International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 1 Issue 4, June - 2012

Performance analysis of single cylinder diesel engine fuelled with Pyrolysis oil - diesel and its blend with Ethanol

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Abstract

Around the world, initiatives are being taken to replace gasoline e and diesel fuel due to the impact of the fossil fuel crisis, increase in oil price, and the adoption of stringent emission norms. Many alternate fuels like Alcohols, Biodiesel, methanol, ethanol, LPG, CNG etc have been already commercialized in the transport sector. In this context, pyrolysis of solid waste is currently receiving renewed interest. Tests have been carried out to evaluate the performance analysis of a single cylinder direct injection diesel engine fueled with 10%, 15%, and 20% of tyre pyrolysis oil (TPO) blended with Diesel fuel (DF). The TPO was derived from waste automobile tyre through vacuum pyrolysis. Best suitable blend was found and pyrolysis oil was added in concentration of 10%,15% and 20%.It is observed that D85 P15 blend found less fuel consumption compared to D90 P10 and D80 P20. Ethanol was added in the concentration of 5%,10% and 15% to this D85 P15 blend. It was concluded that DP95 E5(95% of 85% pyrolysis oil-Diesel blend and 5% ethanol) found less fuel consumption and better brake thermal efficiency and can be used as an alternative fuel for Diesel engine without any engine modification.

1. Introduction

There are around billions tires which are thrown away every year in India. The numbers are expected to increase due to increasing numbers of vehicles. If the scrap tires are not managed well, the the scrap tire can give bad effects to the environment and people's health. One of the solutions is pyrolysis process. Pyrolysis oil is made by this process.

By the way world is facing problem of shortage of fossil fuel. There are initiatives to replace gasoline and diesel fuel due to the impact of fossil fuel crisis, hike in oil price and stringent emission norms. Due to the increase in automotive vehicle population, the disposal of waste automobile tyre has become essential. Different alternatives for tyre recycling, such as retreading, reclaiming, incineration, grinding, etc., have been used. It can be considered as a non-conventional method for tyre recycling, which is currently receiving renewed attention. In the pyrolysis process mainly the rubber polymers are heated and decomposed to low molecular weight products, like liquid or gases, which can be useful as fuels or chemicals source.

Pyrolysis of waste vehicle tires with the purpose of fuel production for the usage as a fuel in internal combustion engine can be Seen as a hygienic, environmentally acceptable and efficient way of disposing them. In an experimental study, it was reported that, cross-section samples of 2–3 cm wide, representative of a whole car tire, have been pyrolysed under nitrogen in a 3.5 dm3 autoclave at 300, 400, 500, 600 and 700 °C. At over 500 °C there is no effect of temperature on gas and liquid yields which were about 17 and 38%, respectively. Besides, catalysts have been applied in several studies for upgrading the quality and quantity of the products obtained from waste tire pyrolysis. Tire pyrolysis oil derived from waste automobile tires was analyzed and compared with the petroleum products and was found that it can also be used as a fuel for compression ignition engine [1].

It was reported that pyrolysis of scrap tyres produced oil similar in properties to a light fuel oil, with similar calorific value, and sulphur and nitrogen contents. The oil was found to contain 1.4% sulphur and 0.45% nitrogen by mass, and had similar properties to diesel fuel. The oils contained a significant concentration of polycyclic aromatic hydrocarbons, some of which had been shown to be carcinogenic and/or mutagenic. The derived oil was combusted in an 18.3 kW ceramic-lined, oil-fired, spray burner furnace, 1.6 m in length and 0.5 m internal diameter. The emissions of NOx, SO2, particulate and total unburned hydrocarbons were determined in relation to excess oxygen levels. Throughout the combustion tests, comparison of the emissions was made with the combustion of diesel. The oil was found to contain 1.4% sulphur and 0.45% nitrogen on mass basis and have similar fuel properties to those of DF [2].

I.de Marco Rotriguez et al. studied the behavior and chemical analysis of Tyre pyrolysis oil. In this work it is reported that Tyre Oil is a complex mixture of organic compounds of 5–20 carbons and with a higher proportion of aromatics. The percentage of aromatics, aliphatic, nitrogenated compounds, benzothiazol were also determined in the Tyre pyrolysis oil at various operating temperatures of the pyrolysis process. Aromatics were found to be about 34.7% to 75.6% when the operating temperature was varied between 300 °C and 700 °C, while Aliphatics were about 19.8% to 59.2%. In the same work, an automatic distillation test was carried out at 500 °C to analyze the potential use of Tyre pyrolysis oil as petroleum fuels. It was observed that more than 30% of the Tyre pyrolysis oil was easily distillable fraction with boiling points between 70 °C and 210 °C, which is the boiling point range specified for commercial petrol. On the other hand, 75% of the pyrolytic oil has a boiling point under 370 °C, which is the upper limit specified for 95% of distilled product of diesel oil. It was mentioned that distillation carried out between 150 °C and 370 °C has a higher proportion of the lighter and heavier products and a lower proportion of the middle range of products than commercial diesel oil [7].

Roy et al. conducted experiments on the recycling of scrap tyres to oil and carbon black by vacuum pyrolysis. In this work, a step-by-step approach has been used, from bench-scale batch systems, to a process development unit and finally a pilot plant, to experiment and develop vacuum pyrolysis of used tyres. It was reported that the yield is 55% oil, 25% carbon black, 9% steel, 5% fiber and 6% gas. The maximum recovery of oil is obtained at 415 °C below an absolute pressure of 2 kPa. The specific gravity of this oil was 0.95 and its gross heating value was 43 MJ/kg and total sulphur content about 0.8%. It was rich in benzyl and other Petrochemical components.The heat of pyrolysis for the reactions is low and is estimated to be 700 kJ/kg [5]

Kinetic constants of sulfur compound reactions were evaluated as collecting all sulfur compounds in a single group [6]. Only about 1% of the sulfur present in the loaded tire was detected in the liquid phase, the remaining being released as H2S in the gas phase. The sulfur content of the liquid products of tire pyrolysis should be lower to the commercial diesel fuel.

Bertoli et al. [10], did studies on the performance, emission and combustion characteristics of a Light duty DI Diesel Engine withwood pyrolysis oil (WPO)which was blendedwith different percentage of oxygenated compounds. It was concluded that reliable operations were recorded with WPO–diglyme blends with WPO content up to 44.1% by weight. Nomajor trouble was observed on the critical components of the engine [3].

A single oil droplet combustion study was carried out and also the oil was analysed in detail for its content of polycyclic aromatic hydrocarbons (PAH). The derived oil was combusted in an 18.3 kW ceramic-lined, oil-fired, spray burner furnace, 1.6 m in length and 0.5 m internal diameter. The emissions of NOx, SO2, particulate and total unburned hydrocarbons were determined in relation to excess oxygen levels [4].

From above researches, it is found that tyre pyrolysis oil can be used in IC engine without any engine modifications

2. Property Table

Table-1 Compression of property of tyre pyrolysis oil and Diesel

Property	Diesel	Tyre Pyrolysis oil
Density (kg/m^3)	0.830	0.9239
Kinematic viscosity	2.58	3.77
Net calorific value(MJ/kg)	43.8	38
Flash point, ˚c	50	43
Fire point, □c	56	50

3. Experimental Setup

The engine setup is shown in Figure 1. Single cylinder, vertical, water-cooled, self governed diesel engine made by "kilorskar" is used for this experiment. The engine was able to produce power of 5 HP. Rope brake dynamometer with spring balances and loading screw is attached to the engine for measuring brake power. For fuel consumption, Calibrated fuel burette measurement was used. The inlet side of engine has anti-pulsating drum which is attached with manometer for measurement of suction pressure of air supplied to the engine. Calorimeter is provided after exhaust from engine which cooled the exhaust gases from engine. Temperature display unit is attached to sense the exhaust gas temperature.

4. Methodology

First of all engine was run on pure diesel fuel. Readings were taken using conventional Diesel fuel for performance analysis. Than diesel was blended with tyre pyrolysis oil in the proportion of 10%,15% and 20% and performance analysis was done. Than ethanol was added in the concentration of 5%, 10% and 15 to this Diesel-pyrolysis oil blend to improve performance of engine. Than all results were compared with conventional diesel fuel, Diesel-pyrolysis oil blend and Diesel-pyrolysis oil –ethanol blends. Best suitable blend of Diesel-pyrolysis oil and ethanol were found using of performance analysis.

Table-2 Engine specifications

Parameter	Details
Engine	Single Cylinder High Speed Diesel Engine
Cooling	Water cooled
Bore × Stroke	80 mm × 110 mm
Compression ration	16 : 1
Maximum Power	5 hp or 3.7 kw
Rated speed	1500 rpm
Capacity	553 CC

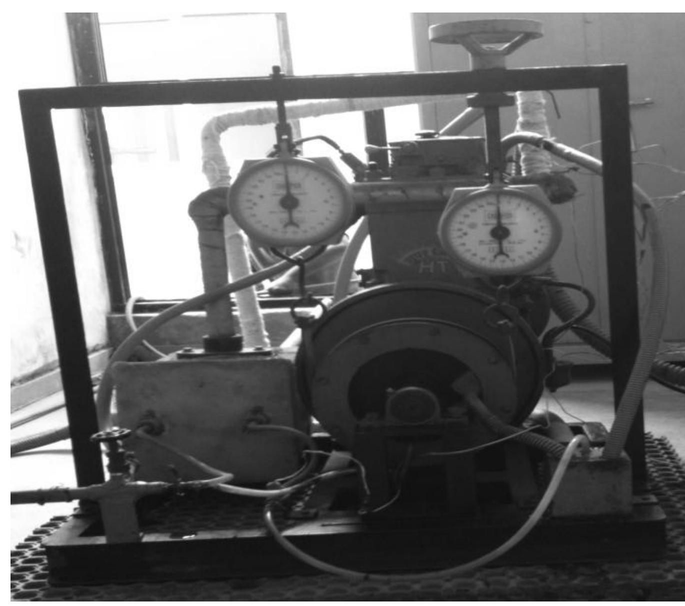

Fig 1 Experimental setup

5. Results

5.1 Fuel consumption

Fig.2 shows variation of fuel consumption with brake power. The fuel consumption found increased with increase in break power. Pyrolysis oil from tyre waste is added in proportion of 10%, 15% and 20%.There is an increase in fuel consumption found with increase in pyrolysis oil concentration in TPO-DF blend compared to Diesel Fuel.The fuel consumption found less in D85 P15 (85% Diesel and 15% pyrolysis oil) blend compared to D90 P10(90% Diesel and 10 % pyrolysis oil) and D80 P20(80% Diesel and 20% pyrolysis oil) .This may due to the proper mixture. If 5% ethanol is added to D85 P15 then fuel consumption in DP95 E5(95% of 85% diesel-15% pyrolysis oil blend and 5% ethanol) blend is less compared to DP90 E10 (90% of 85% Diesel-15% pyrolysis oil blend and 10% ethanol) and DP85 E15 (85% of 85% Diesel-15% pyrolysis oil blend and 15% ethanol) blend but found higher compared to Diesel Fuel. Because ethanol is a good oxygenated additive so the combustion process will be better.

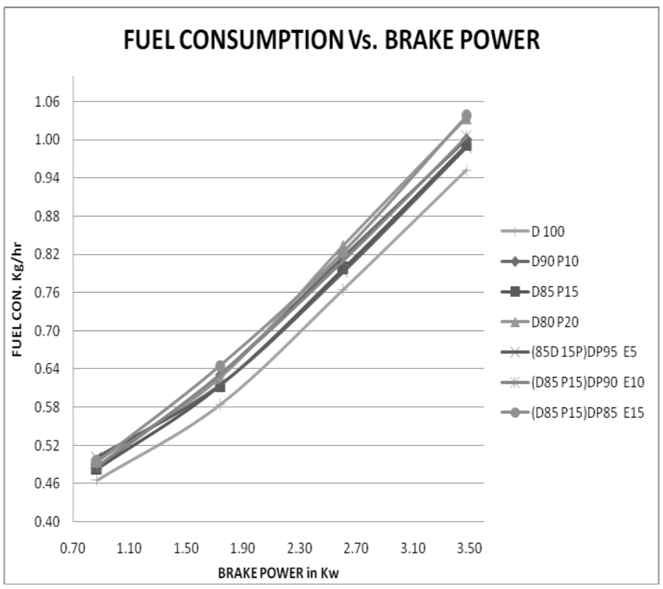

Fig 2 Variation of Fuel consumption with brake power

5.2 Brake Thermal Efficiency

Fig.3 shows that the break thermal efficiency increased with increased in the break power. The break thermal efficiency found decreased with increase in pyrolysis oil concentration compare to D100.The brake thermal efficiency of D85 P15 found batter than D90 P10 and D80 P20 but found less compared to Diesel fuel. Higher viscosity and poor mixture preparation are the due reasons for the lower brake thermal efficiency.. If ethanol is added, the break thermal efficiency of DP95 E5 found slightly higher compared to DP90 E10 and DP85 E15 but it is found less than DF.This may because of complete combustion due to addition of ethanol..

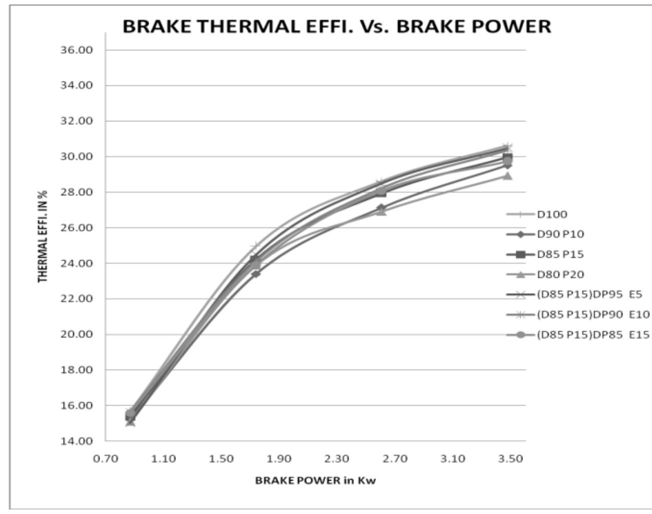

Fig 3 Variation of Brake Thermal efficiency with brake power

5.3 Mechanical efficiency

The variations of Mechanical efficiency with Load under various blends are shown in fig. 4

In Diesel-pyrolysis oil blend, the mechanical efficiency of D90 P10 is higher compare to D85 P15 and D80 P20.If ethanol is added, the mechanical efficiency of DP85 E15 found higher than DP95 E5 and DP90 E10.From graph it is seen that the mechanical efficiency of DP985 E5 is also found higher compare to Diesel.

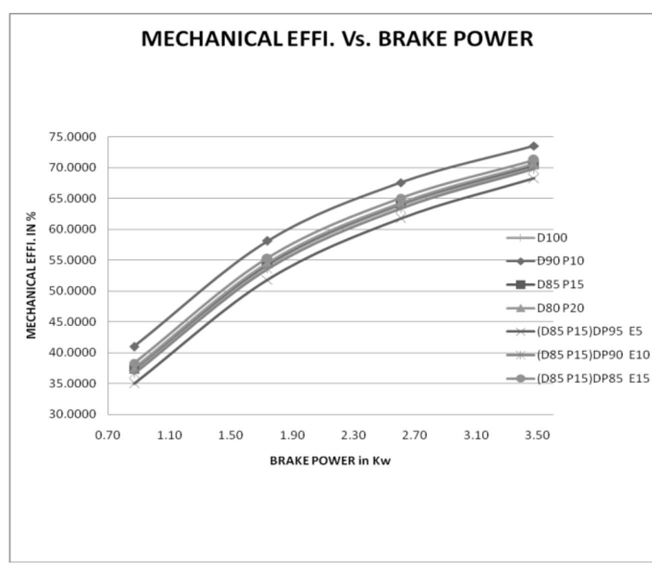

Fig 4 Variation of mechanical efficiency with brake power

ISSN: 2278-0181
Vol. 1 Issue 4, June - 2012

Conclusions

- In D85 P15 blend, fuel consumption found less compared to D90 P10 and D80 P20
- If ethanol is added , In DP90 E5 blend found less fuel consumption compared to DP90 E10 and DP85 E15
- Specific fuel consumption is also found less in (D85 P15)DP90 E10 compared to other ethanol blend
- If ethanol is added, in DP85 E15 blend found higher mechanical efficiency compared to DP95 E5 and DP90 E10
- The brake thermal efficiency found higher in D85 P15 blend compared to D90 P10 and D80 P20.
- If ethanol is added to TPO-Diesel blend, Brake thermal efficiency of DP95 E5 blend found slightly higher than D85 P15 and also higher compared to DP90 E10 and DP85 E15.
- It is concluded that DP95 E5 blend found better compared to DP90 E10 and DP85 E 15.
- It is concluded that DP95 E5 blend found better which can be used in a diesel engine without any engine modification.

References

[1] Cumali ilkilic, Fuel production from waste vehicle tires by catalytic pyrolysis and its application in a diesel engine, journal of fuel processing technology 92 (2011) 1129-1135.

[2] S.Murugan, The use of tyre pyrolysis oil in diesel engines,Fuel processing technology 28 (2008) 2743-2749.

[3] S.Murugan, Assessment of pyrolysis oil as an energy source for diesel engines,Fuel processing technology 90 (2009) 67-64.

[4] S.Murugan, Performance, emission and combustion studies of a DI diesel engine using distilled tyre pyrolysis oil-diesel blends,Fuel processing technology 89 (2008) 152-159.

[5] C. Roy, B. Labrecque, B. De Caumia, Recycling of scrap tyres to oil and carbon black by vacuum pyrolysis. Resource, Conservation and Recycling 4 (1990) 203–213.

[6] F. Murena, Kinetics of sulphur compounds in waste tyres pyrolysis, Journal of Analytical and Applied Pyrolysis 56 (2000) 195–205.

[7] I. de Marco Rodriguez, M.F. Laresgoiti, A. Cabrero, Torres, M.J. Chomon, B. Caballero, Pyrolysis of scrap tyres, Fuel Processing Technology 72 (2001) 9–22.