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# Investigation of Performance Analysis and Emission Characteristics of Waste Plastic Fuel

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**Abstract.** Today the world is confronted with the twin crisis of fossil fuel depletion and stringent emission norms, because of the environmental awareness. The disposal and degradation of waste plastic is a major issue and scarcities of fuel were major focus area of the researchers. In this virtue the waste plastic fuel extraction makes more attention to the researchers. In this research work focused to find the performance of the waste plastic fuel and compared to diesel. The waste plastic fuel extract from thermal cracking method this process the polymer chains were breakdown into useful lower molecular weight compounds and it becomes plastic pyrolysis it can be utilized as a fuel. The properties of the waste plastic fuel is obtained by various testing process and which is analyze and compare with the fossil fuel diesel. It is found that almost it has similar properties to the diesel and almost all properties of the pyrolysis is closer to that of diesel. The characteristics of the pyrolysis were tested in the engine test bed. The pyrolysis / waste plastic fuel can be directly used in diesel engines over the entire load spectrum smoothly without any major modification. The performance of the waste plastic fuel / pyrolysis is evidenced that it is one of the best alternative fuel as well as the waste plastic can be converted into a useful fuel

## 1. Introduction

Plastic is a one of the greatest innovation of this century; there are used numerous ways because of the less weight, does not oxidation or decompose, low cost, reusable and conserves natural resources It saves energy and CO<sub>2</sub> emissions during their using as well as; it substitute in all applications with the existing mix of alternative materials. The continuous innovation and application of new things the plastics production has increased by an average of almost 10% in every year since 1950. But the waste plastic management is the biggest problem of the current scenario. Sharma et al. (2016), the disposal of waste plastic very is a serious environment challenge all over the world (1).

The researchers are concentrate to find the fuels for I.C. engines. In this circumstance the waste plastic are currently receiving transformed interest, the oil can be derived from waste plastics. The aim of this paper is to analyze the engine performance, combustion and emission characteristics of diesel engines fuelled with waste plastic oil and its blends with petroleum-based diesel fuel.



## 2. Literature Survey

### *2.1. Sources and properties of plastic wastes*

The major resources of waste plastic were collected from the municipal waste and industrial wastes, done of plastic waste arise as a by-product in industry. From the total waste plastics 78 % of the quantity is thermoplastics and the remaining to thermosets[1]. The thermosets cannot be recycled because they includes epoxy resins and polyurethanes, But thermoplastics can be recycled; they are composed of polyolefins such as polystyrene, polyethylene, polyvinyl chloride and polypropylene [2]. The waste plastics categorized according to their combustibility either burnable or unburnable. burnable wastes are used for heat production, Unburnable waste are used for recycling, or land filling, based on the material. Ampaitepin and Tetsuo , Municipality waste giving high heat value, such as (WPF) waste plastics fuel [3].

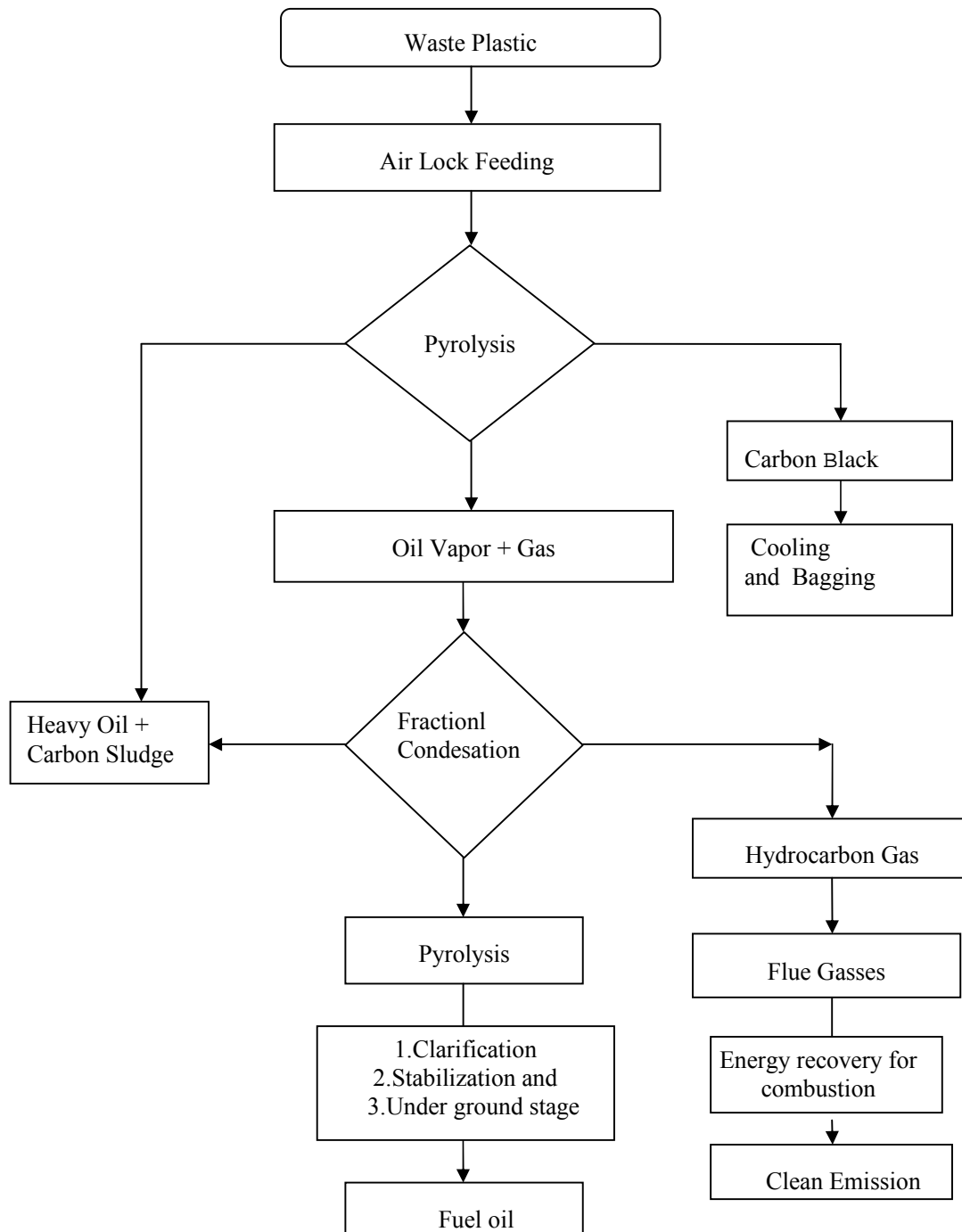
### *2.2. Waste plastic oil / fuel*

The plastic industry had an extraordinary growth rate for the past three decades only. The various formation of plastic has enlarged more than 100 times in the last 30 years The various formation of plastic has been used in different kind of applications (e.x:car industry,robotic industry & aerospace). Now a days plastic handling is biggest issue. So that plastic wastes are safely & quickly recycleable. Mitsuahara et al.,the new trent of eco-friendly waste plastic is a alternative fuel for steel production[4]. Williams and Williams, using the waste plastic fuel in power plant it will help to increase the thermal efficiency[5]. Plastics are non-eco-friendly generally it containing carbon, hydrogen, and few other elements. In 2010 nationwide survey conducted in India the plastic demand is 12 million tons per year. 14,000 metric tons produced every day and remaning is imported from other countries. Mani and Nagarajan says All the plastics are recycled and sometimes it is not done so due to lack of sufficient market value [6].

Hai et al., The extent of conversion of plastics or plastic derived waxes into light engine fuels can be increased by the application of stable hydrocracking catalysts. Similar to petroleum derived cracking products, the fractions from plastics processing contain appreciable quantities of aromatics and unsaturated hydrocarbons [7].

### *2.3. Waste Plastics in to Fuel Conversion Processes*

De-Polymerization of plastic involves breaking down long chains of hydrocarbons present in plastics molecules into smaller components, such as - petrochemical gases & liquid fuels. This process of breaking down plastic into lighter components is known as 'Cracking'. Thermal cracking (or pyrolysis) requires high temperature & pressure conditions. However, in the presence of a specialized catalyst, cracking can be efficiently achieved at relatively much lower temperature & near atmospheric pressure, thus making the process commercially attractive & industrially safe. This method of cracking is known as 'Catalytic De-polymerization'. Our De-polymerization model employs a rotary reactor operating in continuous production mode to convert waste plastic into fuel. A typical output consists of about 70% liquid fuel, 20% coke & 10% petroleum gasses. Liquid fuels are give the high energy with low sulphur content. The fine coke also gives high energy so its used for industrial & domestic applications.



**Figure 1.** Flow processes of waste plastics in to fuel

The petroleum gasses produced are used internally to meet the energy requirements of the process, thereby making the process highly cost effective. Being a closed loop process; it allows mass & enthalpy conservation exercise to be carried out so as to establish that no material is expelled in to the environment. Converted and recovered as output in the form of high calorific value solid, liquid & gaseous fuels. The material balance as well as energy balance at the output vis-à-vis that at the input

make an excellent statement, and that is, the process has nothing to discharge into the atmosphere, thereby, pollutions of air, water & soil are NOT created. The output of the oil contains no chlorine, sulphur, nitrogen or heavy metals. Any of that material would remain in the ash. The Figure. 1 shows that the flowchat of the various process of waste plastics in to fuel conversion processes. This system consists of the knapper, extrusion machine, pyrolysis reactor & catalytic upgrade reactor.

### 3. Properties of the Waste Plastic Fuel To Diesel Fuel

Table 1 and 2 shows the Properties of the Waste Plastic Fuel to Diesel Fuel and Details of Engine Bed.

Table 1. Property of Waste Plastic Fuel vs. Diesel

S.No	Properties	WPF	Diesel
1	Density (kg/m <sup>3</sup> )	793	850
2	Ash Content (%)	<1.01%wt	0.045
3	Calorific Value(kJ/kg)	41,800	42,000
4	Kinematic Viscosity at 40 <sup>0</sup> C(cst)	2.149	3.05
5	Cetane Number	51	55
6	Flash Point <sup>0</sup> C	40	50
7	Fire Point <sup>0</sup> C	45	56
8	Carbon Residue (%)	0.01%wt	0.20%
9	Sulphur Content (%)	<0.002	<0.035
10	Pour Point <sup>0</sup> C	-4	3-15
11	Colour	Pale Black	Orange
12	Specific Gravity at 30 <sup>0</sup> C	0.8355	0.84 to 0.88
13	Atomic Content (%)	55	20
14	Existent Gum (gm/m <sup>2</sup> max.)	36	-

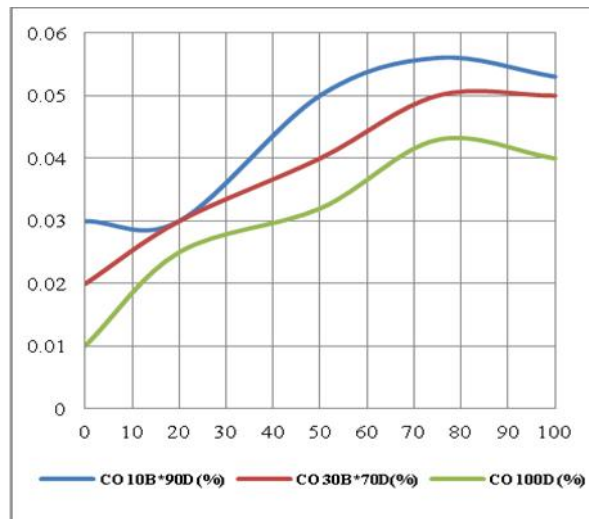
Table 2. Engine test bed detail

Make and Model	Kirloskar, AV1 make
General Details	Four stroke, compression ignition, Constant speed, Vertical, Water Cooled, Direct injection
Number of cylinder	Single cylinder
Bore	80 mm
Stroke	110 mm
Compression ratio	16.5: 1
Rated Output	3.7 kW at 1500 rpm
Rated Speed	1500 rpm
Injection pressure	240 bar
Type of combustion chamber	Hemispherical combustion Chamber
Connecting rod length	235 mm
Fuel	Diesel

## 4. Results and Discussions

### 4.1. Carbon monoxide

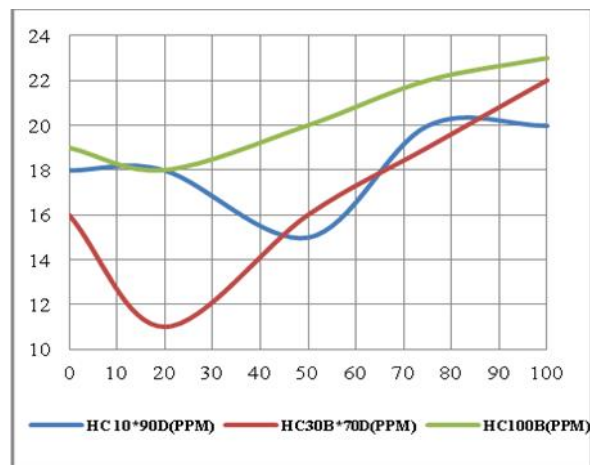
The CO formations shown in Figure 2 for fuels and blends with corresponding load. The emission of CO depending upon the physical and chemical properties of the fuel used. The decrease in CO emission for JB20 is an oxygenated fuel, it leads to better combustion of fuel, resulting in the decrease in CO emission.



**Figure.2** Variation of CO for plastic fuel and diesel blend.

#### 4.2. Hydrocarbons

The variant of hydrocarbons with respect to load for both fuels and their blends is as shown in the Figure 3. HC emissions are observed for the blend at low load conditions.



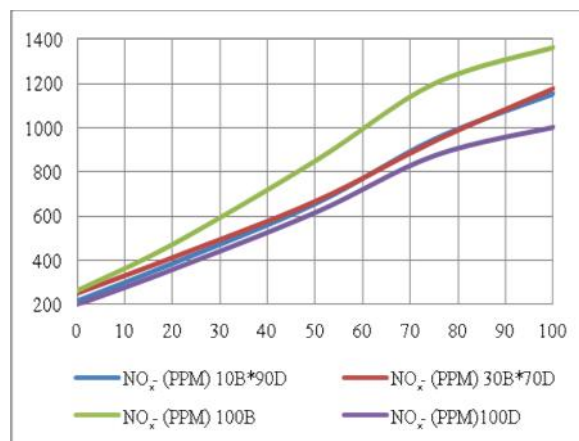
**Figure 3.** Variation of HC for plastic fuel and diesel blend

In low load conditions, fuel injected is leaner mixture result is high HC emission & poor performance. The HC emission of the plastic fuel is less than that of diesel fuel because of higher cetane number .

#### 4.3. Oxides of Nitrogen

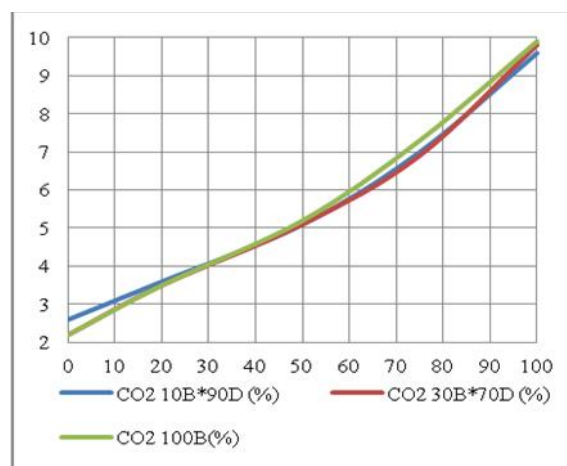
Generally plastic fuel is generates higher amount of Nox than diesel. The NOx emission is enhance the percentage of Particulate matter emission in the fuel. Nitrox of oxide enhance for JB20 may be

associated with the O<sub>2</sub> content of JB20, Causes of the O<sub>2</sub>, present in the fuel, may provide excessive oxygen for NO<sub>x</sub> formation which is shown in Figure 4. The generation of NO<sub>x</sub> emission is particularly governed by the magnitude of peak cylinder temperature and the crank angle at which it mainly occurs.



**Figure 4.** Variation of NO<sub>x</sub> for plastic fuel and diesel blend.

#### 4.4. Carbon dioxide



**Figure 5.** Variation of Carbon dioxide of plastic fuel Vs Load

The increasing volumetric fuel consumption. It is observed that the CO<sub>2</sub> emission of plastic fuel is slightly more than the diesel which is shown in Figure 5. This is attributed to the presence of oxygen and high cetane number of the plastic fuel.

## 5. Conclusion

The properties of the waste plastic fuel is analyzed and compared with the fossil fuel diesel and found that almost it has similar properties to the diesel. The characteristics of the waste plastic fuel is obtained from various studied and summary of the results are the higher heat release rate in waste plastic oil compared with diesel fuel due to better combustion. The No<sub>x</sub> increase 40% due to higher heat release rate and combustion and temperature. The CO emission increased 7% in waste plastic oil compared to diesel operation. Unburned hydrocarbon emission is higher by about 15%. Waste plastic

fuel exhibits higher thermal efficiency up to 75%. Activated carbon using with this experiment fuel is clean and color is bright yellow. This fuel burns cleaner and burning time is also longer.

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