfactant passed the smoke test with flying colors, suggesting that biodiesel Jatropha methyl ester and Diethyl ether may be to blame for the reduced smoke intensity. The small rise in smoke intensity caused by the presence of a higher concentration of microparticles is normal. When comparing Brij58 surfactant to Triton-X100 surfactant for the same fuel combination, the intensity of the smoke increased from 57.7HSU to 69.1HSU, indicating that Brij58 surfactant gives more smoke at part loads, but for full engine operation, the intensity of the smoke is almost the same as that of Triton-X100 surfactant. Figures-19 to 21 show the findings, which agree with them since the K/M variation is the same as HSU's. Results indicate that Al_2O_3 nanoparticles confirm that the intensity of the smoke is mostly determined by the surfactant used.[48]

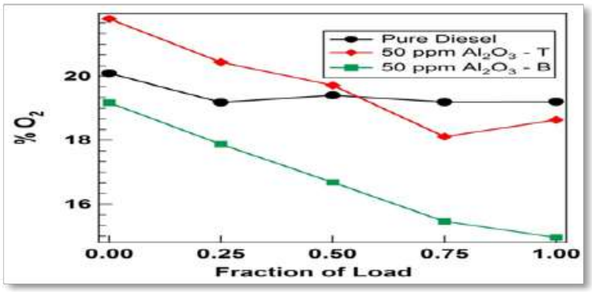

Fig.-16: %O_2 Vs Fraction of Load for pure diesel, 50ppm Al_2O_3-T and 50ppm Al_2O_3 -B

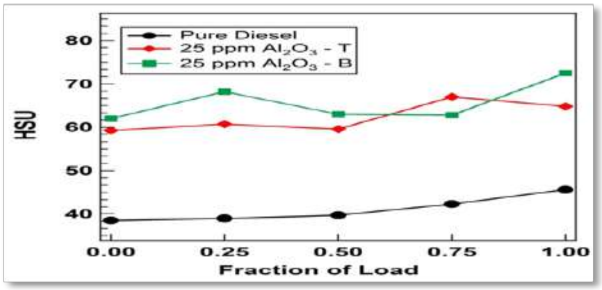

Fig.-17: HSU Vs Fraction of Load for pure diesel, 25ppm Al_2O_3-T and 25ppm Al_2O_3-B

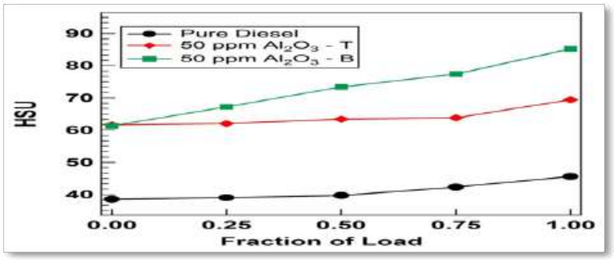

Fig.-18: HSU Vs Fraction of Load for pure diesel, 50ppm Al_2O_3-T and 50ppm Al_2O_3 -B

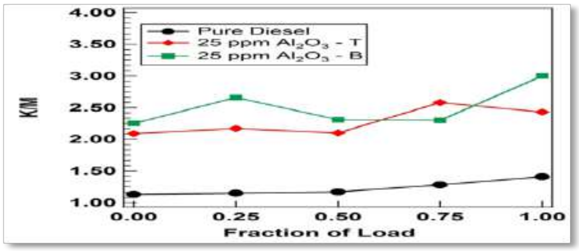

Fig.-19: K/M Vs Fraction of Load for pure diesel, 25ppm Al_2O_3-T and 25ppm Al_2O_3-B

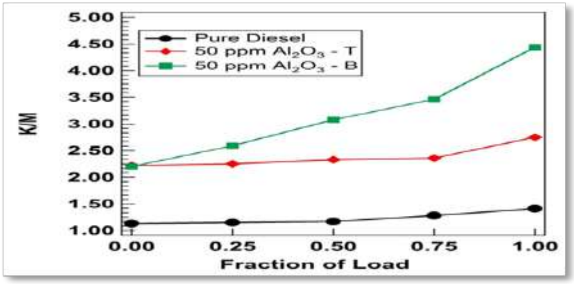

Fig.-20: K/M Vs Fraction of Load for pure diesel, 50ppm Al_2O_3-T and 50ppm Al_2O_3 -B

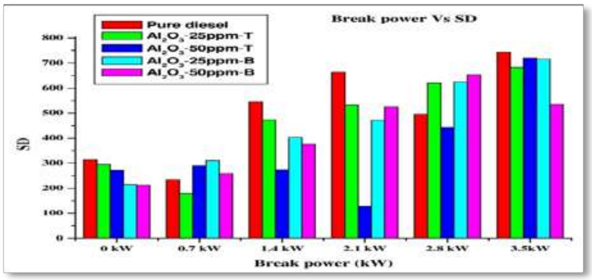

Fig.-21: SD Vs Break Power for pure diesel, 25ppm Al_2O_3-T ,25ppm Al_2O_3-B, 50ppm Al_2O_3-T and 50ppm Al_2O_3 -B

CONCLUSION

The following conclusions may be drawn from the experiments: From 50ppm to 100ppm, surfactant concentration improves viscosity slightly. ASTM regulations restrict the amount of DEE to 5% owing to the flashpoint at 400°C. As nanoparticle size and concentration rise, viscosity increases. The dosage dose of Al_2O_3 nanoparticles has no effect on the thermal efficiency of the brake. The outcome is in line with SFC values. Al_2O_3 –B25ppm with 5% DEE improved the thermal efficiency of brakes by 1.25. At higher engine loads, 25ppm Al_2O_3 promotes lean combustion with a 38:1 equivalence ratio vs 32:1 for 50ppm Al_2O_3. In both Triton-X100 and Brij58 surfactants, Al_2O_3-np particles of 25ppm had nearly the same equivalency ratio as plain diesel fuel. Both Triton-X100 and Brij58 surfactants benefit from a lower 25ppm Al_2O_3-np concentration. The addition of DEE to binary diesel/JME blends reduced both NOx and HC emissions. The combination of Triton-X100 and Brij58 increased smoke levels compared to plain diesel, which only released 48HSU vs 62HSU for Triton-X100. Brij58 released 82HSU compared to Triton-62HSU. X100's This study demonstrates that Triton-X100 surfactant is incompatible with Al_2O_3 nanoparticles in tri-fuel. The tri-fuel mix containing Brij58 surfactant performed better. The tri-fuel mix B25DEE5 with Al_2O_3 nanoparticles of size 25nm is best at 25ppm with Brij58 as the surfactant. 250ppm surfactant is ideal. Higher Al_2O_3 nanoparticle concentrations above 25ppm have no effect on engine performance or emissions. A stable suspension of Al_2O_3 -np fuel mix with DEE was obtained by adding DEE to the fuel blend with Triton-X100 and Brij58 surfactants. The current study showed that low nanoparticle concentrations in gasoline blends perform best for non-ionic surfactants in reducing NOx emissions. Also, in the presence of Al_2O_3 nanoparticles in fuel blends, Ignition improver DEE is required for efficient reduction of both NOx and HC emissions.

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