EXPERIMENTAL & CHARACTERIZATION ANALYSIS OF HYBRID BIODIESEL BLENDS ON COMPRESSION IGNITION ENGINE

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ABSTRACT

This research work reveals the effect of biodiesel unsaturation on its fuel properties and thereby on combustion, performance and emissions characteristics. It was found that the instaurations of biodiesel has a substantial effect on its fuel properties. Important fuel properties such as heating value, and cetane number decreases with increase in unsaturation and density, iodine value increases with increase in unsaturation. The combustion characteristics such as ignition delay and premixed combustion duration increases with increase in unsaturation. But the peak heat release rate and peak cylinder pressure decreases with increase in unsaturation. The thermal efficiency and smoke emissions decrease with increase in unsaturation and oxides of nitrogen, unburnt hydrocarbon and carbon monoxide increases with increase in unsaturation.

KEYWORDS: Transesterification, Brake Specific Fuel Consumption, Engine Efficiency, Pollutants, Methyl Ester

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INTRODUCTION

Transport sector is the major consumer of diesel accounting for 70% of the total Diesel sales. The share of Diesel consumption by cars, utility vehicles and 3-wheeler sector is highest 28.48%. The agriculture sector is a major consumer of Diesel with about 13% of the total consumption accounted for by it. Diesel consumption by other segments is 17 percent. This comprises of industry 9.02% mobile towers (1.54%) and others (6.45%) comprising of gensets for non-industrial purposes, civil construction, etc.

Blends Preparation

The biodiesel blended with diesel by volume as B05 (5% Waste Vegetable Oil and 95% of diesel fuel), B10 (10% Waste Vegetable Oil and 95% of diesel fuel), B15 (15% Waste Vegetable Oil and 95% of diesel fuel), B20 (20% Waste Vegetable Oil and 95% of diesel fuel), B25 (25% Waste Vegetable Oil and 95% of diesel fuel), B30 (30% Waste Vegetable Oil and 95% of diesel fuel) and B00 (0% Waste Vegetable Oil and 100% of diesel fuel) or pure Diesel fuel

METHODOLOGY

Why Waste Vegetable Oil

Due to pressure on edible oil like groundnut, rapeseed, mustard and soybean etc. Non-edible oil like Waste vegetable oil is evaluated as diesel fuel extender. Waste Vegetable oil is easily available at restaurant and that is waste so that no need of that oil to the restaurant. So that oil is waste, due to that waste vegetable oil cost also very

less. So it helps to minimize cost of fuel. [2]

Material & Method

WVO is collected from various restaurants from baramati, Maharashtra. That oil is collected in barrel and that is mixture of various used edible oil. But due to use of edible oil it becomes non-edible. [1]

Transesterification Reaction

Chemical reaction of WCO termed as transesterification. [7]

Filter: Solid particles are removed during filtering.

Engine Analysis Setup

Figure 1: Model of Single Cylinder, Four Stroke, VCR Diesel Engine

The setup enables study of VCR engine performance parameters and Emission Parameters. Labview based Engine Performance Analysis software package “Engine soft” is provided for on line engine performance evaluation.

PERFORMANCE PARAMETERS WITH RESULT AND DISCUSSIONS

Brake Power (KW)

Table 1: Brake Power

Load In Kg	B00%	B6%	B12%	B18%	B24%	B30%	B36%
0	0.07	0.11	0.07	0.09	0.12	0.10	0.09
3	0.85	0.89	0.89	0.83	0.89	0.86	0.90
6	1.72	1.71	1.69	1.68	1.71	1.71	1.70
9	2.55	2.52	2.49	2.54	2.50	2.59	2.61
12	3.37	3.30	3.31	3.33	3.38	3.36	3.41

Figure 1: Load VS BP (KW)

Brake power is the power output of the drive shaft of an engine without the power loss caused by gear transmission, friction, etc. Above figure shows that Brake power of B25 blend was almost same with increasing load as compared to diesel fuel as base line of fuel. [11] So for brake power of an diesel engine B25 blend is more suitable blend compared to other fuel.

Integrated Power (KW)

Table 2: Integrated Power

Load (Kg)	Blend B00%	Blend B6%	Blend B12%	Blend B18%	Blend B24%	Blend B30%	Blend B36%
0	1.47	1.43	1.39	1.36	1.51	1.43	1.36
3	2.07	2.00	2.17	1.98	2.17	2.00	2.09
6	2.77	2.77	2.85	2.76	2.83	2.78	2.88
9	3.45	3.48	3.49	3.48	3.51	3.55	3.61
12	4.16	4.11	4.19	4.14	4.24	4.25	4.27

Figure 2: Load vs IP (KW)

Integrated power is defined as the total power of the engine. It is the sum of the brake power and friction power. Above figure shows that integrated power of B25 blend was highest with increasing load as compared to diesel fuel as base line of fuel. So for Integrated power of a diesel engine B25 blend is more suitable blend compared to other. Same blend was satisfied for brake and integrated power. It shows that brake power is directly proportional to integrated power. [5]

Friction Power (KW)

Table 3: Friction Power

Load (Kg)	Blend B00%	Blend B6%	Blend B12%	Blend B18%	Blend B24%	Blend B30%	Blend B36%
0	1.41	1.32	1.33	1.27	1.39	1.34	1.27
3	1.22	1.11	1.28	1.15	1.28	1.15	1.19
6	1.05	1.06	1.16	1.08	1.13	1.07	1.17
9	0.90	0.97	0.99	0.94	1.00	0.96	1.00
12	0.79	0.8	0.88	0.81	0.86	0.88	0.86

Figure 3: Load vs IP Load vs FP (KW).

Engine having some friction in gears, chain drives and shafts, mating parts. It consumes some energy from the power. Figure show that increasing biofuel which increases friction power. Here B05 blend shows lower friction power. B25 blend was more brake power but it had also high friction power. From above calculation clearly show waste vegetable oil develops more power as compare to diesel fuel. [5]

Efficiency (Brake Thermal %)

Table 4: Brake Thermal Efficiency

Load (Kg)	Blend B00%	Blend B6%	Blend B12%	Blend B18%	Blend B24%	Blend B30%	Blend B36%
0	1.48	2.64	1.65	2.17	2.99	2.39	2.26
3	16.24	16.97	15.35	15.84	15.38	16.40	15.52
6	24.64	24.54	22.44	24.12	22.64	24.57	22.56
9	27.72	27.12	26.85	27.31	26.96	27.86	26.47
12	29.05	29.97	30.03	30.19	29.09	28.99	27.98

Figure 4: Load vs IP Load vs BThE (%)

The specific fuel consumption for different blends of fuel and that of pure diesel at different load was represented in graph. The brake thermal efficiency of B15 blend was almost same at certain load and after it increase as compare to

convectional diesel fuel. The reason behind that better combustion due to inherent oxygen and higher cetane number. But beyond B15 was brake thermal efficiency was slightly lower to that of diesel which may due to lower calorific value and higher viscosity. Because higher viscosity the atomization of fuel is not good as it will be lower viscosity at same level of pressure developed by injector pump. [5]

Brake Specific Fuel Combustion (Kg/KWh)

Table 5: Brake Specific Fuel Combustion

Load (Kg)	Blend B00%	Blend B6%	Blend B12%	Blend B18%	Blend B24%	Blend B30%	Blend B36%
0	5.89	3.31	5.31	4.01	2.91	3.65	3.87
3	0.54	0.51	0.57	0.55	0.57	0.53	0.56
6	0.35	0.36	0.39	0.36	0.39	0.36	0.39
9	0.32	0.32	0.33	0.32	0.32	0.31	0.33
12	0.30	0.29	0.29	0.29	0.30	0.30	0.31

Figure 5: Load vs IP Load vs BSFC (kg/kwh)

Brake specific fuel consumption (BSFC) is a measure of the fuel efficiency of any prime mover that burns fuel and produces rotational, or shaft power. It is typically used for comparing the efficiency of internal combustion engines with a shaft output. It is the rate of fuel consumption divided by the power produced. Figure show that B15 blend was lower fuel consumption compare to all other blend and conventional diesel. As consider power of engine B25 blend is also suitable for lower brake specific fuel consumption.

Mechanical Efficiency (%)

Table 6: Mechanical Efficiency

Load (Kg)	Blend B00%	Blend B6%	Blend B12%	Blend B18%	Blend B24%	Blend B30%	Blend B36%
0	4.66	7.52	4.80	6.50	8.06	6.77	6.72
3	41.07	44.42	41.11	41.84	41.14	42.73	43.15
6	62.01	61.75	59.3	60.89	60.25	61.61	59.18
9	73.80	72.29	71.48	72.90	71.35	72.91	72.26
12	80.94	80.43	78.96	80.36	79.62	79.19	79.82

Figure 6: Load vs IPLoad vs ME (%)

Mechanical efficiency measures the effectiveness of a machine in transforming the energy and power that is input to the device into an output force and movement. Figure show that with increasing biofuel which decreases Mechanical efficiency of engine. [11] Here B05 blend was getting more Mechanical efficiency than other fuel.

VOLUMETRIC EFFICIENCY (%)

Table 7: Volumetric Efficiency

Load (Kg)	Blend B00%	Blend B6%	Blend B12%	Blend B18%	Blend B24%	Blend B30%	Blend B36%
0	76.06	75.20	75.33	75.37	75.60	75.35	75.22
3	75.86	75.53	75.36	75.24	75.82	75.60	75.20
6	75.85	74.86	74.62	75.71	74.70	74.95	74.61
9	74.48	74.04	73.74	74.50	73.98	74.35	73.64
12	73.46	73.77	73.37	73.99	73.13	73.64	72.94

Figure 7: Load vs IPLoad vs VE (%)

Figure show that all blend have almost same volumetric efficiency but slightly more as compare to diesel fuel. Here B10 blend has higher volumetric efficiency. Because density of biofuel blends has higher as compare to diesel

EMISSION PARAMETERS WITH RESULT AND DISCUSSION

Hydrocarbon (ppm)

Table 8: Hydrocarbon

Load (Kg)	Blend B00%	Blend B6%	Blend B12%	Blend B18%	Blend B24%	Blend B30%	Blend B36%
0	2	12	3	4	2	6	7
3	0	9	2	6	6	3	8
6	15	10	11	13	6	9	19

9	14	12	16	11	17	15	15
12	18	28	28	25	27	28	34

Graph 8: Load vs IP Load vs HC (ppm)

Hydrocarbon is an organic compounds consisting entirely of hydrogen and carbon. Figure show that with increasing percentage of vegetable oil (biofuel) which result in decrease of HC. Because of oxygen percentage is more in vegetable oil which gives complete combustion and help to decreases HC. Actually oxygen percentage is more in biofuel like jatropha or fuel made from edible part. Figure shows all blends have lower HC percentage than diesel fuel. But B30 has lower Hydrocarbon emission than other. [3]

5.2 Carbon Monoxide (%)

Table 9: Carbon Monoxide

Load (Kg)	Blend B00 %	Blend B6 %	Blend B12 %	Blend B18 %	Blend B24 %	Blend B30 %	Blend B36 %
0	0.093	0.103	0.107	0.078	0.0104	0.093	0.122
3	0.069	0.077	0.066	0.084	0.099	0.081	0.097
6	0.073	0.062	0.060	0.064	0.068	0.072	0.077
9	0.061	0.058	0.063	0.062	0.055	0.071	0.072
12	0.067	0.064	0.064	0.075	0.085	0.074	0.097

Figure 9: Load vs IP Load vs CO (%)

Figure show that B15 blend was almost same CO percentages compare to diesel. But Waste vegetable oil indicates higher CO emission than diesel because may be high viscosity of bio fuel. [10]

Carbon Dioxide (%)

Table 10: Carbon Dioxide

Load (Kg)	Blend B00 %	Blend B6 %	Blend B12 %	Blend B18 %	Blend B24 %	Blend B30 %	Blend B36 %
0	1.74	1.82	2.07	1.51	1.69	1.52	1.88
3	2.14	2.30	2.31	2.5	2.68	2.33	2.69
6	3.19	3.27	3.24	3.19	3.23	3.19	3.20
9	3.91	4.08	4.22	3.98	4.14	4.07	4.23
12	4.99	5.48	5.58	5.34	5.62	5.50	5.98

Figure 10: Load vs IP Load vs CO2 (%)

Figure show that CO2 emission of blended biofuel is lower than diesel. B15 has lowest CO2 emission than other.

[4]

Nitrogen Oxide (ppm)

Table 11: Nitrogen Oxide

Load (Kg)	Blend B00 %	Blend B6 %	Blend B12 %	Blend B18 %	Blend B24 %	Blend B30 %	Blend B36 %
0	110	96	153	76	90	60	68
3	318	302	347	344	367	251	306
6	983	970	975	923	911	865	808
9	1716	1791	1776	1712	1778	1746	1751
12	2528	2603	2540	2560	2648	2638	2611

Figure 11: Load vs IP Load vs NOX (ppm)

Figure show B30 blend has lowest NOx emission than Diesel fuel. The figure denotes the emission of NOx with

respect to load. From above figure it can be noted as the NO_x emission of all fuels get increased with increase in load. The diesel fuel is considered as a base line fuel so that other blends emission were calculated and presented. Usually plant oil such as Jatropha and Karanja biodiesel emitted highest NO_x emission than diesel fuel but here reverse results were observed. It may be due to highest oxygen content and various mixture of material in feedstock oil. [3]

SMOKE (%)

Table 12: Smoke

Load (Kg)	Blend B00%	Blend B6%	Blend B12%	Blend B18%	Blend B24%	Blend B30%	Blend B36%
0	7.5	3.5	2.8	2.8	4.5	4.8	5.3
3	15.4	5.5	5.8	5.55	15.3	14	9.8
6	22	8.4	8	15.2	19	20.3	18.1
9	24.5	14.8	13	18.2	19.6	21.5	22
12	30	20.5	24.5	25.2	29.5	32	36.5

Graph 12: Load vs smoke (%)

Figure show that smoke of waste vegetable oil very lower than diesel. B15 has less than half smoke than diesel fuel. So it is clearly show that bio fuel has very less smoke than diesel. [4]

CONCLUSIONS

- Brake power is directly proportional to load.
- Blend B25 has highest power developed by Diesel Engine.
- Blend B15 has better brake thermal efficiency as well as better brake specific fuel consumption.
- Blend B10 has better volumetric efficiency than other fuel.
- BlendB30 has lower Hydrocarbon emission than Diesel fuel.
- Blend B15 has lowest CO₂ emission than Diesel fuel.
- B30 blend has lowest NO_x emission than Diesel fuel.
- 08. Waste vegetable oil has very low percentage of smoke than Diesel. B15 blend has lowest smoke than other fuel.

FUTURE SCOPES

Testing of diesel engine can be carried on by adding additives with blends which may eliminate some unwanted properties of blends.

REFERENCES

1. Cetinkaya, M.; Karaosmanolu, F. (2004). Optimization of base-catalyzed transesterification reaction of used cooking oil. *Energy. Fuel*, 18 (6), 1888-1895
2. Bobade S.N. and Khyade V.B. (2012), detail study on the properties of *Pongamia pinnata* (karanja) for the production of biofuel, *R.J.C.S (research journal chemical science)* 2(7),
3. Li, S.; Wang, Y.; Dong, S.; Chen, Y.; Cao, F.; Chai, F.; Wang, X. *Renewable Energy* 2009, 34, 1871–1876.
4. Sheehan, J., V. Camobreco, J. Duffield, M. Graboski, and H. Shapouri. 1998. Life cycle inventory of biodiesel and petroleum diesel for use in an urban bus. NREL/SR-580-24089, NREL, Golden CO.
5. Sharma, Y. C.; Singh, B. *Renewable Sustainable Energy Rev.* 2009, 13, 1646–1651
6. Knothe, G., J. Krahl, and J. Van Germe. 2005. *The Biodiesel Handbook*. AOCS Press, Champaign, IL.
7. SULOCHANA, GADDALA, and SK BHATTI. "PERFORMANCE AND EMISSION CHARACTERISTICS OF A TWIN CYLINDER DIESEL ENGINE BLENDED BIODIESEL WITH NANO ADITIVES USING RESPONSE SURFACE METHODOLOGY." *International Journal of Mechanical and Production Engineering Research and Development (IJMPERD)* 8, .3, Jun 2018, 635-646
8. Emissions From High Grade Low Heat Rejection Diesel evaluation of the transesterification of waste palm oil into Engine with Crude *Jatropha* oil, (2009) *International Journal of biodiesel, Bio-resource Technology*, 85, 25306 (2002) *Engineering Studies*, 1(1), 25-30
9. Bobade S.N. and Khyade V.B., (2012), Preparation of Methyl Ester (Biodiesel) from Karanja (*Pongamia Pinnata*) oil, *Res. J. Chem. Sci.*, 2(8), 43-50
10. Girish, C. R. "Review of various feedstocks used and the operating conditions for biodiesel production." *International Journal of Mechanical and Production Engineering Research and Development (IJMPERD)* 8.4 (2018): 357-370.
11. Deshpande D.P., Urunkar Y.D. and Thakare P.D. (2012), Production of biodiesel from castor oil using acid and base catalysts, *Res. J. Chem. Sci.*, 2(8), 51-56
12. Md. N. Nabi, Md. S. Akhter, M. Shahadat, (2006), "Improvement of engine emissions with conventional diesel fuel and diesel-biodiesel blends". *Bioresource Technology* 97 372-378.
13. Senthil Kumar M, Ramesh A, Nagalingam B. An experimental comparison of methods to use methanol and *Jatropha* oil in compression ignition engine. *Biomass Bio Energy* 2003; 25:309–18.
14. S.K. Karmee, A. Chadha, (2005), "Preparation of biodiesel from crude oil of *Pongamia Pinnata*", *Bioresource Technology* 96 1425-1429
15. JOSHI, MP, and SS THIPSE. "AN EVALUATION OF ALGAE BIOFUEL AS THE NEXT GENERATION ALTERNATIVE FUEL AND ITS EFFECTS ON ENGINE CHARACTERISTICS: A REVIEW." *International Journal of Mechanical and Production Engineering Research and Development (IJMPERD)* 9. 1, Feb 2019, 435-440
16. Pradeep Uttam Gaikwad, G Senthilkumar, Supriya Bobade, (2019) "Experimental Investigation and Performance Parameter Analysis of Biodiesel Blend-Methyl Ester on Single Cylinder Diesel Engine, Book Techno-Societal 2018, Pages 315-333, Publisher Springer, Cham

17. Gnanamani Senthilkumar, Akhil Kuruvilla, Anil Joy, (2018), Impact of second-generation alcohols on emission characteristics of biodiesel, *Journal International Journal of Ambient Energy* Volume 39 Issue 6 Pages 547-550 Publisher Taylor & Francis
18. MURALI, BINKAM NAGA, KVP CHAKRADHAR, and G. SWAROOP KUMAR YADAV. "EXPERIMENTAL INVESTIGATION TO DETERMINE THE EFFECT OF HHO BOOSTER ON THE PERFORMANCE OF A TWO WHEELER." *International Journal of Mechanical and Production Engineering Research and Development (IJMPERD)* 8. 2, Apr 2018, 441-450
19. A Rameshbabu, G Senthilkumar., (2018) Emission and performance investigation on the effect of nano-additive on neat biodiesel, *Journal -Energy Sources, Part A: Recovery, Utilization, and Environmental Effects*, Pages, 1-14 Publisher Taylor & Francis
20. G Senthilkumar, JB Sajin, D Yuvarajan, T Arunkumar, (2018),.
21. Evaluation of emission, performance and combustion characteristics of dual fuelled research diesel engine, *Journal - Environmental Technology*, Pages 1-8, Publisher Taylor & Francis
22. PU Gaikwad, KN Balan, B.R. Ramesh Babu, (2017), review., *International Review of Mechanical Engineering*.
23. PU Gaikwad, G Senthilkumar, S Bobade, (2020) Experimental Investigation and Performance Parameter Analysis of Biodiesel Blend-Methyl Ester on Single Cylinder Diesel Engine, *Techno-Societal*
24. S Bobade, P Gaikwad, G Senthilkumar, R Kumbhar, (2020), To Study the Impact of Emissions of Methyl Esters Blends in Diesel Engine, *Techno-Societal*
25. Santosh Kumar Dash, Pradip Lingfa, Supriya B Chavan, (2018), An experimental investigation on the application potential of heterogeneous catalyzed Nahar biodiesel and its diesel blends as diesel engine fuels., *Journal -Energy Sources, Part A: Recovery, Utilization, and Environmental Effects*, Volume-40, Issue-24, Pages-2923-2932, Publisher-Taylor & Francis