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Experimental Investigation to Study the Performance and Emission Characteristics of Diesel Engine by Using Waste Plastic Oil- Diesel Blend

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Abstract

This paper investigates the possibility of replacing diesel with an alternative fuel. The Alternative fuels used in this paper are waste plastic pyrolysis oil blended with diesel. The blends are tested for properties like viscosity, flash point, fire point and calorific value, density and then compared with the properties of diesel to ensure that the alternative fuel is similar to the diesel. Then only we can use this alternative fuel for our performance and emission test that conducted on the single cylinder four stroke diesel engines. The results of this investigation proves that the above made blends may be used an alternative fuel for diesel in engines and automobiles as the shows similar physical properties as that of diesel.

Keywords: *Diesel, Ethanol, Waste plastic oil [WPO], Pyrolysis, Blend, flash point, Fire point, Viscosity, Calorific value*

1. Introduction

The Economic growth and changing consumption and production patterns are resulting into rapid increase in generation of waste plastics in the world. The increase in generation cause waste plastics becoming a major stream in solid waste. After food waste and paper waste, it is observed that plastic waste is the major constitute of municipal and industrial waste in cities. Even the low economic growth cities are also aim on producing more plastic waste due to plastic packaging, plastic shopping bags, PET bottles and other goods/appliances which uses plastic as the major component. This leads to the major challenge and responsible for local authorities for solid waste management and sanitation. Most of the plastic waste is neither collected properly nor disposed of in appropriate manner to avoid its negative impacts on environment due to the lack of solid waste plastic management and this leads to public health and waste plastics are causing littering and chocking of sewerage system.

On the other hand, to collect and dispose of plastic waste in the most environmental friendly way and it can be converted into a resource will greatly helpful for plastic recycling methods. Plastic waste recycling could also concentrate to be economically viable, as it generates resources, which are in high demand. In the current environmental condition, Plastic waste recycling could also

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has a great potential for resource conservation and GHG emissions reduction, such as producing diesel fuel from plastic waste. Rapid industrialization and economic development is putting a lot of pressure on natural resources, this leads to the resource conservation goal is very important for most of the national and local governments. Some of the developed countries have already established commercial level resource recovery from waste plastics for a remedial measure to reduce the amount of waste plastic. Waste plastics are now become one of the most promising resources for fuel production because of its high heat of combustion and due to the increasing availability in local communities.

Unlike paper and wood, plastics do not absorb much more moisture. So that the water content of plastics is far lower than the water content of biomass such as crops and kitchen wastes. The conversion methods of waste plastics into fuel depend on the types of plastics to be targeted and used in the process also the properties of other wastes that might be used in the process.

The production method for the conversion of plastics to liquid fuel is based on the pyrolysis process of the plastics, which is the burning of waste plastic in the absence of oxygen and also the condensation of the resulting hydrocarbons. Pyrolysis refers to the thermal decomposition of the matter under an inert gas like nitrogen. The boiling point of the produced oil is controlled by the operation conditions of the reactor, the type of reactor, and presence of catalyst used in the pyrolysis process.

2. Experimental Study

The method of preparation of waste plastic oil, experimental methods for obtaining various fuel properties and performance and emission analysis of waste plastic oil , ethanol and diesel blend .

2.1 Production of Waste Plastic Oil

2.1.1 Fabrication Setup

The reactor is constructed in the work shop from metal sheet in mechanical work shop. First the metal sheet is rolled, and then welded. The dimensions of the reactor are 60centimeter height and 80centimeter diameter. In the thesis work batch reactor was used because it is simple to operate. GI pipes of one inch diameter are connected by welding to the reactor through which the gases pass. It should be air tight by using screw bolt which holds the metal tube tight with the reactor so that the yield of the oil is maximized also a nylon washer is provided inside the furnace to be air tight. Waste plastics are first collected from engineering college campus. After the waste plastics were collected, it was washed to remove the impurities and then was dried to remove any water droplets. Then the washed plastic was sorted according to their categories. Finally, it was shredded and cut into pieces for ease of feeding the raw materials and for good heat transfer. 2.5kg of it was weighed and feed to the reactor and the reactor was properly sealed to protect the gas from leaking. Adequate precautions were put in place to make sure there is no leakage before start of experiment

2.1.2 WPO Preparation Procedure

The heart of the process is the reactor and is being air tight in order to provide pyrolysis process inside the reactor. First a 2.5 kg of shredded plastic has been fed in to the reactor an then maintained pressure below 10bar and maintained temperature at the range of 150^0 c, so that the plastic has been melt at 121^0c and through the GI pipes which is connected to the reactor it is quenched at the cold water. There is a layer of oil which is formed on the top of the cold water. It is separated from the water using a syringe by sucking it and injected in to another bottle. Actually the density difference between the WPO and water creates them immiscible. Physical properties like density, flash point, fire point, calorific value are determined using respective apparatus

3. Analysis and testing of the WPO/Diesel blend

After the waste plastic has been prepared, there need to be the preparation of WPO/Diesel blend. So a suitable blending ratio is selected and it has been prepared in the effective manner. So next is to check

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its properties using various apparatus that are available in the laboratory

3.1 Analysis of Blend

a) Calorific value

Calorific value is defined as the energy released as heat when compound undergoes complete combustion with oxygen under standard conditions. Waste plastic oil, blend of waste plastic/diesel has been separately checked in a bomb calorimeter to determine the calorific values. If the calorific value almost similar to the diesel then it can be used as an alternative fuel.

a.1) Calorific value of WPO

Mass of sample burned=0.826 gm.
Initial water temperature, $T_1=1.7^0C$
Final water temperature, $T_2=4.82^0C$
Water equivalent to calorimeter, $m_w=2350$ gm.
Specific heat of water, $C_{pw=}$ 4.187 J/gm./K
$m_f C_v = m C_{pw} [T_2-T_1]$ (1)

$C_v=(2350*4.187*[4.824-1.7]) / 0.826$
=37165.96 J/Kg
=37.165 MJ/Kg

a.2) Calorific Value of WPO/Diesel Blend

Mass of sample burned,m_f =0.4023 gm.
Initial water temperature,$T_1=2.04^0C$
Final water temperature,$T_2=3.87^0C$
Water equivalent to calorimeter, $m_w=2350$ gm.
Specific heat of water flow, $C_{pw}=4.187$ J/gm./K
$m_f C_v=mC_w[T_2-T_1]$
$C_v=(2350*4.187*[3.87-2.04]) / 0.4023$
=44.758 MJ/Kg

b) Density

The density of a substance is its mass per unit volume. Aerometer, Hydrometer, Pycnometer, Gas collecting tube are the apparatus that are commonly used to measure the density

Density of waste plastic oil=857 Kg/m^3
Density of Diesel/plastic oil=817 Kg/m^3

c) Viscosity

The viscosity of a fluid is a measure of its resistance to gradual deformation by shear stress or tensile stress. Viscosity is due to the friction between neighboring particles in a fluid that are moving at different velocities.
Viscosity is measure by means of Redwood viscometers
Dynamic viscosity of plastic oil=6.70 centipoise
Dynamic viscosity of WPO/Diesel blend=2.67 centipoise

Dynamic viscosity/Density =Kinematic Viscosity (2)

d) Flash Point

The flash point of a volatile material is the lowest temperature at which it can vaporize to form an ignitable mixture I air. Measuring a flash point requires an ignition source.
Flash point of the waste plastic oil=42^0C

e) Fire point

Fire point of a fuel is defined as the temperature at which it will continue to burn for at least 5seconds after ignition by an open flame. At the flash point, a lower temperature, a substance will ignite briefly, but vapor might not be produced.

Fire point of the waste plastic oil=45^0C

The physical properties of the waste plastic oil and its blend with diesel in the ratio 5:95 have been checked. The comparison between the properties of diesel, WPO, WPO/Diesel blend are shown in table 1

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Table 1: Comparison of Diesel from WPO and WPO/Diesel blend

Sl No	Specifications	Diesel	WPO	WPO 5
1	Calorific value(KJ/Kg)	46500	37165	44758
2	Density@50^{0}C(Kg/m^3)	840	857	817
3	Kinematic Viscosity@50^{0}C (cSt)	2.0	2.52	
4	Dynamic Viscosity(cps)	1.68	6.70	2.67
5	Flash Point(^{0}C)	50	42	46
6	Fire Point(^{0}C)	56	45	48

3.2 Emission and Performance results

After the desired properties of the WPO/diesel blend has been checked and next wanted to test this blend in a single cylinder four stroke diesel engine and wanted to compare the results with diesel of emission and performance characteristics

3.2.1 Performance characteristics

Performance characteristics actually check the relationship between the Break thermal efficiency (BTE) and Specific Fuel Consumption (SFC) towards the load. So that characteristics for each diesel and blend has been compared after the load test has been conducted on the single cylinder four stroke diesel engine. Table 2 shows the SFC and BTE of diesel towards the Load and Table 3 as that of Blend

Load(Kg)	0	3.2	6.32	8.91	12.76
SFC(Kg/KW-hr)	0	0.72	0.46	0.39	0.33
BTE (%)	0	11.81	18.43	21.66	25.95

Table 2: SFC and BTE of Diesel towards load

Load(Kg)	0	3.2	6.32	8.91	12.76
SFC(Kg/KW-hr)	0	0.7	0.45	0.32	0.32
BTE (%)	0	11.42	18.05	24.77	25.32

Table 3: SFC and BTE of WPO 5 towards load

3.2.2 Emission Characteristics

Now a days the exhaust gases from the automobile mainly contains the presence of CO, CO2, NOx, HC etc. So that the content of this gases from the smoke has been detected using the gas analyzer.

Load(Kg)	CO(%)	CO_2(%)	HC(ppm)	NO_X(ppm)	O_2(%)
0	0.04	2.15	1.92	106.25	17.64
3.2	0.05	3.025	14.25	157	16.75
6.32	0.04	3.875	16	245.25	15.34
8.91	0.03	4.25	15.25	316	15.60
12.76	0.02	5.075	15.75	535	14.12

Table 4: Emission Characteristics of Diesel

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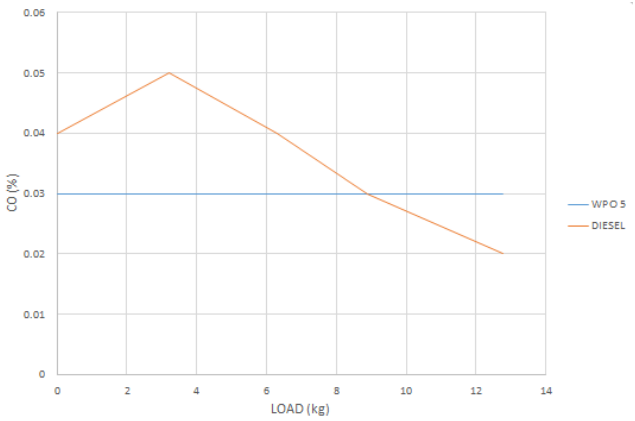
Load(Kg)	CO(%)	CO_2(%)	HC(ppm)	NO_X(ppm)	O(%)
0	0.03	1.47	7	67.75	18.65
3.2	0.03	1.85	6	103.75	18.21
6.32	0.03	2.925	9.25	202	16.59
8.91	0.03	3.8	9.75	289	15.1
12.76	0.03	2.92	8.2	428.2	15.1

Table 5: Emission characteristics of WPO 5

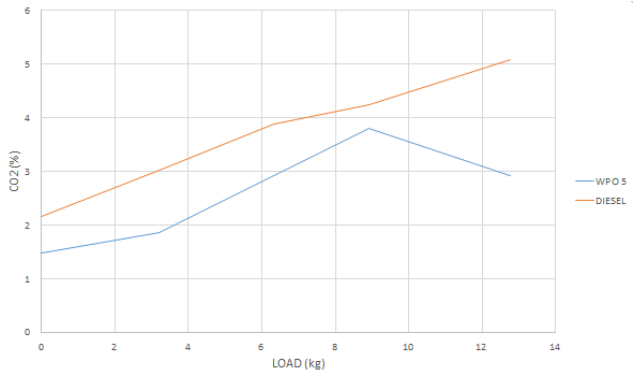
3.3 Results and Discussion

The results obtained from the experimental investigations on the emission and performance parameters using diesel, WPO 5 are presented and discussed in this section

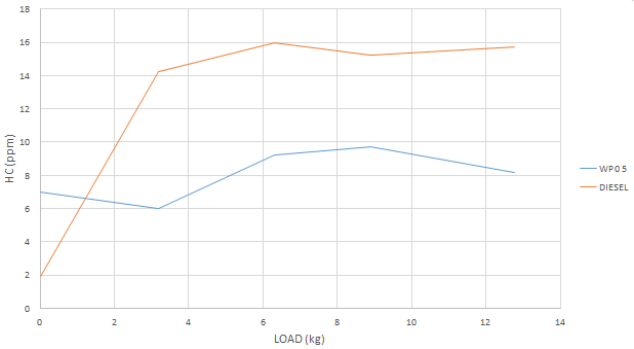
3.3.1 Carbon monoxide emission



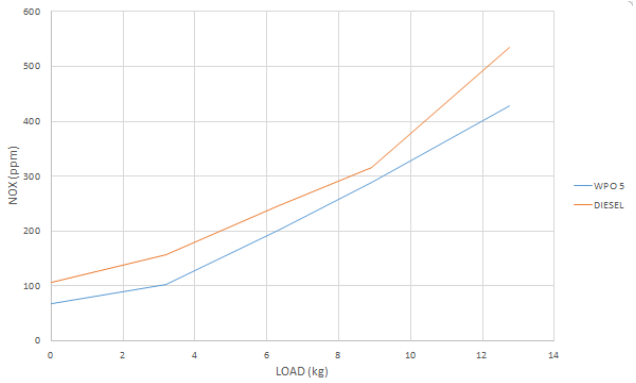
3.3.2 CO2 emission



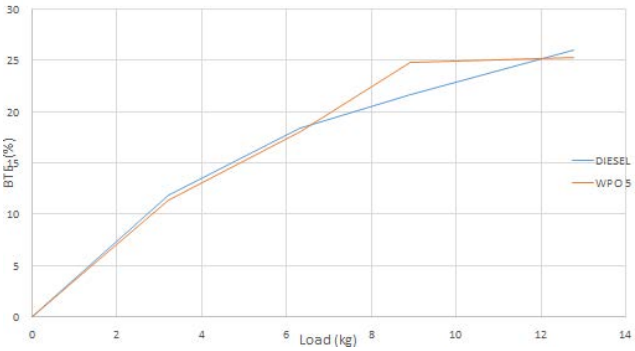
3.3.3 HC emission



3.3.4 NO_X emission



3.3.5 BTE Vs Load characteristics



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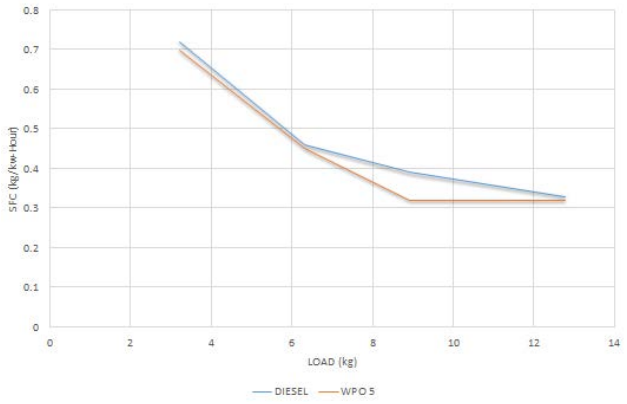
3.3.6 SFC Vs Load characteristics



4. Conclusions

WPO5 exhibits almost same brake thermal efficiency as that of diesel and varies from 11.42-25.32 where diesel value varies from 11.81-25.95, which is almost same. The specific fuel consumption of the blend WPO5 decreases from 70% to 32%,compared to diesel varies from 72% to 33%.Whenever the emission characteristics check it is found that the emission of gases like CO,CO_2,NO_X,HC are comparatively lower than that of diesel. And also the emission of O_2 has been increased for the blend compared to diesel. So that blend of WPO and diesel can be used as an alternative fuel

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