A Review study for Enhancing the Performance & Emission for the Blend of Diesel & Pyrolysis oil of Tyre

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Abstract— Due to the higher energy demand, constrict emission norms and shortage in oil resources led the researchers to find alternative fuels for IC engines. Many alternatives fuels such as Alcohols, Biodiesel, LPG, CNG, etc. already have been developed and commercialized. In this context, the pyrolysis oil obtained from the waste tyre is receiving renewed interest. The properties of the Tyre pyrolysis oil was compared with the petroleum products and found that it can also be used as a fuel for diesel engine. So, tyre pyrolysis oil can be used as an alternate fuel in a diesel engine. The present paper represents the literature review for enhancing the performance and emission of the compression ignition engine for the blend of pyrolysis oil of tyre and diesel fuel.

I. INTRODUCTION

Diesel engines are attracting greater attention due to higher efficiency and cost effectiveness, because of that they have been widely used as a power of engineering machinery, automobile and shipping equipment. Oil provides energy for 95% of transportation. All countries including India are grappling with the problem of meeting the ever increasing demand of transport fuel within environment concerns and limited resources. So, the most attentive question arises in our country and at world level is "How long we can use this petroleum fuels? "The solution of this question is in three words `Reduce',' Reuse' and `Recycle'.

Scientists are putting much effort on the potentials of utilizing appropriate technologies to recover energy and useful by-products from domestic and industrial solid wastes. Thus considerable research has been done to recover energy from waste materials, including materials that are not bio-degradable. Such materials include biomass, municipal solid wastes, industrial wastes, agricultural wastes and other low grade fuels as well as high energy density materials such as rubber and plastics. Rubber containing wastes such as tyre and tube waste are causing a big environmental problem because it is an artificial polymer and also not biodegradable. Rubber containing waste takes significantly much longer time as compared to biomass materials in case of photo degradation.

There is a predominant increase in tyre wastes due to phenomenal increase in number of vehicles within India. The annual disposal of waste tyre volume will increase at the same rate as new tyre is manufactured. These discarded wastes pose a threat to the environment and human health if not handled properly. Thus timely action regarding recycling of used tyres is necessary to solve the problem keeping in view the increasing cost of raw material, resource constraints and environmental problems including fire and health hazards associated with the stockpiles of the used tyres.

The recycling of waste tyre can be done by the pyrolysis process. 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 carbon black.

Fig.1. Pyrolysis tyre oil

The use of pyrolysis oil of tyre as a substitution to diesel fuel is an opportunity in minimizing the utilization of the natural resources. Several research works have been carried out on the pyrolysis of waste automobile tyres.

The important requirement for diesel fuel is its ignition quality, viscosity, and water, sediment, and sulphur contents. Therefore, the pyrolysis oils were requiring preliminary treatments such as decanting, centrifugation, filtration, desulphurization, and hydro-treating to be used as fuels. The treated pyrolysis oil could be used directly as fuel oils or blended with diesel fuels, which will reduce the viscosity and, increase the pH value and flash point of the resulting blends. Consequently, the atomization will be improved, ensuring a complete burnout of the fuel. Based on its fuel properties, tyre-derived pyrolysis oil may be considered as a valuable component for use with automotive diesel fuels. The following table indicates the Diesel and Tyre Pyrolysis oil Properties Comparison:

Sr. No.	Properties	Diesel	Tyre Pyrolysis oil
1.	Density @ 15 ˚C, kg/m³	0.830	0.9239
2.	Kinematics Viscosity, cst@40˚C	2.58	3.77
3.	Net Calorific Value , MJ/kg	43.8	38
4.	Flash Point, ˚C	50	43
5.	Fire Point, ˚C	56	50
6.	Sulphur Content, %	0.29	0.72
7.	Ash Content, %	0.01	0.31
8.	Boiling Point, ˚C	198.5	70

Table.1. Diesel and Tyre Pyrolysis oil Properties Comparison [2]

II. ENGINE PERFOMANCE AND EMISSION ANALYSIS

P.T.Williams [1], Scrap tyres were pyrolyse in a one tonne batch pyrolysis unit to produce an oil, char, gas and steel product. The derived oil was analysed for fuel properties, including calorific value, elemental analysis, sulphur, nitrogen, chloride and Fluoride content. Comparison of the tyre oil fuel properties with those of petroleum-derived fuels was made. The oil was combusted in an 18.3 kW ceramic-lined, oil-fired, spray burner furnace, 1.6m in length and 0.5m internal diameter. The emissions of NOx, 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 fuel as a representative of a petroleum-derived fuel with similar properties. Combustion of the tyre pyrolysis oil in the furnace showed that emissions of NOx were higher than when diesel fuel was used, which was attributed to the higher nitrogen and sulphur contents in the tyre oil.

S. Murugan [2], Tests have been carried out to evaluate the performance, emission, and combustion characteristics of a single cylinder direct injection diesel engine fuelled with 10%, 30%, and 50% of tyre pyrolysis oil (TPO). Results showed that the brake thermal efficiency of the engine fuelled with TPO–DF blends increased with an increase in blend concentration and reduction of DF concentration. NOx, HC, CO, and smoke emissions were found to be higher.

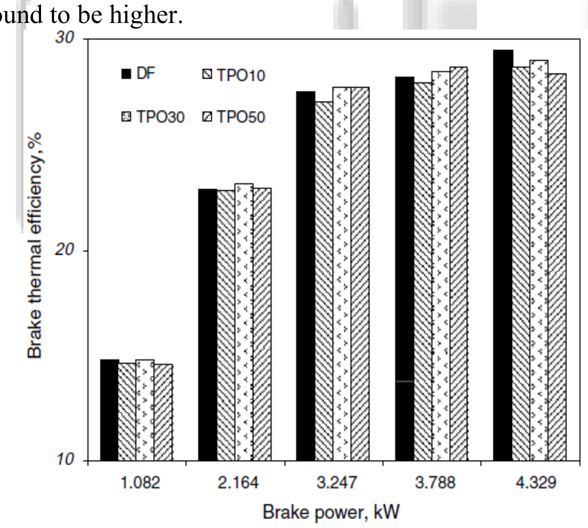

Fig.2. Variation of brake thermal efficiency with brake power [2]

S. Hariharan [3], Experiments were conducted on a single cylinder four stroke DI diesel engine using TPO as a main fuel. The performance, emission and combustion characteristics of the DI diesel engine were investigated and compared with the conventional diesel fuel (DF). Diethyl ether (DEE) was admitted along with intake air at three flow rates viz 65 g/h, 130 g/h and 170 g/h. Results indicated that the engine performs better with lower emissions when DEE was admitted at the rate of 170 g/h with TPO. It was observed that NOx emission in TPO–DEE operation reduced by 5% compared to diesel fuel operation. HC, CO and smoke emissions were higher for TPO–DEE operation by 2%, 4.5% and 38% than diesel mode.

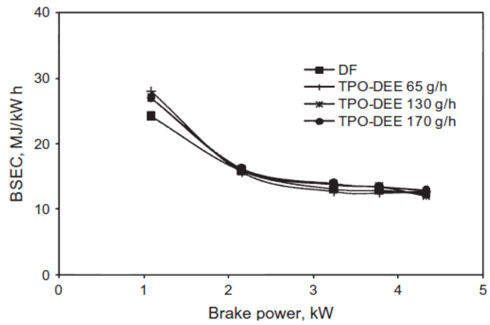

Fig.3. Variation of BSEC with brake power [3]

Cumali İlkılıç and Hüseyin Aydın [4] used alternative fuel production was performed by pyrolysis of waste vehicle tires under nitrogen (N_2) environment and with calcium hydroxide ($Ca(OH)_2$) as catalyst. The sulphur content of liquids obtained were reduced by using $Ca(OH)_2$. The liquid fuel of waste vehicle tires(TF) was then used in a diesel engine to blend with petroleum diesel fuel by 5%(TF5), 10%(TF10), 15%(TF15), 25%(TF25), 35%(TF35), 50%(TF50), and 75% (TF75) wt. and pure (TF100).

Performance characteristics such as engine power, engine torque, brake specific fuel consumption (bsfc) and exhaust temperature and emission parameters such as oxides of nitrogen (NOx), carbon monoxides (CO), total unburned hydrocarbon (HC), sulphur dioxides ($_{SO2}$) and smoke opacity of the engine operation with TF and blend fuels of TF–diesel were experimentally investigated and compared with those of petroleum diesel fuel.

It was concluded that the blends of pyrolysis oil of waste tires TF5, TF10, TF25 and TF35 can efficiently be used in diesel engines without any engine modifications. However, the blends of TF50, TF75 and TF100 resulted considerably to high CO, HC, SO_2 and smoke emissions. The reaction of pyrolysis was carried out in the inert environment with N_2 and with $Ca(OH)_2$ as a catalyst. It was concluded that the highest yield of the liquid product was obtained at the conditions when reaction temperature was 500 °C with 200 cm3/min N_2 flow rate and with 5% $Ca(OH)_2$ addition. The purpose of using $Ca(OH)_2$ was to reduce the sulphur content of the liquid oil of tire pyrolysis. Thus, the sulphur content of the liquid product was reduced to the amount of 34%.

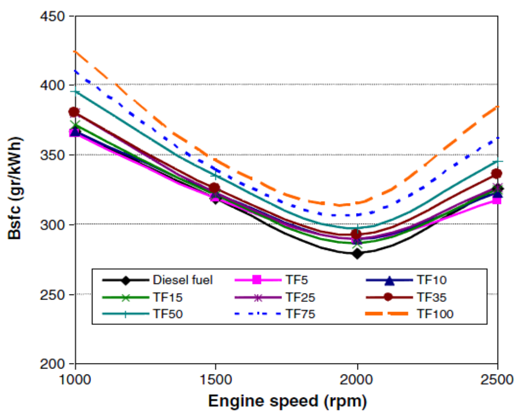

Fig.3. Variation of BSFC with engine speed for TF blends and diesel fuel [4]

III. EFFECT OF SUPERCHARGING ON THE PERFOMANCE OF DISEL ENGINE

It is well known that supercharging improves the combustion process of Diesel engines. An increase in pressure and temperature of the engine intake reduces ignition delay, resulting in a quiet and smooth operation with a lower rate of pressure rise. Thus, supercharging encourages the use of low grade fuels in Diesel engines. The increase in intake air temperature reduces the unit air charge and also reduces the thermal efficiency moderately, but the increase in the density due to the supercharging pressure compensates for the loss, and intercooling is not necessary except for highly supercharged engines.[5]

G. Amba Prasad Rao [6], A direct injection type Diesel engine, Water cooled, producing power 3.68kW@1500 r.p.m. , 80mm bore, 110mm stroke was chosen for experiment. Constant speed performance tests maintaining steady jacket water temperature of 55˚C under Supercharged conditions (supercharging pressures kept at 0.2, 0.3 and 0.4 bar (g)) at three different fuel IPs. It was observed that there was a reduction in BSFC of about 15% when the engine is run at the recommended IP and supercharging pressure of 0.4 bar in comparison with the engine operation run under naturally operated conditions.

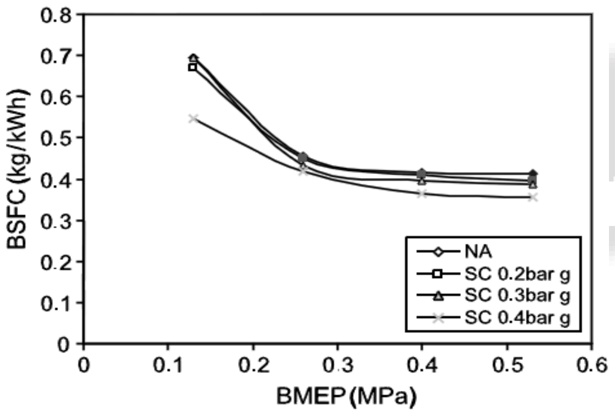

Fig.4. Performance comparison with and without supercharging [6]

IV. EFFECT OF INJECTION PRESSURE ON THE PERFOMANCE OF DISEL ENGINE

Rosli Abu Bakar [7], Fuel injection pressures in diesel engine plays an important role for engine performance obtaining treatment of combustion. The present diesel engines such as fuel direct injection, the pressures can be increased about 100 – 200 bar in fuel pump injection system. The experimental investigated effects of fuel injection pressure on engine performance. Experiments have been performed on a diesel engine with four-cylinder, two-stroke, direct injection. Engine performance values such as indicated pressure, indicated horse power, shaft horse power, brake horse power, break mean effective pressure and fuel consumption have been investigated both of variation engine speeds - fixed load and fixed engine speed – variation loads by changing the fuel injection pressure from 180 to 220 bar. According to the results, the best performance of the pressure injection has been obtained at 220 bar, specific fuel consumption has been obtained at 200 bar for fixed load – variation speeds and at 180 bar for variation loads – fixed speed.

The experiment results shows that, the fixed load variation speeds and fixed speed-variation loads have been given that the higher engine speed (rpm) given higher engine power. The increasing injection pressure is in-line with increasing power. The fuel consumptions experiment result for fixed load-variation speeds and fixed speed-variation loads have been given that increasing injection pressure given increased of fuel consumption for the diesel engine. The best engine performance for indicated pressure (IP), indicated horse power (IHP), shaft horse power (SHP), break horse power (BHP) and break mean effective pressure (BMEP) obtained at 220 bar and the best engine SFC obtained at 200 bar or in current fuel injection pressure.

H. Rehman and A G Phadatare [8], made an attempt to assess the suitability of vegetable oil for diesel engine operation, without any modifications in its existing construction. One of the important factors which influence the performance and emission of diesel engine is fuel injection pressure. In the present investigation a vegetable oil, Sea lemon oil has been investigated in a constant speed, DI diesel engine with varied fuel injection pressures (170, 190,210 and 230 bar). The main objective of this study is to investigate the effect of injection pressures on performance and emissions characteristics of the engine. The injection pressure was changed by adjusting the fuel injector spring tension. The performance and emission characteristics were presented graphically and concluded that increase in injector opening pressure increases the brake thermal efficiency and reduces unburned hydrocarbon and smoke emissions significantly.

Increasing the injector opening pressure (IOP) from the rated value for the diesel i.e. 170 bar to 190 bar resulted in a significant improvement in performance and emissions with Sea lemon oil due to better spray formation. The changes noted at maximum engine output were: 1. Brake thermal efficiency increases from 27.3% to 29.1%, 2. HC reduced from 166 to 130ppm, 3. NOx level increases with increasing IOP due to faster combustion and higher temperatures reached in the cycle and 4. Smoke level reduced from 4.6BSU to 3.2 BSU. Smoke levels steadily fall with increase in the injector opening pressure due to improved mixture formation because of well-atomized spray. On the whole a significant improvement in the performance and emissions can be realized by properly optimizing the injector opening pressure when a diesel engine is to be operated with neat Sea lemon oil.

V. CONCLUSION

With an increase in supercharging pressure, the performance of the engine is gradually improves. There is a reduction in BSFC at full load with a supercharging pressure. Moreover there is reduction in smoke density due to supercharging pressure.

1. The fuel injection pressure in a standard diesel engine is in the range of 200 to 1700 atm depending on the engine size and type of combustion system employed. The fuel penetration distance become longer and the mixture formation of the fuel and air was improved when the combustion duration became shorter as the injection pressure became higher.

2. When fuel injection pressure is low, fuel particle diameters will enlarge and ignition delay period during the combustion will increase. This situation leads to inefficient combustion in the engine and causes the increase in NOx, CO emissions.

3. When the injection pressure is increased fuel particle diameters will become small. The mixing of fuel and air becomes better during ignition delay period which causes low smoke level and CO emission. But, if the injection pressure is too high ignition delay become shorter. So, possibilities of homogeneous mixing decrease and combustion efficiency falls down. Therefore, smoke is formed at exhaust of engine.

4. Finally from above literature review it can be concluded that performance and emission can be enhanced for the blend of diesel & pyrolysis oil of tyre in C.I. engine using the effect of supercharging and injection pressure.

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REFERENCES

[1] P.T.Williams, *"Combustion of tyre pyrolysis oil"*, Process Safety and Environmental Protection 76(4): 291-301, 1998.

[2] Murugan, S., *"The use of tyre pyrolysis oil in diesel engines."* Waste Management 28(12): 2743-2749, 2008.

[3] Hariharan, S., *"Effect of diethyl ether on Tyre pyrolysis oil fueled diesel engine."* Fuel 104: 109-115, 2013.

[4] İlkılıç, C. and H. Aydın ,*"Fuel production from waste vehicle tires by catalytic pyrolysis and its application in a diesel engine."* Fuel Processing Technology 92(5): 1129-1135, 2011.

[5] Heywood JB. *Internal combustion engine fundamentals.* McGraw-Hill Publications; 1988.

[6] G. Amba Prasad Rao, *"Effect of supercharging on the performance of a DI Diesel engine with cotton seed oil"*, Energy Conversion and Management 44 (937–944), 2003.

[7] Rosli Abu Bakar, Semin and Abdul Rahim Ismail, *"Fuel Injection Pressure Effect on Performance of Direct Injection Diesel Engines Based on Experiment"*, American Journal of Applied Sciences 5 (3): 197-202, 2008, ISSN 1546-9239.

[8] H Raheman and A G Phadatare, *"Effect of injection pressure on diesel engine performance with Sea lemon oil"*, Indian Journal of Science and Technology Vol. 4 No. 8 (Aug 2011) ISSN: 0974-6846.

