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Experimental Analysis of CI Engine Fuel with Jatropha Bio-Diesel, Diesel

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ABSTRACT: In contemporary times, the continuous rise in fuel prices and the rapid depletion of available fossil fuel reserves necessitate the exploration of alternative fuels for engines. Direct use of vegetable oils in diesel engines presents challenges due to their higher viscosity compared to conventional diesel fuel. Various techniques, including preheating, blending, and esterification, are employed to address viscosity-related issues. Jatropha oil holds promise as a versatile resource with diverse applications ranging from renewable energy production to industrial and medicinal uses, contributing to sustainable development goals. Ongoing research aims to improve Jatropha varieties for better oil yield and adaptability to different climatic conditions. Additionally, efforts are made to optimize oil extraction methods and develop more efficient processes for biodiesel production from Jatropha oil. One such method is fuel blending, wherein different proportions of Jatropha oil are mixed with diesel fuel (e.g., 30%, 40%, and 50%) in diesel engines. The objective is to determine the optimal blend ratio for improved performance like brake thermal efficiency, specific fuel consumption.

I. INTRODUCTION

The surge in demand for alternative fuels is propelled by several factors: escalating fuel prices, burgeoning vehicle populations, dwindling petroleum reserves, and the persistent buildup of greenhouse gases. A variety of fuel blends or alternatives have been identified and effectively trialed in existing engines, with and without requisite modifications. Nevertheless, ongoing research endeavors persist in identifying the optimal replacement for conventional diesel fuel. Utilizing alternative fuel sources in diesel engines has been demonstrated as feasible through various previous studies. Diesel engines are specifically engineered to operate on diesel fuel, with all components designed accordingly. Their specifications are tailored for diesel fuel use. However, simply blending diesel with other supplementary fuels may not yield the desired performance level. Hence, parameter optimization for blended fuels becomes essential to achieve optimal engine performance. Automobile R.Prakash, R. K.Singh, and S.Murugan [2011] said in their research paper Wood Pyrolysis Oil is the best alternative fuel. By using WPO as a blend Percentage increase in the brake thermal efficiency and the exhaust gas temperatures of different WPO diesel emulsions are lower than diesel fuel operation. the percentage reduction in NO emissions was 19.21, 28.38 and 34.81 for WPO diesel emulsion, The CO emissions of WPO-diesel emulsions are slightly higher than diesel fuel due to reduction in gas temperature. WPO can be used in the diesel engines in the form of fuel emulsions along with some ignition improver addition. R. Prakash, R. K. Singh, and S. Murugan (2011) asserted in their study that Wood Pyrolysis Oil (WPO) emerges as a promising alternative fuel. They observed an increase in brake thermal efficiency and lower exhaust gas temperatures in various WPO-diesel emulsions compared to pure diesel operation. Additionally, they noted a reduction in NO emissions by 19.21%, 28.38%, and 34.81% for different WPO-diesel emulsions. Despite slightly higher CO emissions in WPO-diesel emulsions due to reduced gas temperature, the study suggests that WPO can be effectively utilized in diesel engines in the form of fuel emulsions with the addition of ignition improvers. K. Sivaramakrishnan and P. Ravikumar (2012) conducted research utilizing Taguchi's approach to optimize the performance of karanja biodiesel engines. Their analysis revealed that parameters such as biodiesel blend, compression ratio, nozzle pressure, and injection timing significantly influence brake thermal efficiency (BTHE), brake specific fuel consumption (BSFC), and emissions. They identified an optimum engine performance configuration characterized by a high compression ratio of 17.9, injection pressure of 230 bar, injection timing of 27° before top dead center (bTDC), and a biodiesel blend of B30. P. Suresh Kumar, Ramesh Kumar Donga, and P. K. Sahoo (2012) explored the impact of fuel injection pressure on the performance of Jatropha blend with diesel in diesel engines at full load. They observed that increasing fuel injection pressure enhances brake thermal efficiency for Jatropha blends, while it decreases for pure diesel. Additionally, they noted a reduction in NOx emissions with Jatropha blend usage. Similar to WPO, Jatropha blend can be utilized in diesel engines in the form of fuel emulsions with the addition of ignition improvers. Mukesh Kumar Bunkar, Nitin

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Shrivastava, and Vipin Shrivastava (2012) evaluated the performance of methyl tertiary butyl ether (MTBE) blended diesel fuel in single-cylinder direct injection diesel engines. They concluded that increasing the blend ratio of MTBE leads to a decrease in brake thermal efficiency with varying loads and an increase in brake specific energy consumption. Prasad. D, G. Venkateswara Rao, and Kiran Kumar. K (2013) investigated the performance of Mahua Oil Methyl ester blend M30 in comparison to other blends (M10 & M20). They found that M30 exhibited superior performance parameters such as brake thermal efficiency, brake specific fuel consumption, and reduced emissions of oxides of nitrogen and carbon monoxide, thus establishing M30 as the optimum blend for diesel substitution. Maharaja Gasti M. C. Navindgi (2013) studied the effects of a 20% blend of castor biodiesel in diesel fuel on engine performance. They observed similar mechanical efficiency, specific fuel consumption, and indicated thermal efficiency compared to pure diesel. Moreover, they noted a slight increase in brake thermal efficiency, suggesting that castor biodiesel can serve as an effective alternative fuel without compromising engine performance. Hifjur Raheman, Prakash C. Jena, and Snehal S. Jadav (2013) examined biodiesel obtained from a mixture known as MSO and its blends in diesel engines. They found that B10 blend exhibited optimal performance with minimal increase in brake specific fuel consumption and exhaust gas temperature and lesser reduction in brake thermal efficiency compared to pure diesel. B10 blend was selected for long-term use based on its performance and emissions characteristics. D. Appanna, G. Venkateswara Rao, and G. Vijaya Rao (2013) evaluated Neem Oil Methyl ester blend N20 and found it to exhibit superior performance parameters compared to other blends (N10 and N30). N20 demonstrated better brake thermal efficiency, lower brake specific fuel consumption, decreased emissions of oxides of nitrogen and carbon monoxide, and increased carbon dioxide, establishing N20 as the optimum blend for diesel substitution.

II. CONCLUDING REMARKS FROM LITERATURE REVIEW

Based on the literature review, it is evident that various alternative fuels show promising potential for use in diesel engines, offering benefits such as improved thermal efficiency, reduced emissions, and enhanced performance. Wood Pyrolysis Oil (WPO) emerges as a notable alternative fuel, demonstrating increased brake thermal efficiency and lower NO emissions compared to pure diesel. Similarly, Jatropha blend and Mahua Oil Methyl ester blend M30 exhibit favorable performance parameters, including reduced emissions and improved thermal efficiency, making them suitable alternatives for diesel substitution.

III. JATROPHA BIODIESEL

Jatropha biodiesel, derived from the seeds of the Jatropha curcas plant, has garnered significant attention as a renewable and sustainable alternative to conventional fossil fuels. Jatropha curcas, a perennial shrub native to tropical and subtropical regions, has gained prominence due to its ability to thrive in marginal lands with low nutrient availability and minimal water resources, making it an attractive option for biodiesel production. The growing interest in Jatropha biodiesel stems from its potential to mitigate the environmental impacts associated with fossil fuel consumption, including greenhouse gas emissions and air pollution. Additionally, Jatropha cultivation offers opportunities for rural development, poverty alleviation, and economic growth in regions where conventional agriculture may not be viable. The extraction process of Jatropha oil and its subsequent conversion into biodiesel involves various techniques, including mechanical pressing, solvent extraction, and transesterification. These processes yield a biodiesel product that can be blended with conventional diesel fuel or used as a standalone fuel in diesel engines with minimal modifications. In recent years, extensive research has been conducted to optimize Jatropha cultivation practices, enhance oil extraction efficiency, and improve biodiesel production processes. Furthermore, studies have explored the performance characteristics of Jatropha biodiesel in diesel engines, assessing factors such as fuel efficiency, emissions, and engine durability. Overall, Jatropha biodiesel presents a promising avenue for achieving energy security, environmental sustainability, and rural development goals. As efforts continue to advance in the field of biofuels, Jatropha biodiesel stands out as a viable and renewable alternative to conventional fossil fuels, offering numerous benefits for both the environment and society. Jatropha biodiesel is derived from the seeds of the Jatropha curcas plant, a perennial shrub native to tropical and subtropical regions. Jatropha curcas is well-suited for biodiesel production due to its high oil content, which ranges from 30% to 40% by weight in its seeds. The seeds undergo an extraction process to obtain Jatropha oil, which serves as the feedstock for biodiesel production. The extraction process typically involves mechanical pressing or solvent extraction methods to separate the oil from the seeds. Once the oil is obtained, it undergoes transesterification, a chemical reaction where the oil is reacted with an alcohol (such as methanol or ethanol) and a catalyst (usually sodium hydroxide or potassium hydroxide) to produce biodiesel and glycerin as a byproduct. This process converts the triglycerides present in the Jatropha oil into fatty acid methyl esters (FAME), which constitute biodiesel. The resulting Jatropha biodiesel can then be further processed and refined to meet

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quality standards and specifications for use as a transportation fuel. It can be blended with conventional diesel fuel in various proportions or used as a standalone fuel in diesel engines after minor modifications. Jatropha biodiesel offers a renewable and sustainable alternative to conventional fossil fuels, with the potential to reduce greenhouse gas emissions and dependency on finite fossil fuel resources.

Table 1:Comparison of the property of diesel and Jatropha Fuel

Fuel Property	ASTM	Plastic Fuel	Diesel	Unit
Density at 15^0C	D4052	927	830	kg/m^3
Kinematic Viscosity at 40^0C	D445	41.41	3.05	cSt
Flash Point (PMCC)	D93	264	56	^{0}C
Fire Point	D93	320	63	^{0}C
Gross Calorific Value	D4809	41002	42000	kj/kg

IV. EXPERIMENTAL SETUP

The setup consists of single cylinder, four stroke, multi-fuel, research engine connected to eddy type dynamometer for loading. The operation mode of the engine can be changed from diesel to Petrol of from Petrol to Diesel with some necessary changes. In both modes the compression ration can be varied without stopping the engine and without altering the combustion chamber geometry by specially designed tilting cylinder block arrangement. The injection point and spark point can be changed for research tests. Setup is provided with necessary instruments for combustion pressure, Diesel line pressure and crank-angle measurements. These signals are interfaced with computer for pressure crank-angle diagrams. Instruments are provided to interface airflow, fuel flow, temperatures and load measurements. The set up has stand-alone panel box consisting of air box, two fuel flow measurements, process indicator and hardware interface. Rota meters are provided for cooling water and calorimeter water flow measurement. A battery, starter and battery charger is provided for engine electric start arrangement. The setup enables study of VCR engine performance for brake power, indicated power, frictional power, BMEP, IMEP, brake thermal efficiency, indicated thermal efficiency, Mechanical efficiency, volumetric efficiency, specific fuel consumption, A/F ratio, heat balance and combustion analysis. Lab view based Engine Performance Analysis software package “Engine soft” is provided for on line performance evaluation.

Model	TV1
Make	Kirlosker Oil Engines
Type	Four stroke, Water cooled, Diesel
No. of cylinder	One
Bore	87.5 mm
Stroke	110 mm
Combustion principle	Compression ignition
Cubic capacity	0.661 liters
Compression ratio 3 port	17.5:1
Lubrication system	Forced feed system

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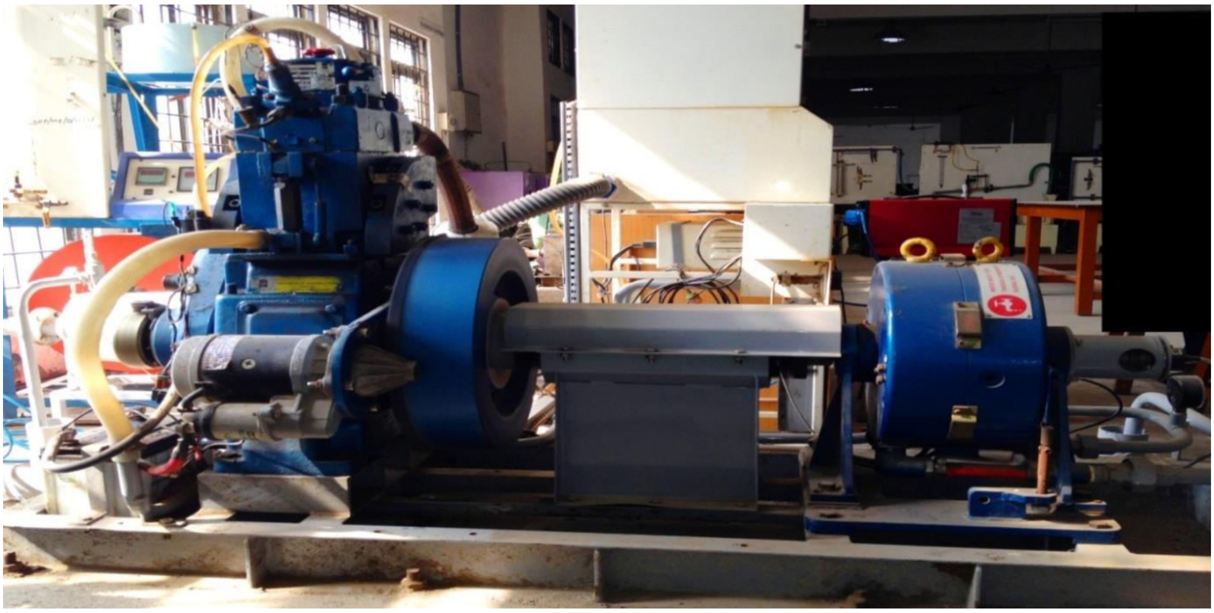

Figure 1 Experimental View

V. RESULT TABLE

Table 2 Result table for the conventional diesel as a fuel in diesel engine

Sr. No.	load(kg)	Fuel (cc/min)	torque T (N-m)	Bbrake power (kW)	Indicated power (kW)	Mechanical efficiency (%)	Fuel consumption (kg/hr)	BSFC (kg/kWh)	BThE (%)
1	0	9	0.14	0.02	2.26	1.03	0.45	19.23	0.45
2	2	11	2.85	0.48	2.72	17.57	0.55	1.15	7.47
3	4	13	5.49	0.92	3.16	29.05	0.65	0.71	12.15
4	6	15	8.47	1.39	3.63	38.25	0.75	0.54	15.92
5	10	20	13.28	2.17	4.41	49.20	1.00	0.46	18.67

Table 3 Result table for the Jatropha30 Diesel70 blend as a fuel in diesel engine

Sr. No.	load(kg)	Fuel (cc/min)	torque T (N-m)	Bbrake power (kW)	Indicated power (kW)	Mechanical efficiency (%)	Fuel consumption (kg/hr)	BSFC (kg/kWh)	BThE (%)
1	0	9	0.14	0.02	2.26	1.03	0.46	19.90	0.43
2	2	10	2.85	0.48	2.72	17.63	0.52	1.07	8.03
3	4	13	5.49	0.91	3.15	28.91	0.67	0.74	11.74
4	6	16	8.47	1.39	3.63	38.23	0.82	0.59	14.51
5	10	19	13.28	2.17	4.41	49.17	0.98	0.45	19.10

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Table 4 Result table for the Jatropha40 Diesel60 blend as a fuel in diesel engine

Sr. No.	load(kg)	Fuel (cc/min)	torque T (N-m)	Bbrake power (kW)	Indicated power (kW)	Mechanical efficiency (%)	Fuel consumption (kg/hr)	BSFC (kg/kWh)	BThE (%)
1	0	9	0.14	0.02	2.26	1.03	0.47	20.13	0.43
2	2	8	2.85	0.48	2.72	17.58	0.48	0.87	9.91
3	4	10	5.49	0.92	3.16	29.01	0.52	0.57	15.20
4	6	12	8.47	1.40	3.64	38.42	0.63	0.45	19.33
5	10	17	13.28	2.08	4.32	48.17	0.89	0.43	20.33

Table 5 Result table for the Jatropha50 Diesel50 blend as a fuel in diesel engine

Sr. No.	load(kg)	Fuel (cc/min)	torque T (N-m)	Bbrake power (kW)	Indicated power (kW)	Mechanical efficiency (%)	Fuel consumption (kg/hr)	BSFC (kg/kWh)	BThE (%)
1	0	9	0.14	0.02	2.26	1.03	0.47	20.35	0.43
2	2	10	2.85	0.48	2.72	17.59	0.53	1.10	7.87
3	4	12	5.49	0.92	3.16	29.00	0.63	0.69	12.55
4	6	14	8.47	1.41	3.65	38.56	0.74	0.52	16.53
5	10	18	13.28	2.15	4.39	48.99	0.95	0.44	19.67

VI. RESULT AND DISCUSSION

Brake Thermal Efficiency: Figure 2 shows the variation of a brake thermal efficiency for diesel and jatropha bio diesel blend with different proportions at different load condition. From figure it shows that BTE For diesel fuel increased continuously for no load to full load condition. And for 40% of blend BTE increased upto 20.33% higher than diesel fuel. And into 30 & 50% of blend BTE increased upto 19.10 & 19.67% respectively.

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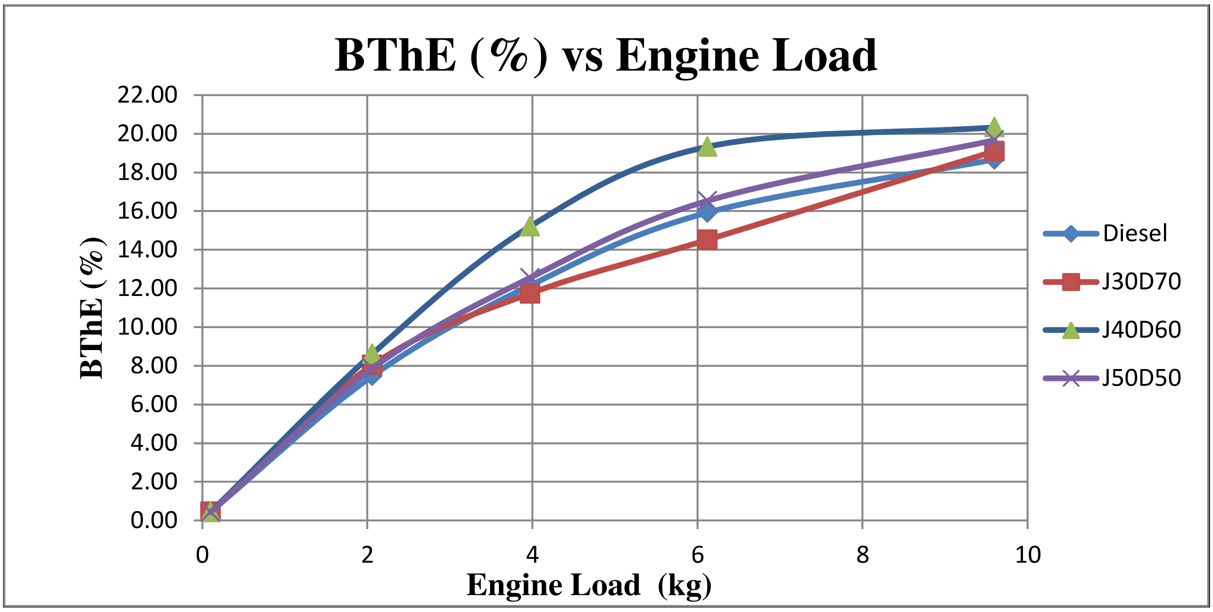

Figure 2 Variation of Brake Thermal Efficiency for Test Fuel at different Load

The thermal efficiency of the engine is improved by increasing the concentration of the biodiesel in the blends. Brake thermal efficiency is mainly depends on calorific value of fuel which is used in engine.

Fuel Consumption: Figure 3 shows the variation of fuel consumption for diesel and jatropha bio diesel blend with different proportions at different load condition. From figure it is clearly shows that SFC For diesel fuel reduced continuously for no load to full load condition. And for 40% of blend SFC reduced same as diesel fuel. And into 30% & 50% of blend SFC reduced up to 0.98 & 0.95 kg/hr respectively.

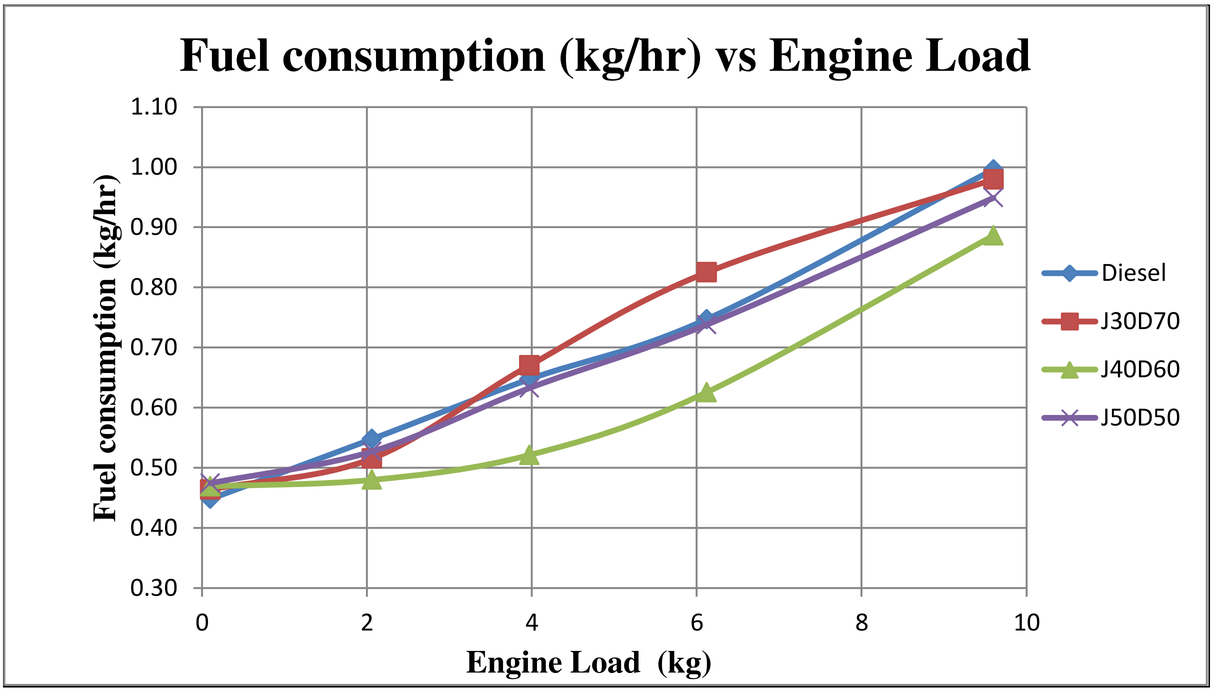

Figure 3 Variation of Specific Fuel Consumption for Test Fuel at different Load

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Brake specific fuel consumption: Figure 4 shows the variation of brake specific fuel consumption for diesel and jatropha bio diesel with different proportions at different load condition. From figure it is clearly shows that SFC For diesel fuel reduced continuously for no load to full load condition. And for 30% of blend SFC reduced same as diesel fuel. And into 40 & 50% of blend SFC reduced up to 0.43 & 0.44 kg/kwh respectively. The specific fuel consumption is depends on fuel consumption. For 40% blend, Up to 4kg load BSFC reduced linearly after that BSFC reduced very highly and from Figure it shows that for 40% blend BSFC reduced better than other tested fuel.

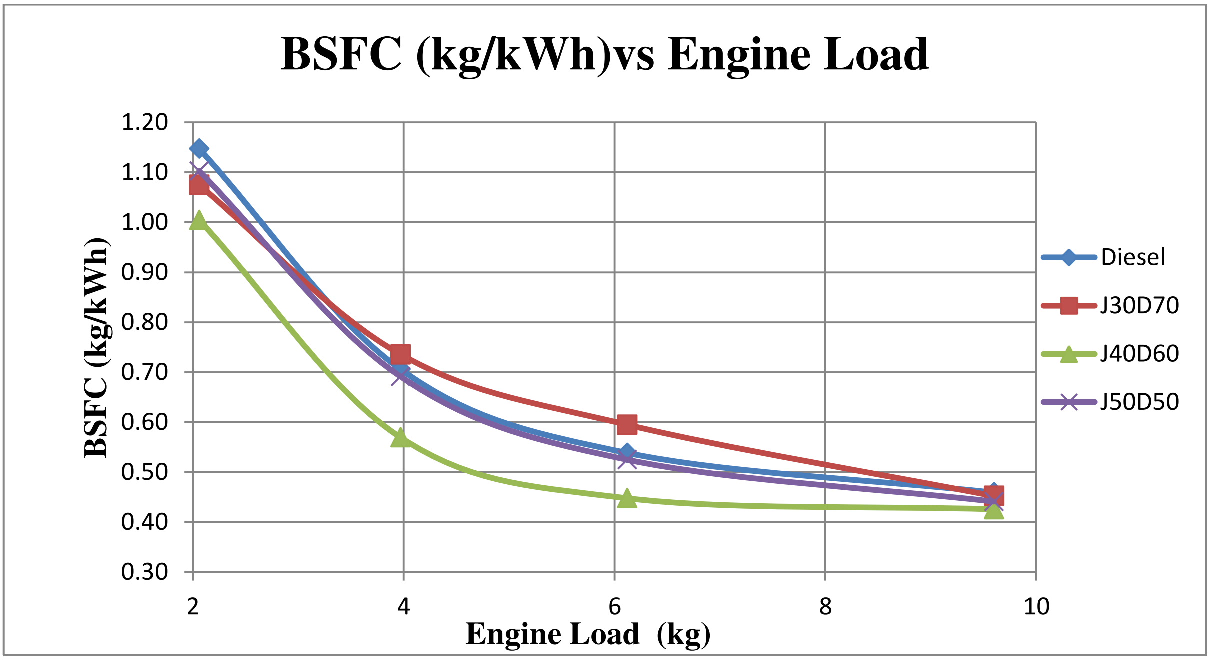

Figure 4 Variation of Brake specific fuel consumption for Test Fuel at different Load

VII. CONCLUSION

- BTE For diesel fuel increased continuously for no load to full load condition. And for 40% of blend BTE increased upto 20.33% higher than diesel fuel. And into 30 & 50% of blend BTE increased upto 19.10 & 19.67% respectively.
- FC For diesel fuel reduced continuously for no load to full load condition. And for 40% of blend SFC reduced same as diesel fuel. And into 30% & 50% of blend SFC reduced up to 0.98 & 0.95 kg/hr respectively.
- IP For diesel fuel increased continuously for no load to full load condition. And for 50% of blend IP increased higher than diesel fuel. And into 30 & 40% of blend IP increased upto 4.41 & 4.32 kw respectively.
- SFC For diesel fuel reduced continuously for no load to full load condition. And for 30% of blend SFC reduced same as diesel fuel. And into 40 & 50% of blend SFC reduced up to 0.43 & 0.44 kg/kwh respectively. The specific fuel consumption is depends on fuel consumption. For 40% blend, Up to 4kg load BSFC reduced linearly after that BSFC reduced very highly and from Figure it shows that for 40% blend BSFC reduced better than other tested fuel.
- Jatropha 40% with Diesel 60% shows optimum blend ration which gives better result for performance of the CI engine.

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