PERFORMANCE & ENERGY ANALYSIS OF CI ENGINE USING KARANJA BIODIESEL WITH DIESEL

[1]Pandey Kumkumlata.P,[2]Amit I. Pandey,[3]Dr.Tushar M Patel
[1]M.E. Scholar, Mechanical Engineering Department,LDRP-ITR,Gandhinagar,India
[2]Assistance Professor, Mechanical Engineering Department,LDRP-ITR,Gandhinagar,India
[3]Professor, Scholar, Mechanical Engineering Department,LDRP-ITR,Gandhinagar,India

Abstract:*Now days, as we know that energy is basic need of every life. Basic source of energy is fossil fuel such as coal, natural gas and petroleum products such as gasoline and diesel. This increased fuel demand resulted in producing an efficient alternative renewable fuel for power generation that can be proved as a good substitute accompanying environmentally friendly for today's power crisis situation. Infect many alternative fuels such as bio-diesel are available to overcome such situations, which can be produced from resources available locally within the country but at the same time to improve the performance of IC engine an appropriate proportion of biodiesel addition is also necessary to formulate a new fuel, so in this paper, performance and energy analysis of karanja biodiesel is done to choose the optimum amount of biodiesel that can be used as an additive with diesel and can be used as an alternative fuel with maximum efficiency and least unaccounted losses.*

IndexTerms - **Karanja Biodiesel, Energy analysis, Exergy Analysis, C.I engine**

I INTRODUCTION

In recent years, the world's energy supply has relied heavily on non-renewable crude oil derived (fossil) liquid fuels out of which 90% is estimated to be consumed for energy generation and transportation. , the supply of primary energy resources fossil fuel seem to decrease to a critical point. Thus, to fight against the problem of petroleum base fuel crisis, a considerable effort has been made to develop alternative fuel sources and reduce its influence on environment. Bio-diesel made from agricultural products (oxygenated by nature) reduce the world's dependence on oil imports, support local agricultural industries and enhance farming incomes, while offering serious benefits in terms of sustainability, reduced emissions and increased energy and economic security. [1]. The primary advantage of this kind of fuels is that they are eco-friendly and renewable. In addition to this the blends of bio-diesel can be used directly in CI engines with little or no modification. It is a fact that biodiesel blends have advantages in terms of performance and emission over diesel. However, the blend mixture proportion along with the engine operating parameters also play a vital role in deciding the performance of the engine. In the present study, performance and energy analysis of CI engine is done by using Karanja biodiesel blend with diesel in the proportion of KB05, KB15, KB25, KB35, KB45.

Generally, a common measure for energy efficiency is based on the first law of thermodynamics. It is known as that first law efficiency η_I which is defined as output energy of a device to the input energy. In actual First law deals with quantities of energy i.e it makes sense to distinguish between useful energy and energy forms that cannot be utilized. for example, friction causes energy "losses" in the sense that the heat developed because of friction is scattered and has a fairly low temperature, thus it cannot easily be utilized. Thus energy analysis helps in undertaking the optimization and assess the comparative performance of of the biodiesel.

II LITERATURE

G.Vidyasagar . Reddy .et.al [2] from the experiment focused on combination of two different biodiesel blends jatropha oil (B20J),Mahua oil (B20M with diesel. His Results showed that at full load conditions and constant engine speed of 1500 rpm the BTHE of B20J is higher than other blends. BSFC lowest for diesel compare to other blends. The emissions of CO and HC of dual biodiesel are lower than that of diesel. But NOx is higher in dual biodiesel compare to diesel.

S.Prabhakar.et.al. [3] in his projectused esterified Nerium oil as an alternate fuel to compare the performance and emission characteristics between pure diesel and Nerium blends. He selected suitablenerium blend and optimized injection timing for the blend. The Nerium oil blends were in percentage of 20%, 40%, 60%, 80%, and 100% of Nerium oil to 80%, 60%, 40%, 20% & 0% of diesel and it was concluded that among all nerium and diesel blends 20% of nerium and 80% of diesel blend at 30º BTDC gives better performance nearing the diesel. When comparing the emission characteristics HC, CO is reduced when compared to diesel, however NOx emission is slightly increased when compared to diesel. Hence Nerium blend can be used inexisting diesel engines with minimum modification in the engine. It also describes the usage of non-edible oil to a greater extent.

R.D.Misra a M.S. Murth [4] in his experiment karanja oil and karanjabiodiesel were blended with petroleum diesel in various proportions to evaluate and compare the performance and emission characteristics of a single cylinder direct injection constant speed diesel engine. with fuel blends(10%, 20%,30% and 40%) in terms of 25% load increments from no load to full loads. Among the blends KO10 and KB20 have shown a better performance with respect to BTE and BSEC.

R. Senthilkumar.et.al.[5] carried out Experimental investigations to examine properties, performance and emissions of different blends (BJO, B20, B30, B40, B50) of Neem methyl Esters in comparison to diesel. Results indicated that B30 and B50 have the closer peiformance to diesel. However, its diesel blends showed reasonable efficiencies, lower smoke, carbon monoxide, hydrocarbon and Nitrogen oxide. [

H J Yadav [6]assessed the suitability of Karanja oil for diesel engine operation, without any modifications in its existing construction. However, for long-term use and for heavy and big engines, blend of diesel and vegetable oils is recommended. F,Halek et al. also found same result for rapeseed oil

NabnitPanigrahi.et.al [7] from the experimental investigation on a four stroke single cylinder diesel engine fuelled with the blends ofMahuaoilmethylester (MOME) anddiesel. The performance emission, energy, and exergy analysis was being carried out with B20(mixture of 80% diesel by volume with 20% MOME). From energy analysis, it was observed that the fuel energy input as well as energy carried away by exhaust gases was 6.25% and 11.86% more in case of diesel than that of b20. The unaccounted losses were 10.21% more in case of diesel than b20. The energy efficiency was 28% ,while the total losses were 72% for diesel .in case of b20 ,the efficiency was 65.74% higher than that of diesel.

BaharSayinKul and Ali Kahraman[8] from their studyof energy and exergy analysis performed for a single cylinder ,water-cooled diesel engine using biodiesel, diesel and bio ethanol blends . found that the fuel blends, prepared by mixing biodiesel and diesel in different proportions fuel with 5% bioethanol, are identified as D92B3E5 (92% diesel, 3% biodiesel and 5% bioethanol), D85B10E5 (85% diesel, 10% biodiesel and 5% bioethanol), D80B15E5(80% diesel, 15% biodiesel and 5% bioethanol) and D75B20E5 (75% diesel, 20% biodiesel and 5% bioethanol) shows.the maximum thermal efficiency 31.42%, 28.68%, 28.1%, 28% and 27.18% at 1400 rev/min, respectively, forD92B3E5, D85B10E5,D80B15E5, D75B20E5 in comparison to D100 with efficiency .

Table 2.1 Comparative properties of Karanja biodiesel over diesel.

Testing Properties	**Karanja Biodiesel**	**Diesel**
Density	0.93 gm/cm³	0.855 gm/cm³
Flash point	167 (°C)	76 (°C)
Kinematic viscosity at 40^0 C	46 (mm^2/s)	3.06(mm^2/s)
Cetane no	51	50
Cloud point	5(°C)	-6 (°C)
Pour point	1(°C)	-16 (°C)
Calorific value	39870(kJ/kg)	44000(kJ/kg)

III EXPERIMENT SETUP

Figure 3.1 Engine Setup

Table 3.1 Test Engine Specification

PARTICULAR	SPECIFICATIONS
Engine	1 cylinder, 4 stroke, water cooled engine
Bore and stroke	87.5mm by 110 mm
Rated power	3.5 kW at 1500 rpm
CR range	12:1 to 18:1
Injection Variation	0-25 degree BTDC
Propeller shaft	With universal joints
Dynamometer	Eddy current type, water cooled with load unit
Air box	M S Fabricated with orifice meter and manometer
Calorimeter	Pipe in pipe type
Load sensor	Load cell, type strain gauge, range 0-50 kg
Temperature sensor	RTD type PT100 and Thermocouple , type K
Load indicator	Digital , range 0-50 kg, supply 230V AC
Digital voltmeter	Range 0-20V, panel mounted
Rotameter	Engine cooling 40-400 LPH, Calorimeter 25-250 LPH
Fuel tank	15 liter capacity with fuel metering pipe of glass

3.1 EXPERIMENT METHOD

First engine was made to run at manufacturers set value of compression ratio 17.5 with the diesel till the engine warms up and then load is increased and readings for energy analysis were taken for different blends (B5 to B55 with increment of 10). Engine was made to run for three different loading conditions such as low, medium and high for same blends of karanja biodiesel and diesel. The measurements were taken after the steady state condition was reached. Here engine setup has facility of automatic reading measurements at some fixed interval of time with data acquisition system. Load was varied with the help of voltage knob and reading directly indicates values in terms of load in kilogram. Fuel consumption and manometer difference which is used to calculate mass of air consumption were also shown by same I.C engine software after each measurement of 60 sec at different loading conditions.. Mass flow rate of water for engine cooling and for calorimeter was set by valves and values of flow rates were indicated by Rota meter. Temperature readings and reading such as such as engine cooling water inlet and outlet, calorimeter water inlet and outlet and exhaust gas inlet and outlet temperature in calorimeter were generated in the same software after each measurement reading of 60 secte

IV OBSERVATION TABLE AND CALCULATION

By following the experimental method discussed in previous chapter, readings were taken during the experiment for the energy analysis.

Table 4.1 Observation table for energy analysis

Sr no	fuel	ρ (kg/m^3)	$\dot{m}f$ (cc/ min)	Cv (kJ/kg)	L0AD (kg)	rpm	T (Nm)	t1 (°c)	t2 (°c)	t3 (° c)	t4 (°c)	t5 (°c)	t6 (°c)
1	Diesel	832	8	44000	1	1623	2.65	31	38	30	32	178	143
2	Diesel	832	13	44000	5	1596	10.11	30	39	30	33	235	195
3	Diesel	832	16	44000	9	1563	16.59	31	41	30	35	358	291
4	KB05D95	833	11	43793	1	1665	3.48	31	37	30	32	158	132
5	KB05D95	833	13	43794	5	1586	9.98	31	40	30	33	317	264
6	KB05D95	833	17	43794	9	1570	16.71	31	41	30	35	389	320
7	KB15D85	836	10	43381	1	1663	2.60	31	36	30	32	189	151

8	KB15D85	836	13	43381	5	1589	9.60	31	40	29	33	257	215
9	KB15D85	836	17	43381	9	1564	16.71	31	42	30	35	331	268
10	KB25D75	840	10	42968	1	1665	2.60	31	37	30	32	182	155
11	KB25D75	840	13	42968	5	1589	9.44	31	39	30	34	267	213
12	KB25D75	840	17	42968	9	1567	16.62	31	40	29	36	353	281
13	KB35D65	844	10	42555	1	1673	2.58	31	37	29	31	221	192
14	KB35D65	844	13	42555	5	1585	9.62	31	39	30	32	296	258
15	KB35D65	844	16	42555	9	1572	16.52	31	40	30	34	393	335
16	KB45D55	846	10	42142	1	1672	2.58	31	38	30	32	197	158
17	KB45D55	846	13	42142	5	1584	9.56	31	39	30	33	309	262
18	KB45D55	846	18	42142	9	1571	16.33	31	42	30	36	421	345

V CALCULATIONS

Where t1 & t2 = Cooling water inlet and outlet temperature
t3 & t4 = Calorimeter water inlet and outlet temperature
t5 & t6 = Exhaust gas inlet and outlet temperature
C_{pex} =specific heat of exhaust gas

1) Heat supplied to the engine per unit time

$\dot{Q}_{in} = mf \times LCV$ (kW)

2) Brake power of the engine

$\dot{Q}_{bp} = 2\pi NT/60{,}000$ (kW)

3) Heat carried away by cooling water of the engine

$\dot{Q}_{CW} = m_{cw} \times C_{pw} \times (T_2 - T_1)$ (kW)

4) Heat carried away by exhaust gases .

Heat gain by water in calorimeter = Heat loss by exhaust gases in calorimeter

$\dot{m}_{wcal} \times C_{pw} \times (T_4 - T_3) = m_{ex} \times C_{pex} \times (T_5 - T_6)$

Heat carried away by exhaust gases is now calculated as

$\dot{Q}_{ex} = \dot{m}\, ex \times Cp_{ex} \times (T_5 - T_0)$ (kW)

5) Unaccounted losses

$\dot{Q}u = \dot{Q}_{in} - (\dot{Q}_{bp} + \dot{Q}_{cw} + \dot{Q}_{ex})$ (kW)

6) Brake thermal efficiency (BTHE)

$\eta = \{ \frac{Q_{bp}}{Q_{in}} \} \times 100\%$

7) Break Specific fuel consumption

BSFC = $\frac{B.P}{mf * C.V}$ (kW/ kg.hr)

VI RESULT AND DISCUSSION

Table 5.1 Result Table

Sr. no	fuel	ρ (kg/m³)	BSFC (kg/kW.hr)	Qin (kW)	Qbp (kW	Qcw (kW	Qex (kW	Un (kW	BTHE (%)
1	Diesel	832	0.98	5.49	0.45	2.44	1.02	1.59	8.20
2	Diesel	832	0.44	7.93	1.69	3.14	1.83	1.27	21.29
3	Diesel	832	0.31	10.37	2.71	3.54	2.89	1.23	26.16
4	B05D95	833	1.13	6.69	0.61	2.20	1.19	2.69	9.08
5	B05D95	833	0.46	7.90	1.66	3.30	1.92	1.02	20.96
6	B05D95	833	0.32	9.73	2.75	3.60	3.07	0.31	26.57
7	B15D85	836	1.09	6.04	0.45	1.84	1.00	2.75	7.47
8	B15D85	836	0.43	7.86	1.60	3.32	2.57	0.37	20.32
9	B15D85	836	0.32	9.67	2.74	3.83	2.82	0.28	26.63
10	B25D75	840	1.12	6.02	0.45	2.19	1.35	2.02	7.52
11	B25D75	840	0.43	7.82	1.57	2.88	2.08	1.29	20.07
12	B25D75	840	0.32	10.23	2.73	3.23	3.71	0.56	26.66
13	B35D65	844	0.95	5.99	0.45	2.09	1.57	1.87	7.54
14	B35D65	844	0.40	7.78	1.60	2.91	1.66	1.61	20.51

15	B35D65	844	0.30	9.58	2.72	3.26	2.95	0.65	28.37
16	B45D55	846	1.12	5.94	0.45	2.44	1.03	2.02	7.59
17	B45D55	846	0.43	7.72	1.59	2.87	2.11	1.16	20.53
18	B45D55	846	0.32	10.70	2.74	3.95	3.68	0.32	25.61

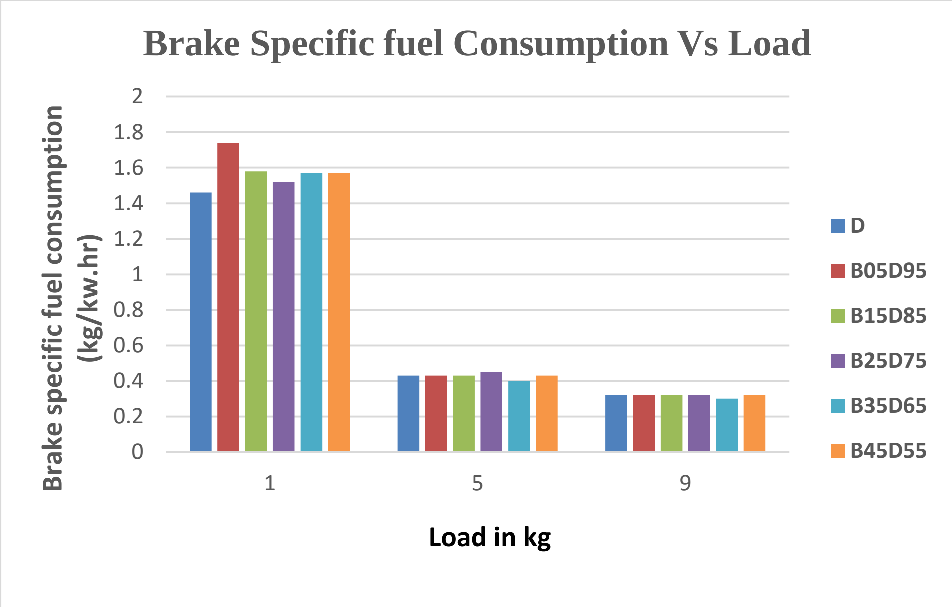

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Figure 5.1 Comparison of BSFC for All Fuels

From the above **Fig. 5.1** it can be conclude that the value of the BSFC is decreased as load increases. The range of BSFC values is in between 0.3011(kg/kW.hr**)** -1.130 (kg/kW.hr**)**. The highest value of BSFC is 1.130 (kg/kW.hr) at low load (1 kg) condition for B05 blend and the lowest value of BSFC is 0.3011 at high load (9 kg) condition for B35 blend. Also it can be seen from the graph that at all loads BSFC for B35 blend is lowest in comparison to all other blends. BSFC for B05 and B25 remains higher at all loading condition compare to others blends

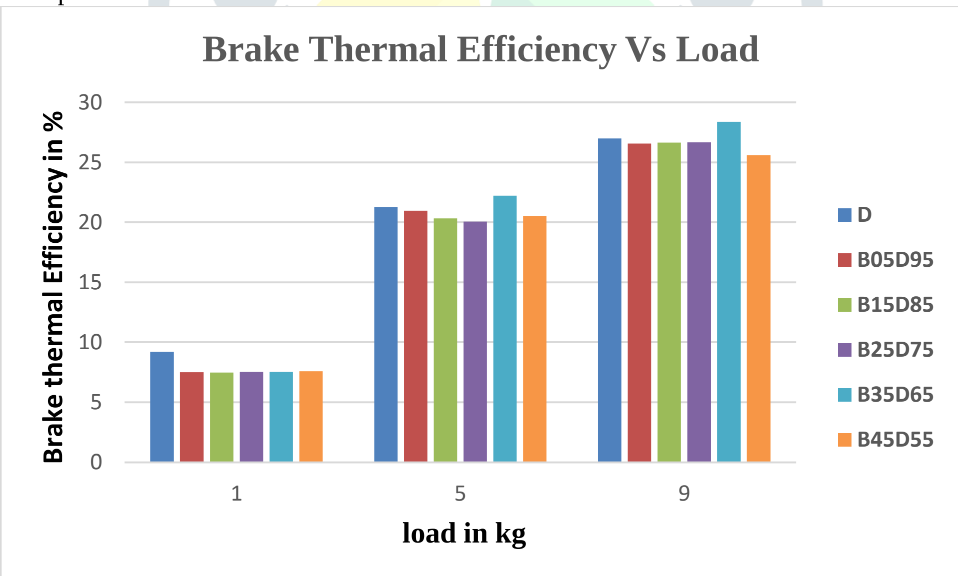

Figure 5.2 Comparison of Brake Thermal Efficiency

Figure 5.2 shows the graph of comparison of brake thermal efficiency vs load for all tested fuel. It is seen from the graph that engine gives higher brake thermal efficiency at higher loading condition for all fuels. If compare for all the fuel tested then at lower load brake thermal efficiency of all the fuels is almost same .however to be accurate hence say that efficiency of diesel is marginally higher. But at medium and higher load condition it can be seen that B35 fuel has higher efficiency 28.30% than all other fuel and diesel 27.80% remains at second position. At the higher load condition highest efficiency was found for B35 blend that is 28.30%. Also one other thing observed from the **Fig. 5.2** is that the thermal efficiency of other biodiesel blends was found higher but less than diesel fue lat this higher load condition and that might be due to better combustion process in the cylinder for biodiesel blends due to oxygen content in them.

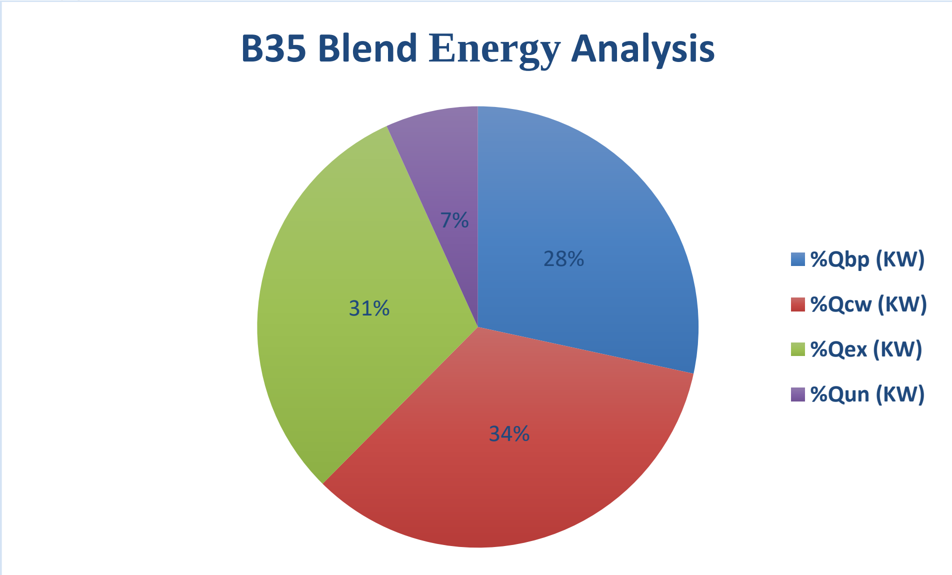

Figure 5.3 B35 Blend Energy Analysis

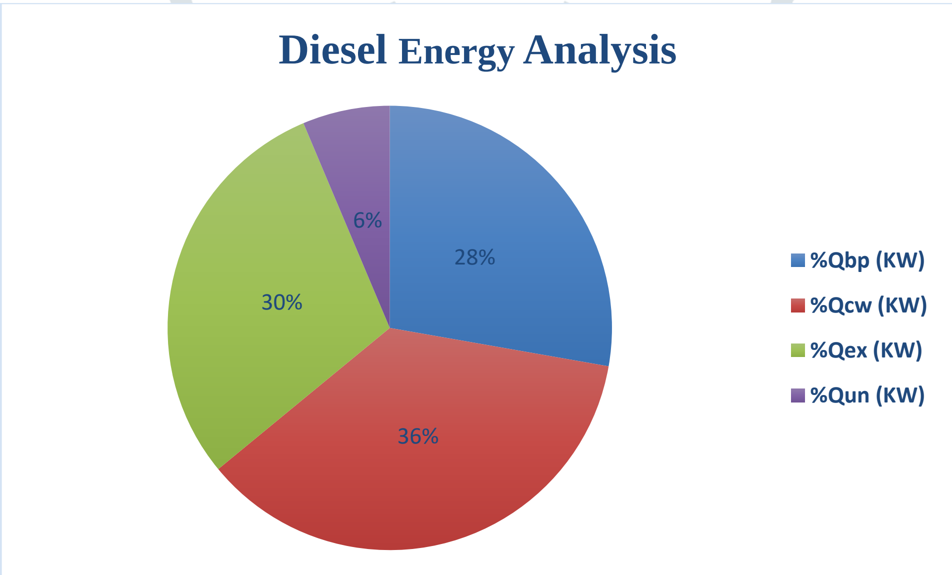

Figure 1.4 Diesel Energy Analysis

From the energy analysis it can be said that KB35 blend performance is better in comparison to other blends at low and medium load and performance is higher than the diesel and all other blends at high load.

VII Conclusion

- At constant Injection Pressure 180 bar and constant compression ratio 18 with varying load condition of low, medium and high then BTHE of (KB35) Karanja Biodiesel is found maximum.
- BSFC is found decreasing from minimum to maximum load condition.KB35 is found to have minimum BSFC at higher load condition.
- The value of unaccounted losses is found to be decreasing at with higher load condition.
- The unaccounted losses of biodiesel is found maximum in comparison to diesel.
- More Exhaust gas energy losses are found at high load condition for all fuels including Diesel with biodiesel.
- Thus Karanja Biodiesel with an average blend ratio KB35 i.e more than the minimum blend ratio KB05 is found to have maximum first law efficiency, Thus, from energy analysis it can be conclude that biodiesel gives similar performance compare to diesel.
- Thus Biodiesel with less calorific value and high oygen content gives comparable and similar kind of performance compared to diesel.

VIII REFERENCE

[1] Gaurav S, Devendra D, Agrawal S K. Experimental investigation of performance parameters of single cylinder ic engine usinmustard oil. International Journal of Modern Engineering Research (IJMER) 3 (2013) 832-838

[2] G.Vidyasagar Reddy, Prof N. GovindhaRasu&T.Hari Prasad. " Experimental Investigation OnThe Performance Of CI engine Using Dual Biodiesel" 978-1-5090-3564-9/16/$31.00 ©2016 IEEE.

[3] Prabhakar, S., Banugopan, V. N., Annamalai, K., &Jayaraj, S. (2010, November). Analysis of chosen parameters of CI engine for Nerium oil—An alternative fuel. In *Frontiers in Automobile and Mechanical Engineering (FAME), 2010* (pp. 88-91). IEEE.

[4] Misra, R. D., & Murthy, M. S. (2011, June). Comparative performance evaluation of karanja vegetable oil and karanja biodiesel blends with diesel in CI engine. In *Clean Energy and Technology (CET), 2011 IEEE First Conference on* (pp. 6-10). IEEE.

[5] Gongping, M., Zhong, W., Peiyong, N., &Xiaozhe, W. (2011, April). Experimental research on the flame temperature of biodiesel fuel combustion in open-air conditions. In *Electric Information and Control Engineering (ICEICE), 2011 International Conference on* (pp. 2171-2174). IEEE.

[6] Panigrahi, N., Mohanty, M. K., Mishra, S. R., & Mohanty, R. C. (2014). Performance, emission, energy, and exergy analysis of a CI engine using mahua biodiesel blends with diesel. *International scholarly research notices*, *2014*.

[7] Panigrahi, N., Mohanty, M. K., Mishra, S. R., & Mohanty, R. C. (2014). Performance, emission, energy, and exergy analysis of a CI engine using mahua biodiesel blends with diesel. *International scholarly research notices*, *2014*.

[8] Sayin Kul, Bahar, and Ali Kahraman. "Energy and exergy analyses of a diesel engine fuelled with biodiesel-diesel blends containing 5% bioethanol." *Entropy* 18.11 (2016): 387.