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# Performance test on single cylinder CI-engine waste plastic fuel blend with diesel fuel

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***Abstract :****As the fossil fuels are depleting at a very faster rate, there is a need to find out an alternative fuel to fulfill the energy demand of the world. Plastic fuel is one of the best available sources to fulfill the energy demand of the world. The petroleum fuels play a very significant role in the development of industrial growth, transportation, agricultural sector and to meet many other basic human requirements. However, these fuels are limited and depleting day by day as the consumption is increasing very rapidly. Moreover, their use is alarming the environmental problems to society. Hence, there is a need of research for alternative fuels. There is a long list of syringe water bottle etc. waste plastic chair available abundantly in India, which can be exploited for the production of plastic fuel. Recent research on plastic fuel focused on performance of plastic fuel and its blends with diesel. The present work aims to investigate the possibilities of the application of mixtures of two plastic fuel and its blends with diesel as a fuel for diesel engines. The present investigations are planned after a thorough review of literature in this area. The combinations of plastic fuel, along with diesel are taken for the experimental analysis. There was no evidence of any practical multi-blend plastic fuel source engine. Experiments are conducted using a single cylinder direct-injection diesel engine with different loads at rated 1500 rpm. The brake thermal efficiency of PF-10 has maximum 18.1% compares to pure diesel 18.71% at 1.5 kW brake power. Maximum specific fuel consumption is obtained in PF-30 (0.715) compare to pure diesel at 0.5 kW brake power. The results which obtained are significantly comparable to pure diesel. The multi-blend plastic fuel is suitable alternative fuel for diesel in stationary/agricultural diesel engines.*

***Keywords****-alternate fuel; diesel engine; performance; multi-blend plastic fuel.*

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## I. INTRODUCTION

### 1.1Introduction

The resources of petroleum as fuel are dwindling day by day and increasing demand of fuels, as well as increasingly stringent regulations, pose a challenge to science and technology. With the commercialization of bio-energy, it has provided an effective way to figurant against the problem of petroleum scarce and the influence on environment. India is one of the fastest developing countries with a stable economic growth, which multiplies the demand for transportation in many folds. Fuel consumption is directly proportionate to this demand. India depends mainly on imported fuels due to lack of fossil fuel reserves and it has a great impact on economy. The present investigations are planned after a thorough review of literature in this area. The combinations of plastic fuel, along with diesel are taken for the experimental analysis. There was no evidence of any practical multi-blend plastic fuel source engine. Experiments are conducted using a single cylinder direct-injection diesel engine with different loads at rated 1500 rpm. The brake thermal efficiency of PF-10 has maximum 18.1% compares to pure diesel 18.71% at 1.5 kW brake power. Maximum specific fuel consumption is obtained in PF-30 (0.715) compare to pure diesel at 0.5 kW brake power. The results which obtained are significantly comparable to pure diesel. The multi-blend plastic fuel is suitable alternative fuel for diesel in stationary/agricultural diesel engines

### 1.2 History about plastic

Plastic were invented in 1860, but have only been widely used in the last 30 years. Plastic are light, durable, modifiable and hygienic. Plastic are made of long chain of molecule called polymers. Polymers are made when naturally occurring substance such as crude oil or petroleum is transformed into other substance with completely different properties. These polymers can then be made into granules, powders and liquids, becoming raw materials for plastic products.

Plastics have become an indispensable part in today's world. Due to their lightweight, durability, energy efficiency, coupled with a faster rate of production and design flexibility, these plastics are employed in entire gamut of industrial and domestic areas. Plastics are produced from petroleum derivates and are composed primarily of hydrocarbons but also contain additives such as antioxidants, colorants and other stabilizers. Disposal of the waste plastics poses a great hazard to the environment and effective method has not yet been implemented. Plastics are non-biodegradable polymers mostly containing carbon, hydrogen, and few other elements like nitrogen. Due to its non-biodegradable nature, the plastic waste contributes significantly to the problem of waste management. According to a nationwide survey which was conducted in the year 2000, approximately 6000 tonnes of plastic waste were generated every day in India, and only 60% of it was recycled, the balance of 40% could not be disposed off. Today about 129 million tonnes of plastics are produced annually all over the world, out of which 77 million tones are produced from petroleum.

In India alone, the demand for plastics is about 8 million tonnes per year. More than 10,000 metric tonnes per day of plastics are produced in India and almost the same amount is imported by India from other countries. The per capita consumption of plastics in India is about 3 kg when compared to 30 kg to 40 kg in the developed countries. Most of these come from packaging and food industries. Most of the plastics are recycled and sometimes they are not done so due to lack of sufficient market value. Of the waste plastics not recycled about 43% is polyethylene, with most of them in containers and packaging

## II. Research Methodology

### 2.1 Introduction

This chapter focuses on the methodology of the study and is divided into 4 sections. The first will discuss the material used in the study. This will be followed by a description of the experimental methods applied in this study in order to achieve the objective of the study. The following section will discuss experimental equipment, the set-up and test procedures. Lastly, the procedures followed for the data analysis will be outlined and discussed.Experiments were performed in the internal combustion engine laboratory, department of mechanical engineering, Narsimhareddy engineering college.

### 2.2 Materials and method

Based on the availability of plastic fuel, the properties like calorific value, kinematic viscosity, flash point and fire point, plastic fuel is estimated in the table 3.1 selected for bio-fuel preparation and experimental analysis. Various blending combinations of multi-blend biodiesel i.e. PF-1 (plastic fuel 10%, diesel 90% by volume), PF-2 (plastic fuel 20%, diesel 80% by volume), PF-3 (plastic fuel 30%, diesel 70% by volume) are prepared as shown in table 2.1

**Table 2.1** Preparations of flue samples of multi-blend plastic fuel along with diesel

| Sl. No. | Fuel samples | plastic fuel + Pure diesel = Quantity obtained |
|---|---|---|
| 1. | PF-10 | 100ml + 900ml = 1-litre |
| 2. | PF-20 | 200ml + 800ml = 1-litre |
| 3. | PF-30 | 300ml + 700ml = 1-litre |

### 2.3 Modification

In present unit a little modification has been done. While working of pyroplysis unit mainly two problems were faced. First one is reaching the temperature. Of course pyrolysis of waste plastic mainly depends on operating at higher temperature. So that higher proportion of product distribution (waste plastic) inside reactor is takes place. Hence in order to enhance the conversion efficiency and higher product yield it must need's to reach the reactor temperature within few minutes. Here we take a sheet metal of suitable thickness and that is to be made over the original pyrolysis unit. So it would reduce the temperature loss to atmosphere and it keeps temperature of pyrolysis unit to longer time.

Second one is, in last case pyrolysis unit was facilitated with easy opening and closing of flanges and that needs small hole to be inserted in the central reactor pipe. So it create small gap around the reactor pipe and flange assembly while working it needs to close by some adhesive material continuously. From that small gap pressure and temperature loss to atmosphere .Hence in order to solve problem and easy operation by making use of simple collar which is to be welded in the central reactor pipe and make welding between reactor pipe and closing flanges. The whole assembly is facilitates to easy opening and closing of flanges so it eliminate loss of pressure and temperature to the atmosphere.

By this little modification we can operate pyrolysis unit more efficient and effective. So that maximum yield can be obtained with reducing the residence time of pyrolysis process

**2.4 Production Of Plastic Liquid Fuel Compounds From Agricultural plastic Waste**


**Fig.2.1-** Set-up for Production of plastic liquidFig.2.2-Edible oil cover

fuel from waste plastic

**Fig.2.3**-Agricultural produced plastic coverFig.2.4-Medicine bottles

**2.4.1 Pyrolysis breakdown**

In this project work cracking (Pyrolysis) is used to convert waste plastic into liquid fuel compounds. Pyrolysis is generally defined as the controlled burning or overheating of a material in the absence of oxygen. In plastics pyrolysis, the macromolecular structures of polymers are broken down into smaller molecules or oligomers and sometimes monomeric units. Further degradation of these subsequent molecules depends on a number of different conditions including temperature, residence time, and the presence of catalysts and other process conditions. The pyrolysis reaction can be carried out with or without the presence of catalyst.

**2.4.2 Thermal Pyrolysis**

The non-catalytic or thermal pyrolysis of polyolefins is a high energy, endothermic process requiring temperatures of at least 350–500 8C. Thermal cracking, or Pyrolysis, involves the degradation of the polymeric materials by heating in the absence of oxygen. The process is usually conducted at temperatures between 350 and 550C and results in the formation of carbonized char (solid residues) and a volatile fraction that may be separated into condensable hydrocarbon oil consisting of paraffins, isoparaffins, olefins, naphthenes and aromatics, and a non-condensable high calorific value gas. The proportion of each fraction and their precise composition depends primarily on the nature of the plastic waste but also on process conditions. The extent and the nature of these reactions depend both on their action temperature and also on the residence of the products in the reaction zone, an aspect that is primarily affected by the reactor design. However, the thermal degradation of polymers to low molecular weight materials requires high temperatures and has a major drawback in that a very broad product range is obtained.On the other hand, only a few have worked on the thermal decomposition of other common plastics such as polyvinylchloride, polyurethane and polyethylene terephthalate. Generally, thermal cracking results in liquids with low octane value and higher residue contents at moderate temperatures, thus an inefficient process for producing gasoline range fuels. The gaseous products obtained by thermal pyrolysis are not suitable for use as fuel products, requiring further refining to be upgraded to useable fuel products.

**2.4.3 Catalytic Pyrolysis**

Addition of catalyst enhances the conversion and fuel quality. As compared to the purely thermal pyrolysis, the addition of catalyst in polyolefin pyrolysis. Significantly lowers pyrolysis temperatures and time. A significant reduction in the degradation temperature and reaction time under catalytic conditions results in an increase in the conversion rates for a wide range of polymers at much lower temperatures than with thermal pyrolysis. Narrows and provides better control over the hydrocarbon products distribution in Low density polyethylene (LDPE). High density polyethylene (HDPE), polypropylene and polystyrene pyrolysis. While thermal pyrolysis, results in a broad range of hydrocarbons ranging from C5 to C28 the selectivity of products in the gasoline range (C5–C12) are much more enhanced by the presence of catalysts. Again, oils obtained by catalytic pyrolysis contain less olefins and more branched hydrocarbon and aromatic content .Increases the gaseous product yields. Under similar temperatures and reaction times, a much higher gaseous product yield is observed in the presence of a catalyst for plastic wastes.Hence in this project work we use dry catalyst to reduce reaction time and residence time. Mainly two types of dry catalyst have used which are wood powder and ash. By use of these catalysts we got a maximum oil yield with reducing the operating temperature

Fuel sample PF-10    Fuel sample PF-20    Fuel sample PF-30

**Figure: 2.5**-Photographs of PF fuel samples

| Fuel samples / Properties | Diesel | PF-10 | PF-20 | PF-30 | Apparatus used |
|---|---|---|---|---|---|
| Fuel density Kg/$m^3$ | 830 | 835 | 840 | 850 | Hydrometer |
| Kinematic viscosity @ $40^0$C in cSt | 3.0 | 3.3 | 3.5 | 3.8 | Water bath viscometer |
| Flash point $^0$C | 50 | 54 | 58 | 64 | Pensky-marten’s |
| Fire point $^0$C | 57 | 64 | 68 | 74 | Pensky-marten’s |
| Calorific value kj/kg | 42,680 | 42,461 | 42,243 | 41,807 | Bomb calorimeter |

**TABLE: 2.2** ESTIMATED PROPERTIES OF MULTI-BLEND PLASTIC FUEL WITH DIESEL FUEL

**2.5 Experimentation set-up**

**Figure: 2.6** - Photograph of experimentation I.C engine set-up

| | | |
|---|---|---|
| 1. | Manufacturer | Kirloskar oil engines ltd., India |
| 2. | Model | TV_SR II, naturally aspirated |
| 3. | Engine | Single cylinder, direct injection diesel engine |
| 4. | Bore/stroke/compression Ratio | 87.5 mm/110 mm/17.5:1 |
| 5. | Rated power | 5.2 KW |
| 6. | Speed | 1500 rpm, constant |
| 7. | Injection pressure/advance | 200bar/23 degree before TDC |
| 8. | Dynamometer | Eddy current |
| 9. | Type of starting | Manually |
| 10. | Air flow measurement | Air box with 'U' tube |
| 11. | Exhaust gas temperature | RTD thermocouple |
| 12. | Fuel flow measurement | Burette with digital stopwatch |
| 13. | Governor | Mechanical governing (Centrifugal type) |
| 14. | Sensor response | Piezo electric |
| 15. | Time sampling | 4 micro seconds |
| 16. | Resolution crank | 1 degree crank angle |
| 17. | Angle sensor | 360 degree encoder with resolution of 1 degree |

**Table-2.3:** Technical specifications of thekirloskar diesel engine.

## III. Results And Discussion

### 3.1Introduction

The experimental results obtained from the tests carried out on engine performance presented in this section. These include results at constant speeds with different loads for the different fuels i.e. standard diesel fuel and the three multi-blend plastic fuel products. The results are discussed from the viewpoint of using multi-blend plastic fuel as an alternative fuel for compression ignition engines.

### 3.2 Variation of brake thermal efficiency with respect to brake power

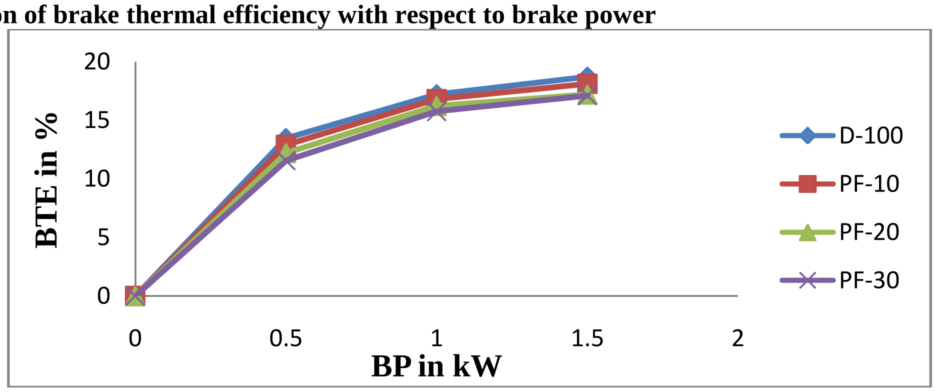


**Figure 3.1** Variation of brake thermal efficiency with respect to brake power.

Figure 4.1 shows the variation of brake thermal efficiency with brake power for various multi-blends of plastic fuel are PF-10, 20, 30 along with pure diesel respectively. Brake thermal efficiency is increasing with increasing brake power for all multi-blends of plastic fuel and diesel. It may be due to reduction in heat loss and increase in power with increase in load. At rated power of 1.5 kW almost all the multi-blends have near efficiency to diesel in which PF-10 have maximum thermal efficiency (18.1%) as compared to diesel (18.71%). It may be because of the presence of oxygen in plastic fuel which enhances the combustion as compared to diesel and plastic fuel is more lubricant than diesel that provides additional lubrication. Multi-blends of plastic fuel have higher viscosity, density and lower calorific value than diesel. Higher viscosity leads to decreased atomization, fuel vaporization and combustion. These may be the possible reasons of PF-30 have lowest brake thermal efficiency for all loads.

**3.3 Variation of specific fuel consumption with respect to brake power**

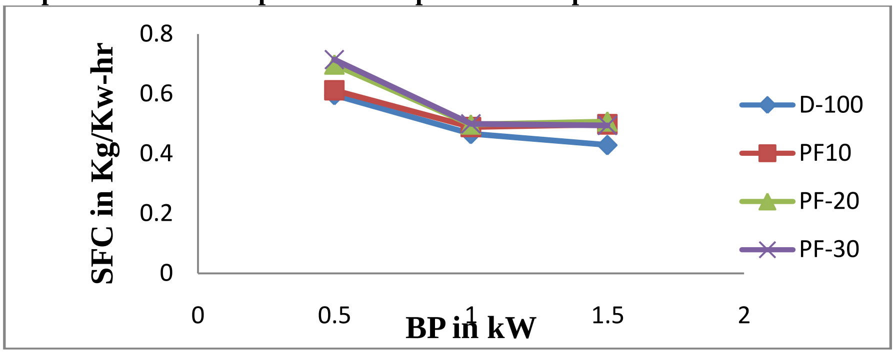


**Figure 3.2** Variation of specific fuel consumption with respect to brake power

The variation in SFC (specific fuel consumption) with brake power for different fuel samples of PF-10, 20, 30 and pure diesel as shown in figure 4.2 the specific fuel consumption when using multi-blend plastic fuel is expected to increase as compared to the consumption of diesel fuel. SFC decreased sharply with increase inload for all fuel samples.The main reason for this may be that the percent increase in fuel required to operate the engine is less than the percent increase in brake power due to relatively less portion of the heat losses at higher loads. As the SFC is calculated on weight basis, so higher densities resulted in higher values of SFC. Maximum SFC is obtained in PF-30 (0.715) at 0.5 kW.

**3.4 Variation of mechanical efficiency with respect to brake power**

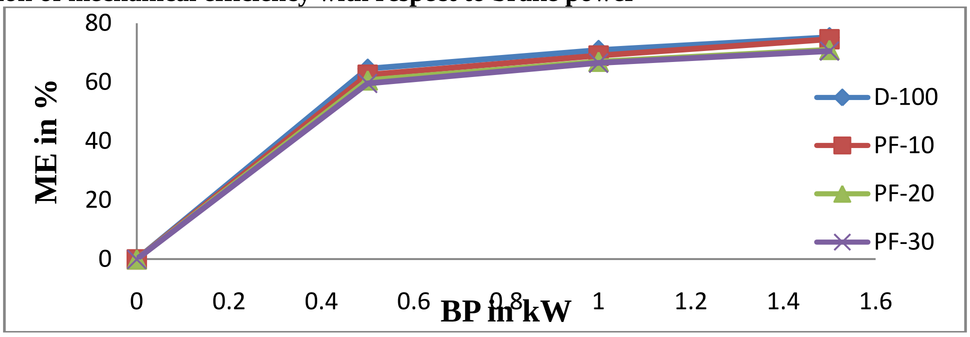


**Figure 3.3** Variation of mechanical efficiency with respect to brake power

The variation of mechanical efficiency with brake power for pure diesel and multi-blend plastic fuel are shown in figure 4.3 the mechanical efficiency of pure diesel is slightly higher than the multi-blend plastic fuel. In this case the pure diesel and PF-10 are almost nearer to each other. From the graph it is evident that as the percentage of multi-blend plastic fuel increases in diesel the mechanical efficiency goes on decreasing. The mechanical efficiency of the engine is maximum at 1.5 kW pure diesel compare to other multi-blend plastic fuel. This happens due to lower calorific value and higher viscosity of multi-blend plastic fuel compared to pure diesel.

**3.5 Variation of indicated thermal efficiency with respect to brake power**

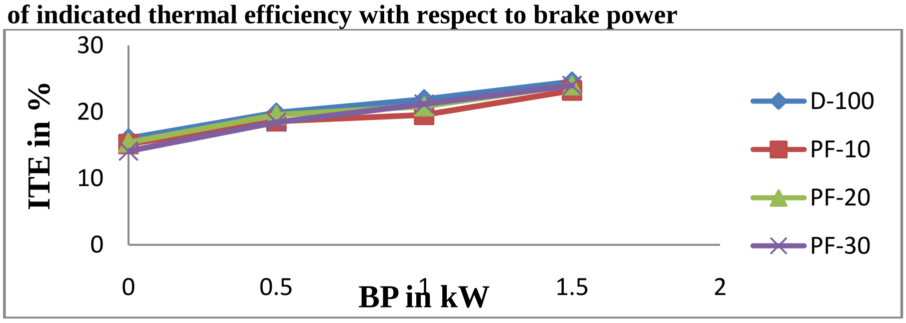


**Figure 3.4** Variation of indicated thermal efficiency with respect to brake power

Figure 4.4 shows variation of indicated thermal efficiency with respect to brake power. From the graph it observed that the indicated thermal efficiency is maximum at starting brake power in the range of 0-0.5 kW brake power. Pure diesel has higher indicated thermal efficiency compared with all multi-blend plastic fuel. This is due to higher calorific value of diesel with lower viscosity. Maximum indicated thermal efficiency is obtained that 23.96% at 1.5kW

**3.6 Variation of volumetric efficiency with respect to brake power**

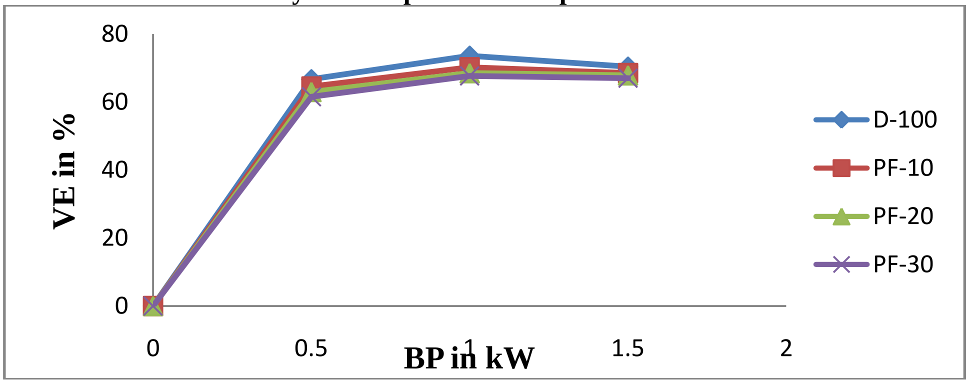


**Figure 3.5** Variation of volumetric efficiency with respect to brake power

Figure 4.5 shows variation of volumetric efficiency with respect to brake power. From the graph it observed that the volumetric efficiency is slightly variation in the average brake power and almost constant. There is no much variation in the pure diesel compared to multi-blend plastic fuel. From the graph pure PF-30 having least it observed that 61.578%,67.65% and 67% at 0.5 kW, 1kWand 1.5kW.This is due to presence of oxygen during the combustion.

## IV. Conclusions

Use of a multi-blend plastic fuel is considered as a new possible source of alternative fuel for diesel engine. No difficulty was faced at the time of starting the engine and the engine ran smoothly at constant engine speed of 1500 rpm. Based on the experimental work with multi-blend plastic fuel, at maximum load, the following conclusions are drawn. The performance parameter like brake thermal efficiency, brake specific fuel consumption, brake specific energy consumption, torque have similar result at wide range of power output.

- The brake thermal efficiency of PF-10 has maximum 18.1% compare to pure diesel 18.87% at 1.5 kW brake power due to the presence of oxygen in the molecular structure of multi-blend plastic fuel intensifies the complete combustion phenomenon.
- The mechanical efficiency of pure diesel is slightly higher than the multi-blend plastic fuel at 1.5 kW brake power due to lower calorific value of multi-blend plastic fuel.
- The indicated thermal efficiency have maximum at average brake power in the range of 0.5-1.5 kW. Pure diesel has higher indicated thermal efficiency compared with other multi-blend plastic fuel.
- The volumetric efficiency is slightly decreases in the average brake power and almost constant. There is no much variation in the pure diesel compared to multi-blend plastic fuel.
- Maximum specific fuel consumption is obtained in PF-30 (0.71) compare to pure diesel at 0.5 kW brake power.

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