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Performance Analysis on PP blended Bio-Diesel tested on a CI Engine

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ABSTRACT:

The presence of existing fossil fuels has come to an extinction stage from where feasibility and further availability is very much restricted. This led to the introduction of novel biofuels by blending them with existing diesel. In recent day's plastics plays a major role in the human society in all aspects in day-to-day life. The decomposition of these materials nearly takes hundreds of years when dumped under the earth and causes many hazards to the environment in which we live. Hence recycling of these materials plays a vital role. This can be done in many ways; one among them is to convert them in to fuels by pyrolysis process in which the plastic is thermally degraded under vacuum stage to extract the plastic oil. All types of plastic wastes can be converted plastic oil but in our work we are mainly concentrating on the Polypropylene (PP) wastes. This is preferred as it is used in a very vast quantity everywhere because it is used in packing materials, as cans holding chemicals, low cost to make and posses' good strength too. This material is used in a very large quantity in automobile industries and medical appliances. This material plays a major consumption of about 19.5% which is next to polythene of about 33.5%. The main drawback of this material is it is not an easy one to recycle as it burns and chars on heating. Hence it is a very costly process to recycle. Hence alternative sources such as pyrolysis are highly preferred. In this work the pyrolysised PP was blended with pure diesel of about 4% to 12% and the performance test was conducted on four-stroke constant speed water cooled Kirloskar CI diesel engine. The performance parameters such as indicated power, brake power, friction power, fuel consumption and mechanical efficiency were evaluated. These values where then compared with the existing pure diesel's performance. The results projects more are less equal performance in all aspects.

KEYWORDS:

Polypropylene; Plastics; Bio Diesel; CI Diesel Engine; Pyrolysis

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1. Introduction

Dumping lots of polymer waste has created very high global impact in the environment and the pyrolysis of the same can reduce such impacts. Polypropylene content will increase the formation of alkanes and its octane rating [1]. The increase in cetane content in the PP based fuel helps the engines to avoid premature ignition and resist knocking. The demand for more fuel and an increased number of vehicles on roads has increased the cost of the existing fuel. This can be reduced by introducing the alternative bio diesel [2]. With respect to the various types of alternative fuels announced, only a very little can be produced in large quantity [3] one among that is the fuels extracted from plastics as it is available in large quantity as wastes. Most of the alternate fuels possess better pollution properties against oxides of nitrogen and soot [4]. The recycling of the polymer fuels makes it eco-friendly and helps in increasing the performance of the engine [5]. The biofuel powered vehicles plays a vital role in the enrichment of the global ecological impact and to maintain the freshness in the atmospheric air [6].

The polymer powered materials plays a major role in our day today life in various aspects because of it good properties. It provides additional strength when it is added with some other materials. It can be used as a very good fuel when blended with diesel. This fuel will increase with increase in usage of plastics and its leftovers [7]. Pyrolysis is an innovative technology used to convert the plastic material into its respective fuel to produce mechanical energy in vehicles. These oils, which are produced out of polymeric material, have enhanced calorific values when compared to existing fossil diesel fuel [8]. As the plastics were produced from petroleum products which can be recycled to its earlier stage [9]. Pyrolysis process helps to recover most of the energy from the plastics at lower cost [10-11]. The factors that influence the production of oil by pyrolysis method are: temperature maintained; selection of the reactors for the purpose; time given for the process; pressure maintained and finally the gas and catalyst selected for the process.

For the polypropylene material a thermal degradation temperature of about 350°C was maintained. Temperatures between 300°C and 500°C were suggested for all the types of plastics [12-13]. The prepared fuel was blended with diesel in various proportions, and it was identified that bio diesel with 20% addition can be used in diesel engine without modifying the engine [14]. Produced fuel should be globally accepted, cost wise and easily manufactured [15]. The test conducted using plastic biofuel indicated that this fuel has higher energy conversion, and lower greenhouse pollutions. The fuel extracted from polypropylene can be used as a potential additive [16].

2. Materials and methods

The process of decomposing chemically all the organic contents present at higher temperature is known as pyrolysis. PP waste in the form of packing materials, cans etc. were collected and crushed into pieces using a pulveriser. The crushed PP material was fed into the pyrolysis reactor in which it was heated to about 300°C to 500°C. The PP material starts to melt when the degrading temperature of PP was attained around 240°C. The oil starts evaporating at 350°C and converted gaseous form. Then the evaporated gas is passes through the condensing chamber where it is condensed to liquid form. Some gaseous which couldn't liquefy was allowed to pass through and collected in another chamber. Once this process was complete, the liquefied fuel was allowed to settle down by cooling so that the carbon content can be removed easily. The produced fuel is blended with the pure diesel in the range of 4%, 8% and 12% out of 100% of pure diesel. The blending proportion is tabulated in Table 1. The blended fuels were then subjected to performance analysis on four stroke constant speed water cooled Kirloskar CI diesel engine. The blended fuel was named as A, B and C. The pure diesel as D and are tested on the CI engines to obtain the indicated, brake and friction power initially followed by fuel consumption and mechanical efficiency.

Table 1: Composition of biofuel

Abbreviation	Fuel composition
A	PP 4% + Diesel 96%
B	PP 8% + Diesel 92%
C	PP 12% + Diesel 88%
D	Diesel 100%

3. Results and discussion

In this experiment all the tests were conducted by varying the loads in kg. The load vs. fuel test was conducted in various aspects and finally the end results were tabulated as follows. The indicated power can also be represented as the actual horsepower. This is the exact theoretical power available in the crank during the process of operation of the engine. The intended data for indicated power by varying the loads are shown in Table 2. The results show the pure diesel exhibits better IP followed by 4%, 8% and 12% plastic fuel respectively. The brake power, also called brake horsepower, is the actual power available in the crank after evaluating all the losses due to friction. The calculated data for brake power by changing the loads are shown in Table 3. The results emphasize that, apart from pure diesel, 4% plastic oil added biofuel exhibited better brake power when compared to 8% and 12% added biofuel.

Table 2: Load vs. Indicated power

Load (kg)	4% Plastic oil IP (kW)	8% Plastic oil IP (kW)	12% Plastic oil IP (kW)	Pure diesel IP (kW)
0.04	2.21	2.19	2.16	2.22
4.40	3.56	3.52	3.49	3.63
9.03	4.63	4.61	4.57	4.64
12.60	5.79	5.78	5.75	5.81
17.04	6.64	6.62	6.60	6.66

Table 3: Load vs. Brake power

Load (kg)	4% Plastic oil BP (kW)	8% Plastic oil BP (kW)	12% Plastic oil BP (kW)	Pure diesel BP (kW)
0.04	0.02	0.01	0.01	0.02
4.40	1.31	1.30	1.29	1.32
9.03	2.53	2.54	2.57	2.52
12.60	3.71	3.69	3.66	3.72
17.04	4.78	4.76	4.72	4.80

The friction power is the power available after the absorption of all the losses due to friction. The evaluated values for friction power by varying the loads are shown in Table 4. The fuel with 4% plastic fuel additive exhibited a slightly better performance than 8 and 12% additives. This is represented as the quantity of fuel utilised for travelling a certain distance. This can be evaluated as fuel used in litre/distance covered in kms. The calculated records for fuel consumption by varying the loads are shown in Table 5. At lower load level all the fuels showcased equal amount of fuel consumption rates. But when it moves on with higher load, the fuel with 12% and 8% outperformed the other two. The mechanical efficiency by varying the load applied on the engine was tabulated in Table 6. The specimen with 4% and 8% added plastic fuel has outperformed diesel and 12% at varying load conditions.

Table 4: Load vs. Friction power

Load (kg)	4% Plastic oil FP (kW)	8% Plastic oil FP (kW)	12% Plastic oil FP (kW)	Pure diesel FP (kW)
0.04	2.17	2.16	2.13	2.19
4.40	2.23	2.12	2.09	2.32
9.03	2.04	1.98	1.92	2.14
12.60	1.87	1.82	1.80	1.93
17.04	1.62	1.64	1.66	1.58

Table 5: Load vs. Fuel consumption

Load (Kg)	4% Plastic oil fuel (kg/hr)	8% Plastic oil fuel (kg/hr)	12% Plastic oil fuel (kg/hr)	Pure diesel fuel (kg/hr)
0.04	0.32	0.32	0.33	0.32
4.40	0.57	0.58	0.60	0.57
9.03	0.80	0.83	0.84	0.79
12.60	1.06	1.05	1.08	1.07
17.04	1.25	1.29	1.29	1.24

Table 6: Load vs. Mechanical efficiency

Load (kg)	4% Plastic oil mech. eff. (%)	8% Plastic oil mech. Eff. (%)	12% Plastic oil mech. Eff. (%)	Pure diesel mech. eff. (%)
0.04	0.66	0.62	0.59	0.87
4.40	39.89	39.11	38.94	37.96
9.03	56.17	56.04	55.80	55.78
12.60	69.04	68.89	66.74	66.66
17.04	76.94	76.89	76.07	77.05

4. Conclusion

The tests conducted using varying load conditions on a CI engine for the pyrolysised PP based polymer oil along with pure diesel. The indicated power at 0.04 kg load for 4% of plastic oil has a difference of about 0.01 kW and increased to about 0.02 kW at 17.04 kg load. The brake power at 0.04 kg load is 0.02 kW for 4% plastic oil which is equal to the BP at the same load condition of that of diesel. At higher load condition the brake power for 4% plastic oil shows a slight deviation of about 0.02 kW with respect to diesel. The friction power too exhibits a deviation of 0.02 to 0.04kW at minimum and maximum load condition. The fuel consumption for all the fuels said to be close to equal, which shows a deviation ranging from 0.00 to 0.04 kg/hr when compared to diesel. Finally, the mechanical efficiency of all the plastic blended fuels shows a fantastic performance nearing equal to diesel which makes this PP blended bio diesel a passive-aggressive fuel to be used as an alternative one for diesel.

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