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Analysis of Diesel Engine Characteristics with Selective Vegetable Oil Biodiesel.

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ABSTRACT

Exhaustion of petroleum possessions, energy precautions and climate transform are the major motivating forces for universal bio-fuel development which also ensures the prospective to reassure the agro-industry. Vegetable oils may offer substitute and their impending has been studied in the early years by numerous researchers. The chief objective of the study is to equate performance and pollution features of biodiesel resulting from the selective vegetable oil based biodiesel of Jatropha oil, Pongamia oil, Neem oil and Waste Cooking oil in the diesel engine with baseline results of diesel fuel. The outcomes from the tryouts recommend that biodiesel resulting from Neem biodiesel (N20) and Pongamia biodiesel (P20) could be a good alternate to diesel fuel in a diesel engine in the upcoming years as far as reorganized energy making is concerned. The Neem and Pongamia oil have sizable forecasts as a stretched tenure alternate for diesel fuels.

Keywords: Engine, Vegetable Oil, Biodiesel, Performance, Pollutants

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INTRODUCTION

Ever mounting population, heightening the living standard of humanity, industrialization and the worldwide claim for energy is projected to rise expressively in the upcoming years. To resolve energy and environmental anxieties, there is an imperative need to search environment kindly, cost effective, renewable energy bases. The rise in crude oil rates, restricted possessions of fossil fuels and the ecological alarm were enforced to renew emphasis on vegetable oils and biodiesel fuel. Finding substitute sources of fossil fuels for diesel engines is a major imperative due to thinning petroleum assets and the environmental concerns of exhaust gases from fossil fueled engines. The claim of fossil fuel rises day to day, the need to catch a renewable energy base becomes more vital all over the world. The secondary to diesel fuels necessities to be idealistic and globally acceptable, and economically feasible. Vegetable oil is one of the substitute fuels designed to spread the efficacy of petroleum, the elasticity and purity of diesel engines. Vegetable oils and biodiesel have the prospective to diminish the level of pollution and global warming.

Sizable quantity of examination has been conceded towards the combustion and pollutant features of diesel engines powered by diesel - biodiesel blends. Researchers were found that the BTE of Jatropha oil and its methyl ester remained closer to diesel, fuel consumption is higher for jatropha oil and its blend, HC and CO emission were upper with Jatropha oil as equated to diesel, smoke denseness was also noticed high, EGT rises with the load and the NO_X emission level upsurges with load (1-5). Researchers were tested the Karanja Methyl Ester and observed the increased BTE, lowered BSFC, reduced emissions like CO, smoke and NO_X for all blends with and without preheating are inferior than mineral diesel at all load conditions (6-9). Researchers were reported that the lesser CO and smoke emission, but upper NO_x emission for Neem blends. Lower BTE was chiefly owed to its higher viscosity equated to diesel and BSFC was lower at part load and higher at maximum load (10-14). Researchers were experimented with Waste Cooking Oil (WCO) and noticed that the biodiesel blends burned more competently with improved fuel economy and further created lesser emissions, including lesser carbon monoxide and UBHC, noticed that the brake thermal efficiency of WCO was marginally greater than that of standard diesel, the SFC of the blend is inferior than the other blends and diesel (15-19). The intention of this analysis is to study the enactment and emissions of a CI engine fueled with selective vegetable oil based biodiesel.

MATERIALS AND METHODS

The prospect of utilizing vegetable oils as fuel has been acknowledged ever since the launch of CI engines. Vegetable oil has higher a viscosity for usage in most prevailing CI engines as a conventional auxiliary fuel. There are dissimilar methods to lessen the vegetable oil viscosity. Dilution, Transesterification, Emulsification and Pyrolysis are the four practices to resolve the difficulties met by the high viscosity. The best collective method used to shrink oil viscosity in the biodiesel production is termed as transesterification. Organic alteration of oil to its identical oily ester is named as transesterification (20).

Biodiesel Production Process

The schematic of the biodiesel production method as shown in Figure 1 is as follows:

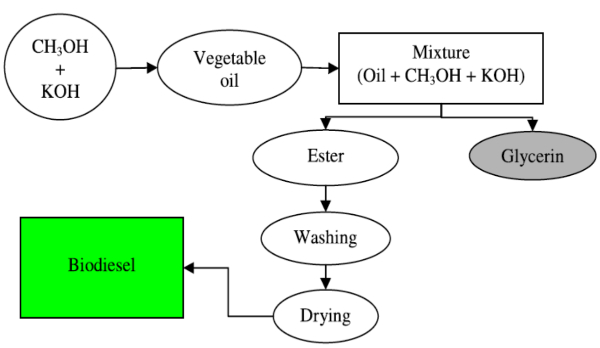

Fig 1: Schematic of the biodiesel production method

The drive of the transesterification procedure is to lessen the oil viscosity. The transesterification ensues fine in the firm of certain identical substances such as potassium hydroxide, sodium hydroxide and sulphuric acid, or dissimilar compounds such as metal oxides or carbonates. Sodium hydroxide is well recognized and extensively utilized, because of its lower cost and higher yield (21). Transesterification is the exercise of switching the alkoxy cluster of an ester combined with added alcohol. These responses are often catalyzed by the tallying an acid and base. Bases can catalyze the response by eradicating a proton in the alcohol, thus creating it added responsive; whereas acids can catalyze the response by contributing a proton to the carbonyl group, therefore building it further responsive (22).

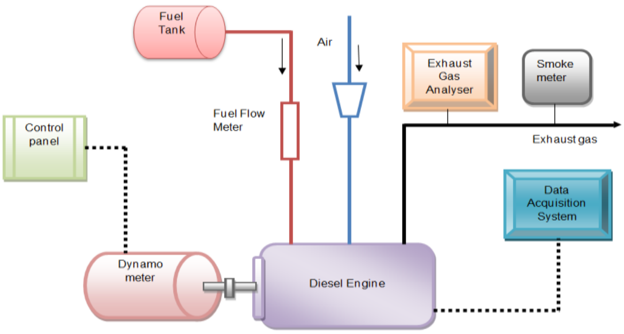

Fig 2: Experimental Setup Line Diagram

Table 1: Fuel properties of biodiesel

Properties	Jatropha Biodiesel	Pongamia Biodiesel	Neem Biodiesel	WCO Biodiesel
Density (kg/m^3,40^{0}C)	862 - 886	865 – 898	820 - 942	887
Viscosity (mm^2,40^{0}C)	3.0 - 5.65	3.8 - 9.6	3.2 - 10.7	5.16
Flash Point (^{0}C)	180 – 280	110 – 187	-	122
Cetane Number	43 – 59	36 – 61	51 – 53	48
Calorific Value (MJ/kg)	37.2 – 43.0	36.0 – 42.1	39.6 – 40.2	36.59

EXPERIMENTAL WORK

Experimentation was conceded on a KIRLOSKAR Model SV1, single cylinder, four strokes, water cooled diesel engine and the performance and pollutant features of the engine with biodiesel blends were gauged and equated using the outcomes of diesel. The exhaust emissions were quantified by a Crypton290 series Exhaust Gas Analyzer and AVL make Smoke meter was utilized to size the smoke intensity.The engine was started and run to achieve the stable condition and the engine load was increased gradually to maximum recommended value. The applications of loads were 0%, 25%, 50%, 75%, and 100% respectively. The engine speed was constant at 1800 rpm. Fig. 2 demonstrates the experimental organization. For every load stages, the quantity of fuel consumption, exhaust gas temperature, fuel injection timing, crank angle, hydrocarbon (HC) emission, carbon monoxide (CO) emission, nitrogen oxides (NO_X) emission, smoke emission, combustion chamber pressure and HRR were conceded and recorded the data for several loads. The diesel and biodiesel blends were tried at standard engine specification at normal injection timing 27^0 BTDC, injection pressure of 200bar with compression ratio of 17.5.

Table 2: Engine specifications

Manufacturer	KIRLOSKAR Oil Engines Ltd
Engine Type	Single cylinder Diesel engine
Speed	1800 rpm
Rating at 1500 rpm	5.9 kW
Compression Ratio	17.5:1
Fuel Injection Timing	27˚ BTDC

Method of Cooling	Water Cooling
Injection Pressure	200 bar

RESULTS AND DISCUSSION

Brake Thermal Efficiency (BTE)

Fig.3 shows that the maximum brake thermal efficiency (BTE) for diesel at 75% load is 27.48 %, whereas BTE decreases by 2.35%, 4.37%, 5.21% and 5.36% N20, J20, P20 and WCO20 blends at 75% load respectively. It was clear that the BTE characteristic for diesel was higher and lesser for all biodiesel blends. This impact is owing to the lesser calorific rate and enlarged biodiesel viscosity. Since diesel was less viscous, atomization would be comparatively better, which causes better combustion and thereby can produce higher thermal efficiency.

Specific Energy Consumption (SEC)

Fig.4 displays that the SEC at full load for diesel is 14766.43kJ/kW-hr, where SEC rises by 8.86%, 21.1%, 21.3% and 22.4% for N20, J20, P20 and WCO20 blend at full load correspondingly. It was appreciated that the SEC for diesel was minimum and uppermost in the case of all biodiesel mixtures. This might be owing to the lesser energy content of biodiesel when equated to diesel.

Hydrocarbon (HC) Emissions

Fig.5 illustrates the HC emission for diesel at full load is 74ppm, whereas it declines by 8.2%, 5.2%, 1.4% and 2.6% for N20, J20, P20 and WCO20 at full load blend correspondingly. The HC emission for diesel was uppermost and smaller in the case of all biodiesel combinations. This might be owing to the fact that all the biodiesel comprise oxygen in their chemical structure.

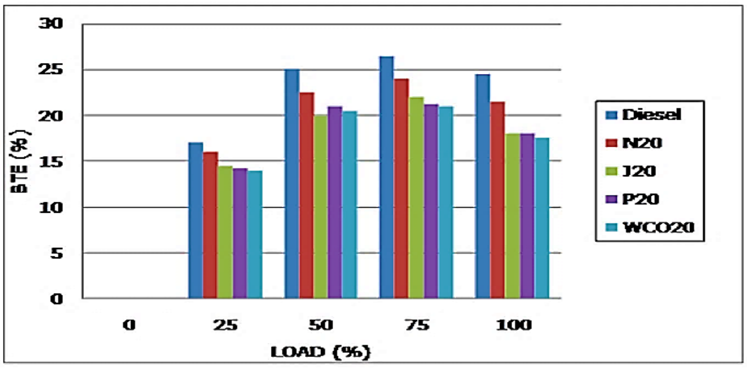

Fig 3: Brake Thermal Efficiency vs. Load

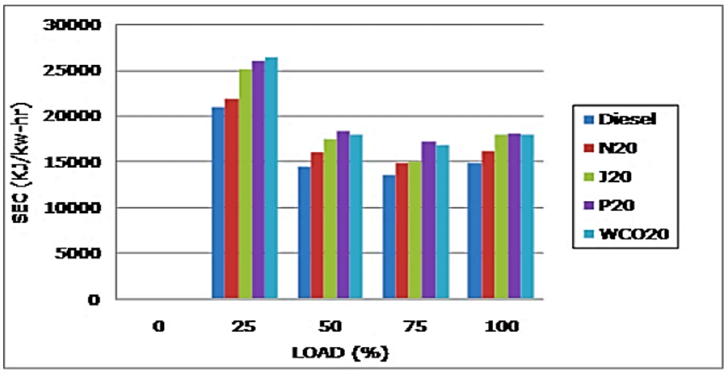

Fig 4: Specific Energy Consumption vs. Load Carbon Monoxide (CO) Emissions

Fig.6 displays that the CO emission for diesel at full load is 0.09%, whereas it is 0.075%, 0.08% and 0.085% for N20, J20 and P20 blend at maximum load correspondingly. For all the combinations, Carbon monoxide emission decreases with a rise in brake power. The CO emission for diesel was uppermost and least in the case of all biodiesel mixtures. This influence is owing to the lesser carbon to hydrogen ratio of biodiesel when equated with diesel.

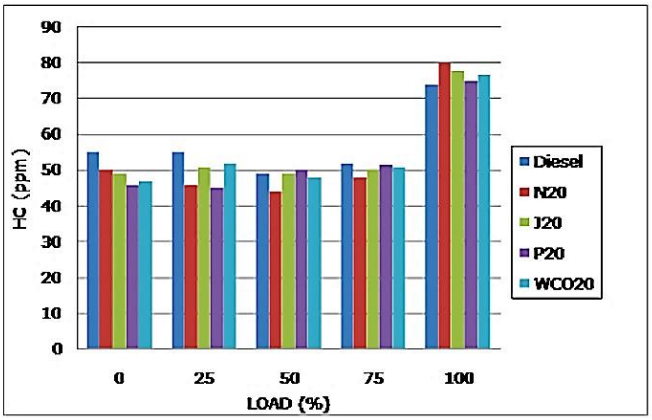

Fig 5: Hydrocarbons vs. Load

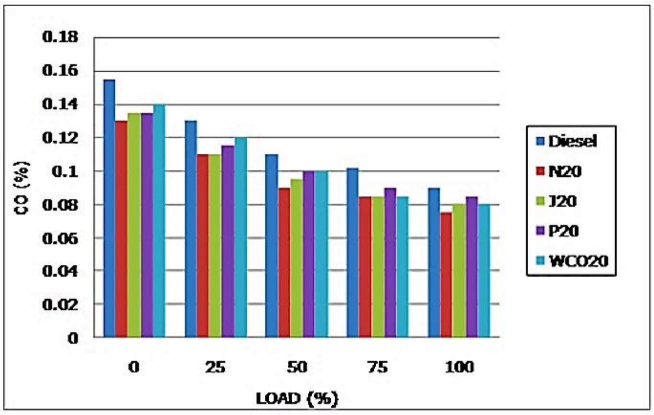

Fig 6: Carbon Monoxide vs. Load

Nitrides of Oxygen (NO_X) Emissions

Fig.7 shows that the NO_X emission for diesel at full load is 483 PPM, whereas it is more by 17.8%, 12.2%, 7.3% and 5.7% for N20, J20, P20 and WCO20 blend at maximum load respectively. The NO_X emission for diesel was least and more in the case of all biodiesel mixtures. The presence of oxygen in the biodiesel had led to the proper burning of biodiesel better than diesel and leading to high adiabatic flame temperature inside the cylinder was more in case of biodiesel than diesel and hence NO_X emission was more for biodiesel.

Exhaust Gas Temperature (EGT)

Fig.8 displays that the EGT accelerates with brake power rise. The Exhaust gas temperature for diesel at full load is 417°C, whereas it is more by 54°C, 37°C, 26°C and 21°C for N20, J20, P20 and WCO20 blends at maximum load respectively. This might be due to the sharp increase in fuel consumption rates at higher loads for biodiesel than their blends. It was also due to the improved quality of biodiesel, which further loads to quick burn, and liberate more heat and high temperature.

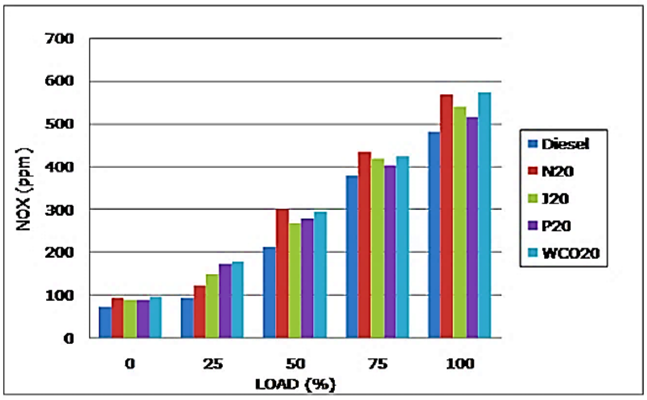

Fig 7: Nitrides of Oxygen vs. Load

Smoke Opacity

Fig.9 shows that the Smoke opacity for diesel at maximum load is 52.3HSU, whereas it was more by 3.8 HSU, 5.6 HSU, 6.3 HSU and 7.4 HSU for N20, J20, P20 and WCO20 blend at maximum load respectively. The Smoke opacity features for diesel was smallest and upper in the case of all biodiesel mixtures. This was owing to the poor atomization of biodiesel blends as equated with diesel.

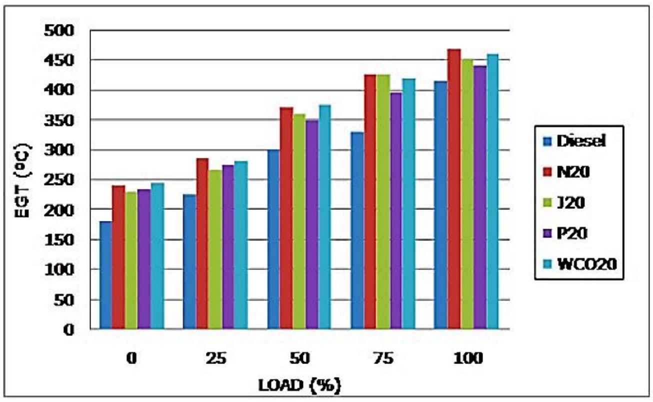

Fig 8: Exhaust Gas Temperature vs. Load

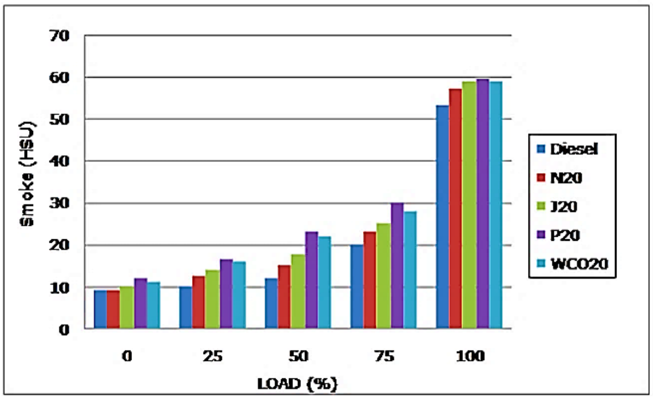

Fig 9: Smoke Opacity vs. Load

Cylinder Pressure

The ultimate peak pressure was perceived at 75% of load for all fuels (Fig.10). The peak pressure in neat diesel at 75% of load was 77 bar, whereas it declines by 14.3%, 18.2%, 20.5% and 23.1% for N20, J20, P20 and WCO20 blend at three fourth of load correspondingly. This might be owing to the rise in delay period and improper diffusion, which effects in lesser pressure in the burning chamber for the biodiesel combinations when equated with diesel. Among all the biodiesel mixtures, N20 blend had higher Peak pressure at 75% of load. This might be owing to the lowered viscosity and enlarged calorific value, which clue to better burning equated to other biodiesel blends. The cylinder pressure is prejudiced on the fuel burned in the premixed burning stage in compression ignition engines. Cylinder pressure symbolizes the competency of the fuel to mingle healthy with oxygen and burn. Upper crowning pressure and extreme pressure rate rise correspond to more amount of fuel burned in premixed burning phase.

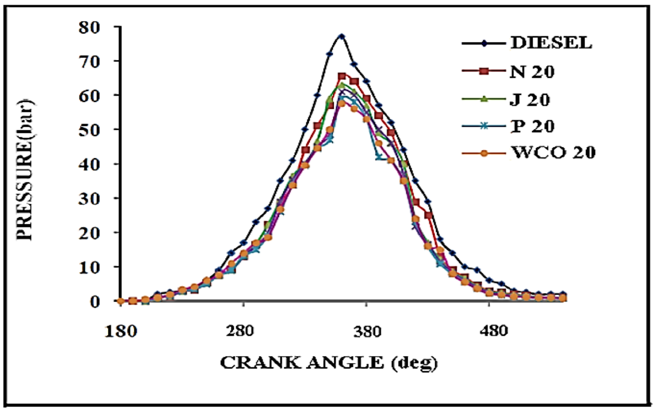

Fig 10: Cylinder Pressure vs. CA

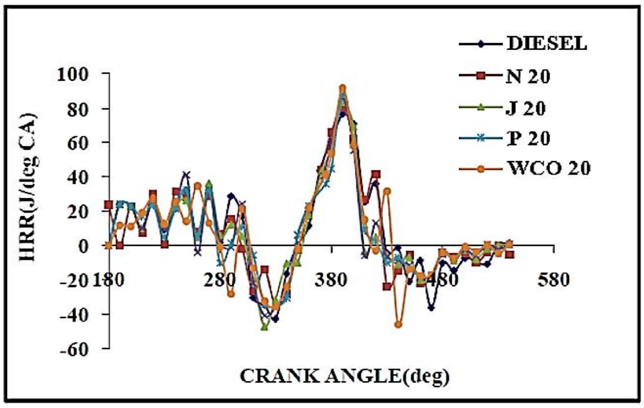

Fig 11: Heat Release Rate vs. CA

Heat Release Rate (HRR)

The HRR of neat diesel at 75% of load was 76.5 J/deg CA, where as it rises by 4.5%, 8.7%, 11.3% and 13.2% for N20, J20, P20 and WCO20 blend at 75% of load respectively (Fig.11). This might be owing to the poor diffusion, which sources the exhaust gases to escape out at a greater rate for the biodiesel mixtures when equated to diesel. Among all the biodiesel blends, N20 blend had a lower heat release rate at 75% of load. This is due to the fact that the heat utilized well for combustion process when equated to other biodiesel combinations. The temperature in theburning chamber throughout the initial phase of burning was notsufficient to entirely combust the biodiesel blends. This effect inquick burning after TDC and henceforth there was an upswing in HRR in the event of biodiesel blends equated to diesel. The amount of energy out as a result of burning was categorizedby the heat release perspective which could be distinct as the crankangle interval requisite concerning the start of the burning and theperiod when a substantial portion of heat energy was out.

CONCLUSIONS

Biodiesel is a stand-in fuel and cleaner than diesel. It could be utilized straight as fuel for CI engine with no modifying the engine system. It has high biodegradability, excellent lubricity and no sulfur content.

From the experimental results, it was clear that the BTE of N20 was 2.35% lesser than diesel owing to the reduced calorific value and increased viscosity of biodiesel. SEC was increased by 8.86% for N20 as compared to diesel due to low energy content of biodiesel. HC emissions decreases by 8.2% for N20 as compared to diesel due to the fact the biodiesel contain more oxygen which improves combustion. CO emission decreases by 0.005% for P20 as compared to diesel due to low carbon to hydrogen ratio of biodiesel. NO_X emission increases by 7.3% for P20 as compared to diesel due to high adiabatic flame temperature. EGT increases by 26^0C as compared to diesel due to increased fuel consumption at higher loads. Smoke intensity increases by 3.8HSU for N20 as compared to diesel due to poor atomization of biodiesel blend. Maximum peak pressure decreased by 14.3% for N20 as compared to diesel due to reduced viscosity and increased calorific value. Heat release rate increases by 4.5% for N20 as compared to diesel due to maximum heat utilization for better combustion.

Biodiesel blends of N20 and P20 produces better performance and reduced emission characteristics as compared to standard diesel.

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