

Observation on Functional and Exhaust Attributes of a CI Engine considering Mustard seed, Castor oil, and Diesel Fuel oil blend

Saroj Kumar Dash^{1*}, Chandrabhanu Malla², Bhabani Sankar Mohanty¹, Nihar Ranjan Behara

¹ Mechanical Engineering Department, GIET, Ghanghapatana, 752054, Bhubaneswar, Odisha, India

² Mechanical Engineering Department, RITE, Bhubaneswar, Odisha, India

*sarojdash@gietbbsr.edu.in

Abstract

Looking at the diesel substitution, bio-diesel confirms the suitable replacement. The significant blend comprising non-consumable diesel and castor oil, along with consumable mustard seed vegetable oil considered for this observation. Here in this approach a 4-stroke twin cylinder Kirloskar Diesel Engine and with a typical underneath detail has been undertaken. At the outset edible castor oil along with their blends are being admitted. The physical as well as chemical attributes of the above mentioned two non-conventional engine fuel oil mixes have been verified. In common, clear oil of vegetable extract, viscosity is of elevated value and eventually it is diminished via admitting diesel oil and heating the duo in combine. The specimen prepared here out of the combination of castor and mustard oil and their blend against diesel have been laid out towards the observation of functional as well as emission features. Consequently the very findings are being adjudged against clean diesel. Studying the graphs based on the findings insist that functional attributes diminishes, emission features elevated at the rated condition in compare with diesel oil. The findings are basically rooted out of diminish calorific value, elevated viscosity, and lately combustion event. The significant observation confirmed that 90 percent clean diesel oil added with 10 percent mix of castor and mustard oil become the optimum suitable blend for diesel engine keeping consumption and engine alteration aside. As a matter of fact this very novelty insists on accepting castor and mustard oil blend become substitute for diesel oil in the long run approach.

Keywords: - Bio-diesel, Castor oil, Mustard seed oil, Diesel, Blend

1. Introduction

Being a substitute diesel fuel oil, bio-diesel produced out of sources which are consistent bio-degradable importance namely animal fats, vegetable oil, etc. Here it insists upon the features like ready decomposable value, non-poisonous, reduced exhaust magnitude. Eco-friendliness also one of its distinct aspect. Considering the chemical significance, biodiesel being confirmed as one single alkyl esters concern to elongate series oily caustics produced out of the recyclable lipid potentials. This mono-alkyl diverse ester relied upon oxygenated fuel oil out of unlimited eco-friendly resources. In exact it primarily requires for compression ignition combustion chamber keeping less or null alteration. Pioneer, Sir Rudolf Diesel, experimented fuel oil derived from vegetables for the sake of his sample combustion chamber around hundred years down the line. As the product of petroleum become cheaper day by day, suitable segments out of the crude oil have been

purified to lay out with usual fuel, diesel fuel as well as diesel engines in contemporary manner. During the World War era, around 1940, this very vegetable extract oil utilized for addressing the difficult period of time. As there rise in the purchase of crude oil worth, fossil fuel reserve constraints along with the atmospheric pollution aspects, precise executions being made over eco-friendly vegetable fuel oil as well as animal fats with revised attention on behalf of making of non-conventional bio-diesel energy oil. It holds power of diminishing contamination as well as global warming portfolios.

2. Materials And Methods

2.1 Caster seed fuel oil

Plant beans are productive in terms of delivering Castor fuel oil of non-volatility fatty oil. The very fuel oil span over specific colour decoration looks from pale to greenish. The same possesses two number of by product i.e. brown castor along with

hydrogenated fuel oil. This fuel oil implemented over the work like fabrics, dyes, lacquers, polymers, greasepaints, hair and drying oils. Conventional as well as medical industry also supported with this very oil.

2.2 Mustard seed oil

Technocrats expect to hold purified mustard seed oil, combined with blend conventional diesel fuel oil. The pressing and purification relies upon the

timing aspect. The maximum seed oil would have a determinant of mustard plantings. The impression brought forward to estimate whether mustard could be a workable, locally produce auxiliary on behalf of the very corn and soy, which are necessarily the primary potentials of biodiesel fuel oil. Most technocrats are previously speaking roughly the subsequent curvature of bio fuel study. Mustard probable can be inspected beside with other plants on behalf of bio fuel sources.

Table: 1- Attributes concern to Mustard and Diesel fuel oil

Attributes	Mustard fuel oil	Diesel fuel oil
Specific Gravity (unit less)	0.671	0.84
Calorific Magnitude of fuel (in MJ/kg)	41.8	42.91
Magnitude of Flash Point (in °C)	516	46
Viscosity (kg.S/cm ²)	34	5.6
Amount of Sulphur Present (mgs/100g)	171	12
Caustic amount	1.6	null
Fire Point temp. (in °C)	92	62
Cetane Number	48	48
Molecular Weight (gm)	99.4	236

Table: 2- Attributes concern with Castor oil, Mustard oil, Blend along with Diesel fuel oil

Attributes	Diesel fuel oil	Castor fuel	Mustard fuel	Blend
Specific Gravity (unit less)	0.79	0.89	0.59	0.79
Calorific fuel Magnitude (MJ/kg)	39.31	40.1	39.2	29.98
Flash Point Temp. (in °C)	39	298	492	398.8
Viscidness (kg.S/cm ²)	5.8	226.82	33.8	130.31
Amount of Sulphur Present (mgs/100g)	9	19	169.6	89.87
Caustic magnitude	Null	0.98	0.9	2.01
Fire Point temp (in °C)	59	298	89	199.8
Cetane Number	51	39	50	39.9
Magnitude of Molecular Mass (gm)	193	897	87.83	498.34

Table: 3- Engine Description

Engine	4 Stroke Twin Cylinder, Water chilled, Direct Injecting, Upright
Manufacturer	Kirloskar
Power @ Rev. Per Min.	10 brake horse power@1500RPM
Cylinder Bore*Piston Stroke	81mm*111mm
Maximum upon minimum cylinder volume (V_2/V_1)	18.5:1

3.PRACTICE

The blend prepare in taking mustard and castor oil collected. The mix proportion considered taking the two fuels 50 percent each followed with 10 percent withdrawing of the same mix and then adding 90 percent of diesel fuel finally to avail the desire blend. This is registered as the first sample fuel opting for observation. Afterwards the mustard and castor combined (50 percent each) taken 20 percent then the rest 80 percent diesel

fuel admitted in order to produce the second sample blend. Similarly the blend sample 30 percent is prepared and carried out the observation.

At first, the sample blend is taken forward to fuel tank. Then the combustion inside the engine is started keeping the load at 0 values and recorded the time for the consumption of 20 ml fuel oil. Consequently the load value rises steadily in magnitude i.e. 0, 5,10,15,20 and 25kg.

Table: 4- Diesel Fuel

Load(in kg-f)	Engine speed (in rpm)	Time (in sec.)	Exhaust temp. (in °C)	Fuel consumption (in kg/h)	BHP (in kW)	B.S.F.C. (in kg/kWh)	Thermal Efficiency η (In %)
0	1500	73	262	1.82	Null	Null	Null
5	1500	53	312	2.12	2.31	1.82	10.2
10	1500	44	342	2.32	3.5	1.49	17.5
15	1500	38	392	2.52	5.01	1.37	22.3
20	1500	32	422	2.82	6.35	1.33	24
25	1500	26	452	3.22	7.71	1.32	25.4

Table: 5- 10 Percent Mix

Load(in kg-f)	Engine speed (in rpm)	Time (in sec.)	Exhaust temp. (in °C)	Fuel consumption (in kg/h)	BHP (in kW)	B.S.F.C. (in kg/kWh)	Thermal Efficiency η (In %)
0	1500	69.53	272	0.86	0	0	0
5	1500	52.8	314	1.11	1.346	0.831	10.1
10	1500	42.72	362	1.38	2.696	0.52	16.3
15	1500	37.32	402	1.58	4.06	0.38	21.4
20	1500	31.45	452	1.88	5.36	0.36	24.1
25	1500	25.86	472	2.32	6.736	0.33	24.7

Table: 6- 20 Percent Mix

Load(kg-f)	Engine speed (rpm)	Time(sec.)	Exhaust temp. (°C)	Fuel oil used (kg/h)	BHP (kW)	B.S.F.C. (kg/kWh)	η
							Thermal (%)
0	1500	78.82	273	1.85	Null	Null	Null
5	1500	59.42	322	2.22	2.35	1.92	18.3
10	1500	51.22	363	2.46	3.7	1.55	24.41
15	1500	45.22	412	2.72	5.1	1.44	19.62
20	1500	39.65	462	3.06	6.4	1.39	22
25	1500	23.5	474	2.52	6.74	1.38	23

Table: 7- 30 Percent Mix

oad (kg-f)	Crank shaft speed(in rpm)	Time Period (in sec.)	Exhaust temp.(in °C)	Fuel oil used (in kg/h)	BHP (in kW)	BSFC(in kg/kWh)	η_{Thermal} (In %)
0	1500	65.32	282	0.92	0	0	0
5	1500	46.62	332	1.29	1.4	1.0	9.0
10	1500	38.11	374	1.6	2.7	0.6	14.8
15	1500	32.03	422	1.82	4.1	0.5	18.9
20	1500	27.76	463	2.2	5.4	0.36	21.42
25	1500	22.66	492	2.7	6.8	0.36	21.92

Exhaust Detail:

Table: 8- Diesel Fuel

Load	Hydrocarbon	CO	NO _x
0	20	0.02	3
5	16	0.07	6
10	12	0.13	8
15	8	0.17	12
20	6	0.23	18
25	4	1.6	41

Table: 9- 10 Percent Mixing

Load	Hydrocarbon	CO	NO _x
0	21	0.02	2.6
5	17	0.04	2.8
10	14	0.11	4.6
15	12	0.20	7.2
20	7	0.24	13
25	5	1.5	33

Table: 10- 20 Percent Mixing

Load	Hydrocarbon	CO	NO _x
0	17	0.08	10
5	13	0.13	12
10	8	0.17	17
15	6	0.22	21
20	4	0.32	31
25	2	2.8	47

Table:11- 30 Percent Mixing

Load	Hydrocarbon	CO	NO _x
0	20	0.02	3
5	16	0.07	6
10	12	0.13	8
15	8	0.17	12
20	6	0.23	18
25	4	1.6	41

4. RESULTS AND DISCUSSIONS

4.1 Functional Aspects

η

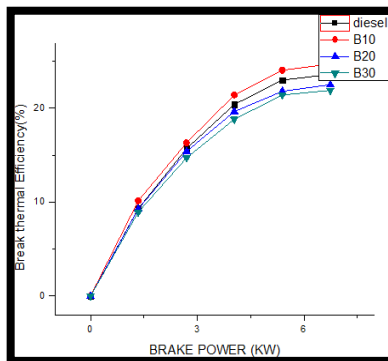


Figure: 1 η (brake thermal kind in %) v/s BP (in kW)

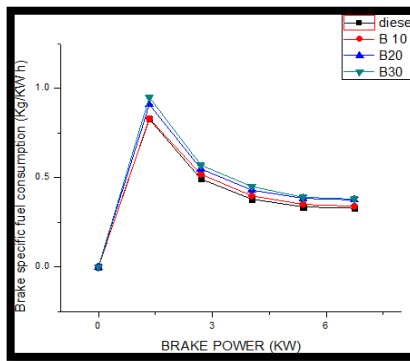


Figure:2 Brake specific Fuel Consumption (Kg/kWh) V/S Brake Power (kW)

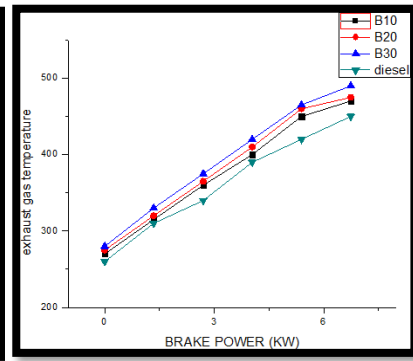


Figure: 3 Exit Gas Temperature value V/S Engine Brake Power magnitude

As per the observation 10 percent blending recorded as highest break thermal efficiency magnitude in compare with 20 percent mix, 30 percent mix, and clean diesel fuel value. Considering the aspect i.e. brake specific fuel consumption, clean diesel holds minimum optimum in compare with 10, 20 as well as 30% fuel mixing value. Diesel fuel establishes optimum low exhaust gas temperature in comparison to other prepared mix fuel.

4.2 Emission Observations

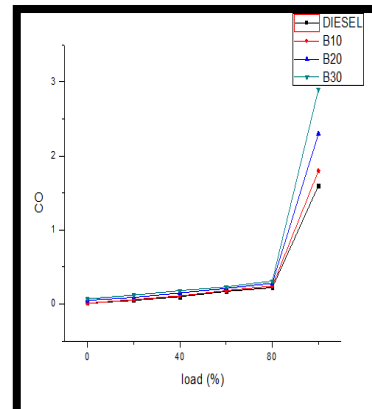
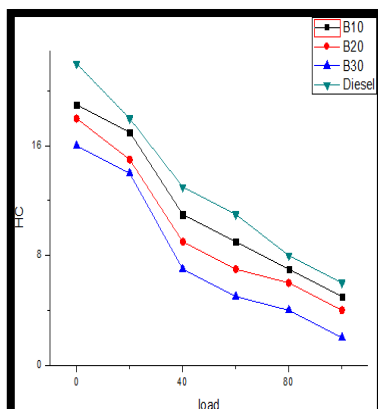
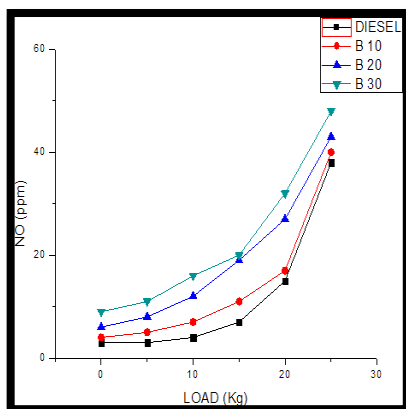


Figure: 4 NO (in ppm) Vs Load (in %)

Figure: 5 HCVs Load (in %)

Figure: 6 Carbon Monoxide (CO)V/S Load

Since vegetable oil contains superior amount of O₂ in compare with diesel fuel, hence fuel burns more actively inside the combustion chamber experiencing greater value of temperature inside and consequently yields higher significance of NO_x.

As a matter of fact, superior oxygen availability reduces hydrocarbon (HC) content percentage. Since greater oxygen magnitude possesses with vegetable oil, hence radiate lower hydrocarbon (HC). In a nut shell superior percentage of blend value move with reduced hydrocarbon significance. Here it is established that vegetable oil possesses greater amount of oxygen in compare with diesel fuel, and as a matter of fact the same functioning as a combustion accelerator inside the combustion chamber. Hence it experiences superior combustion act than diesel fuel, which yields diminished magnitude of Carbon Monoxide (CO) consequence to improper combustion.

CONCLUSION

It has been successfully registered that an amount of 10 percent blend provides optimized magnitude of functional as well as exhaust attributes. The exhaust elements like CO, un burnt hydrocarbon in compare with diesel fuel found to be less. This event is the very cause of satisfactory combustion process within the engine cylinder. The digital outcomes out of this fresh kind of fuel in compare

with diesel engine efficiency (i.e. brake thermal), b.s.f.c. i.e. brake specific fuel consumption are 10 percent less and more respectively on behalf of superior viscosity as well as reduced calorific value of fuel. Apart from it the characteristics like viscosity, density value, flash point of amalgamated specimen are being enhanced magnitude whereas the calorific value appears 80 to 90 percent amount of diesel value.

SCOPE OF FUTURE STUDY

It should be considered that there has been plentiful accessibility of non-edible feedstock. Although the outcomes concern with biodiesel production possesses capability to diminish the absolute production amount, a complete study upon the industrialization disposal on behalf of huge standard biodiesel making is reasonable. Estimating biodiesel production should be prioritized in the upcoming period to promote an additional through study of life cycle cost exploration. Again in afterward approach, improving the production standards of NO_x at the moment of combustion of the very fuel biodiesel is required since the superior capability of nitrous oxide (N₂O) as a greenhouse gas against the CO₂. Nevertheless design of cheap catalyst will become pivotal for the arrangement of huge-scale biodiesel making implementing cheap non-consumable feedstock.

REFERENCES

1. M. Elsayed, M. Eraky, A.I. Osman, J. Wang, M. Farghali, A.K. Rashwan, *et al.* "Sustainable valorization of waste glycerol into bio ethanol and biodiesel through bio-circular approaches: a review, *Environ Chem Lett* (2023), 10.1007/s10311-023-01671-6.
2. G. Sahu, N.K. Gupta, A. Kotha, S. Saha, S. Datta, P. Chavan, *et al.*, A review on biodiesel production through heterogeneous catalysis route, *Chem BioEng Rev*, 5 (2018), pp. 231-252, 10.1002/cben.201700014
3. H. Venu, P. Appavu, Al₂O₃ nano additives blended Polanga biodiesel as a potential alternative fuel for existing unmodified DI diesel engine, *Fuel*, 279 (2020), Article 118518, 10.1016/j.fuel.2020.118518.
4. J.V.L. Ruatpuia, G. Halder, D. Shi, S. Halder, S. Lalthazuala, Comparative life cycle cost analysis of bio-valorized magnetite nanocatalyst for biodiesel production: modeling, optimization, kinetics and thermodynamic study, *Bioresour Technol*, 393 (2024), Article 130160, 10.1016/j.biortech.2023.130160
5. B.Q. Doan, X.P. Nguyen, V.V. Pham, T.M.H. Dong, M.T. Pham, T.S. Le, Performance and emission characteristics of diesel engine using ether additives: a review, *Int J Renew Energy Dev*, 11 (2022), pp. 255-274, 10.14710/ijred.2022.42522.
6. M. Balat, Potential alternatives to edible oils for biodiesel production - a review of current work, *Energy Convers Manag*, 52 (2011), pp. 1479-1492, 10.1016/j.enconman.2010.10.011.
7. C. Chen, S. Qu, M. Guo, J. Lu, W. Yi, R. Liu, *et al.*, Waste limescale derived recyclable catalyst and soybean dregs oil for biodiesel production: analysis and optimization, *Process Saf Environ Prot*, 149 (2021), pp. 465-475, 10.1016/j.psep.2020.11.022.
8. M.Y. Koh, T.I. Tinia, A review of biodiesel production from *Jatropha curcas* L. oil, *Renew Sustain Energy Rev*, 15 (2011), pp. 2240-2251, 10.1016/j.rser.2011.02.013.
9. [9]S.P. Singh, D. Singh, Biodiesel production through the use of different sources and characterization of oils and their esters as the substitute of diesel: a review. *Renew Sustain Energy Rev*, 14 (2010), pp. 200-216, 10.1016/j.rser.2009.07.017.
10. L. Axelsson, M. Franzén, M. Ostwald, G. Berndes, G. Lakshmi, N.H. Ravindranath, Perspective: *Jatropha* cultivation in southern India: assessing farmers' experiences, *Bio fuels Bioprod Biorefin*, 6 (2012), pp. 246-256, 10.1002/bbb.
11. S.H.Y.S. Abdullah, N.H.M. Hanapi, A. Azid, R. Umar, H. Juahir, H. Khatoon, *et al.*, A review of biomass-derived heterogeneous catalyst for a sustainable biodiesel production, *Renew Sustain Energy Rev*, 70 (2017), pp. 1040-1051, 10.1016/j.rser.2016.12.008.
12. A. Buasri, N. Chaiyut, V. Loryuenyong, C. Wongweang, S. Khamsrisuk, Application of eggshell wastes as a heterogeneous catalyst for biodiesel production, *Sustain Energy*, 1 (2013), pp. 7-13, 10.12691/rse-1-2-1
13. P.L. Boey, G.P. Maniam, S.A. Hamid, Performance of calcium oxide as a heterogeneous catalyst in biodiesel production: a review, *Chem Eng J*, 168 (2011), pp. 15-22, 10.1016/j.cej.2011.01.009.
14. Z.E. Tang, S. Lim, Y.L. Pang, H.C. Ong, K.T. Lee, Synthesis of biomass as heterogeneous catalyst for application in biodiesel production: state of the art and fundamental review, *Renew Sustain Energy Rev*, 92 (2018), pp. 235-253, 10.1016/j.rser.2018.04.056.