Nanoparticle Additive to Plastic Biofuel

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Abstract - *Waste plastic in municipal solid wastes degrade very slowly over several millions of years and poses a serious challenge for a sustainable environment. Hydrocarbons embodied in waste plastic could be converted into liquid fuel. Employing waste plastic oil (WPO) in diesel engines offers a sustainable solution for ecological safety and energy security. The properties of the oil derived from waste plastics were analyzed by previous researchers and they found that it has properties similar to that of diesel. Hence a comparative study was conducted taking in the theoretical data and experimental values of the properties and performance characteristics of Waste Plastic Oils (WPOs) with Jatropha and Rubber seed oil biodiesels with additives and an experiment was conducted utilizing three control groups (100% Diesel Fuel (DF), JRP20, and JRP20+Al2O3 nanoparticles). Their performance and emission characteristics were tested in a Variable Compression Ratio (VCR) Compression Ignition (CI) engine.*

Key Words: Waste Plastic oil 1, Jatropha oil 2, Rubber seed oil 3, VCR engine 4, Aluminium Oxide 5, Nanoparticle 6.

1.INTRODUCTION

The In the beginning of the 20th century, research went into the production of environmentally derived oils that can act as substitutes for diesel and petrol (vis-à-vis fossil fuels). Initially different oils were taken into consideration, that were derived from different kinds of nuts (eg. Groundnut oil, Rubber seed oil), but then research spread out into the study of oils utilizing FAME (Fatty Acid Methyl Esters) i.e. formation of fatty acid alkyl esters and glycerol. Although blends of these individual oils with diesel were able to reduce carcinogenic emissions significantly, their calorific value, as well as the Brake Thermal Efficiency (BTE) could not match up to the full performance characteristics of diesel fuels.

From the middle of the 20th century, different kinds of plastics have emerged, catering to every need of the commercial and industrial sectors, as well as consumer needs. Over the last 100 years, the use in these plastics have been rising exponentially to a point where a significant chunk of the world's solid waste is in the form of plastics. These plastics remain non-biodegradable, and remain on the earth's surface for millions of years, threatening the chemical integrity of the Lithosphere. Their incineration also releases gases like CO2, NOx, CO, SOx, etc, which act as greenhouse gases, and partake in advancing the global warming effect on the earth's atmosphere. An estimated 275 million metric tons (MT) of plastic waste was generated in 192 countries in 2010 and its disposal is critical from an environmental point of view.

Another area of research that has sprung up over the last decade, is in the area of waste plastic oils. Plastics are essentially a form of stored energy and the hydrocarbons embodied in them can be later converted into liquid fuel by pyrolysis or de-polymerization. The calorific values of polyethylene and polypropylene are comparable to that of diesel and petrol and the oils derived from these sources can be prospective fuels to internal combustion engines which are heavily dependent on fossil reserves that are facing near depletion. Diesel engines are efficient, durable and serve as powertrains in public transportation, power generation, heavy-duty, agricultural and industrial equipment. Waste plastic oil (WPO) as a fuel offers a sustainable solution for conservation of both environment and energy.

The objective that this present study aims at presenting a comparative analysis between the properties of waste plastic oils and three FAME derived oils (namely Jatropha oil, Rubber seed Oil, and Waste Cooking Oil), as a review between their properties and characteristics, in order to determine the most suitable fuel for usage in a Compression Ignition (CI) Diesel Engine. The properties of the fuels taken into consideration are listed and a decision is taken based on the trends seen from the theoretical data available, as well as experimental data available. Using the data procured, an experiment was conducted, aiming at a niche gap in research regarding the addition of additives into WPO-based blends, to evaluate their performance and emission characteristics. The methodology involved utilizing three control groups of fuels (100% Diesel Fuel (DF), JRP20, and JRP20+Al2O3 nanoparticles), wherein their performance and emission characteristics were calculated from a Variable Compression Ratio (VCR) Compression Ignition (CI) engine. Their performance and emission characteristics were recorded and plotted out for conducting a comparative study, and for utilization in further research.

1.1 Experimental Set up

The experimental set up consists of a VCR engine whose compression ratio can be varied from 5:1 to 20:1, AVL make DI Gas analyser and AVL smoke meter to analyse the performance and emission characteristics. The engine specifications were given in the table below.

Engine Specifications

No: of Cylinders	1
Injection Type	Direct Injection
Cooling System	Water - Cooled
Bore	0.08m
Stroke	0.11m
Piston Offset	0.00002m
Connecting-rod Length	0.235m
Compression Ratio	18:1
Cycles Averaged	20

Fuel Properties

Sample	Calorific Value (MJ/kg)	Density (kg/m3)
Jatropha, Rubber seed oil, Waste Plastic Oil blend	37.7129	866
JRP Mixture (20%) & Diesel (80%) blend	42.4056	821

1.2 Experimental Procedure

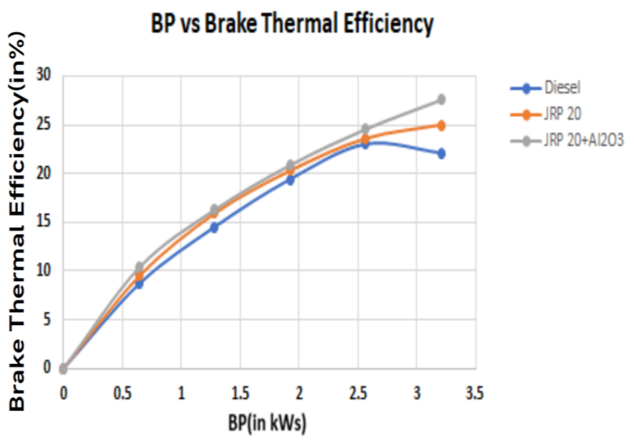
The blending of fuels and nanoparticle addition was done prior to the experiments and then the emission and performance characteristics of fuel blends were measured at a rated speed of 1500 rpm at no load and varying Brake Power conditions. The outputs were accessed by various sensors attached to the VCR engine and the datas were recorded by the data acquisition software to the computer unit. The BTE, BSFC of the engine, as well as cylinder pressure values were obtained directly from the unit attached to the engine. The AVL DI gas analyzer gave a reading of the Emission parameter levels present in the exhaust. The temperature of the lubricating oil was maintained between 85 and 90 °C. The engine was made to run for 10 min to allow stabilization before the readings were recorded. Each test was repeated three times and the values were averaged to improve reliability. These data were all correlated and categorically analyzed to produce the results into a graphical form, depicting the differences and diversions from the experimental mix, when compared to conventional diesel and a conventional biodiesel blend.

2. RESULTS AND DISCUSSIONS

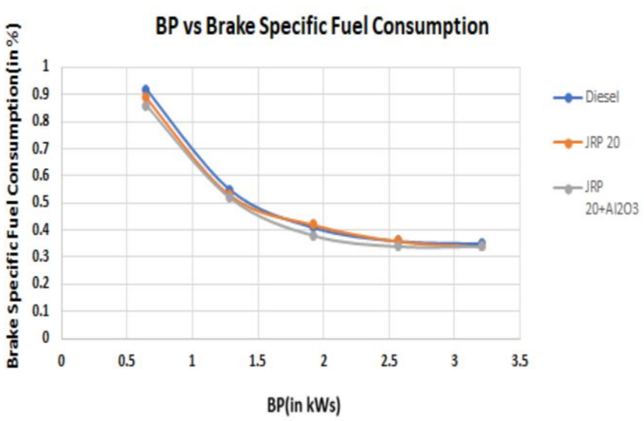
The results obtained from the experimental investigations on emission and performance parameters using diesel, JRP20, and (JRP20+Al2O3) are presented and discussed in this section.

2.1 Performance Characteristics

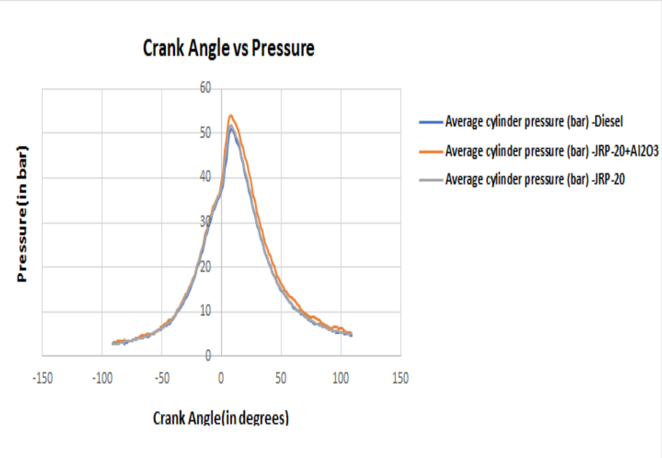
2.1.1 Brake Power Vs Brake Thermal Efficiency



2.1.2 Brake Power Vs Brake Specific Fuel Consumption

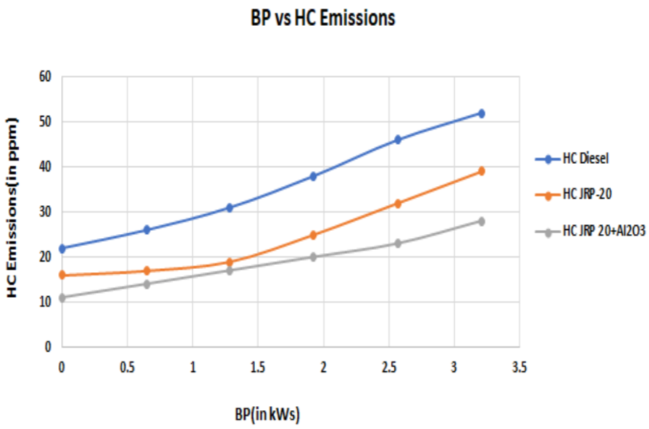


2.1.3 Pressure Vs Crank Angle

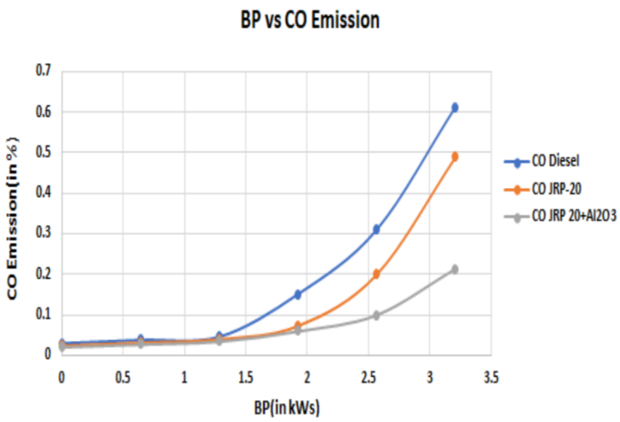


2.2 Emission Characteristics

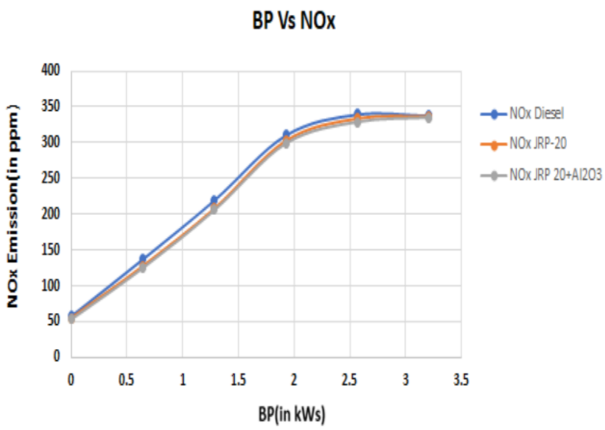
2.2.1 Brake Power Vs Hydrocarbon



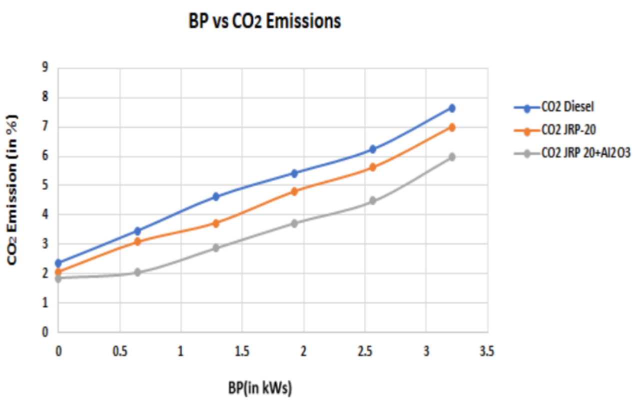
2.2.2 Brake Power Vs Carbon Monoxide



2.2.3 Brake Power Vs Oxides of Nitrogen



2.2.4 Brake Power Vs Carbon Dioxide



3. CONCLUSIONS

Comparative research between various fuels was done and it was concluded that waste plastic oil when combined with Jatropha and Rubber seed-based biodiesel along with nanoparticle additives formed an effective substitute for the conventional diesel fuel. Then an experimental analysis between Diesel Fuel, JRP20 and JRP20+Al_2O_3 fuel was carried out on the basis of emissions and performance on a single-cylinder VCR DI diesel engine. The fuel mixture of the JRP20+Al_2O_3 composition showed the best performance with 1.6% increase in BTE when compared with diesel and 1% increase when compared with JRP20. Compared to diesel, BSFC of JRP20+Al_2O_3 is 2-6% lower and with JRP20 it is 1-3% lower. On analyzing peak pressure values JRP20+Al_2O_3 showed the highest value followed by JRP20 and then Diesel. On examining emission characteristics, JRP20+Al_2O_3 showed the lowest values for CO, HC, CO_2 and NOx emissions. It was also observed that on analyzing O_2 emission, JRP20+Al_2O_3 held the highest value. Another advantage of this devised blend is that there is no need for any changes in engine design. So, JRP20+Al_2O_3 may be used as a suitable counterpart for Diesel fuel in the CI engine. Further studies can be conducted on the efficacy of other nanoparticles, the optimal quantity of nanoparticles that can be utilized, as well as utilizing lower amounts of other combustion enhancer additives in the fuel blend, to reduce HC and CO emissions.

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