Performance studies of Tire Pyrolysis Oil blends with Diesel Fuel

Jinang M.Patel, Krunal J.Patel,Vatsal V.Patel, Kalpesh V.Vaghela

***Abstract** The present rate of consumption of gasoline would lead to severe shortage of it within next few decades. An urgency of finding an alternative fuel in its place has led to several researches around the world. In this study oil obtained from pyrolysis of waste tire was studied upon for its suitability to be used with diesel fuel. A study was carried out to evaluate the use of various tire pyrolysis oil (TPO) blends with diesel fuel. Performance and emission characteristics of TPO blends with diesel on a 4 cylinder direct injection engine are presented in this study. In the initial stage the test were conducted on four stroke single cylinder diesel engine by using diesel and base line data was generated .A constant speed off 1500rpm was maintained throughout the experiment. Then commercially available TPO was blended with diesel fuel at the volumetric ratios of 5 %(D5), 10% (D10) and15 %(D15).The results showed that brake thermal efficiency of the engine was maximum for D10 blend than diesel at same loading conditions. The BSFC was also found to be less for D10 blend compared to diesel. There was no significant increase in exhaust gas temperature for the blends as compared to diesel.*

***Keywords**- Compression ignition engine, Tire pyrolysis oil, Performance Characteristics, Brake thermal efficiency, Brake specific fuel consumption*

I. INTRODUCTION

There has been an increasing need of generating an alternative source of energy for the automobiles along with the regular gasoline used at present. This need has arisen mainly owing to the ever depleting available sources of this gasoline reserves. Various alternative biodiesel such as rice bran oil, waste cooking oil, ricinus communis oil have been researched upon for their suitability as a diesel blend.

With scrap tires are generated at about the rate of one per person in the US, or about 300 million per year, the importance of tire recycling cannot be understated The use of waste tire for producing a commercially usable blend with diesel will greatly affect the consumption of the diesel fuel. Obtaining energy from utilizing the waste is a trend greatly appreciated from around late 20th century. Large amount of used tire get dumped without having any proper usage. Forming TPO from them will be a great advantage to both the recycling of tires and open up a viable source of energy. Pyrolysis is the process of thermally degrading a substance into smaller, less complex molecules. Pyrolysis produces three principal products: such as pyrolysis oil, gas and char. The quality and quantity of these products depend upon the reactor temperature and design.

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***** Correspondence Author (s)

Jinang M.Patel, Mechanical Department, Charotar University of Science and Technology Changa, Anand

Krunal J.Patel, Mechanical Department, Charotar University of Science and Technology Changa, Anand

Vatsal V.Patel, Mechanical Department, Charotar University of Science and Technology Changa, Anand

Kalpesh V.Vaghela, Mechanical Department, Charotar University of Science and Technology Changa, Anand

It is reported that pyrolysis of scrap tires 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.

Roy et al [1] conducted experiments on the recycling of scrap tires 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 tires. 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

S.Murugan et al [2] carried out to evaluate the performance and emission characteristics of a single cylinder direct injection diesel engine fuelled by 10, 30 and 50 percent blends of Tire pyrolysis oil (TPO) with diesel fuel (DF).Results showed that the brake thermal efficiency of the engine fuelled by TPO-DF blends decreased with increase in blend concentration and higher than Diesel. NOx, HC, CO and smoke emissions were found to be higher at higher loads due to high aromatic content and longer ignition delay.

M. Mani et al [3] conducted performance test on diesel engine by using waste plastic oil as alternate fuel. The experimental results have showed stable performance with brake "thermal efficiency similar to that of diesel. Carbon dioxide and unburned hydrocarbons were marginally higher than that of the diesel baseline. The toxic gas CO emission of waste plastic oil was higher than diesel. Smoke reduced by about 40% to 50% using waste plastic oil at all loads

Tushar Patel et al [4] conducted Performance analysis of single cylinder diesel engine fuelled with Pyrolysis oil - diesel and its blend with Ethanol. It was concluded that 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.

From the above citations it is clear that TPO can be produced easily from waste tire and that blending it with diesel in small proportions can improve performance parameters and reduce emissions without modifying the engine design.

II. MATERIALS AND METHOD

In present investigation, tests have been conducted on a DI diesel engine. The specifications of the diesel engine are given in table 1.

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The Tire Pyrolysis Oil used as a blend was obtained from a commercial producer and its properties are given in table 2.

Table 1. Engine specifications

Engine type	Kirloskar model JAV1
No of strokes	4
No of cylinders	4
Cooling method	Water cooled
Combustion chamber position	Vertical
Bore (D)	85mm
Stroke (L)	80mm
Rated power	5HP (3.7KW)

Table 2 TPO properties

Property	
Density (kg/l)	.8340
Sulphur content (%wt)	.3083
Kinematic viscosity(40C° mm2/s)	1.913
Calorific value KJ/kg	42596.50
Ash content %wt	.001
Pour point	<-21

2.1 Experimental setup and procedure

The engine setup is shown in Figure 1. Four cylinders, vertical, water-cooled, self governed diesel engine is used for this experiment. The engine was able to produce power of 5 HP. Hydraulic dynamometer and loading screw is attached to the engine for measuring brake power. For fuel consumption calibrated fuel burette measurement was used. Water cooling arrangement is used in order to keep the temperature of engine under control and a constant flow rate of cooling water was maintained. Temperature display unit is attached to sense the exhaust gas temperature, cooling water inlet and outlet temperature.

Figure 1 Engine setup

The engine was first operated on diesel fuel on no loading conditions and a constant cooling water flow rate was established. A constant speed of 1550rpm was maintained and fuel consumption, temperatures and brake power were recorded for different loading conditions for pure diesel fuel. Three blends D15, D10 and D5 were then subsequently used as engine fuel and readings were recorded.

III. RESULTS AND DISCUSSION

3.1 Brake thermal efficiency

The variation of brake thermal efficiency with brake power for diesel and its TPO blends is shown in Fig 2.The brake thermal efficiency increased with brake power for all the fuel modes. It was found that the brake thermal efficiency for D10 was higher than diesel over the entire range. The efficiency was found to least for D5 blend.

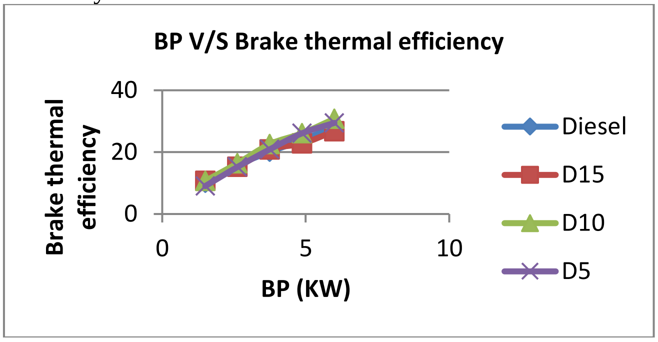

Figure 2: Graph of brake power versus brake thermal efficiency

3.2 Brake specific fuel consumption (BSFC)

The variation of brake specific fuel consumption and brake power for diesel and its TPO blends is shown in Fig 3.The BSFC decreased with increase in loading condition .A decrease in BSFC for the D10 blend was found as compared to diesel. Also a lower loading conditions D5 blend had the maximum BSFC.

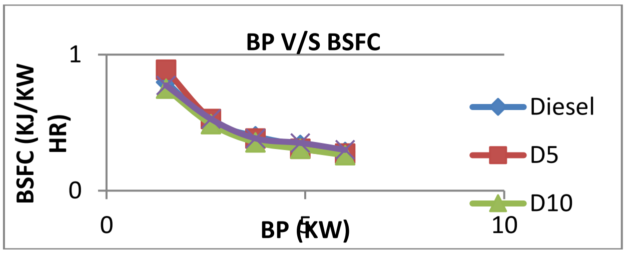

Figure 3: Graph of brake power versus brake specific fuel consumption

3.3 Exhaust gas temperature

The variation of exhaust gas temperature and brake power for diesel and its TPO blends is shown in Fig 4. The temperature of exhaust gas was found to increase with increase in loading conditions. At low loading conditions the temperatures of D10 and D15 blends was lower than diesel, but at higher loading D10 blend had exhaust temperature similar to diesel.

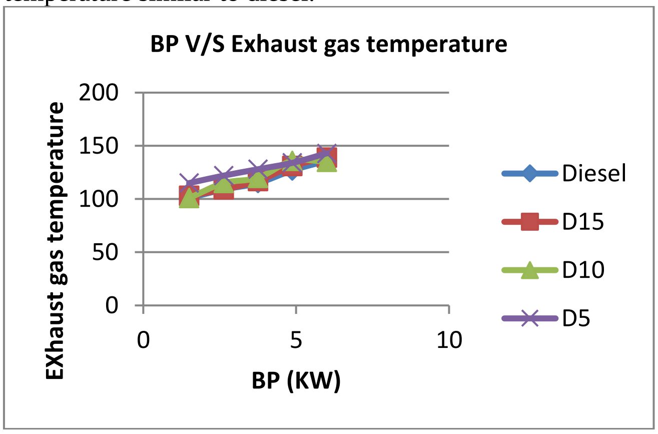

Figure 4: Graph of brake power versus exhaust gas temperatures

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IV. CONCLUSIONS

The performance characteristics of neat diesel and its TPO blends are investigated on a multi cylinder diesel engine. The conclusions of these investigations are as follows:

- Brake thermal efficiency increased for all D10 when compared to neat diesel fuel. The maximum brake thermal efficiency was found to be 2.68% higher than neat diesel.
- Brake specific fuel consumption was lower than neat diesel over entire range. At maximum loading condition BSFC of neat diesel was 9.55% higher than D10 blend.
- The exhaust gas temperatures were significantly lower than neat diesel for D10 and D15 at low loading conditions.

REFERENCES

[1] C. Roy, B. Labrecque, B. De Caumia, Recycling of scrap tires to oil and carbon black by vacuum pyrolysis. Resource, Conservation and Recycling 4(1990) 203–213.
[2] S.Murugan, M.C.Ramaswamy, G.Nagarajan, "The Use of Tire Pyrolysis Oil in Diesel Engines". Waste Management, Volume 28, Issue 12, December 2008, Pages 2743-2749
[3] M.Mani ,C,subash,G.Nagarajan "performance Emission and Combustion Characteristics of a DI Diesel Engine Using Waste Plastic Oil" Applied Thermal Engineering, volume 29, Issue 13, September 2009, Pages 2738-2744
[4] International Journal of Engineering Research & Technology (IJERT) Vol. 1 Issue 4, June – 2012 Mr.Tushar Patel 1Student, L.D.R.P engineering college, Gandhinagar

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