

Investigation of Performance and Emission Characteristics of Jackfruit Seed Methyl Ester Blends on Diesel Engine

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Abstract

The effort of this object is to deal with the requirement for a jackfruit seed oil based bio diesel. In this study we can perform the experiments on a single cylinder four stroke diesel engine with a constant speed of 1500rpm by utilizing jackfruit seed methyl ester bio fuel blends. To prepare the blends we can mix the JSME bio fuel with pure diesel at different concentrations. JSME20, JSME30, JSME40, JSME50 and JSME100 are the blends utilized for the testing. The impact of JSME bio fuels on BTE, BSFC and EGT were obtained by the performance tests. And impacts of JSME bio fuels on emissions CO₂, CO, HC, NO_x and smoke opacity are researched by the emission tests. Here we can observe that the Brake thermal efficiency results of JSME bio fuels were nearer to the pure diesel. And also we noticed that the emissions CO, HC and smoke opacity of JSME bio fuels were lesser than that of the pure diesel. The emissions CO₂ and NO_x of JSME bio fuels were slightly higher than that of pure diesel.

Keywords: Biodiesel; JSME; Transesterification; Emission; Performance; Diesel Engine

1. INTRODUCTION

India is a developing economy and subsequently the interest for diesel energizes is about multiple times that of gas in India, henceforth looking for option in contrast to mineral diesel is the need of great importance. Elective alternative fuel ought to be accessible requiring little to no effort, be eco-accommodating and satisfy energy security needs without relinquishing engine's performance. Producing energy from waste is the ongoing pattern in the determination of interchange alternative fuel. Variance in the fuel costs and constrained quantities of oil holds accessible are the reasons for elective fuel innovation in India. At present, India is obtaining about 70% of the petroleum oil that is being consumed.

T. Balamurugan et al. [1] in this paper investigation is done on corn oil biodiesel and conducted the emission, performance and combustion characteristics. The blends prepared at 10%, 20%, 30% of corn oil biodiesel mixed with diesel it's named as B10, B20, B30. To perform the performance on

compression ignition diesel engine at various loads up to 0 to max load by the fuels diesel and biodiesel blends. The BTE of diesel is high compare with blends and the brake thermal efficiency is decreased when increase in the blend concentration. Brake specific fuel consumption is grows to increase the blends concentration. HC, CO emissions are producing more rates to rise the blend percentage. NO_x releases lower when increase the blend concentration. Cylinder pressure is low for all blends compared to the diesel.

Radha Krishna Gopidesiet al. [2] had investigated in this paper on cotton seed oil biodiesel blends B5, B10, and B15 and conducted the performance, emission tests. By using the CI diesel engine to calibrate the performance parameters. In this study the blend B10 give 30.02% of brake thermal efficiency it's better than the diesel because of pure diesel give 25.84% compare these two B10 blend gives 13.9% better perform than the diesel. And the brake specific fuel consumption for the B10 is 3.12% and for the diesel is 0.32%. HC and CO emissions are less due to complete combustion of B10 blend compare with diesel fuel. NO_x and smoke will high in the blend of B15. Overall comparison B10 blend perform batter.

Venkata Srinivasa Rao et al. [3] in this paper had shows the performance and emission characteristics of Palmyra oil biodiesel comparison with the pure diesel. The blends were prepared biodiesel 10%, 20%, 30% in the combination of diesel it's indicated samples B10, B20, B30. Mechanical efficiency of diesel is 70.6% and the blend B30 gives more mechanical efficiency i.e. 71.1%. Brake thermal efficiency for diesel 32.6% and B30 gives 35.7%. Produced exhaust gases the HC and CO are high in the normal diesel. In the combustion of B30 producing less HC and CO. NO_x and smoke are somewhat higher compare with diesel. Finally they conclude B30 is the better biodiesel blend for the performance and emission point of view also.

Swarup Kumar Nayak et al. [4] in this investigation mahua oil is used as a biodiesel to prepare the B100, B95, B90, and B85. In the preparation B100 having pure mahua biodiesel methyl ester, and remaining blends 95%, 90%, 85% are biodiesels and 5%, 10%, 15% are the Dimethyl carbonate additive. In this paper the investigation on performance and emission by the various concentrations of mahua oil biodiesel blends and diesel. The BP increases with the increase the percentage of

additive and lower with the diesel. BSFC value gets down by growing the biodiesel concentration. The emissions hydrocarbons and carbon monoxide were very lesser through the biodiesels and NOX, smoke decreased when the biodiesel concentration is increased. Exhaust gas temperature reduced when increase in additive in the biodiesels.

Agarwal A.K. et al. [5] had reported that, the utilization of bio fuel significantly reduced the emissions and increase the performance of the diesel engine.

Avinash Kumar Agarwal et al. [6] had studied the emission and performance characteristics of single cylinder diesel engine when it fueled with Karanja bio fuel, and reported that they have obtained improved spray and atomization characteristics while the bio fuel was preheated.

S. Karthikeyana et.al. [7] had conducted the experiments at the loads of 25%, 50%, 75%, 100% at the speed of 1500 RPM with 220 bar of IP on diesel engine to evaluate the characteristics of Promolin Stearin wax oil 20%, blended with 80% pure diesel. The average particle size of the zinc oxide was less than 100nm and concentration was vary 50 PPM and 100 PPM. All the results were shown against the BMEP. Owing to the energetic materials zinc oxide to increase the calorific value of the blends although in other properties do not observe any considerable improvement. Due to, the complete combustion took place in the combustion chamber BTE improved and BSFC decrease with the adding additive of ZnO amount of concentration increased in the blends. The HC & CO were noticeably declined when the increments in dosing level of the ZnO when compare with B20 blend. There is no significant effect of NOx emissions of the all blends.

G.V. Churchill et al. [8] have investigated the effect of Indian Jujube seed oil as bio fuel and the emission and performance characteristics of a 1-cylinder diesel engine be performed with blends of JB25, JB50, JB75 and JB100. And the final result had revealed that the BTE is marginally decreased, and the emission analysis will gave the best result, and the exhaust gas temperature had lower for JB75. And also it reveals that non-edible oil is a promising source which can sustain bio fuel growth.

R.Satish Kumar and K.Suresh Kumar [9] had introduced a third generation bio fuel called Manilkara Zapota Seed Oil. They had produced crude MZO (Manilkara Zapota oil) from Manilkara Zapota Seed by means of a mechanical expeller, and founded the physicochemical properties of crude MZO and produced Manilkara MZME (Zapota Methyl Ester) after transesterification. Finally they had confirmed that new bio fuel Manilkara Zapota Methyl Ester meets the EN14214 bio fuel standards and might be a reliable substitute to the diesel in diesel engine applications.

Sanjid Ahmed et al. [10] had used Brassica Juncea methyl ester (Mustard Oil) and its blends in CI engine and had investigated the emission, performance and noise characteristics. The experimental investigation had founded that 10 % and 20 % MB (Mustard Biodiesel) blends produced 8 - 13% higher specific fuel consumption, 7 - 8% less brake power, 9 - 12% higher NO, 24 - 42% lower HC, 19 - 40%

lower CO and 2 - 7% lower noise compared to diesel.

Finally, the literature survey concluded that the bio fuel had the prospective to be utilized as a diesel fuel substitute in diesel engines to solve the energy and environmental crisis.

2. MATERIALS AND METHODS

2.1 Fuel Preparation

Artocarpus heterophyllus normally has known as jackfruit, it is a type of flowering plant. Jackfruit is normally utilized in Southeast and South Asian countries. for Bangladesh and Sri Lanka The jackfruit is the national fruit, and for Indian states of Kerala and Tamil Nadu it is the state fruit. Jackfruit seed oil be extricated from seeds of the jackfruit. And its oil could be a light yellow colour having melting point (33-430C) (91-1090F). The jackfruits and their seeds are presented in Fig 1.



Figure 1 Jackfruit tree with fruits and their seeds

Initially we need to collect the jackfruit seeds and then they are cleaned by water washing now the seed are dried in the outside for nearly 14 days. After drying process we need to crush the seeds to collect the oil in the mechanical crusher and then compressed to get the oil. The obtained jackfruit seed oil will having high viscosity than that of the diesel fuel. We know that the bio fuel used as a substitute for the diesel will have the properties like low viscosity and low cost and eco friendly. This issue can be resolved by converting the crude oil in to biodiesel by a technique known as transesterification. Due to this process the properties of the biodiesel are equivalent to the pure diesel. The crude oil which will extracted from the jackfruit seed is represented in Fig 2.

2.2 Transesterification of jackfruit seed oil to bio fuel

Within this procedure methanol is utilized as alcohol and sodium hydroxide (NaOH) is utilized as the catalyst. The response is held between methanol, jackfruit seed oil and NaOH at 65°C about 3hrs and constantly stirring the solution to obtain proper mixing. The bio fuel and glycerol was produced due to the reaction between them. The required methyl esters is obtained and it is separated after the glycerol is filtered which is presented at the top layer, and in the next step we can washing the methyl ester with the help of water and the top layer having (850 ml) bio fuel is separated and is the properties were tested after drying. The bio fuel Properties for the samples was tested and are exhibited in Table 1. The various steps involved with Transesterification procedure of jackfruit seed bio fuel is appeared in Fig 3.



Figure 2 Jackfruit seed crude Oil

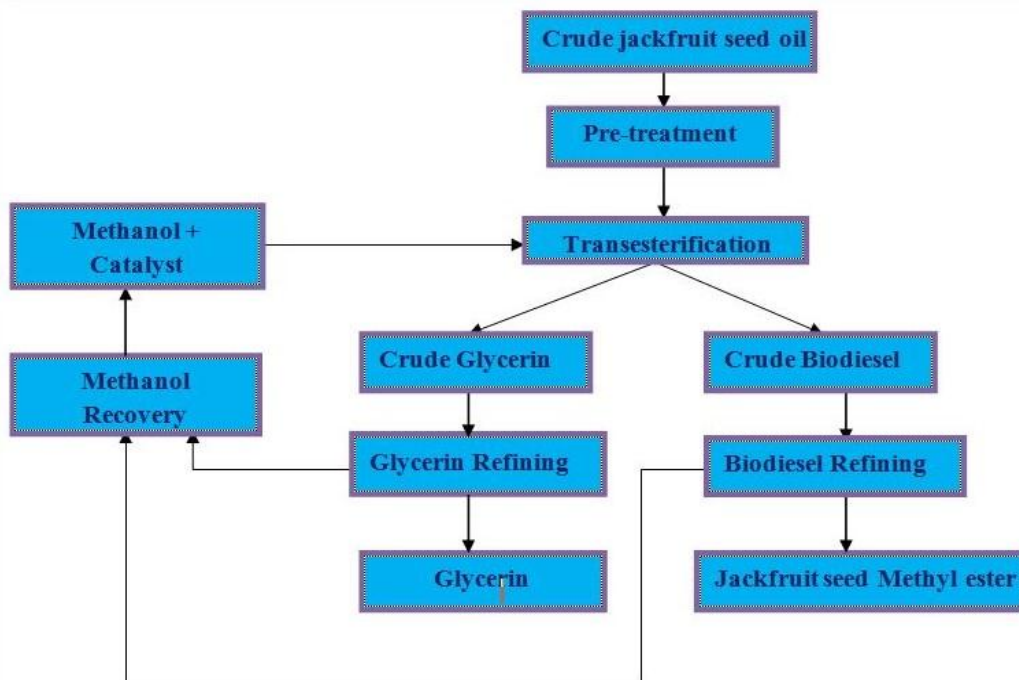


Figure 3 Steps followed in transesterification process

2.3 Properties of Jackfruit seed methyl ester blends and diesel

The properties of the diesel and jackfruit seed methyl ester blends are tabulated in the Table 1.

Table 1. Properties of diesel and jackfruit seed biodiesel blends

Fuel Properties	DIESEL	JSME (20)	JSME (30)	JSME (40)	JSME (50)	JSME (100)
Density (kg/m ³)	834	845	851	857	863	892
Fire Point (°C)	66	89	101	113	125	185
Flash Point(°C)	54	78	91	103	115	177
Kinematic viscosity (mm ² /sec)	2.4	3.04	3.36	3.68	4.1	5.6
Calorific Value (KJ/kg)	42,500	41,587	41,130	40,674	40,217	37,935

3. EXPERIMENTAL SETUP & PROCEDURE

3.1 System Performance Benchmark

The entire experimental research work was investigated by using Kirloskar engine powered by diesel fuel model number: TAF-1 was elected for the experimentation process and its layout was displayed in Fig 4. The complete specifications of the test setup are shown in Table 2. The engine be loaded with the use of eddy current dynamometer. In this analysis the Characteristics of jackfruit seed biodiesel with its blends (20%, 30%, 40%, 50%, 100% v/v) for example JSME20, JSME30, JSME40, JSME50 and JSME100, were evaluated by means of single cylinder 4 strokes, and water as coolant CI engine operating with a stable speed of 1500 rpm and with a fixed compression-ratio of 17.5.



Figure 4. Experimental Test Setup

3.2 Specifications of the Engine

The table 2. Will shows the complete test engine setup specifications.

Table 2. Specification of experimental engine setup

CI engine type	Single cylinder with 4-strokes, and water as coolant diesel engine
Makes by	Kirloskar
Compression ratio	17.5:1
Bore	87.5 millimeter
Connecting rod or bar length	234 millimeter
Stroke length	110 mm
Orifice diameter	20 mm
Evaluated or rated power	3.75 KW@1500 Revolutions per minute
Coolant type	Water cooled
Dynamometer arm length	145 millimeter
Load indicator	Range 0-50 Kg, Supply 230V AC, Digital
Load or burden Sensor	Load Or Burden Cell, Type strain gauge or check , Range from 0-50 Kg
Loading device	Eddy current dynamometer
Rota-meter	Engine cooling (40-400 LPH); Calorimeter (25-250 LPH)
Temperature sensor	Thermocouple, type K
Speed Indicator	Digital with non-contact type speed sensor

4. RESULTS AND DISCUSSION

4.1 PERFORMANCE CHARACTERISTICS

4.1.1 Brake thermal efficiency, Brake specific fuel consumption and Exhaust gas temperature

The Fig 5. Shows the BTE at various Loads for pure diesel, JSME20, JSME30, JSME40, JSME50 and JSME100 i.e. blends of JSME. In this we can observed that when the load was increased then it leads to increases the BTE. And also we can observe that the BTE for diesel was higher when compared with the JSME blends. And we can also detect that the JSME blends will give the closer BTE when compared with the diesel. The obtained BTE values at 100% load for diesel, JSME20, JSME30, JSME40, JSME50 and JSME100 are 28.36, 27.25, 26.02, 25.21, 24.25, and 21.57%

respectively. From the graph we can noticed that the blend JSME20 will give 20.84% more BTE than JSME100 blend and 3.91% lower than the pure diesel.

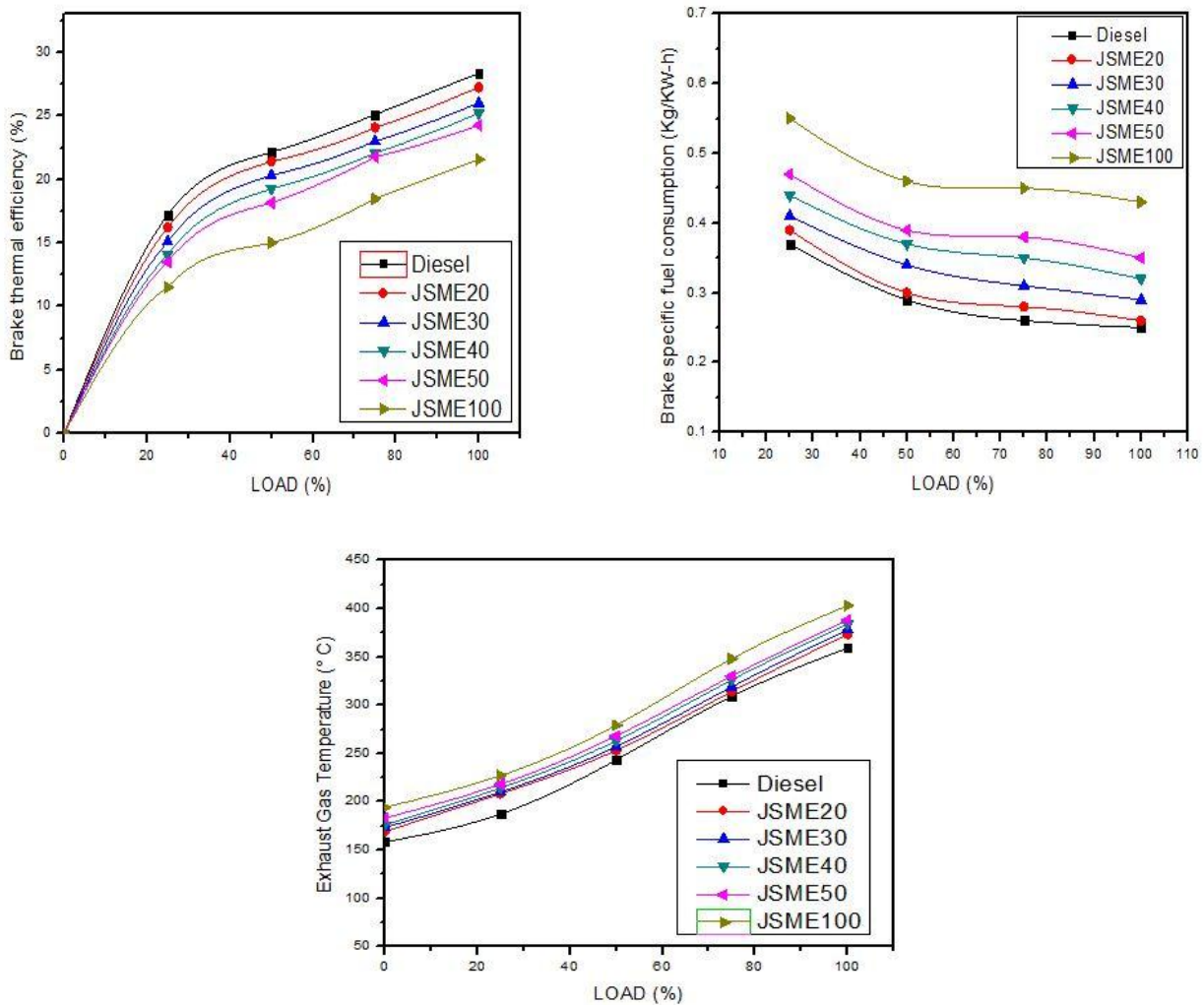


Figure 5. Variation of brake thermal efficiency, brake specific fuel consumption and exhaust gas temperature with load

The Fig 5. Shows the variation of BSFC with different Loads for pure diesel, JSME20, JSME30, JSME40, JSME50 and JSME100. In this we noticed that when the load was increased then it leads to decreases the BSFC and also we can observe that the BSFC for JSME100 was higher when compared with the diesel. From the graph noticed that because of the diesel having better oxygenate content will leads to lower BSFC. And we can also notice that the JSME blends will give the closer BSFC when compared with the diesel. The obtained BSFC values at 100% load for diesel, JSME20, JSME30, JSME40, JSME50 and JSME100 are 0.25, 0.26, 0.29, 0.32, 0.35, and 0.43 Kj/Kw-h respectively. From the graph we can noticed that the blend JSME20 will give 3.84% lower BSFC when compared with the pure diesel.

The Fig 5. Shows the variation of EGT with different Loads for pure diesel, JSME20, JSME30, JSME40, JSME50 and JSME100. And we can also notice that the JSME bio fuels produce high EGT compare with diesel. The EGT will not

reach a peak point because it will seriously affect the walls of the cylinder. The EGT will be increased when the loads were increased. And we can also notice that the JSME blends will give the closer EGT when compared with the diesel. The obtained EGT values at 100% load for diesel, JSME20, JSME30, JSME40, JSME50 and JSME100 are 359, 373, 378, 384, 388, and 403°C respectively. From the graph we can noticed that the blend JSME20 will give 3.75% better EGT when compared with the pure diesel.

4.2 EMISSION PARAMETERS

4.2.1 CO (Carbon monoxide), CO₂, and HC (Hydro carbons) emissions

The Fig 6. Shows the variation of CO with different Loads for pure diesel, JSME20, JSME30, JSME40, JSME50 and JSME100. The CO emissions were increased because of the stoichiometric value of air fuel ratio was highest. And we

noticed that when the load was increased which leads to the increases in CO emissions for the pure diesel. And we noticed that the CO emissions for JSME blends were decreased then the diesel. Also we noticed that at all loading conditions JSME20 blend will give the smallest amount of CO emission.

The obtained CO values at 100% load for diesel, JSME20, JSME30, JSME40, JSME50 and JSME100 are 0.12, 0.074, 0.08, 0.088, 0.09, and 0.11% respectively. From the graph we can noticed that the blend JSME20 will give 38.33% lowest CO when compared with the pure diesel.

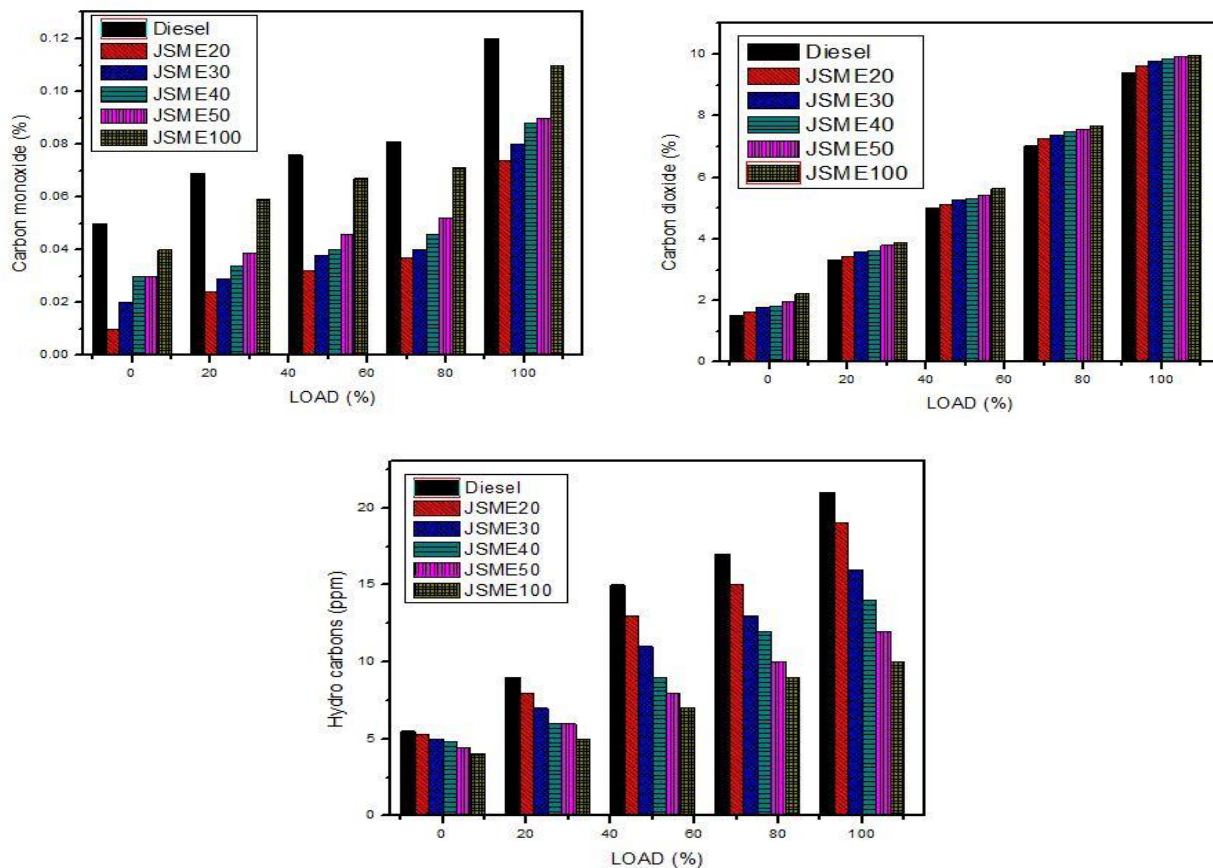


Figure 6. Variation of carbon monoxide emissions with load

The Fig 6. Shows the variation of CO₂ with different Loads for pure diesel, JSME20, JSME30, JSME40, JSME50 and JSME100. And we noticed that when the load was increased which leads to the increases in CO₂ emissions for the pure diesel and JSME blends. And we noticed that the CO₂ emissions for JSME blends were increased then the diesel. Also we noticed that at all loading conditions JSME100 blend will give the highest amount of CO₂ emission. The obtained CO₂ values at 100% load for diesel, JSME20, JSME30, JSME40, JSME50 and JSME100 are 9.4, 9.64, 9.79, 9.84, 9.93, and 9.98% respectively. From the graph we can noticed that the blend JSME100 will give higher CO₂ when compared with the other JSME blends.

Fig 6. Shows the variation of CO₂ with different Loads for pure diesel, JSME20, JSME30, JSME40, JSME50 and JSME100. When the engine power output is increased then the HC emission will also increased. HC emission will be less when the cylinder temperature was more. We know that the JSME bio fuels are having more O₂ content will leads to improved combustion hence JSME bio fuels will liberate less HC. Due to this reason we can noticed that complete combustion will occur for JSME bio fuels compare to diesel.

The obtained HC values at 100% load for diesel, JSME20, JSME30, JSME40, JSME50 and JSME100 are 21, 19, 16, 14, 12, and 10 ppm respectively. From the graph we can noticed that the blend JSME100 will give 42.85% lower HC and JSME20 produce 9.52% lower HC than compared with the pure diesel.

4.2.2 NO_x emissions and Smoke opacity

The Fig 7. Shows the variation of CO₂ with different Loads for pure diesel, JSME20, JSME30, JSME40, JSME50 and JSME100. Combustion gas temperature and residence time are factors which influence the formation of NO_x emissions. Here for all JSME bio fuels NO_x emissions will be high when compared with pure diesel. The NO_x will be increases with increase in the load. The obtained NO_x values at 100% load for diesel, JSME20, JSME30, JSME40, JSME50 and JSME100 are 1617, 1629, 1643, 1665, 1687, and 1729 ppm respectively. From the graph we can noticed that the blend JSME20 will give 7.783% lower NO_x when compared with the JSME100 blend.

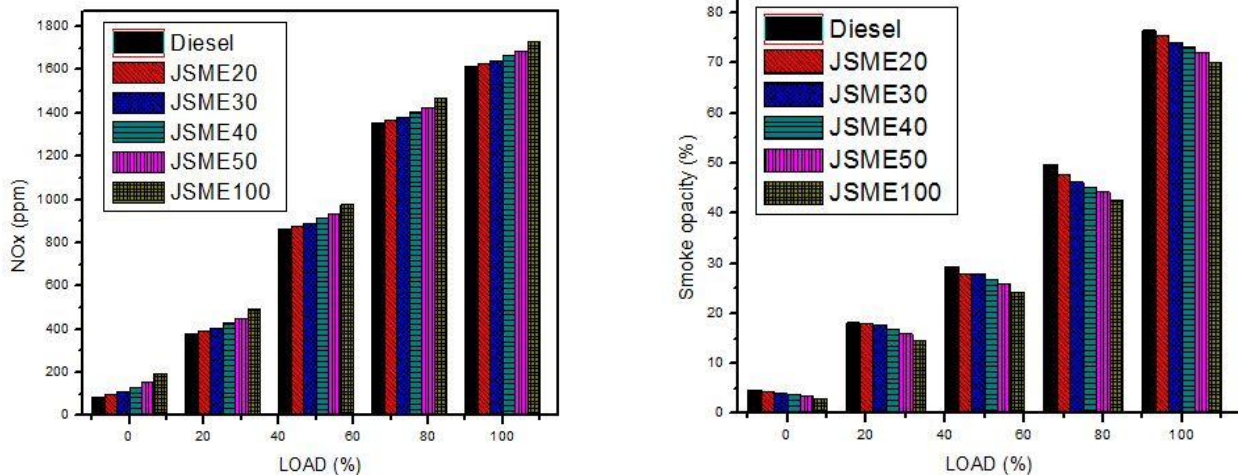


Figure 7. Variation of nitrogen oxide emissions and Smoke opacity with load

The Fig 7. Shows the variation of CO_2 for pure diesel at various loads, JSME20, JSME30, JSME40, JSME50 and JSME100. Due to the incorrect mixing of fuel and air will impact the burning rate which leads to the discharge of smoke or soot. It will appear like black dust and will cause several health issues if inhale into the human body. The obtained values at 100% load for diesel, JSME20, JSME30, JSME40, JSME50 and JSME100 are 76.5, 75.4, 74.2, 73.1, 72.2, and 70.1% respectively. From the graph we can noticed that the blend JSME100 will give lower smoke opacity when compared with the other JSME blends.

- JSME20 had showed lesser emissions and better performance than that of the other blends formed from the jackfruit seed methyl ester.
- Hence the blends of the jackfruit seed bio fuel could be utilized directly in the CI engine without any major or significant modification in the equipment or hardware.

Therefore, it is recommending the use of jackfruit seed biodiesel at smaller concentrations for generating the promising results of diesel engine.

5. CONCLUSION

Present investigation going on, the specialized or technical possibility of utilizing JSME bio fuel in the CI engine at various loads for analyses. The evaluation of engine characteristics for diesel and JSME blends with a fixed compression ratio 17.5 and at speed constant of 1500 rpm. The conclusions from the results:

- The blend JSME20 will give better BTE when compared with the other JSME blends.
- The blend JSME20 will give lower BSFC when compared with the other JSME blends.
- The JSME blends will give the closer EGT when compared with the diesel.
- The blend JSME20 will give least CO when compared with the other JSME blends.
- The blend JSME100 will give higher CO_2 when compared with the other JSME blends.
- The blend JSME100 will give least HC when compared with the other JSME blends.
- The blend JSME20 will give lowest NO_x when compared with the other JSME blends.
- The blend JSME100 will give lowest smoke opacity when compared with the other JSME blends.

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