iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 3 **Issue:** IV **Month of publication:** April 2015

DOI:

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Evaluation on performance of CI engine with Waste Plastic oil-Diesel blends as Alternative fuel

Baskaran R[1], Sathish Kumar P[2]
Pre final year, Department of Automobile Engineering
Bharathidasan Institute of Technology, Anna University, Tiruchirappalli

***Abstract*: As a developing and one of the most populous countries in the world, India faces major challenges in supplying energy resources and solid plastic waste management. The plastic –pyrolysis oil stands to be a solution for the above problems. This article discusses on the production of plastic oil from waste plastics and its performance with diesel as blend in CI engines. The experiment was performed using 10%, 20%, 30% plastic pyrolysis oil-diesel blends on a constant speed, stationary diesel engine. The performance characteristics including engine brake power, brake thermal efficiency, specific fuel consumption, mechanical efficiency, and total fuel consumption were studied. The results indicate no significant power reduction in the engine operation and had an increase in brake thermal efficiency and mechanical efficiency on 20% with plastic pyrolysis oil – diesel blend as compared to diesel alone.**
Keywords: Alternative fuel, Pyrolysis, Plastic oil, Diesel blends.

I. INTRODUCTION

The demand for diesel fuel is greater than that of gasoline throughout the world hence seeking alternative to mineral diesel is a natural choice. Alternative fuels should be easily available at low cost, be environment friendly and fulfil energy security needs without sacrificing engine's operational performance. Waste to energy is the recent trend in the selection of alternate fuels. Plastics waste has become an indispensable part in today's world. Plastics are produced from petroleum derivatives and are composed primarily of hydrocarbons. Disposal of the waste plastics poses a great hazard to the environment and an effective method has not yet been implemented. Due to its non-biodegradable nature, the plastic waste contributes significantly to the problem of waste management also. Panda et al described that production of liquid fuel from plastic waste would be a better alternative as the calorific value of the plastics is comparable to that of fuels, around 40 MJ/kg. This option also reduces waste and conserves natural resources [3]. It was found that the physical property of plastic oil is good due to zero water content, near neutral pH and low viscosity [2].

II. PLASTIC AS ALTERNATIVE FUEL

Waste plastics are 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 moisture and 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 the properties of other wastes that might be used in the process. Additionally the effective conversion requires appropriate technologies to be selected according to local economic, environmental, social and technical characteristics.

III. PYROLYSIS OF WASTE-PLASTIC OIL

Pyrolysis is usually the first chemical reaction that occurs in the burning of many solid organic fuels, like wood and paper and also some kinds of plastics. Pyrolysis technology is thermal degradation process in the absence of oxygen [1]. Plastic waste is treated in a cylindrical reactor at temperature of 300ºC – 350 ºC. The plastic waste is gently cracked by adding catalyst and the gases are condensed in a series of condensers to give a low sulphur content distillate. All this happens continuously to convert the waste plastics into fuel that can be used for generators. The catalyst used in this system will prevent formation of all the dioxins and Furans (Benzene ring). All the gases from this process are treated before it is let out in atmosphere. The flue gas is treated through scrubbers and water/ chemical treatment for neutralization. The non-condensable gas goes through water before it is used for burning. Since the plastic waste is processed about 300ºC - 350ºC and there is no oxygen in the processing reactor, most of the toxics are burnt. However, the gas can be used in dual fuel diesel-generator set for generation of electricity. The main products of pyrolysis are oil, hydrocarbon gas and carbon black.

Volume 3 Issue IV, April 2015
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

A. Synthesis procedure

The apparatus consists of a reactor-furnace system in which the furnace temperature was maintained constant using a PID controller. At the outlet of reactor, a condenser was attached to condense the vapours coming out of it. The condensed liquid was collected in a collecting jar at the end of condenser. The plastic shreds is filled in a reactor of 300 ml and the reactor is kept in the furnace for heating at constant temperature, where the maximum yield of liquid product is obtained. When the reaction starts, vapours coming out of reactor through the provided outlet are condensed in a condenser. Water is circulated as a cooling medium in the condenser via a pump as shown in figure 3.1. The condensed vapours are collected in a container as the liquid product whereas there is some amount of non-condensable gases which are simply left out.

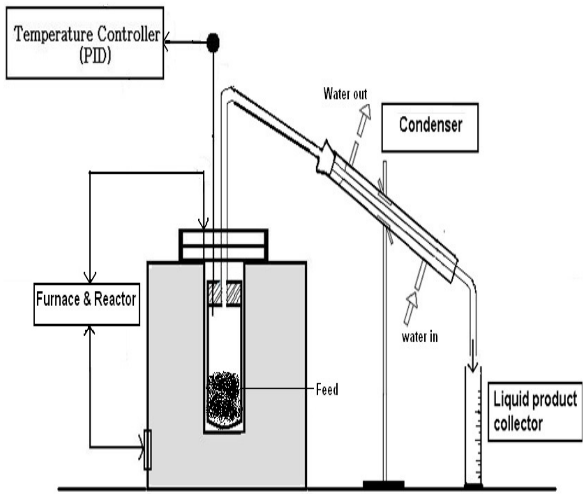


Fig 3.1: Extraction process setup for plastic oil.

The liquid product collected contains oily water and liquid-oil. Oily water is basically water with some dissolved hydrocarbons. Oily-water and liquid-oil is further separated by difference in their density.

B. Sample Pyrolysis Runs

Once the temperature range was found out then sample pyrolysis runs were done with 30gms of plastic shreds in that range at intervals of 50°C to determine the temperature at which maximum yield of liquid product is obtained. And by following the same process required amount of waste plastic pyrolysis oil is obtained and their properties were studied.

IV. COMPARISON OF PROPERTIES

S.No.	Properties	WPPO (Waste plastic pyrolysis oil)	Diesel
1.	Density@ 30˚C in (g/cc)	0.7930	0.84 to 0.88
2.	Ash content (%)	<0.01% (wt)	0.045
3.	Calorific value (KJ/Kg)	41,858	42000
4.	Kinematic viscosity, cSt@ 40˚C	2.149	5
5.	Cetane number	51	55
6.	Flash point (˚C)	40	50
7.	Fire point (˚C)	45	56
8.	Carbon residue (%)	0.01 % (wt)	0.20
9.	Sulphur content (%)	<0.002	<0.035
10.	Acidity (mg KOH/gm)	0.16	0.20
11.	Pour point, ˚C	-4	3-15

Table4.1: Comparison of properties.

Most of the research work has been done by mixing oil developed from waste plastic disposal with heavy oil for marine applications. The results showed that Waste plastic disposal oil when mixed with heavy oils reduces the viscosity significantly

Volume 3 Issue IV, April 2015
ISSN: 2321-9653

and improves the engine performance. However, very little research has been done to test their use in high-speed diesel engines. A pilot level method of recycling waste plastic disposal in India produces waste plastic oil of 25,000litres/day. The kind of plastic materials are Polyethylene, Polypropylene, Teflon, Nylon and Dacron. For marine application, waste plastic oil is used in marine diesel engine. An industry plastic waste with marine heavy fuel oil reduces the viscosity of the heavy oil significantly.

V. ENGINE SPECIFICATION

Engine Type	Kirloskar, Vertical, Four stroke diesel engine
Bore Diameter	80mm
Stroke Length	110mm
Brake Power	3.68kW
Compression Ratio	16:01
Speed	1500rpm
Injection Type	Direct Injection
Cooling	Water
Fuel Injection	23˚ before TDC
Number of Cylinder	1
Loading	Electrical dynamometer loading

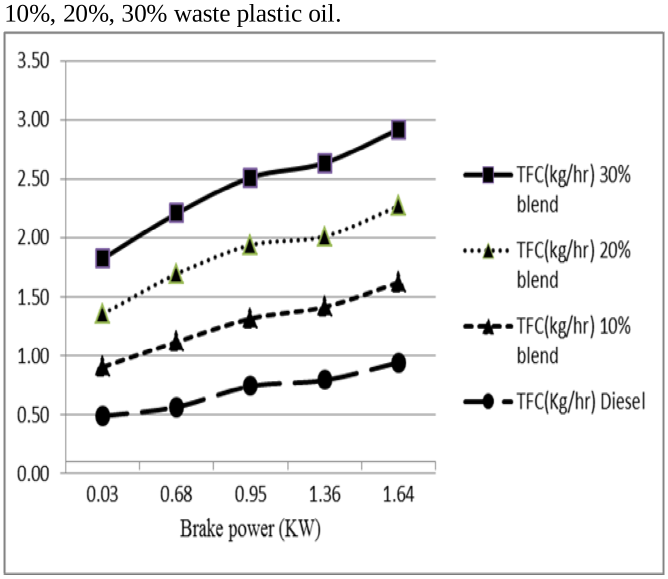
Table: Engine specifications.

VI. EXPERIMENTAL SUMMARY

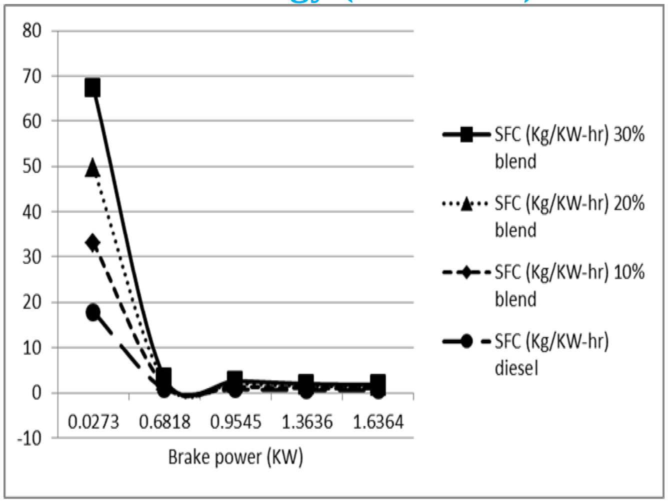
The experiment is carried out in a single cylinder four stroke water cooled diesel engine(make kirloskar) here the engine is mounted on a MS channel frame and is coupled to a AC generator. The electrical loading arrangement is coupled with the AC generator. The engine load is varied by changing the amps with constant voltage.

VII. RESULTS AND DISCUSSIONS

The following graphs shows the variation of TFC, SFC, mechanical efficiency and brake thermal efficiency with diesel and blends in varied proportions of 10%, 20%, 30% waste plastic oil.

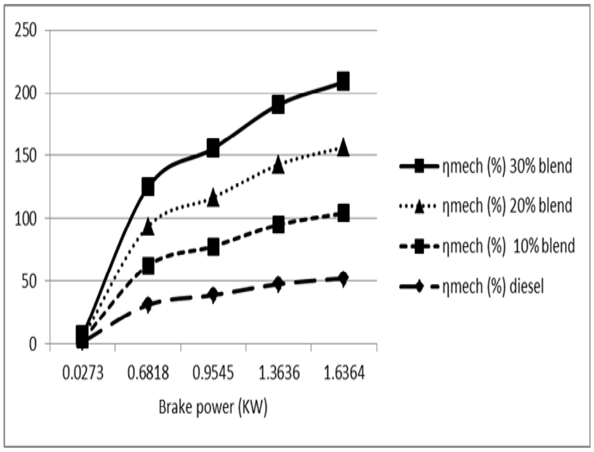


Graph 7.1: BP Vs TFC.



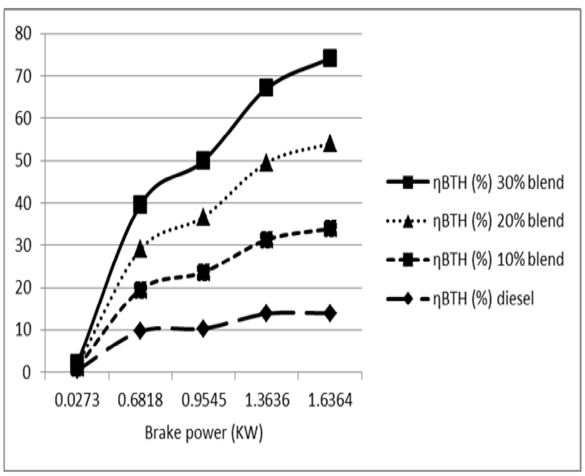
Graph 7.2: BP Vs SFC.

It is observed that the TFC is found to be increasing with increase in BP but SFC is seemed to be likely similar to that of diesel with increase in brake power.



Graph 7.3: BP Vs $\eta_{mech.}$

It is clear from the graph that the mechanical efficiency is found to be always higher than that of the diesel at any level of BP (Brake power).



Graph 7.4: BP Vs $\eta_{BTH.}$

Also looking into the above graph it is clear that the brake thermal efficiency of the engine is improved at all levels of blend when compared to diesel.

VIII. CONCLUSION

Based on the above inspection it is found that there is no significant power reduction in the engine operation on plastic pyrolysis oil – diesel blends with 20% level of significance.

A. The volumetric efficiency is found to be decreased when compared to diesel, at all three levels of blends.
B. The brake thermal efficiency is increased up to 20% with an increased blend of plastic pyrolysis oil as compared to diesel.
C. Similarly, the mechanical efficiency is also increased up to 20% with an increased blend of plastic pyrolysis oil blend when compared to diesel.

Hence, it can be concluded that the oil derived from waste plastic can be used as a promising alternate fuel for transportation.

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