Energy Analysis of CI engine using Jatropha Bio diesel blends with Diesel

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Abstract: In recent year, energy is the basic need of everyone in the world and also the energy consumption is increasing with time. Basic source of energy are fossil fuel such as coal, natural gas and petroleum products such as gasoline and diesel. But these sources of energy are limited in quantity and they are non-renewable. They will not be available in nearby future for use hence growing concern regarding energy resources and environment has increased interest in the study of alternative sources of energy. To meet increasing energy requirement, these have been growing interest in alternative fuel like biodiesel to provide a suitable diesel oil substitute for internal combustion engine. Biodiesels are offers a very promising alternative to diesel oil since they are renewable and have been similar properties. One of the economical sources for biodiesel production which doubles in the reduction of liquid waste and the subsequent burden of sewage treatment is Jatropha bio diesel. This research work aims to carried energy analysis of Compression Ignition (CI) Engine to study performance and its characteristics. The thermal efficiency and the energy losses in the system are calculated from the 1st law of thermodynamics. Energy analysis is carried out for biodiesel blends (B10 to B50 with increment of 10). From this analysis best performed blend was chosen and we get energy analysis.

Keywords: Jatropha bio diesel energy analysis.

1. INTRODUCTION

In the world of today, energy is an actual existence line of every single human action. It has now become a need for everyday schedule life. Oil is the biggest contributing vitality source to humankind, outperforming every other asset like: coal, atomic, hydro, flammable gas and wind. It is fundamental in the field of mechanical, nourishment and agrarian creation, as the fuel for transportation just as for the age of power. The number of diesel engine increasing continuously every year because of having high efficiency, enhanced fuel economy. Diesel engines are preferred over spark ignition engines in almost all heavy duty application due to their reliability and durability. Along these lines, the world interest for diesel fuel expands each year. Since the non-renewable energy source assets are constrained and non-inexhaustible and will gradually diminish. Also vestige fuels causes air pollution, global warming and to provide an effective way to fight against the problem of petroleum base fuel crisis and the influence on environment stimulating the researchers and engineers required to find renewable energy sources and fuels.

Biodiesel is a fuel produced using common, sustainable sources, for example, new and utilized vegetable oils and creature fats, for use in a diesel motor (G. Antolın et al. 2002). Biodiesel has physical properties fundamentally the same as oil determined diesel fuel, yet its discharge properties are prevalent. Utilizing biodiesel in a traditional diesel motor significantly decreases discharges of unburned hydrocarbons, carbon monoxide, sulphates, polycyclic sweet-smelling hydrocarbons, nitrated polycyclic sweet-smelling hydrocarbons, and particulate issue(Canaski et al. 2006). Diesel mixes containing up to 20% biodiesel called B20 can be utilized in almost all diesel-controlled hardware, and more significant level mixes and unadulterated biodiesel, B100 can be utilized in numerous motors with next to zero change. Lower-level mixes are perfect with most stockpiling and dispersion gear, yet unique taking care of is required for more significant level mixes(Sekmen et al. 2011., Panigrahi et al. 2014).

Biodiesel can be utilized in any diesel motor when blended in with mineral diesel. In certain nations producers spread their diesel motors under guarantee for 100% biodiesel use. Numerous individuals have run their vehicles on biodiesel without issues. Be that as it may, most of vehicle producers limit their suggestions to 15% biodiesel mixed with mineral diesel. In numerous European nations, a 5% biodiesel mix, B5 is broadly utilized and is accessible at a large number of corner stores (K.V.Narayanan et al. 2015). Biodiesel can be produced using waste and virgin vegetable and creature oil and fats (fluids). Virgin vegetable oils can be utilized in altered diesel motors. Truth be told the diesel motor was initially intended to run on vegetable oil instead of petroleum product. There are also studies and efforts to commercialize biodiesel from algae (C. Sayin et al. 2016).considered the generation of biodiesel from Jatropha and its application to diesel motor. Execution and outflow tests were led on a solitary chamber diesel motor to fuelled with biodiesel mixes and diesel fuel. The test outcomes demonstrated that the decrease in execution for B5, B20 and B50 energizes were 2.2%, 6.3% and 11.2% individually than that of diesel fuel. These low decrease can be kill by increment in BSFC. For biodiesel mixes B5, B20 and B50 expanded in BSFC by 2.8%, 3.9% and 7.8% separately (Likita Bwonsi et al. 2017). Oxygen in biodiesel fuel leads to better combustion and hence combustion related irreversibility can be reduced means good energetic performance. Combustion process involve most of the irreversibility of the system hence combustion system must be analyzed for optimum performance on energetic way. Fuel consumption is always higher for biodiesel and in some preferable condition reaches near to diesel. Brake thermal efficiency of the engine with biodiesel fuel mostly higher than diesel fuel and it may be due to better combustion.

The additives in biodiesel are used for the improve combustion, fuel economy and to decrease the emission. A metal based additive will minimize the viscosity, pour point and increase the flash point properties of biodiesel fuel. The BSFC decreases significantly due to their catalyst effect by adding the metal based additives. the oxygenated additives will affect directly the properties such as cetane number, density, viscosity, volatility, flash point and calorific value. The oxygenated additive helps in reducing the viscosity and density as well as raising the quantity of oxygen in biodiesel fuel. Normally all exhaust emissions of carbon dioxide, carbon monoxide, hydrocarbon and smoke emissions are decreased very much with the addition of oxygenated additives to diesel and biodiesel fuels. Cetane number additives are very important in decreasing ignition delay period. Antioxidant additives are the most successful to increase cetane number and flash point, but calorific value gets reduce with antioxidant. Antioxidant is quite successful in controlling NOx emission (M. Vijay Kumar et al. 2016).

2. MATERIALS AND TEST METHODS

2.1. Experimental setup and test installations

The reason for mixing Jatropha bio diesel with Diesel was to inquire about the probability direct utilization of vegetable oils in Diesel motors. Therefore, test fuels were prepared by blending (Diesel 90% + Jatropha 10%), (Diesel 80% + Jatropha 20%), (Diesel 70% + Jatropha 30%), (Diesel 60% + Jatropha 40%), (Diesel 50% + Jatropha 50%). Some of the properties of the Jatropha Bio diesel and Diesel were estimated and are introduced in table 1.

Table 1: Properties of fuel

	Jatropha Bio diesel	**Diesel**
FLASH POINT	135 °C	150°C
VISCOSITY	At 20°C (4.9 cP)	At 20 °C(6cP)
DENSITY	0.880 g/mL	0.832 g/mL
CETANE NUMBER	-	45-55
CALORIFIC VALUE	39100 kJ/kg	43000 kJ/kg

Calorific value and Density of the (Diesel 90% + Jatropha 10%), (Diesel 80% + Jatropha 20%), (Diesel 70% + Jatropha 30%), (Diesel 60% + Jatropha 40%), (Diesel 50% + Jatropha 50%). is show in table 2.

Table 2: Calorific value and density

	Calorific Value	**Density**
(Diesel 90% + Jatropha 10%)	42583.20 kJ/kg	838.4 kg/m^3
(Diesel 80% + Jatropha 20%)	42172.72 kJ/kg	844.8 kg/m^3
(Diesel 70% + Jatropha 30%)	41768.42 kJ/kg	851.2 kg/m^3
(Diesel 60% + Jatropha 40%)	41370.14 kJ/kg	857.6 kg/m^3
(Diesel 50% + Jatropha 50%)	40977.77 kJ/kg	864.0 kg/m^3

Schematic diagram of preliminary course of action is found in Figure. 1. The course of action involves single chamber, four strokes, VCR (Variable Compression Ratio) Diesel engine related with vortex current sort dynamometer for stacking. The weight extent can be changed constantly the engine and without altering the start chamber geometry by exceptionally organized tilting chamber square strategy. Course of action is given significant instruments for consuming weight and wrench edge estimations. This sign is interfaced to PC through engine marker for Pθ-PV traces. Game plan is also made for interfacing wind current, fuel stream, temperatures and weight estimation. The set-up has stayed singular board box containing air box, two fuel tanks for blend test, manometer, fuel assessing unit, transmitters for air and fuel stream estimations, process pointer and engine marker. Rotameters are obliged cooling water and calorimeter water stream estimation. The game plan enables examination of VCR engine execution with EGR for brake control, exhibited power, frictional force, BMEP, IMEP, brake warm capability, demonstrated warm efficiency, Mechanical adequacy, volumetric profitability, express fuel use, A/F extent and warmth balance. Labview based Engine Performance Analysis programming pack "ICEngineSoft" is obliged on line execution appraisal. An automated Diesel mixture pressure estimation is on the other hand given. Table 3 show the Specifications of the Diesel motor.

Figure 1: Schematic outline of trial arrangement

Table3: Specifications of the Diesel engine

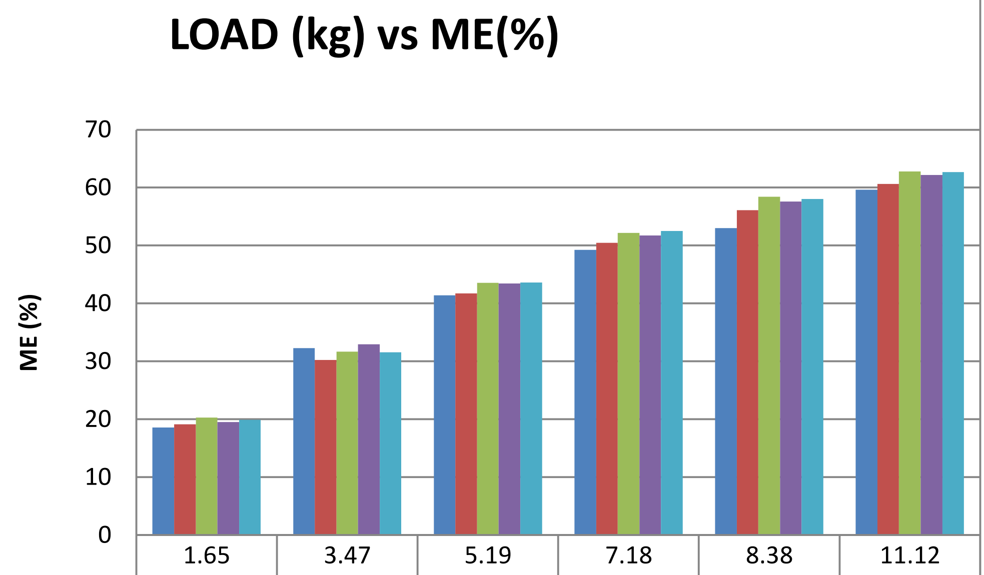
Engine Manufacturer	**Apex Innovation**
Product	Research motor arrangement single chamber, 4-stroke, multi fuel, Electronic
Engine cylinder size	Stroke 110mm, Bore 87.5mm, limit 661 cc
Diesel mode	Power 5.2 kW, speed 1500 rpm, CR go 12:1-18:1, infusion variety 0-25º BTDC
Petrol mode	Power 4.5 KW at 1800 rpm, speed go 1200-1800 rpm, CR extend 6:1-10:1, flash variety 0-700 BTDC
Dynamometer	Whirlpool ebb and flow, water cooled with stacking unit
Temperature sensor	RTD type, PT 100 and thermocouple
Load indicator	Computerized, run 0-50 kg
Load sensor	Strain check, 0-50 kg
Software	Enginesoft, engine performance and analysis

3. EXPERIMENTAL RESULT AND DISCUSSION

results

Specific Fuel Consumption(SFC), Fuel Consumption(FC), Exhaust Gas Temperature, Mechanical Efficiency(ME%), Brake Thermal Efficiency(BTHE%) and Volumetric Efficiency effective efficiency of the engine according to the operation load, for all the test fuels are presented and analyzed in this section, as the performance parameters.

Analysis for Mechanical Efficiency

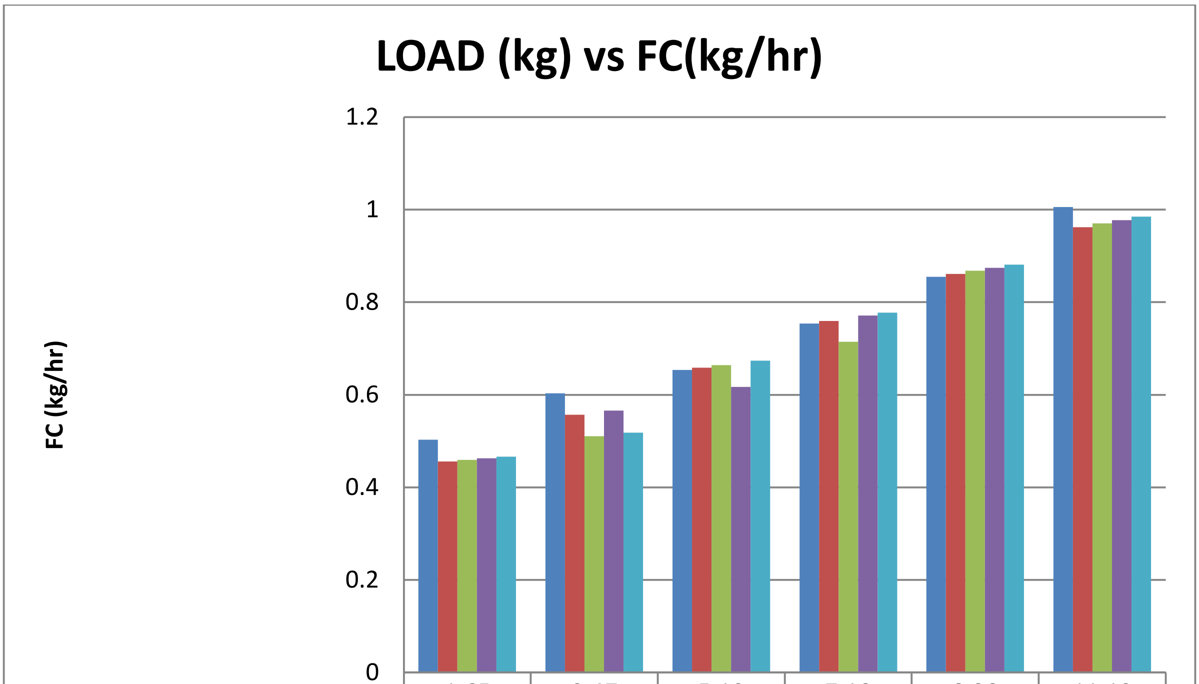


	1.65	3.47	5.19	7.18	8.38	11.12
DIESEL 90% + JATROTHA 10%	18.5778716	32.3146229	41.3810179	49.2476225	52.9946048	59.6547133
DIESEL 80% + JATROTHA 20%	19.143203	30.2245135	41.755538	50.4823501	56.098978	60.623562
DIESEL 70% + JATROPHA 30%	20.3204622	31.7032983	43.571336	52.1897417	58.3973881	62.777095
DIESEL 60% + JATROPHA 40%	19.5533572	32.954712	43.4601643	51.7490462	57.6171023	62.1782865
DIESEL 50% + JATROPHA 50%	19.9044278	31.5556603	43.6336775	52.5263242	58.0622661	62.6890025

Figure2: Load (kg) Vs ME %

- Mechanical efficiency vs Load graph for various blends is shown in figure 2.
- For all load conditions (Diesel 70% + Jatropha 30%) blend gives better result for Mechanical efficiency, which is less than Mechanical Efficiency when fueled with (D100%) but greater than rest of the blends.

Analysis for Fuel Consumption

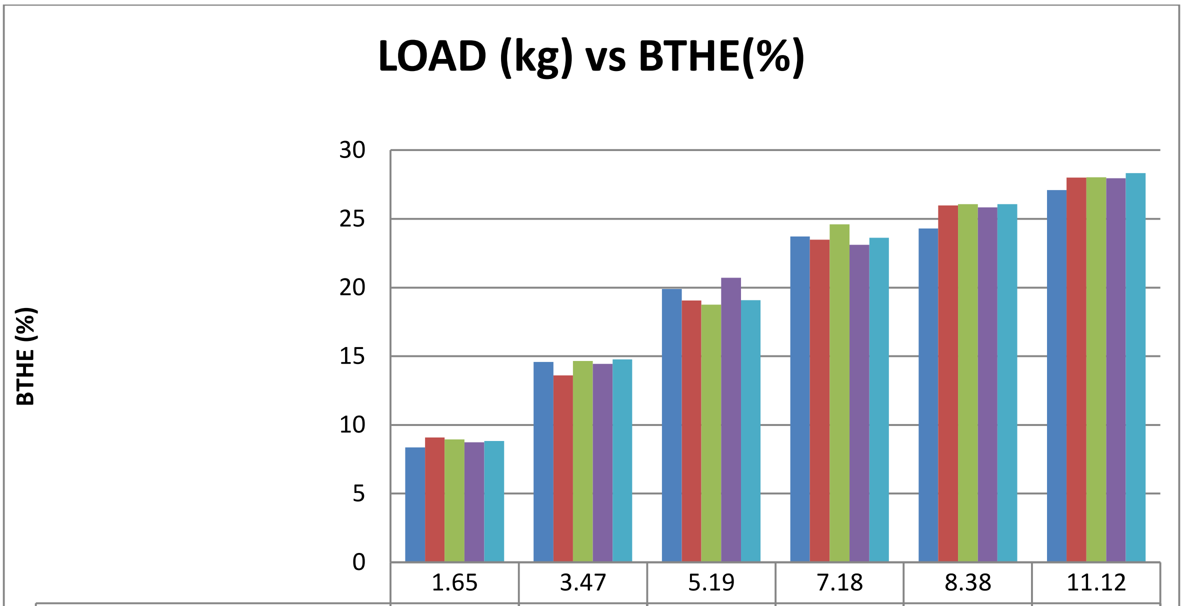


	1.65	3.47	5.19	7.18	8.38	11.12
DIESEL 90% + JATROTHA 10%	0.5028	0.60336	0.65364	0.7542	0.85476	1.0056
DIESEL 80% + JATROTHA 20%	0.45576	0.55704	0.65832	0.7596	0.86088	0.96216
DIESEL 70% + JATROPHA 30%	0.45954	0.5106	0.66378	0.71484	0.86802	0.97014
DIESEL 60% + JATROPHA 40%	0.46278	0.56562	0.61704	0.7713	0.87414	0.97698
DIESEL 50% + JATROPHA 50%	0.46656	0.5184	0.67392	0.7776	0.88128	0.98496

Figure 3: Load (kg) Vs FC (kg/hr)

- Fuel consumption vs Load graph for various blends is shown in figure 3.
- For 3kg load conditions (Diesel 70% + Jatropha 30%) blends gives good result for Fuel Consumption. It is less than Fuel Consumption when fueled with (Diesel 50% + Jatropha 50%) blend.
- For 7kg load conditions (Diesel 70% + Jatropha 30%) blends gives good result for Fuel Consumption. It is less than Fuel Consumption compare to all blends.
- For 11kg load conditions (Diesel 70% + Jatropha 30%) blend gives good result for Fuel Consumption.

Analysis for Brake Thermal Efficiency

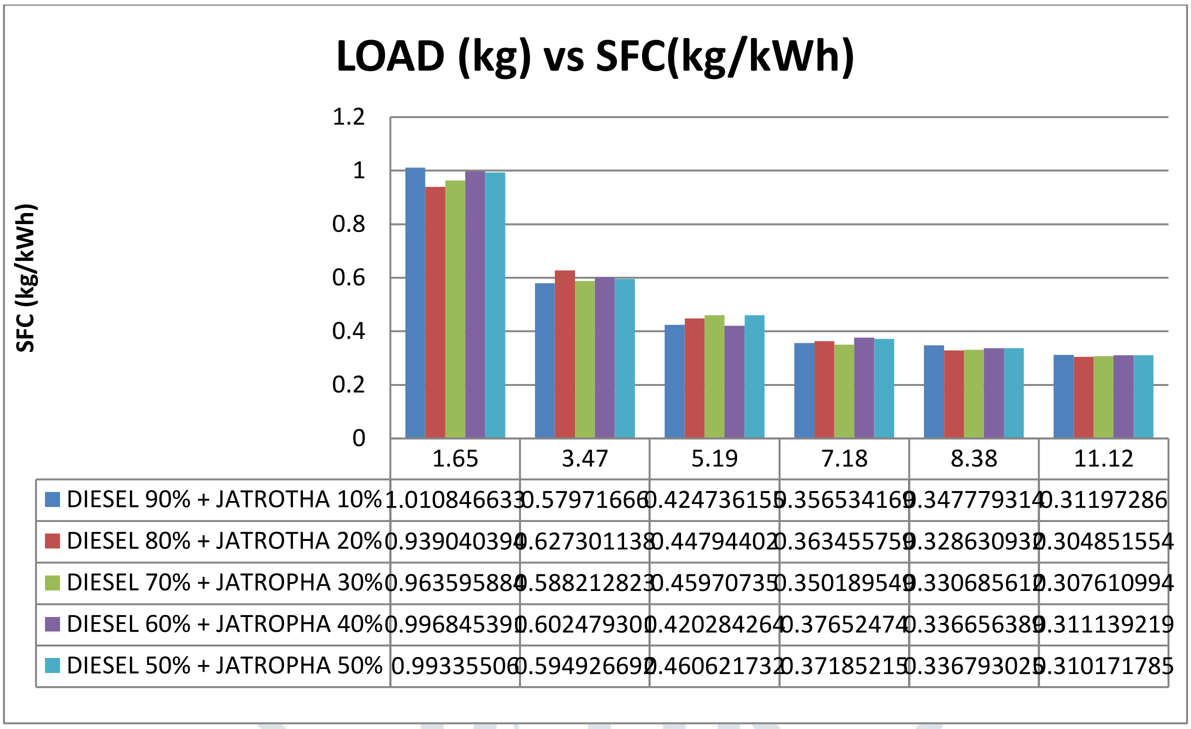


	1.65	3.47	5.19	7.18	8.38	11.12
DIESEL 90% + JATROTHA 10%	8.363324302	14.58305203	19.90421138	23.71171955	24.30862869	27.09863353
DIESEL 80% + JATROTHA 20%	9.090475774	13.60801604	19.05667578	23.48655572	25.97541234	28.00157598
DIESEL 70% + JATROPHA 30%	8.944571027	14.65277786	18.74877972	24.61224742	26.06388517	28.018998
DIESEL 60% + JATROPHA 40%	8.72946655	14.44353104	20.70486393	23.11117322	25.84810142	27.96795759
DIESEL 50% + JATROPHA 50%	8.844019103	14.76694733	19.07259364	23.62565639	26.08501504	28.32382425

Figure4: Load (kg) Vs BTHE %

- Brake thermal efficiency vs Load graph for various blends is shown in figure 4.
- For 5kg load conditions (Diesel 70% + Jatropha 30%) blend gives better result for Brake Thermal Efficiency. It is less than Brake Thermal Efficiency when fueled with B10, B20, B40and B50 blends.
- For 5kg load conditions (Diesel 70% + Jatropha 30%) blend gives good result for Brake Thermal Efficiency.

Analysis for Specific Fuel Consumption

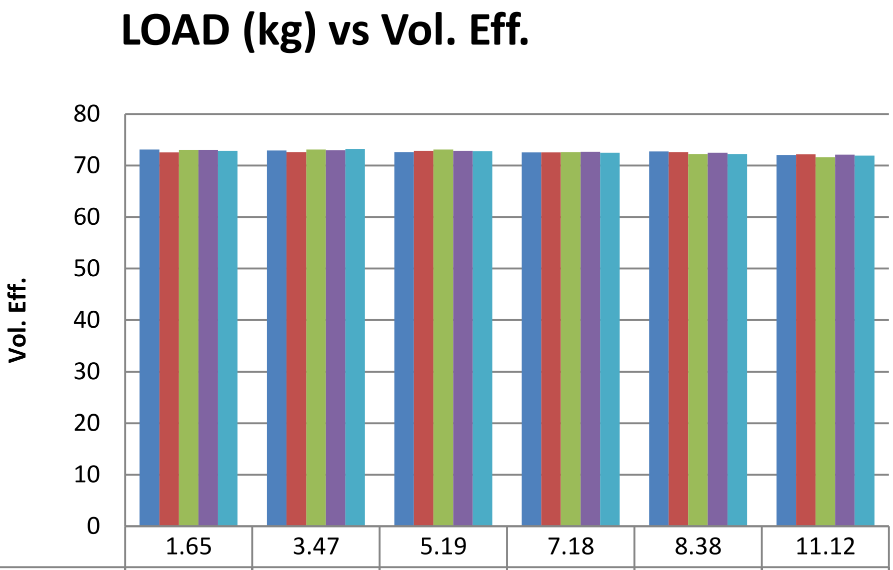


	1.65	3.47	5.19	7.18	8.38	11.12
DIESEL 90% + JATROTHA 10%	1.010846633	0.57971666	0.424736155	0.356534169	0.347779314	0.31197286
DIESEL 80% + JATROTHA 20%	0.939040394	0.627301138	0.44794402	0.363455759	0.328630932	0.304851554
DIESEL 70% + JATROPHA 30%	0.963595884	0.588212823	0.45970735	0.350189549	0.330685612	0.307610994
DIESEL 60% + JATROPHA 40%	0.996845391	0.602479301	0.420284264	0.37652474	0.336656389	0.311139219
DIESEL 50% + JATROPHA 50%	0.99335506	0.594926692	0.460621732	0.37185215	0.336793025	0.310171785

Figure5: Load (kg) Vs SFC (kg/kWh)

- Specific fuel consumption vs Load graph for various blends is shown in figure 5.
- For 2kg load conditions (Diesel 80% + Jatropha 20%) blend gives better result for Specific Fuel Consumption. It is less than Specific Fuel Consumption when fueled with B10, B30, B40 and B50 blends.
- For 5kg load conditions (Diesel 70% + Jatropha 30%) blend gives better result for Specific Fuel Consumption. It is less than Specific Fuel Consumption when fueled with B10, B20, B40 and B50 blends.

Analysis for Volumetric Efficiency

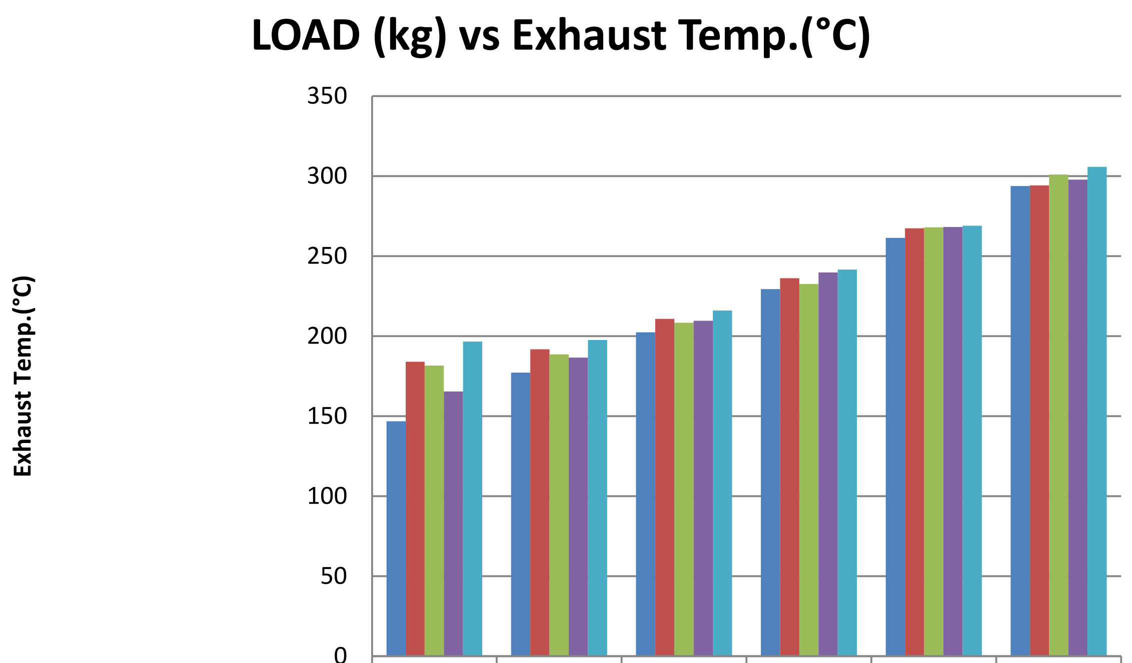


	1.65	3.47	5.19	7.18	8.38	11.12
DIESEL 90% + JATROTHA 10%	73.085053	72.915699	72.61466	72.547987	72.728173	72.046898
DIESEL 80% + JATROTHA 20%	72.558598	72.628505	72.860896	72.560854	72.628399	72.188705
DIESEL 70% + JATROPHA 30%	73.073287	73.11561	73.13155	72.617812	72.245562	71.64119
DIESEL 60% + JATROPHA 40%	73.06947	72.9984	72.894324	72.701081	72.511486	72.097297
DIESEL 50% + JATROPHA 50%	72.875037	73.246539	72.799199	72.49622	72.218906	71.921966

Figure6: Load (kg) Vs Vol.Eff.

- Volumetric efficiency vs Load graph for various blends is shown in figure 6.
- For 1kg load conditions (Diesel 70% + Jatropha 30%) blend gives good result for Volumetric Efficiency. It is greater than Specific Fuel Consumption when fueled with B10, B20, B40 and B50 blends.
- For 5kg load conditions (Diesel 70% + Jatropha 30%) blend gives good result for Volumetric Efficiency. It is greater than Specific Fuel Consumption when fueled with B10, B20, B40 and B50 blends.
- For 11kg load conditions (Diesel 80% + Jatropha 20%) blend gives good result for Volumetric Efficiency. It is greater than Specific Fuel Consumption when fueled with B10, B30, B40 and B50 blends.

Analysis for Exhaust Gas Temperature



	1.65	3.47	5.19	7.18	8.38	11.12
DIESEL 90% + JATROTHA 10%	146.82	177.31	202.34	229.34	261.4	293.73
DIESEL 80% + JATROTHA 20%	184.05	191.8	210.76	236.14	267.32	294.21
DIESEL 70% + JATROPHA 30%	181.67	188.58	208.46	232.57	267.96	300.96
DIESEL 60% + JATROPHA 40%	165.38	186.6	209.69	239.73	268.15	297.75
DIESEL 50% + JATROPHA 50%	196.55	197.63	216.08	241.64	269.04	305.72

Figure7: Load (kg) Vs Exhaust Temp.(°C)

- Exhaust gas temperature vs Load graph for various blends is shown in figure 7.
- For 1kg load conditions (Diesel 90% + Jatropha 10%) blend gives better result for Exhaust Gas Temperature. It is less than Exhaust Gas Temperature when fueled with B20, B30, B40 and B50 blends.
- For 5kg load conditions (Diesel 90% + Jatropha 10%) blend gives better result for Exhaust Gas Temperature. It is less than Exhaust Gas Temperature when fueled with B20, B30, B40 and B50 blends.
- For 11kg load conditions (90% + Jatropha 10%) blend gives better result for Exhaust Gas Temperature. It is less than Exhaust Gas Temperature when fueled with B20, B30, B40 and B50 blends.

9 kg load

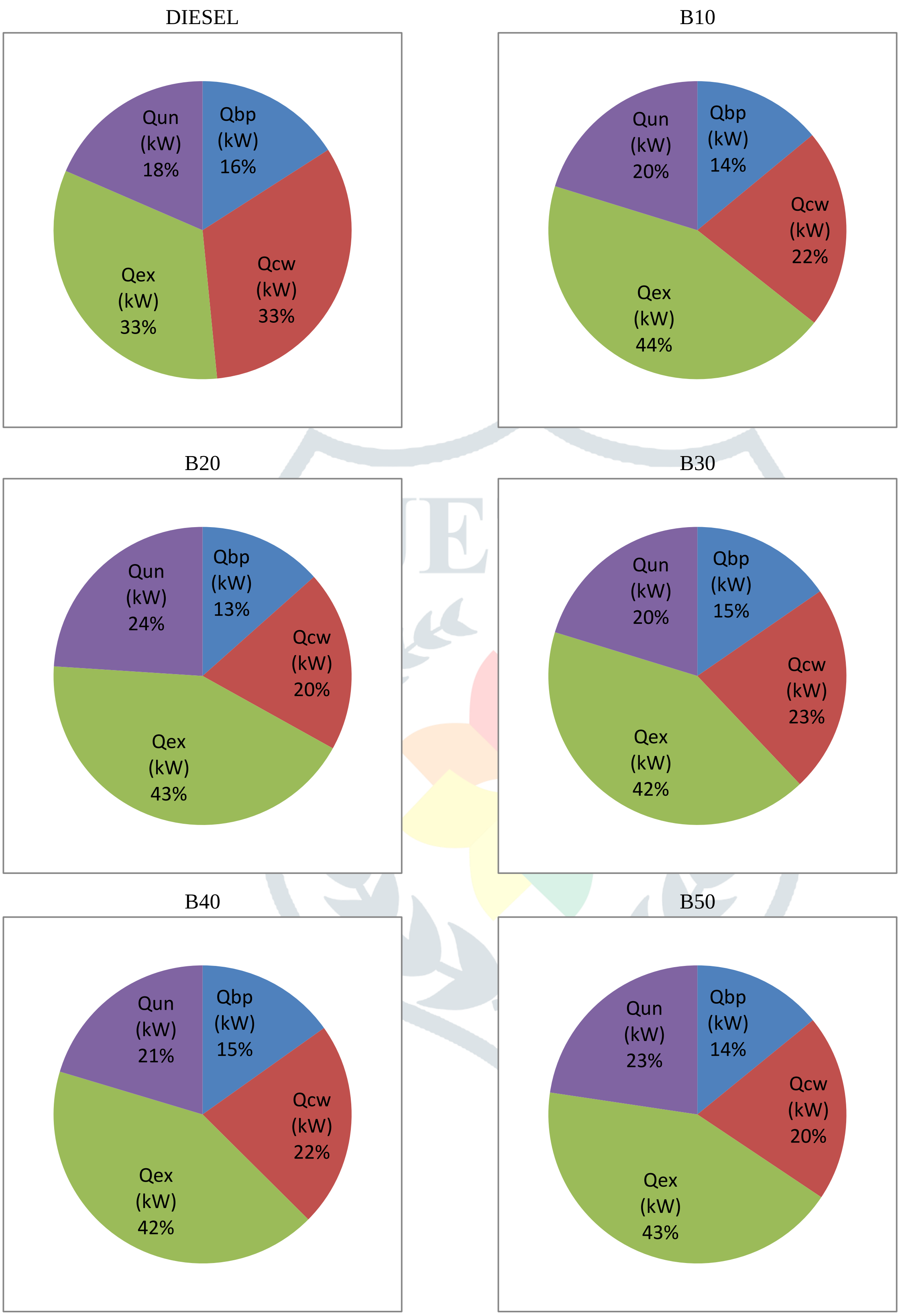


Figure8: All blend energy analysis for 9kg load

From the energy analysis it can be said that B30, B40 blend performance is better in comparison to other blends at 9kg load and performance is equal compare to the diesel.

That means more than 50% of energy input is got wasted in terms of heat energy into atmosphere hence this should be utilising. All amount of this heat energy is not available because of limitations from nature which is also indicated by the second law of thermodynamics. From the figures it can be also seen that more than 20% energy is unaccounted which includes friction loss and other heat loss such as radiation heat loss to atmosphere and heat loss to engine oil.

4. CONCLUSIONS

From the energy analysis it can be concluded that brake thermal efficiency of the biodiesel blends tends to increase toward that of conventional diesel fuel as load increases from low to high. At the high load brake thermal efficiency of all the biodiesel blends is observed higher than the diesel so it can be concluded that the biodiesel blends have slightly higher calorific values than diesel but improved combustion process and less exergy destruction or less irreversible process of combustion might be the reason for the higher performance than the diesel. Fuel consumption of biodiesel blends is found comparatively higher than the diesel at all load condition except B20 blend which shows almost similar values as that of diesel. Reason for the higher fuel consumption is their comparatively higher calorific value. So from this performance analysis it can be conclude that lower blend ratio of biodiesel can be successfully used for diesel engine without modification. Effect of operating parameter must be checked to optimize the performance for lower blends. For higher blend ratio fuel consumption is higher which may restrict the use of higher blends ratio in engine. In this experiment B20 blend has comparatively higher performance than others.

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