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An Experimental Comparison on Performance and Emission Characteristics of Diesel Engine Fuelled with Waste Plastic Oil and Karanja Biodiesel Blends

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Abstract: Due to the limitation of fossil fuel sources, environmental concerns and less availability of petroleum fuels have caused the search for alternative fuels for the diesel engine. So we should go as an alternate fuel sourcelike waste plastic oil for using the energy demand in comparison to the karanja seed oil or karanja biodiesel oil blends. Because of the large availability of waste plastic in the India, easily available and less cost of production of waste plastic oil. Development and modernization have brought huge amount of plastic commodities which the causes of environmental impact over the human being so it's a major concerns for life support system. So we need more utilization of waste plastic in comparison to the other alternate fuel source like karanja oil. In the present work, investigating the performance and emission characteristics of a single cylinder, 4- strokes diesel enginefueled with both the waste plastic oil and karanja oil fuel at distinct time process. In this paper we make four blends with 10%, 15%, 20% and 25% of both fuels. All the Various parameters such as Brake Thermal Efficiency, Brake Specific Fuel Consumption, carbon dioxide, unburned hydrocarbon and nitrogen dioxide are determined at all operating load conditions and at compression ratio 18.

Keywords- *Diesel engine, waste plastic oil, karanja biodiesel, performance and emission.*

Nomenclature

Abbreviation	Meaning
D_0	Pure diesel
WPO_{10}	Blend 10%waste plastic oil and 90% diesel oil
WPO_{15}	Blend 15%waste plastic oil and 85% diesel oil
WPO_{20}	Blend 20%waste plastic oil and 80% diesel oil
WPO_{25}	Blend 25%waste plastic oil and 75% diesel oil
KME_{10}	Blend 10% karanja methyl ester and 90% diesel oil
KME_{15}	Blend 15% karanja methyl ester and 85% diesel oil
KME_{20}	Blend 20% karanja methyl ester and 80% diesel oil
KME_{25}	Blend 25% karanja methyl ester and 75% diesel oil
CR	Compression ratio

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I. INTRODUCTION

Alternate fuel provide a huge supporting channel for depleting the conventional fossil fuel and the alternate energy sources such as biomass, hydropower, geothermal energy, wind energy, solar energy, and nuclear energy(**PouyaMohammadi et al, 2012**). By developing of alternative-fuel technologies we can replace the most percentage of fossil fuel. Plastics are basically long hydrocarbon chained organic compounds which is synthesized from petroleum products or crude oil (**P. Senthil Kumar and Sankarnarayanan et al, 2016**). Plastics have become highly popular in short time because of their wide range of application, non-degradable in nature, unmatched usability and low cost. A survey report of the central pollution control board, India in 2015-16 shows nearly 5.9 milliantonnes of waste plastic is generated yearly (**S.L. Wong et al, 2015**).

An interesting things is the production of waste plastic oil from wastes such a double advantage of using the valuable energy content of wastes and mitigating the disposal problem. In direction to minimize the opposing environmental impacts, Plastic Waste Management was applied for controlling and minimizing the plastic waste produced. However, only a less works have been carried out to report the effects of their use in small duty compression ignition engines (**ViswanathK. Kaimal and P. Vijayabalan et al, 2015**). So in this current work, a complete investigation is carried out to calculate the performance and emission characteristics of waste plastic oil and its blends with diesel in a diesel engine and toward evaluate its potential as an alternate fuel for high speed diesel engines.

Diesel engines are the most prevalent power generation units, thanks to their high fuel conversion efficiency, dependability and robustness (**IoannisKalargaris et al, 2017**). There is a much wider scope for recycling in developing countries mainly in India due to low labor cost, plastics consumption increase and therefore raw materials increase (**Tine Seljak et al, 2014**). Plastics packages have its merits but due to its non-biodegradability and improper collection system they become an eyesore along with Municipal Solid Waste (MSW) due to its high visibility (**M.Mani and G. Nagarajan, 2009**).

Karanja biodiesel oil called as in Indian beech, Pongamoiltreeand karanja.Pongamiapinnata is a type of tree which is very rare and temperate Asia including parts of Indian subcontinent, China, Japan, Malesia, Australia and pacific islands (**A. Dhar et al, 2014**). In addition pinnata has the rare property of producing seeds of 25–40% lipid content of which nearly half is oleic acid (**A. Agarwal et al, 2007**). PME was synthesized in reactor vessel using both NaOH& KOH as a catalyst. The ester preparation involved a two-step trans-esterification reaction followed by washing and drying. The two step reaction utilized a 100% excess methanol, or a total molar ratio of methanol-to-oil of 6:1 with methanol equally divided in two steps. 1000gm was placed in dry flask equipped with a magnetic stirrer and thermometer. In another flask, approximately 300gm of methanol was mixed with 7gm of NaOH until all of the catalyst dissolved. This mixture is quickly added to the oil and stirred vigorously for 1 hr maintaining temperature 55-60degree Celsius. After 24 hr, ester layer is set up on upper part and glycerol is set up on lower part. Then using separating funnel separates glycerol and ester is poured into another flask. Finally the ester was dried by silica gel (**Kohle et al, 2014**).

Comparison of both fuel on the basis of fuel properties

Waste plastic are the mixture of C_{10}-C_{30} hydrocarbon chains and has lower density and viscosity in comparison to the karanja biodiesel oil. karanja oil vary from C16 to C24, with the long chain oleic acid (C18:1), linoleic acid (C18:2), palmitic acid (C16:0), stearic acid (C18:0), and behenic acid (C22:0) are the highest.The amount of fatty acids present in karanja oil is, oleic acid: 49.4%, linoleic acid: 19%, palmitic acid: 10.6%, stearic acid: 6.8%, behenic acid: 5.3% (**K. Anand et al, 2011**). Waste plastic oil and karanja biodiesel oil fuel properties are discussed in details in table 2 and table 3 respectively.

Experimental setup

The engine specification are showed in table 1The experimental results were performance on a 4-stokes, water cooled diesel engine at 3.5kw rated power with constant speed 1500rpm. The experiment setup investigates the performance parameters of a waste plastic oil and karanja biodiesel with diesel such as BTE,BSEC. An AVL 4000 Di-Gas analyzer was used to measure UBHC, CO&NOx emission in the exhaust gases.

Test engine setup

Table1 Test engine specifications

parameter	specifications
Manufacturer and model	Kirloskar and TV1
No. of cylinders and stokes	1&4
Speed	1500
Power output	3.5kw

II. RESULTS AND DISCUSSION

Properties of both fuels

Table 2 waste plastic oil fuel properties

S.no	blends	Density(g/mg)@15°C	k.viscosity(cst)@40°C	Acid value(mgkoh/gm)	Calorific value(cal/gm)
1	D_0	0.838	2.20	0.062	10476
2	WPO_{10}	0.835	2.43	0.061	10195
3	WPO_{15}	0.839	2.49	0.072	10135
4	WPO_{20}	0.840	2.60	0.081	10080
5	WPO_{25}	0.852	2.63	0.089	9990

Table 3karanja biodiesel oil properties

S.no	blends	Density(g/mg)@15°C	K.viscosity(cst)@40°C	Acid value(mgkoh/gm)	Calorific value(cal/gm)
1	D_0	0.838	2.20	0,062	10476
2	KME_{10}	0.840	2.80	0.060	10224
3	KME_{15}	0.845	3.12	0.073	10157
4	KME_{20}	0.848	3.43	0.085	10105
5	KME_{25}	0.85	3.51	0.093	10010

Performance characteristics

Brake thermal efficiency

Fig. 2 shows the variation of BTE with respect to the engine load for all test fuels. In an experimental setup waste plastic oil increased ignition delay time promotes fuel-air mixing which can improve efficieny of the engine in comparison to the karanja biodiesel oil (**D. Damodharan et al, 2016**). The results shows that the BTE of waste plastic oil(WPO_{20}) is 27.65% but in case karanja biodiesel oil(KPE_{10}) is 27.05% at the same compression ratio-18 at full load. The thermal efficiency at rated power for diesel is 28.35% and in case of waste plastic oil it is 27.67% for WPO_{20}, 26.53% for WPO_{25}, 26.23% for WPO_{15} and 25.21% for $WPO_{10}$and in case of karanja biodiesel oil it is 27.05% for KME_{10}, 26.57% for KME_{15}, 25.97% for $KME_{20}$and 25.01% for KME_{25} at full load at the same compression ratio -18. All above results shows that the BTE of waste plastic oil is better than the karanja biodiesel oil.

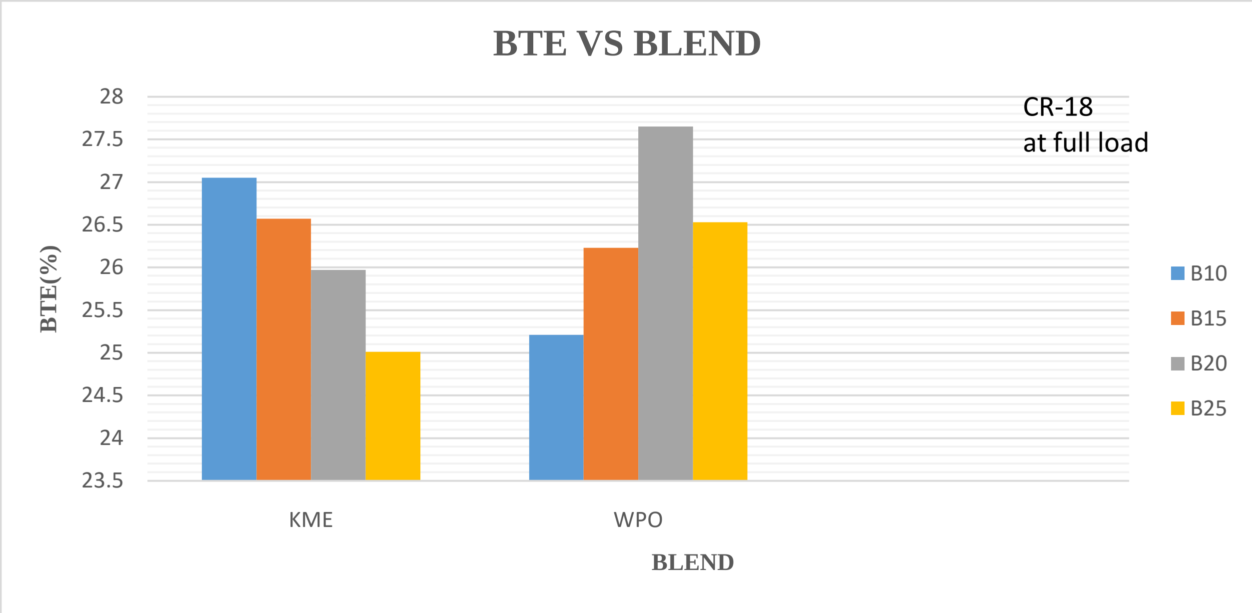

Fig.2 Variation of BTE vs Blends at full load

Brake specific energy consumption

The BSEC gives the ammont of energy consumed by by the engine for produing 1kw power in 1h. The BSEC depends upon the brake power due to which combustion efficiency increases with increases in load (**H. Raheman and A. G. Phadatare, 2004**). The BSEC at rated power for diesel is 0.27% and for WPO_{20} IS 0.33% and for the KME_{20} is 0.39%. Due to the decreases viscosity which causes the proper atomization of waste plastic oil in comparison of karanja biodiesel oil. Waste plastic oil enhancement of BSFC by improving fuel ignition and combustion quality in comparison to the karanja biodiesel oil.

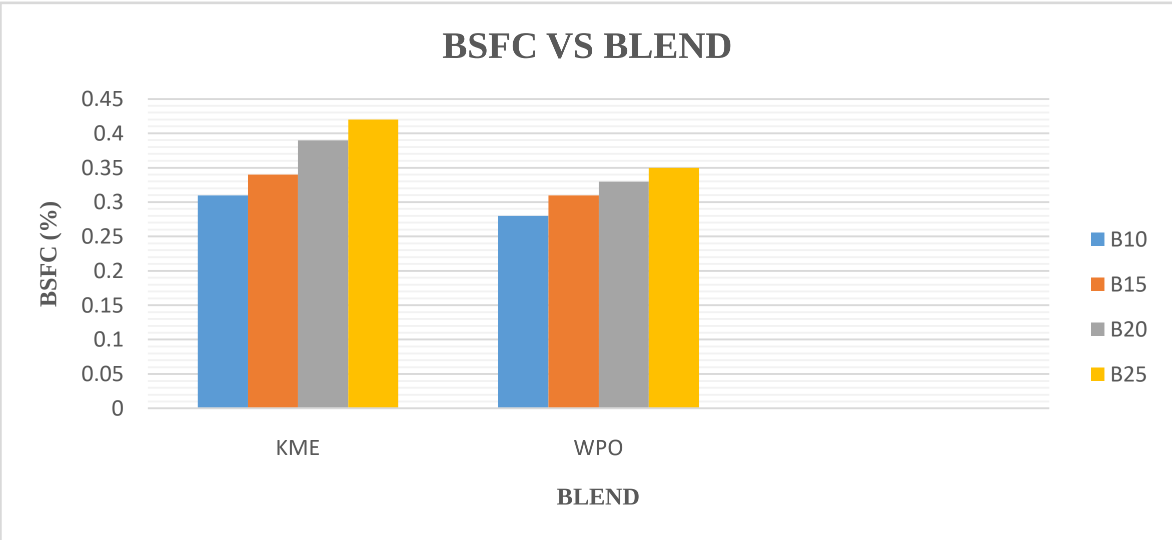

Fig.3 Variation of BSFC vs Blends at full load

Emission characteristics

Unburned hydro carbon

The variation of UBHC with engine load for diesel, WPO and KME is shown in fig.4 The UBHC emission produced because of the higher fumigation rate and non-availability of oxygen present in the combustion chamber (**S. Murugan and SaiGu, 2015**). The UBHC is for diesel is 31ppm and it varies for waste plastic oil blend it is 32ppm for WPO_{10}, 34ppm for WPO_{15}, 35ppm for WPO_{20} and 36ppm for WPO_{25} and in case of karanja biodiesel oil it is 30ppm for KME_{10}, 33ppm for KME_{15}, 39ppm for KME_{20} and 43ppm for KME_{25} at the full load conditions at the same compression ratio-18.

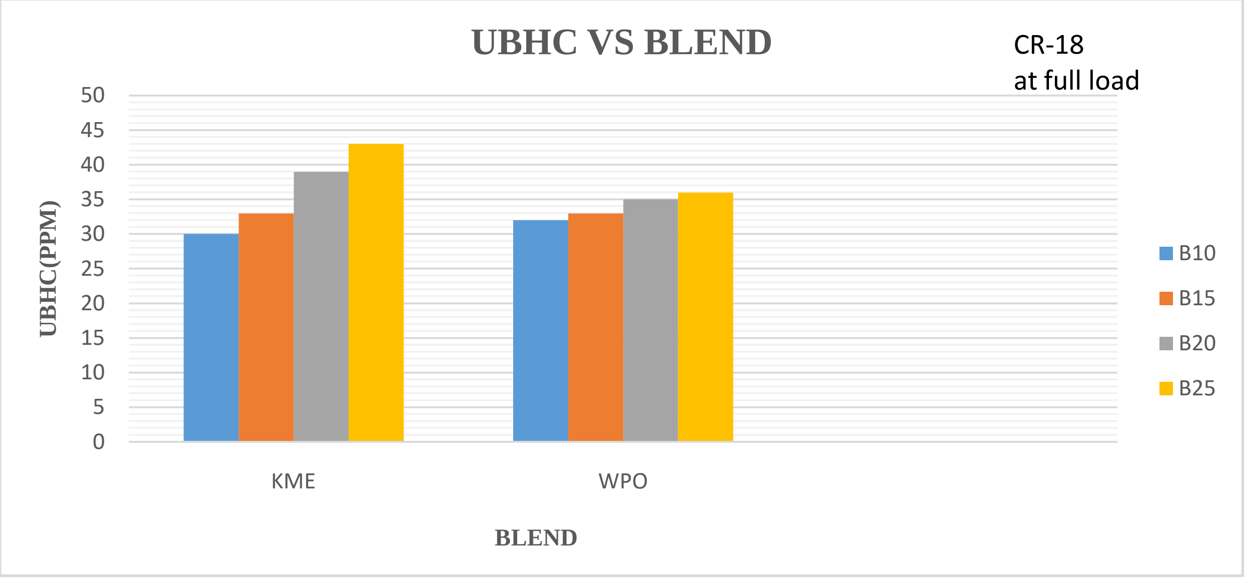

Fig.4 Variation of UBHC vs Blends at full load

Carbon monoxide

CO emission is produced due to incomplete combustion of fuel in the combustion chamber because of non-availability of oxygen and variation of load. CO emission reduces by the CO oxidation at high temperature at high loads (**H. Yadav et al, 2014**). The results shows that the CO emission varies from 0.17 %vol. to 0.19%vol. for waste plastic oil and in case of karanja biodiesel oil it is varies 0.16%vol. to 0.21%vol. so drastic variation in CO emission occurs at full load conditions for KME due to higher BSFC, presence of water and flame temperature is lower than the diesel oil and waste plastic oil respectively.

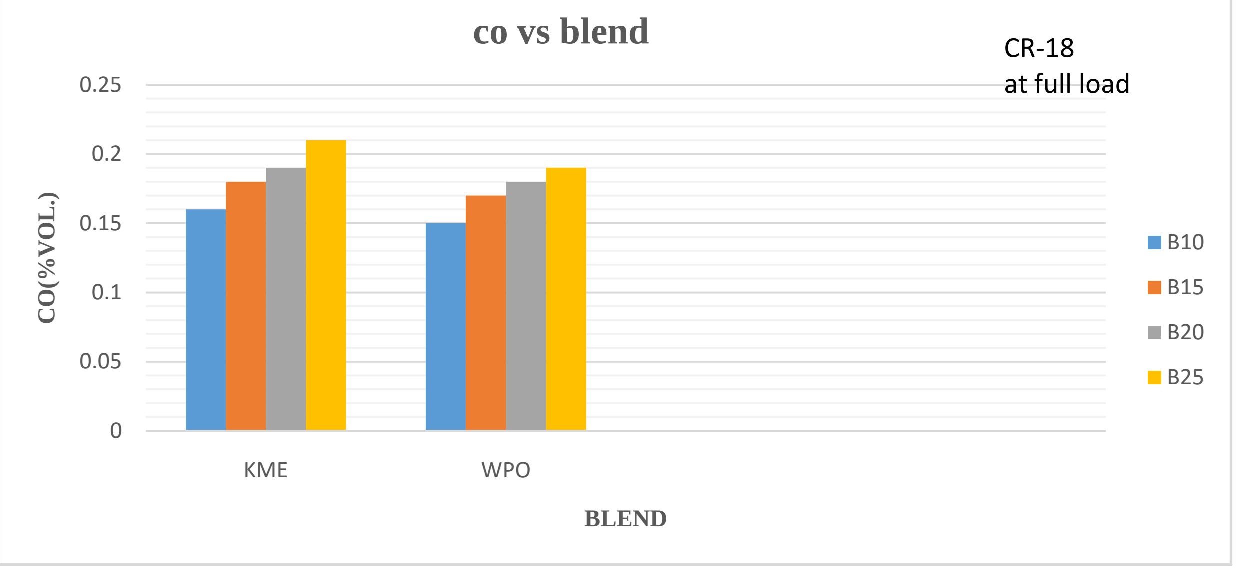

Fig.5 Variation of CO vs Blends at full load

Oxides of nitrogen

It is the most important content in the diesel engine emissions. The formation of oxides of nitrogen depends upon on various parameters like oxygen content, inside cylinder temperature and residence time (**J. Devaraj et al, 2015**). An experimental setup shows the formation of nox is 560ppm for diesel and for waste plastic oil it is varies from 610ppm to 975ppm and in case of karanja biodiesel oil its varies from 735ppm to 1040ppm at the full load conditions at cr-18. The increment of Nox due to the high cylinder pressure and ignition delay for both operating fuel like waste plastic oil and karanja biodiesel oil respectively. And formation of Noxin waste plastic oil because of higher aromatic compounds which increases the adiabatic flame temperature causing high heat release Nox in the exhaust gases (**JunizaMdSaad and Paul T. Williams et al, 2016**).

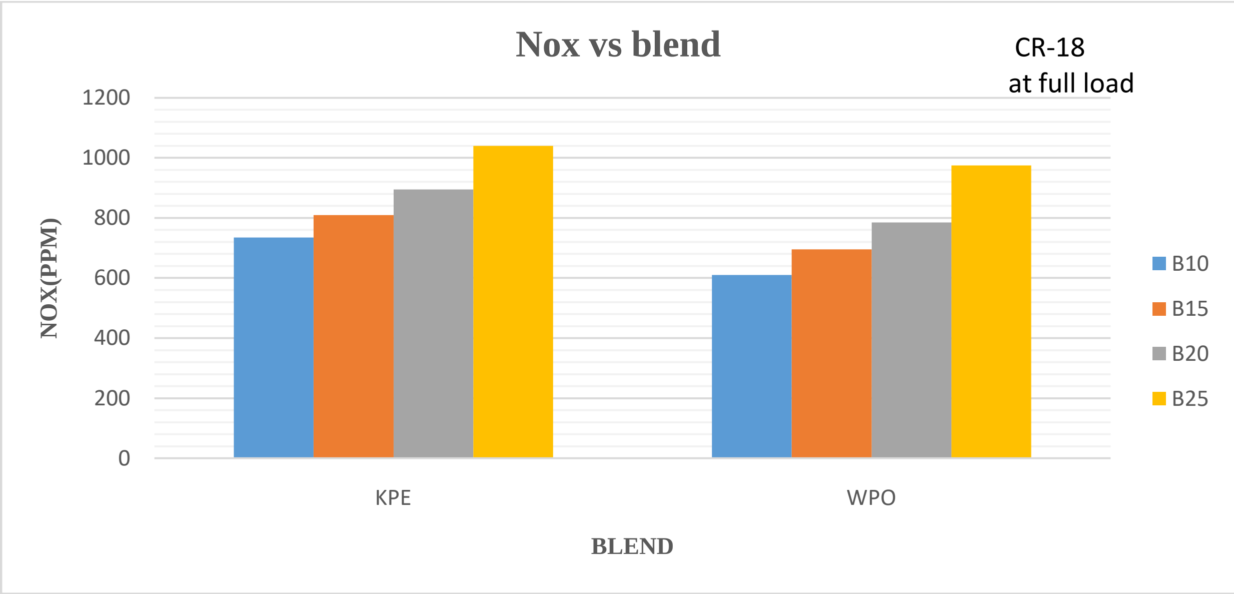

Fig.6 Variation of NOX vs Blends at full load

III. CONCLUSION

The investigation was carried out to analyze the effects on the performance and emissions characteristics 4-strokes, water cooled diesel engine at 3.5kw rated power at constant speed 1500rpm fuelled with both waste plastic oil and karanja biodiesel oil blends. The experimental comparison results are showed for waste plastic oil and karanja biodiesel oil in following points.

- BTE of the engine increased and waste plastic oil blends WPO_{20} delivered better performance than the karanja biodiesel oil blends KME_{20}.
- The waste plastic oil blends showed lower BSEC than the karanja biodiesel oil blends due to lower density and viscosity of fuel.
- The UBHC and CO emission of waste plastic oil are slighter lower than the karanja biodiesel oil blends.
- Noxemission is reduced upto 70-80ppm while operating with WPO_{20} than the KME_{20}.
- It found that, waste plastic oil blends has better performance than the karanja biodiesel oil blends.so it can be used as an alternative fuel in DI engine without any engine modifications.

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