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Experimental Investigation of Performance and Emission Characteristics of DI Diesel Engine Operated on WPO, Home and Diesel

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Abstract – The objective of this research is to present results of the performance (Brake power, thermal efficiency and specific fuel consumption) in a heavy-duty diesel engine when fueled with diesel-waste plastic pyrolysis oil (WPO) blends in variable load condition. The tested engine is installed on an engine test bench and is attached with several sensors. The experimentation is conducted to investigate both main and interaction effects. It shows that as the proportion of biodiesel is more, affects the combustion rate and injection pressure. From experiment it proven the optimum blends of 20% reaches the diesel output to the maximum extent .mechanical efficiency is 43%, brake thermal efficiency is 32%, bsfc increased to 20 %, The emission characteristics shows that NOx emission levels are slightly higher and other emissions like CO, HC are compatible with diesel modes of operation. Hence WPO can be used as substitute fuel in place of conventional diesel fuel. The graphical presentations, the discussions and conclusions are also presented.

Keywords: Waste Plastic Oil, Diesel Engine, Honge biodiesel, Bthef, Meff, BSFC.

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1. INTRODUCTION

Diesel engines are the most efficient prime movers, from the point of view of protecting global environment and concerns for long-term energy security it becomes necessary to develop alternative fuels with properties comparable to petroleum based fuels. Unlike rest of the world, India's demand for diesel fuels is roughly six times that of gasoline hence seeking alternative to mineral diesel is a natural choice. Alternative fuels should be easily available at low cost, be environment friendly and fulfill energy security needs without sacrificing engine's operational performance. Waste to energy is the recent trend in the selection of alternate fuels1. Fuels like alcohol, biodiesel, liquid fuel from plastics etc are some of the alternative fuels for the internal combustion engines. Utilization of biomass as alternative fuel for compression ignition engine has a great scope especially in developing and undeveloped countries. Biodiesel is an alternative fuel similar to conventional or fossil diesel. Biodiesel can be produced from straight vegetable oil, animal oil/fats, tallow and waste cooking oil. The process used to convert these oils to Biodiesel is called Transesterification. The largest possible source of suitable oil comes from oil crops such as rapeseed, palm or soybean.

Biodiesel was prepared from Honge oil (Pongamia) and used as a fuel in C.I engine. Performance studies were conducted on a single cylinder four-stroke water-cooled compression ignition engine. Experiments were conducted for different percentage of blends of Honge oil with diesel at various compression ratios. [1]. Investigations were carried out for the performance and combustion characteristics of Pongamia methyl esters. The results were compared with diesel fuel. For this experiment, a single cylinder, four stroke, water cooled diesel engine at a rated speed of 1500 rpm was used. Tests were carried out over the entire range of engine operation at varying load of 0, 1, 2, 3, 4, 5.2 at rated speed of 1500rpm and results are compared with diesel. [2]. Investigated the potential use of Pongamia oil methyl ester as a substitute for diesel fuel in diesel engine. Various proportions of Pongamia and Diesel (B25, B50, B75, and B100) are prepared by transesterification process on volume basis and used as fuels in a four stroke single cylinder direct injection diesel engine to study the performance and emission characteristics of these fuels and compared with neat diesel fuel [3]. The experimental1results have2showed a stable performance3with brake thermal efficiency4similar to that5of diesel. Carbon dioxide1and unburned hydrocarbon2were marginally higher4than that of the5diesel operation. The toxic6gas carbon monoxide1emission of waste5plastic oil was higher2than diesel [4]. In4this study, a review2of research papers on3various operating1parameters have been2prepared for better3understanding of4operating conditions5and constrains for7waste plastic pyrolysis oil and8its blends3fuelled compression4ignition engine [5].

2. METHODOLOGY

2.1 HONGE BIODISEL

Pongamia pinnata (Honge) is one of the forest based tree borne non- edible oil with a production potential of 135,000 metric tons per year in India. It is capable of growing in all types of lands (sandy and Rocky). It grows even in salt water and can withstand extreme weather conditions with a temperature range of 0-50°C. and annual rainfall of 5-25 dm. The oil content is around 30-40%. It is a fast growing medium sized tree which grows to height of around 40ft. flowers are pink light purple, or white. Pods are elliptical, 3-6cm long and 2-3 cm wide thick walled and usually contains a single seed. Seeds are 10-15 mm long, oblong and light brown in color. A thick yellow-orange to brown non edible oil is extracted from the seeds.

Figure 1: Honge seeds and Tree

Table1.1: The comparison of properties of Honge oil with Diesel

S. No.	Properties	Pongamia oil	Diesel
1.	Flash point (°C)	263	49
2.	Specific gravity	0.912	0.83
3.	Acid value (mg/KOH)	1.52	-
4.	Kinematic viscosity (mm^2/s)	41.06	2.4
5.	Kinematic viscosity after TES	5.6	-
6.	Calorific value (MJ/kg)	34	41.86

On Transesterification process honge oil is extracted from the honge seeds. Transesterification is the process of using an alcohol (e.g. methanol, ethanol or butanol), in the presence of a catalyst, such as sodium hydroxide or potassium hydroxide, to break the molecule of the raw renewable oil chemically into methyl or ethyl esters of the renewable oil, with glycerol as a byproduct.

2.2 PLASTIC PYROLYSIS OIL

The plastics are synthetic organic materials1produced from polymerization and they are indeed of high molecular mass, and may be comprise of other substances to improve performance and reduce costs. These polymers can be extruded into desired shapes. Plastics are polymers of long chain hydrocarbons and they are derived from petro-chemical resources. So we can convert these plastic wastes to petroleum fuels and produced fuels are used as alternative fuel for IC engine. Energy cannot be created nor destroyed, but it can be transferred one form into other forms and these energy resources can be used in future. Plastics are derived from petro-chemical resources.

Polymerization is the process in which individual elements of similar or different molecules combines together in single unit by the chemical reactions to form a large or macromolecules and in the form of long chain structures. But these generated molecules become totally different properties than the starting individual molecules. Polymers mostly depending upon their nature of structure and properties and they are classified as Plastics, Rubbers and Fibers. Recycling perspective of waste plastic are spending lot of resources and energy we can utilize that resources into useful product like fuel because now a day's we required alternative fuel for IC engine due rapid depleting petroleum fuel.

Table 2: Properties of Waste Plastic Pyrolysis Oil and Diesel

Sl No	Properties	WPPO	Diesel
1	Density(Kg/m³)	783	850
2	Calorific value(KJ/Kg)	41800	42000
3	Kinematic Viscosity(Cst)	2.149	3.05
4	Flash Point(°C)	41	50
5	Fire Point(°C)	45	56
6	Cetane number	51	55

On pyrolysis process the waste plastic is converted into the WPPOil. Pyrolysis technology is thermal degradation process in the absence of oxygen. Plastic waste is treated in a cylindrical reactor at temperature of 300ºC – 350ºC. The plastic waste is gently cracked by adding catalyst and the gases are condensed in a series of condensers to give a low sulphur content distillate. All this happens continuously to convert the waste plastics into fuel that can be used for generators. The catalyst used in this system will prevent formation of all the dioxins and Furans (Benzene ring). All the gases from this process are treated scrubbers and water/ chemical treatment for neutralization. The non-condensable gas goes through water before it is used for350ºC and there is no oxygen in the processing reactor, most of diesel-generator set for generation of electricity.

2.3 PREPARATION OF FUEL

Edible or Non Edible oil can be directly mixed with diesel fuel and may be used for running an engine. The blending of vegetable oil with diesel fuel in different proportion were experimented successfully by various researchers. Different proportions of blends are carried out like B5, B10, B15, B20 etc. Blend of 20% oil and 80% diesel have shown same results as diesel and also properties of the blend is almost close to diesel.

Biodiesels are produced using edible and non edible oils using different processes like pyrolysis, transesterification etc. These fuels cannot be used directly in C.I Engines because of its high viscosity, high density, gels at cold temperature and low heating value so these fuels are blended with diesel to make it compatible to use in diesel engines.

B20 contains 20% biodiesel and 80% diesel, B100 contains 100% biodiesel.B20 blend is more compatible with nearly all diesel equipments and it contains 1-2% less energy than diesel. B20 and lower level blends don't require equipment modifications.

Table 3: physical properties of fuel

Parameters	Diesel	Honge oil	Plastic oil	B5	B10	B15	B20
Flash point ^0C	50	225	40	43	45	46	46
Fire point ^0C	56	230	45	59	57	55	54
Kinematic viscosity (Cst)	3.05	40.2	2.149	3.36	3.78	4.18	4.58
Density (kg/m^3)	813	924	1170	800	800	800	800
CV (MJ/kg)	44.41	36.59	41.8	44.15	43.88	43.63	43.36

Figure 2: Computerized Single cylinder 4 stroke Diesel engine (VCR engine)

Table 4: Engine specifications

1	Parameters	Specifications
2	Type	TVI (kirlosker made)
3	Software used	Engine soft.
4	Nozzle opening pressure	200-205 bar
5	Governor type	Mechanical centrifugal type
6	No of cylinders	Single cylinder
7	No of strokes	4 stroke
8	Fuel	H.S. diesel
9	Rated power	5.2 kw (7hp) at 1500 rpm
10	Cylinder diameter (bore)	87.5mm
11	Stroke length	110mm
12	Compression ratio	17.5:1
Air measurement manometer		
13	Made	MX 201
14	Type	U type
15	Range	100-0-100mm

Eddy current dynamometer		
16	Model	AG-10
17	Type	Eddy current
18	Maximum	7.5Kw at 1500-3000rpm

3. RESULTS AND DISCUSSIONS

3.1.1 Mechanical efficiency

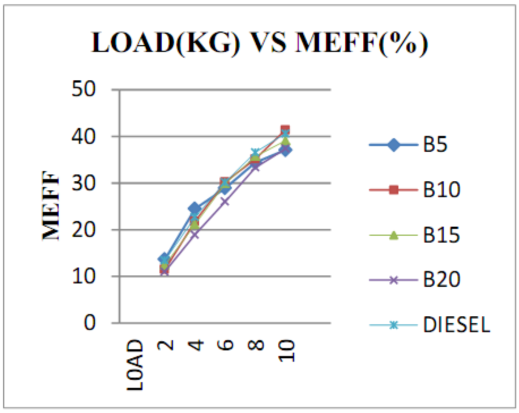

Figure 3: Load v/s Mechanical efficiency

Mechanical efficiency is defined as the ratio of Brake power to Indicated power. The graph is plotted against Load v/s Mechanical Efficiency for compression ratio 18.It is observed that mechanical efficiency is increases for B10, B15 with increases in load in all operating conditions. Comparatively less than neat diesel efficiency.

3.1.2 Brake Thermal Efficiency

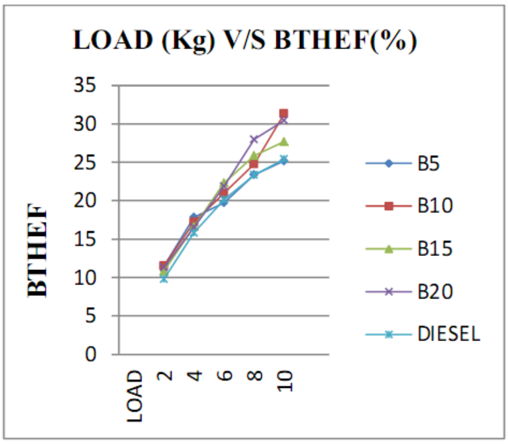

Figure 4: Load v/s Brake Thermal Efficiency

Break thermal efficiency is defined as the ratio of energy in the break power, to the input fuel energy in appropriate units. The graph is plotted against Load v/s Brake Thermal Efficiency for compression ratio 18.The Brake Thermal Efficiency is high for all blends than diesel.B20 blend has highest Brake Thermal Efficiency. This was due to reduction in heat loss and increase in power with increase present load. For B20 blend it is more. Slight variation of brake thermal efficiency with biodiesel blends may also attributed to spray characteristics higher viscosity, lower calorific values.

3.1.3 Brake specific fuel consumption

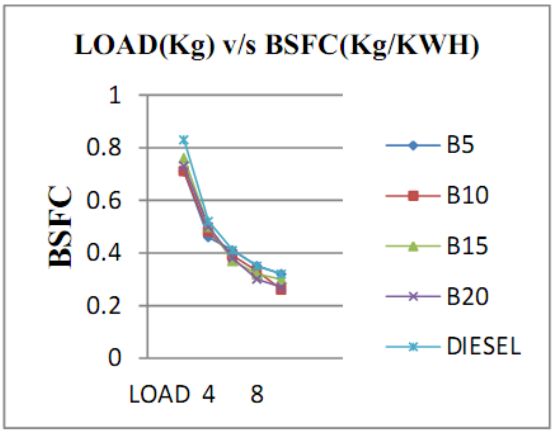

Figure 5: Load v/s BSFC

Specific fuel consumption is defined as the amount of fuel consumed for each unit of brake power developed per hour & a clear indication of the efficiency at which engine develops power from it. The graph is plotted against Load v/s Brake Specific Fuel Consumption for compression ratio 18. Brake Specific Fuel Consumptions descend from lower to higher load level. As load increases BSFC decreases for all fuel blends. At full load, all blends show the specific fuel consumption higher than the diesel.

3.2 Emission Characteristics

3.2.1 Carbon monoxide

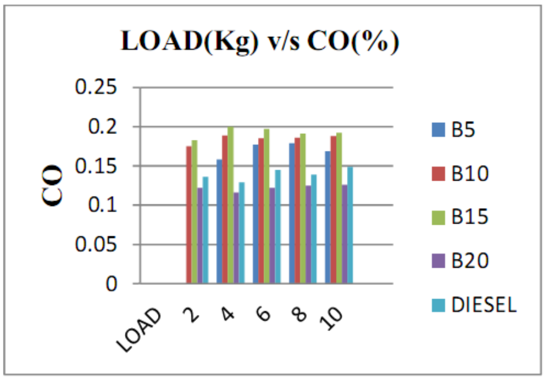

Figure 6: Load v/s CO

The graph is plotted against CO% v/s Load for compression ratio 18. It shows that the carbon emission for B20 blend is less than that of diesel. This is due to the fact that CO is formed when there is not enough oxygen for all of the carbon content of fuel to convert to Carbon Dioxide. Emissions at part loads will be lower and it increases for full load. The emissions have decreased with increased amounts of biodiesel in the blend. The additional amount of oxygen in the biodiesel accounts for better combustion inside the cylinder and hence for reduced CO emissions.

3.2.2 Carbon dioxide

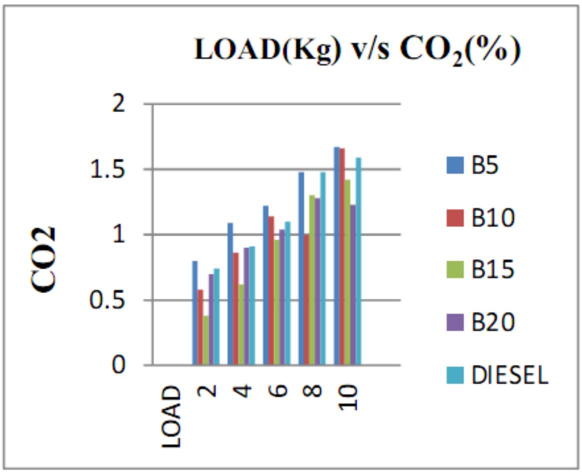

Figure 7: Load v/s CO2

The graph is plotted against CO2% v/s Load for compression ratio 18. It shows that the Carbon Dioxide emission for B20 blend is less than that of diesel. The graph shows that as load increases CO2 emission increases for all blends and diesel also but for B20 blend CO2 emission is less than diesel.

3.2.3 Nitrogen8Oxides

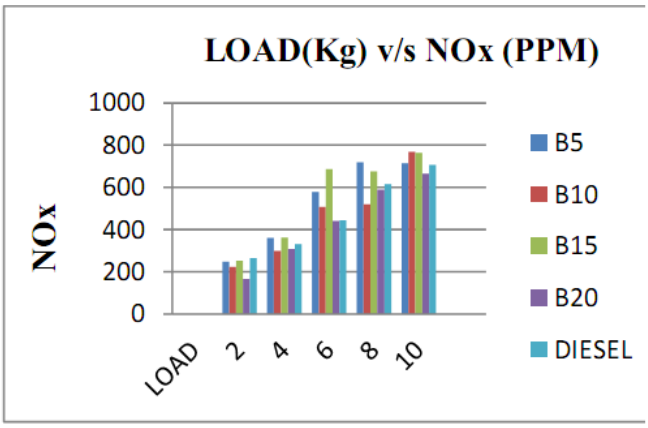

Figure 8: Load v/s NOX

The graph is plotted against NOX v/s Load for compression ratio 18. From the graph it can be observed that NOx emission increases with the load. NOx emission for biodiesel blends is higher than the neat diesel for all compression ratios since they contain in built oxygen in their molecular structure.

4. CONCLUSION

1) The diesel engine performed satisfactorily on biodiesel fuel without any engine modification.

2) Brake thermal efficiencies of all blends are very close to diesel and 20% blend with diesel, B20 provided the maximum efficiency for biodiesel operation for all compression ratios.

3) As the load increases, BSFC decreases for all fuel blends.

4) Using a 20% blend we can reduce the emission of gases like Carbon monoxide, Carbon-dioxide, and Nitrogen oxide gases.

5) Based on the experimental investigation it can be concluded that Honge oil methyl ester and plastic pyrolysis biodiesel with neat diesel blends can be adopted as alternative fuel for existing diesel engines.

REFERENCES

Shivakumar, and Pai, Srinivasa P and Rao, Sriniviasa B R and Samaga, B S (2010) Performance and Emission characteristics of a 4 stroke c.i. Engine operated on honge methyl ester using Artificial neural network. ARPN Journal of Engineering and Applied Sciences, 5 (6). pp. 83-94. ISSN 1819-6608

Dr. Mohammed Yunus, Dr. Mohammad S.Alsoufi, Iftekar Hussain H. Study and Analysis of Performance Characteristics of Biodiesel Formed by Different Blends of Honge and Mustard Oil using 4 Stroke C.I. Engine. International Journal of Emerging Research in Management &Technology ISSN: 2278-9359 (Volume-4, Issue-7)

Ragavendra Prasad. S.K V Suresh Study of Pongamia Pinnata (karanja) Biodiesel as an Alternative fuel for Diesel Engine Advanced Engineering and Applied Sciences: An International Journal; ISSN 2320–3927.

Jagadeesh Alku et al. "Experimental investigation of performance and combustion characteristics of Pongamia biodiesel and its blends on diesel engine and LHR engine" IJRET: International Journal of Research in Engineering and Technology eISSN: 2319-1163 | pISSN: 2321-7308

S. Ghosh & D. Dutta "Performance and Exhaust Emission Analysis of Direct Injection Diesel Engine Using Pongamia Oil" International Journal of Emerging Technology and Advanced Engineering Website: www.ijetae.com (ISSN 2250-2459, ISO

9001:2008 Certified Journal, Volume 2, Issue 12, December 2012)

N. R. Banapurmath, P. G. Tewari, and V. N. Gaitonde, "Experimental investigations on performance and emission characteristics of Honge oil biodiesel (HOME) operated compression ignition engine," Renewable Energy, vol. 48, pp. 193-201, 2012.

S. Murugan, M. C. Ramaswamy, and Nagarajan, "Performance, emission and combustion study of a DI diesel engine using Distilled Tyre pyrolysis oil-diesel blends," Fuel Processing Technology, vol. 89, pp. 152-159, 2008.

M. Mani, G. Nagarajan, and S. Sampath, "An experimental investigation on a DI diesel engine using waste plastic oil with exhaust gas recirculation," Fuel, vol. 89, pp. 1826-1832,2010.

M. Balat and H. Balat, "A critical review of biodiesel as a vehicular fuel," Energy Conversion and Management, vol. 49, pp. 2727-2741, 2008.

S. Shafiee and E. Topal, "When will fossil fuel reserves be diminished?" Energy Policy, vol. 37, pp. 181-189, 2009.

J. Kjarstad and F. Johnsson, "Resources and future supply of oil," Energy Policy, vol. 37, pp. 441-464, 2009.

O. Arpa, R. Yumrutas, and A. Demirbas, "Production of diesel-like fuel from waste engine oil by pyrolitic distillation," Applied Energy, vol. 87, pp. 122-127, 2010.

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