

Performance and Emission characteristics of Diesel Engine Fuelled with Tire Pyrolysis Oil, Utilized Transformer Oil and Diesel Blends

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ABSTRACT: Conventional fuels are decreasing due to increase in industrialization and modernization. The price of conventional fuels is going on increasing day to day and also increasing environmental pollution due to more usage. If this goes on there will be no longer the conventional fuels. There is a need to search for alternative fuels for the automobile applications. Therefore in the present project the oil taken is the tire pyrolysis oil which is obtained by the pyrolysis of the waste automobile tires and utilized transformer oil. In the first step the test were conducted on four stroke single cylinder diesel engine by using diesel and base line was generated. Further in the second step experimental investigations were carried out on the same engine with same operating parameters by using tire pyrolysis oil, utilized transformer oil blended with diesel in different proportions such as 10%, 20%, 30% and 40% of tire pyrolysis oil (TPO), 10%, 20%, 30% and 40% of utilized transformer oil (UTO) with diesel fuel (DF) to find out the performance parameters and emissions. It was observed that there are no CO and HC emissions. NO_x and CO₂ emissions when compared to diesel were seen less. Coming to the engine performance Blend2 gave more mechanical efficiency and brake thermal efficiency than diesel.

KEYWORDS: Diesel Engine, Tire Pyrolysis Oil, Utilized Transformer Oil, Performance, Emission Characteristics.

I. INTRODUCTION

Oil, natural gas and coal form the main constituent of fossil fuel energy. These energy resources were formed millions of years ago as the consequence of decomposition of organic remains trapped in the sediments and subjected to high temperature and pressure conditions in the subsurface of the earth. The consumer demand for crude oil is increasing with annual rate in excess of 2%. This demand is even higher in the advanced Asian countries like China, India and South Korea owing to increase in transportation, using cars and trucks powered by internal combustion engines. Extensive analysis of demand supply by petro consultants, geologists has predicted that the oil production will peak within a span of 20 years in the near future. Fast depletion of the fossil fuels, rising petroleum prices, increasing threat to the environment from exhaust emissions and global warming have generated intense international interest in developing alternative non-petroleum fuels for engines. Due to fast depletion of fossil fuels and increasing of diesel engine vehicle population, the use of renewable fuel like vegetable oils becomes more important. Many alternative fuels like bio gas, methanol, ethanol and vegetable oils have been evaluated as a partial or complete substitute to diesel fuel. In the past 2008 Semin, Rosli Abu Bakar [1] gave a technical review on CNG that is Compressed Natural Gas as alternate fuel for internal combustion engines. Natural gas is made up of primarily CH₄ (methane). CNG is non renewable and largely available from fossil energy. There are five reasons for its attractiveness. They are the cost of fuel is cheaper, lower air pollution, lower greenhouse gas etc. The main disadvantage is the fuel storage tank should be doubled i.e., to meet the same efficiency like S.I engines. It is explosive once so separate arrangement should be done for the fuel tank. In the 2009s M. Pgazhvadivu and S. Rajagopan [2] conducted experiment on single cylinder direct injection diesel engine fuelled with blends of bio diesel and diesel at different proportions such as B25, B50, B75 and B100. In this experiment Performance and Emission characteristics were determined and also compared. At less loads the B25 gave less NO_x emissions and HC, CO emissions. Increasing load and at B50, B75 and B100 the NO_x

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emissions are high. With the addition of diethyl ether there is an increase in the cetane number so the NO_x and smoke emissions were reduced at B25. In 2011 S. Jaichandar and K. Annamalai [3] gave an overview on the status of biodiesel as an alternative fuel for diesel engine. Bio diesel is mainly made from vegetable sources. It is more lubricating than diesel fuel. Bio diesel can be produced from animal fat also. It is having Triglycerides of fatty acids. Because of high molecular weight they are having high viscosity. So it is not suitable for C.I engines. It should be split into simpler molecules. This can be done by Pyrolysis, Micro Emulsification, Dilution and Transesterification. Among these Transesterification is most commonly used process to produce clean bio diesel. By using biodiesel as alternative fuel the fuel consumption increased by 14%. The brake effective power is decreased by 8%. Coming to the emissions there is increase in unburnt HC, CO, NO_x, SO and particulates. When the biodiesel is blended with diesel the emissions decreased. In 2012 M.K. Chopra, Shrikanth ulhas chaudhari [4] conducted experiment on performance of bio mass gasifier using wood. The main aim of this project is to fabricate and design a gasifier which produces a consistent quality of producer gas with less tar content. The gas produced in the gasifier is a clean burning fuel having heating value of about 950-1200 kcal/m³, H₂ (18-20%), CO (18-24%). The producer gas obtained after several modifications is having low calorie gas. This gas is good enough for S.I engines. But for C.I engines 100% gas we cannot use. A pilot jet is necessary for ignition. Producer gas is formed by the partial combustion of solid biomass in a vertical flow packed bed reactor. For proper flow of wood chips 1x1x1 inch is good. Burner diameter and length should be 150mm. Again In 2012 P. Suresh Kumar, Ramesh Kumar, P. K. Sahoo [5] conducted experiment on indirect injection diesel engine fuelled with Jatropa Bio diesel and diesel by varying injection pressure. The injection pressures are 160, 170 and 180 kgf/cm². The results were compared against those obtained using diesel fuel. At 100% load the brake thermal efficiency is increased as the injection pressure is increased up to an angle of fuel injection 25° BTDC beyond that the brake thermal efficiency decreased. For diesel the brake thermal efficiency is decreased at the same conditions. CO emissions decreased up to the advance angle of fuel injection 23° BTDC beyond that increased at an angle of 25° BTDC. CO emissions decreased at an injection pressure of 160,170 and 180kgf/cm². For diesel CO emissions are increased from 19° BTDC to 25° BTDC. The CO₂ emission increased gradually at the advance angle of fuel injection is increased up to 23° BTDC but the CO₂ emission start decreasing beyond 23° BTDC of fuel injection which shows the fuel combustion efficiency starts deteriorating. CO₂ emissions continuously increased when the injection pressure increased from 160 to 180kgf/cm² and for diesel CO₂ is decreased with the increase in injection pressure. The NO_x emissions decreased for jatropa with increasing advance angle of injection up to an angle of 23° BTDC at all load conditions. NO_x emissions increased beyond 23° BTDC. NO_x emissions for diesel increased from 19° BTDC to 25° BTDC. NO_x emissions decreased for increase injection pressure for jatropa. HC emissions decreased as the fuel injection pressure increased for jatropa. HC emissions increased for diesel at all injection pressures. When coming to the smoke emissions there is decrease with increase in angle up to 23° BTDC for jatropa. For diesel it is very less than the jatropa.

II. RELATED WORK

2.1 Pyrolysis of waste automobile tires:

Pyrolysis is the process of thermally degrading a substance into smaller, less complex molecules. Pyrolysis produces three principal products like pyrolytic oil, gas and char. The quality and quantity of these products depend upon the reactor temperature and design. The automobile tires are fed into the 5T capacity rotary horizontal direct heating batch reactor vessel and initially the heat is supplied by means of oil under controlled condition of temperature and pressure. The process will bring about molecular restructuring of rubber and convert into vapours and gases. These vapours and gases come into separator where heavy oil fraction is separated from gases and the gases are passed through the series of heat exchangers to condense the vapour in to liquid form called tire oil (40 to 45%) by means of recirculated water from cooling tower and is collected in to the storage tank. Non condensable gases also called pyro gases (10%) are used for heating the reactor in place of oil. During the process carbon black (30 to 35%) and steel wires (10 to 15%) are also generated, being pulled out of reactor to be sold in to the open market. The properties of tire pyrolysis oil are tabulated below.

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Property	Tire Pyrolysis Oil
Density (g/cc)	0.90
Kinematic Viscosity(cst) at 28°C	7.085
Heating Value (KJ/Kg)	41494.069
Flash point (°C)	42
Fire point (°C)	62

2.2 Utilized Transformer Oil

Inhibited Transformer oil is formulated with hydro treated naphthenic base oil and an oxidation inhibitor to control sludge and deposit formation. It provides an extended service life compared to non-inhibited transformer oils. It has excellent low temperature properties and is non corrosive to copper and copper alloys. This Oil does not contain any polychlorinated biphenyls. Mineral oil, synthetic esters and silicon oils are traditionally used as transformer oils. Mineral transformer oil is composed of hydrocarbons of paraffinic, aromatic or naphthenic structure that are obtained by fractional distillation of crude petroleum. Synthetic oils are produced by substituting a chlorine atom for a hydrogen atom in hydrocarbon molecules. The properties of Utilized transformer oil are shown in below table.

Property	Tire Pyrolysis Oil
Density (g/cc)	0.89
Kinematic Viscosity(cst) at 28°C	12.054
Heating Value (KJ/Kg)	41089.34
Flash point (°C)	132
Fire point (°C)	142

III. EXPERIMENTAL SETUP

3.1 Experimental Test Rig:

The experimental setup shown in figure is a single cylinder four stroke direct injection compression ignition engine. The engine specifications are shown in below table. Fuels used in diesel engine were diesel, tire pyrolysis oil, utilized transformer oil and blends. Load was applied in five levels namely 20%, 40%, 60%, 80% and 100%. Load, Speed, Efficiencies and Exhaust Emissions of HC, CO, CO₂, O₂ and NO_x were measured at all load conditions. The Engler's Viscometer was used to measure the viscosity of fuels at various temperatures. The exhaust gas analyser was used to measure CO, HC, CO₂, O₂ and NO_x levels. All the tests were conducted by starting the engine with diesel only. After the engine was warmed up, it was then switched to tire pyrolysis oil, utilized transformer oil blends. At the end of the test, the engine was run for some time with diesel to flush out the tire pyrolysis from the fuel line and the injection system.



Fig3.1: Diesel Engine



Fig3.2: Emission Analyser

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3.2 Specifications of the test engine

Type of Engine	A single cylinder four stroke water cooled diesel engine
Bore	80 mm
Stroke	110 mm
Compression Ratio	16:1
Coefficient of discharge (C_d)	0.6
Diameter of the orifice (d)	20 mm

IV. EXPERIMENTAL RESULTS

The performance and emission characteristics of a high speed diesel engine at various loads from no load to full load fuelled with tire pyrolysis oil, utilized transformer oil and its diesel blends are discussed below as per the results obtained.

4.1. Performance

4.1.1 Specific Fuel Consumption (SFC):

The graph is plotted in between brake specific fuel consumption and brake power is shown in fig4.1.1. As the load increases the fuel consumption decreases. At full load condition the BSFC obtained are 0.196 kg/kw-hr, 0.2 kg/kw-hr, 0.21 kg/kw-hr, 0.19 kg/kw-hr, 0.19 kg/kw-hr and 0.21kg/kw-hr for fuels of TPO, BLEND1, BLEND2, BLEND3, BLEND4 and DIESEL respectively. The BSFC of tire oil decreased when compared to the diesel at full load condition.

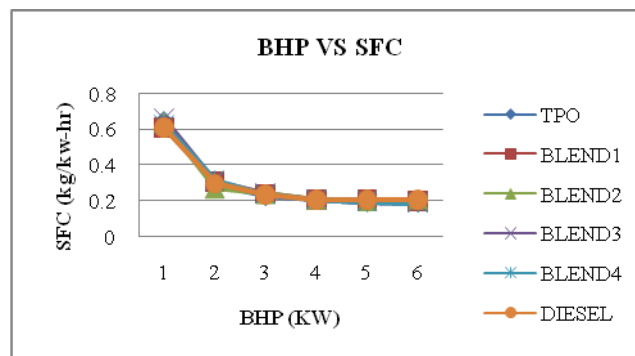


Fig4.1.1: Variation of Specific Fuel Consumption with Brake Power

4.1.2 Brake Thermal Efficiency (BTE):

The graph is plotted in between brake thermal efficiency and brake power is shown in fig4.1.2. As the load increases the brake thermal efficiency increases. At full load condition the brake thermal efficiency obtained are 32.49%, 34.48%, 33.33%, 36.49%, 34.96% and 29.41% for fuels of TPO, BLEND1, BLEND2, BLEND3, BLEND4 and DIESEL respectively. The Brake Thermal Efficiency of tire oil blend2 increased when compared to the diesel at full load condition.

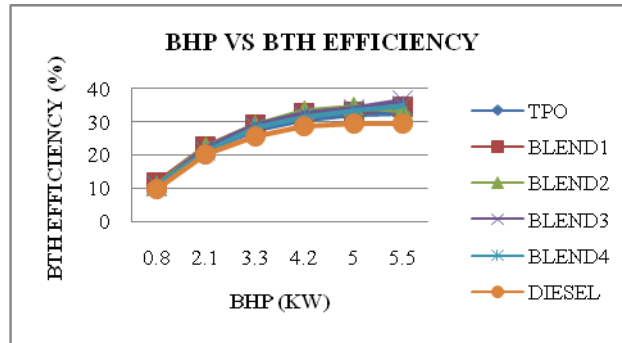


Fig4.1.2: Variation of Brake Thermal Efficiency with Brake Power

4.1.3 Mechanical Efficiency:

The graph is plotted in between mechanical efficiency and brake power is shown in fig4.1.3. As the load increases the mechanical efficiency increases. At full load condition the mechanical efficiency obtained are 80.82%, 70.44%, 74.83%, 68.67%, 69.07% and 73.23% for fuels of TPO, BLEND1, BLEND2, BLEND3, BLEND4 and DIESEL respectively. The mechanical efficiency of tire oil blend2 increased when compared to the diesel at full load.

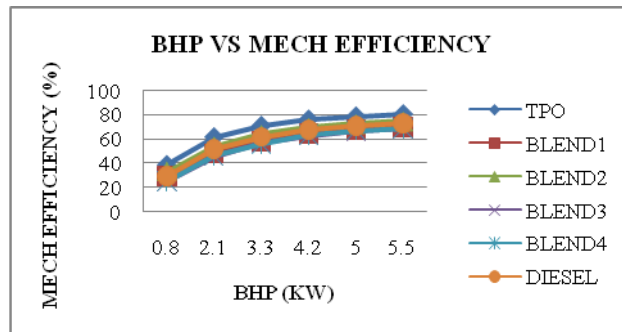


Fig4.1.3: Variation of Mechanical Efficiency with Brake Power

4.2. Emissions

4.2.1 Carbon dioxide (CO₂):

The graph is plotted in between CO₂ emission and brake power is shown in fig4.2.1. As the load increases the CO₂ emission decreases. At full load condition the CO₂ emissions obtained are 0.32%, 0.28%, 0.24%, 0.27%, 0.25% and 0.31% for fuels of TPO, BLEND1, BLEND2, BLEND3, BLEND4 and DIESEL respectively. The CO₂ emission of tire oil blend2 decreased when compared to the diesel at full load condition.

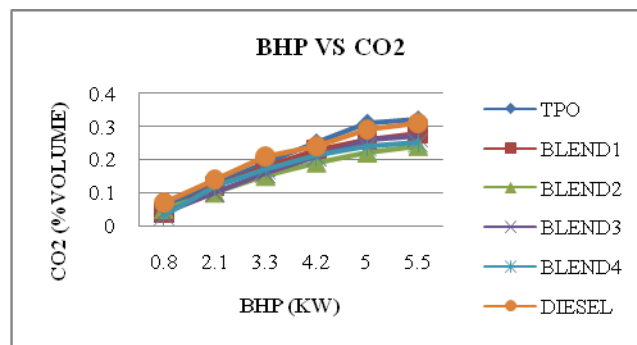


Fig4.2.1: Variation of carbon dioxide with brake power

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4.2.2 Unburned Hydrocarbon (HC):

The graph is plotted in between HC emission and brake power is shown in fig4.2.2. As the load increases the HC emission decreases. At full load condition the HC emissions obtained are 15ppm, 9ppm, 8ppm, 11ppm, 14ppm and 16ppm for fuels of TPO, BLEND1, BLEND2, BLEND3, BLEND4 and DIESEL respectively. The HC emission of tire oil blend2 decreased when compared to the diesel at full load condition.

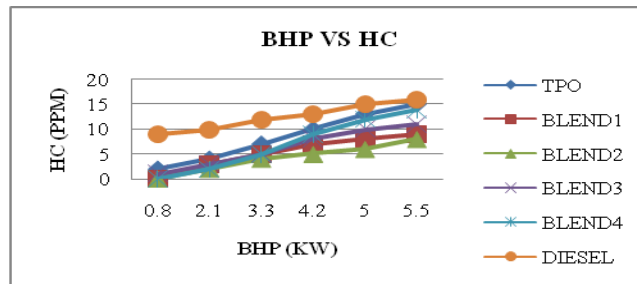


Fig4.2.2: Variation of unburned hydrocarbon with brake power

4.2.3 Carbon Monoxide (CO):

The graph is plotted in between CO emission and brake power is shown in fig4.2.3. At all load conditions there are no CO emissions. At full load condition the CO emissions obtained are 0.038%, 0.036%, 0.032%, 0.032%, 0.031% and 0.036% for fuels of TPO, BLEND1, BLEND2, BLEND3, BLEND4 and DIESEL respectively.

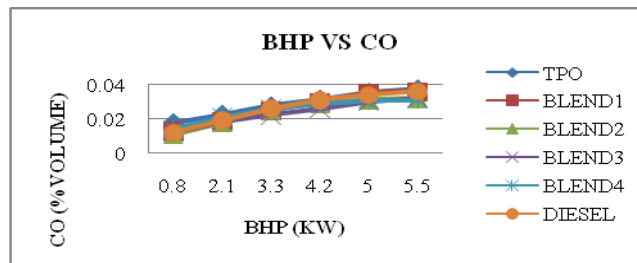


Fig4.2.3: Variation of carbon monoxide with brake power

4.2.4 Oxides of Nitrogen (NOx):

The graph is plotted in between NOx emission and brake power is shown in fig4.2.4. As the load increases the NOx emission decreases. At full load condition the NOx emissions obtained are 12ppm, 6ppm, 8ppm, 8ppm, 8ppm and 10ppm for fuels of TPO, BLEND1, BLEND2, BLEND3, BLEND4 and DIESEL respectively. The NOx emission of tire oil blend2 decreased when compared to the diesel at full load condition.

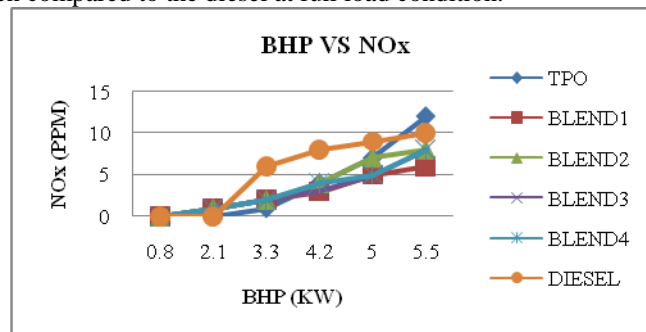


Fig4.2.4: Variation of oxides of nitrogen with brake power

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V. CONCLUSION

The performance and emission characteristics of four stroke single cylinder diesel engine fuelled with diesel, tire pyrolysis oil and utilized transformer oil blends are evaluated. The final conclusion are summarized as follows

- Brake thermal efficiency increased with all blends when compared to the diesel fuel.
- The Brake Specific Fuel Consumption is decreased with the blends when compared to conventional diesel fuel.
- There is no CO, HC emissions and coming to CO₂ emission it is decreased when compared to diesel fuel.
- NO_x emissions are decreased with all blends when compared to the diesel fuel.

From the above analysis the blend2 showed the better performance compared to other blends (blend1, blend3, blend4 & pure tire oil).

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