Evaluation of Combustion Performance of Waste Tyre Pyrolysis Oil On Variable Compression Ratio, Single Cylinder Diesel Engine

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Abstract

Increase in industrialization and transportation of different equipments all over the world in all sectors led to the increasing demand of vehicles.[3] To run these vehicles mostly Diesel engines are used. But due to the scarcity of petroleum based fuel like Diesel, it is necessary to go for the fuels other than conventional fuels which will require little or no engine modification. Again the fuel should be economical as well as environment friendly in order to follow the stringent emission norms. In this context waste tyre pyrolsis oil is the most emerging fuel which is tested to evaluate the performance analysis with Diesel fuel in Single cylinder water cooled variable compression ratio type Diesel engine. Tests were carried out with 100% Diesel and then 10%, and 50% of tyre pyrolysis oil (TPO) blended with Diesel fuel (DF) for different loading conditions. It is observed that the brake power, indicated power as well as Brake mean effective pressure(BMEP) increased when diesel blended with tyre pyrolysis oil at higher loads while friction power decreases with increase in TPO concentration in the blend as well as with increase in load. The variation of Brake thermal efficiency with load was also observed and it is found the tyre blends D75% + TPO25% shows maximum thermal efficiency than other blends with diesel. Again engine can run without any modification with addition of 50 % TPO by volume with Diesel

Keywords : Tyre Pyrolysis oil, Diesel fuel, Brake Power ,Friction Power ,BMEP

1. Introduction

Due to the fuel crisis, hike in oil prize and stringent emission norms there is initiative all over the world to replace gasoline and diesel fuel. Number of researchers are working on different alternative fuels.[7]. The focused technologies in this context are bio-ethanol, bio-diesel, waste oil recycling, pyrolysis, gasification, dimethyl ether and biogas. Various alternative bio-diesels such as rice bran oil, waste cooking oil, have also been researched upon for their suitability as a diesel blend. Rapid growth of vehicles also generating large number of tyres which after use should be disposed properly. But the disposal of waste tyres from automobile vehicles is becoming more and more complex and world is facing to another major problem is the waste management.[4] Since waste management problem is concerned to every metropolitan cities and small cities ,appropriate waste management strategy is important aspect of sustainable development.

Pyrolysis of waste tyres produces oil which can be used in the engines and it is the most emerging alternative fuel in this regard. From the investigation, there are many materials from the waste have

potential to be converted into oil like plastic, biomass and rubber tyres. Pyrolysis process is one of the best possible solutions of waste to energy technology to deliver bio-fuel to replace fossil fuel. Waste plastic and waste tyres are investigated in the research as they can produce oils. The advantage of pyrolysis process is its ability to handle rough tyres and dirty plastics.

The use of Tyre pyrolysis oil as a substitution to diesel fuel is an opportunity in minimizing the utilization of the natural resources. The maximum yield of pyrolytic oil from the waste tire was found to be 42.0% (by weight) at temperature of 450°C with the tyre size of 0.75 cm^3 with a lot size of 1.5 kg [1].Several research works have been carried out on the pyrolysis of waste automobile tyres. When bio-diesel is used in diesel engine, there is need of some modifications in the diesel engines. Also there is trouble in working of diesel engine and increased emissions like Nox.

So many investigators are working on tyre pyrolysis oil and its blends with diesel. The main oil product produced by pyrolysis technology is the fuel oil that is widely used for industrial and commercial purpose. Several studies have also reported that the yield of oil from the pyrolysis of tyres can be used in the Diesel engine without any modification

2. Preparation of Tyre Pyrolysis Oil

In the pyrolysis process, an automobile tyres are cut into number of pieces and the bead, steel wires and fabrics are removed. Thick rubber at the periphery of the tyre is alone made into small chips. The tyre chips are washed, dried and fed into a mild steel pyrolysis reactor unit.Vacuum is created in the pyrolysis reactor and then externally heated by means of 1.5 kW heaters. The process is carried out between 450 ºC and 650 ºC in the reactor for 2 hours and 30 minutes. The products of pyrolysis in the form of vapour are sent to a water cooled condenser and the condensed liquid is collected as a fuel. Around 6 hours takes place for condensation process. The non-condensable gases are let out to atmosphere or burn out in fire chamber. The TPO collected as crude oil in nature. Tyre pyrolysis process is as shown in Figure 1[5]
Properties of TPO and Diesel are shown in table 1

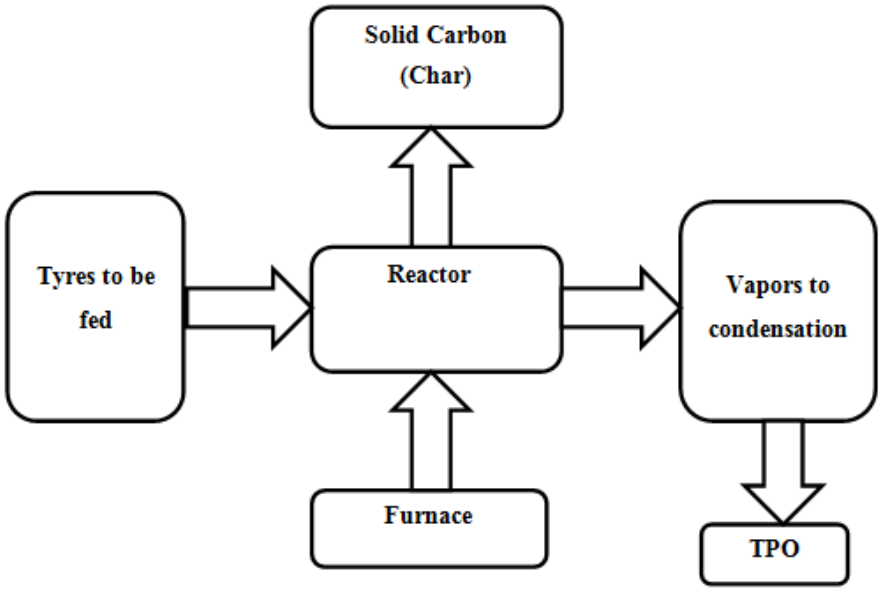

Figure.1 Pyrolysis Process

Table 1 Comparison of Properties of Diesel and TPO [2,6]

Parameter	Diesel	TPO
Density (kg/m^3)	0.83	0.88
Kinematic Viscosity(cm^2/s)	2.58	2
Lower Calorific Value (KJ/kg)	10200	10046.2
Flash point, ˚c	50	43
Fire point, ˚c	56	50

3. Experimental Set Up

A single cylinder, water cooled, four stroke direct injection compression ignition engine with compression ratio of 12 to 18 and it develops 3.5 kW power at 1500 rpm was used for the trial. The specification of the engine used for testing is shown in table 2. The engine was coupled with rope brake dynamometer. The Kirloskar engine setup is shown in figure 2.

Table 2.Engine Specification

PARAMETER	DETAIL
Engine	Single cylinder High speed Diesel
Bore diameter	87.5 mm
Stroke length	110 mm
Maximum Power	3.5 kW
Rated speed	1500 rpm
Compression ratio	12 to 18:1
Cooling	Water cooling
Orifice diameter	20 mm
Dynamometer arm length	185 mm

4. Methodology

In this experiment fuels used were Diesel, Tyre pyrolysis oil and blends. Blends were made on the volume basis. First of all engine was running on diesel from no load to full load. During test load, speed, air flow rate, fuel flow rate, exhaust gas temperature were measured for different load conditions. Then load was applied in three levels namely 10%, 25%, and 50%. At the end of test, the engine was run for some time with diesel to flush out the tyre pyrolysis oil from the fuel line and the injection system. Then all results were compared with conventional Diesel fuel and

Diesel and pyrolysis oil blends. Best suitable blend of Diesel and pyrolysis oil were found using performance analysis

Figure 2. Experimental Set up

4. Results and Discussions

The results that obtained from taking tests on Diesel engine are summarized in the form of graphs. The Brake Power versus Load, Specific fuel consumption versus Load, Brake thermal efficiency versus Load, Mechanical Efficiency versus Load were plotted obtained results.

4.1. Variation of Brake Power Vs Load

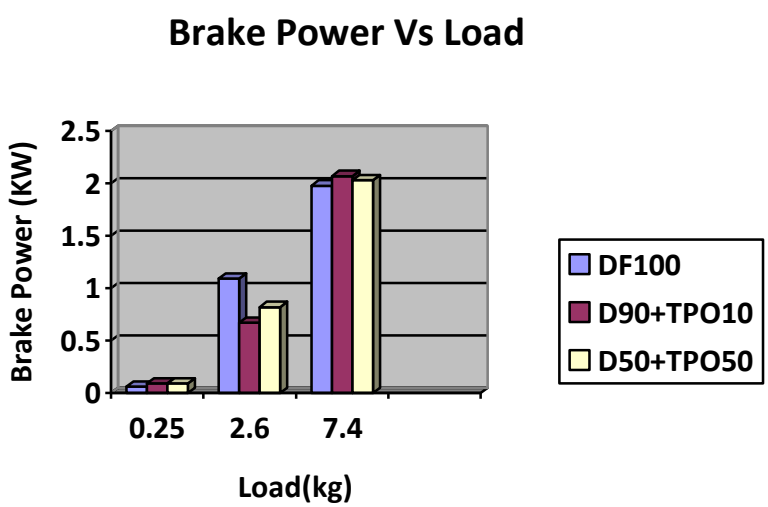

Figure 3. Brake Power Vs Load

The figure 3 shows the variation of brake power with change in load. From the graph, it is clear that with increase in load the brake power increases. Again with increase in the TPO concentration in the blend brake power increases.

4.2. Variation of Friction Power Vs Load

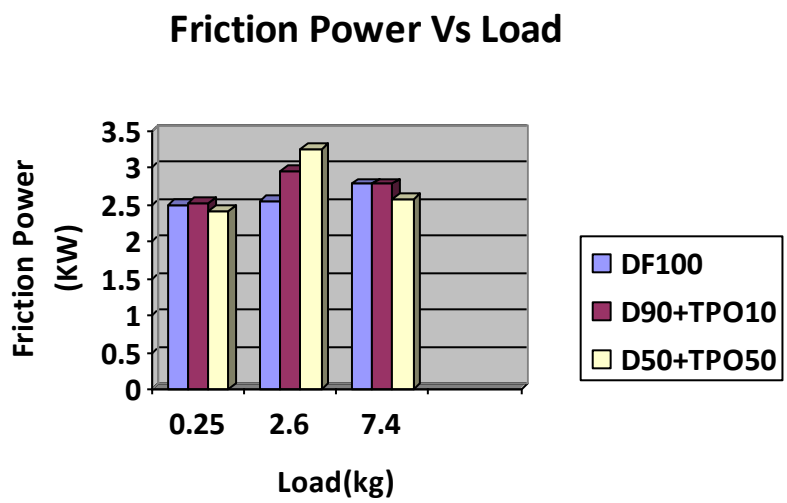

Figure 4. Friction Power Vs Load

The variation of friction Power with load is shown in figure 4.It is observed that as load increases friction power increases but further decreases at higher load. With increase in the TPO concentration ,drop in the friction power is rapid.

4.3.Variation of Indicated Power Vs Load

The variation of Indiacted Power with load is showen in figure 5. It can be observed from the plot that with increase in the load indicated power increases .Again with increase in the TPO concentration it is found that indicated power also increases for all the loading conditions.

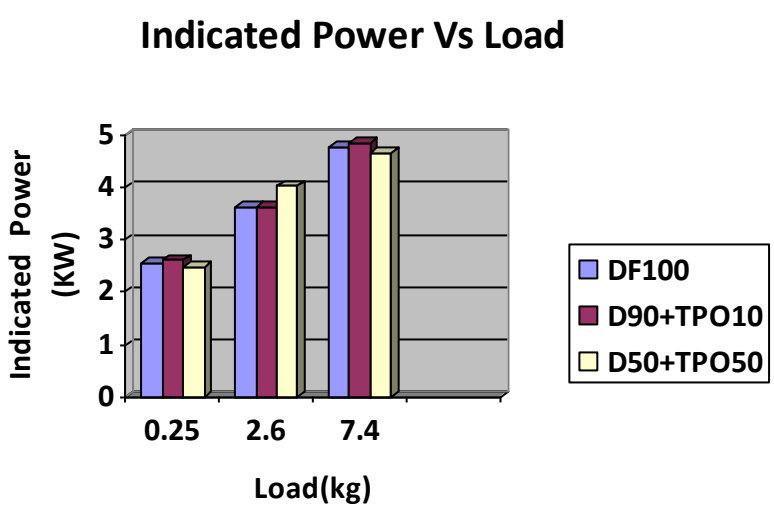

Figure 5. Indicated Power Vs Load

4.5.Variation of Brake Mean Effective Pressure (BMEP) Vs Load

The variations of Brake Mean Effective Pressure with Load under various blends are shown in figure 6.From the plot it is observed that BMEP increases with increase in the load. Again with increase in the TPO concentration, BMEP increase at higher load compared to the rise at lower loads.

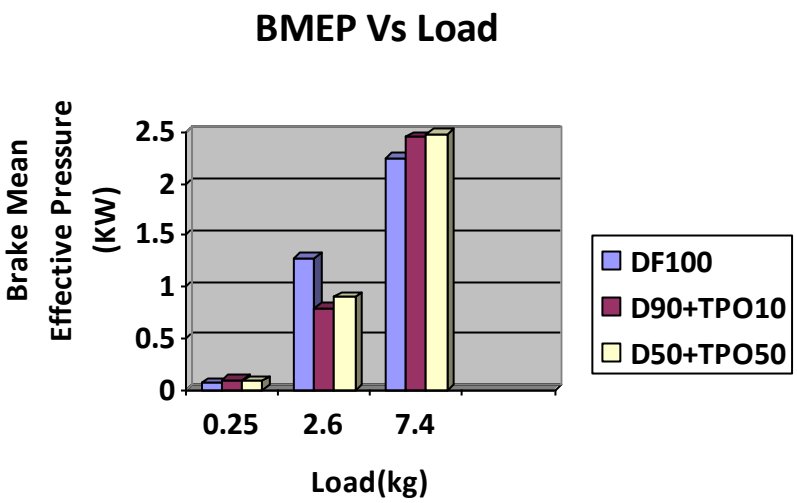

Figure 6. Brake Mean Effective Pressure Vs Load

Conclusions

- The brake power is increased when diesel blended with tyre pyrolysis oil.
- Brake power found to be increased with increase in the loads as well as TPO concentration in the blend.
- Friction power is found to be increasing up to certain load but decrease at higher loads. With increase in the TPO concentration in the blend, friction power increase and then decreases.
- Indicated power found to be increased with increase in the loads but with increase in the TPO concentration in the blend, indicated power is found to be decreased in the blend.
- Brake mean effective pressure increases with increase in the loads. With increase in the TPO concentration in the blend, BMEP decrease at lower load but increases at higher load.
- The variation of Brake thermal efficiency with load was also observed and it is found the tyre blends D75% + TPO25% shows maximum thermal efficiency than diesel as calorific value tyre oil is more than diesel and less viscosity
- All the Diesel +TPO blends are suitable for diesel engine without any engine modification.

- By use of tyre pyrolysis oil in diesel, we can have the new possible solution for waste tyre management

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Biographies

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