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 biofuel blends. To prepare the blends we can mix the JSME biofuel with pure diesel at different concentrations. JSME20, JSME30, JSME40, JSME50 and JSME100 are the blends utilized for the testing. The impact of JSME biofuels on BTE, BSFC and EGT were obtained by the performance tests. And impacts of JSME biofuels on emissions CO_2, CO, HC, NOX and smoke opacity are researched by the emission tests. Here we can observe that the Brake thermal efficiency results of JSME biofuels were nearer to the pure diesel. And also, we noticed that the emissions CO, HC and smoke opacity of JSME biofuels were lesser than that of the pure diesel. The emissions CO_2 and NOx of JSME biofuels were slightly higher than that of pure diesel.**

Index Terms **- Biodiesel; JSME; Transesterification; Emission; Performance; Diesel Engine**

1.INTRODUCTION

India is a developing economy and subsequently the interest in 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 is 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 fuel's 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 growing 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 is better than the diesel because of pure diesel gives 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. NOx 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 shown 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 is indicated samples B10, B20, B3O. 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 biofuel 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 biofuel, and reported that they have obtained improved spray and atomization characteristics while the biofuel 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 bars of IP on diesel engine to evaluate the characteristics of Promo1in 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 all blends.

G.V. Churchill et al. [8] have investigated the effect of Indian Jujube seed oil as biofuel 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 give 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 biofuel growth.

R.Satish Kumar and K.Suresh Kumar [9] had introduced a third generation bio fuel called Mani1kara Zapota Seed Oil. They had produced crude MZO (Mani1kara Zapota oil) from Mani1kara Zapota Seed by means of a mechanical expeller and founded the physicochemica1 properties of crude MZO and produced Mani1kara MZME (Zapota Methy1 Ester) after transesterification. Fina1ly they had confirmed that new biofuel Mani1kara Zapota Methy1 Ester meets the EN14214 biofuel standards and might be a re1iable substitute to the diesel in diesel engine applications.

Sanjid Ahmed et al. [10] had used Brassica Juncea methy1 ester (Mustard Oi1) and its b1ends in CI engine and had investigated the emission, performance, and noise characteristics. The experimenta1 investigation had founded that 10 % and 20 % MB (Mustard Biodiese1) 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 biofuel had the prospective to be utilized as a diese1 fuel substitute in diesel engines to solve the energy and environmental crisis.

2. MATERIALS AND METHODS

2.1 Fue1 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 nationa1 fruit, and for Indian states of Kera1a and Tami1 Nadu it is the state fruit. Jackfruit seed oil be extricated from seeds of the jackfruit. And its oil could be a light ye1low colour having me1ting 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 be having high viscosity than that of the diesel fuel. We know that the biofuel used as a substitute for the diesel will have the properties like low viscosity and low cost and ecofriendly. This issue can be resolved by converting the crude oil into 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.

Figure 2 Jackfruit seed crude Oil

2.2 Transesterification of jackfruit seed oil to biofuel

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 biofuel and glycerol were produced due to the reaction between them. The required methyl esters are 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) biofuel is separated and is the properties were tested after drying. The biofuel Properties for the samples was tested and are exhibited in Table 1. The various steps involved with Transesterification procedure of jackfruit seed biofuel is appeared in Fig 3.

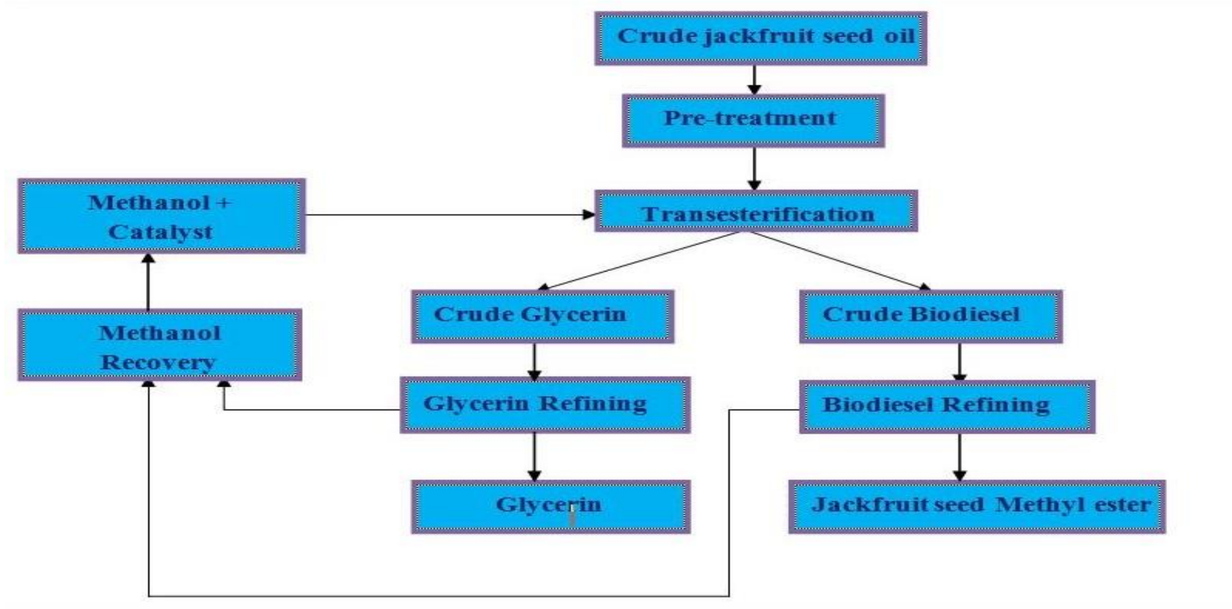


Figure 3 Steps followed in transesterification process

2.3 Properties of Jackfruit seed methyl ester blends and diesel

The properties of the diese1 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/m3)	834	845	851	857	863	892
Fire Point (oC)	66	89	101	113	125	185
Flash Point(oC)	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

3.1System 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 Tab1e 2. The engine be loaded with the use of eddy current dynamometer. In this analysis the Characteristics of jackfruit seed biodiese1 with its b1ends (20%, 30%, 40%, 50%, 100% v/v) for example JSME20, JSME30, JSME40, JSME50 and JSME100, were evaluated by means of sing1e cy1inder 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 diese1 engine
Makes by	Kirloskar
Compression ratio	17.5:1
Bore	87.5 millimeter
Connecting rod or bar length	234 millimeters
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 1ength	145 millimeters
Load indicator	Range 0-50 Kg, Supp1y 230V AC, Digital
Load or burden Sensor	Load Or Burden Ce1l, Type strain gauge or check, Range from 0-50 Kg
Loading device	Eddy current dynamometer
Rotameter	Engine coo1ing (40-400 LPH); Ca1orimeter (25-250 LPH)
Temperature sensor	Thermocouple, type K
Speed Indicator	Digita1 with non-contact type speed sensor

4. RESULTS AND DISCUSSION

4.1 PERFORMANCE CHARACTERISTICS

4.1.1 Brake therma1 efficiency, Brake specific fue1 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., b1ends 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.

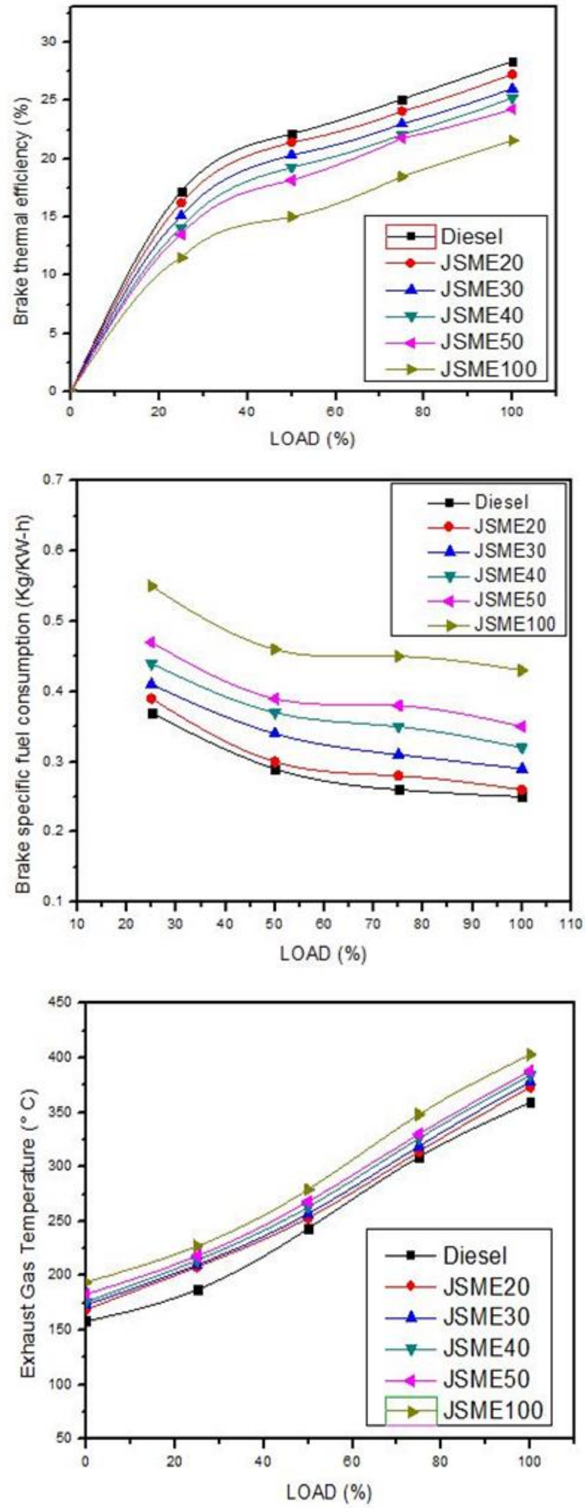


Figure 5. Variation of brake thermal efficiency, brake specific fuel consumption and exhaust gas temperature with load

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 biofuels produce high EGT compare with diesel. The EGT will not reach a peak point because it will seriously affect the wa1ls of the cy1inder. 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 4030C, 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), CO_2, and HC (Hydrocarbons) 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.

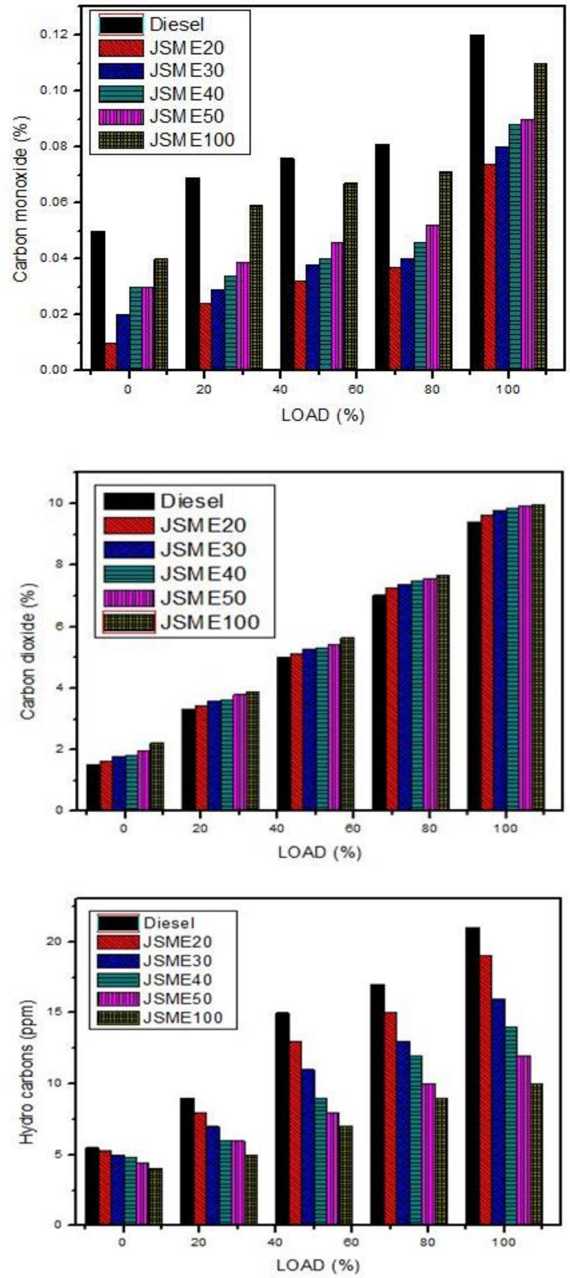
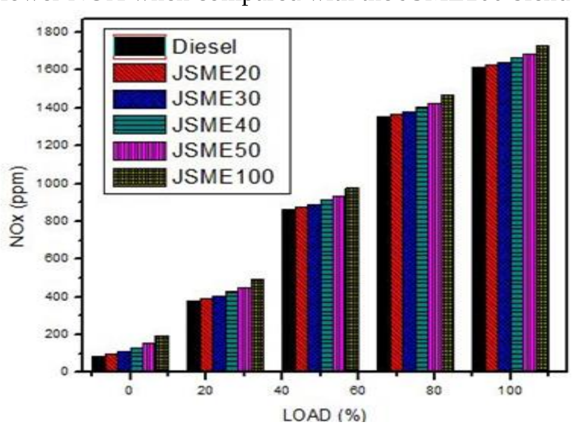


Figure 6Variation of carbon monoxide emissions with load

The Fig 6. Shows the variation of CO_2 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 CO_2 emissions for the pure diesel and JSME blends. And we noticed that the CO_2 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 CO_2 emission. The obtained CO_2 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 CO_2 when compared with the other JSME blends.
Fig 6. Shows the variation of CO_2 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 increase. HC emission wi1l be less when the cy1inder temperature was more. We know that the JSME biofuels are having more O_2 content will leads to improved combustion hence JSME biofuels will liberate less HC. Due to this reason, we can notice that complete combustion will occur for JSME biofuels 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 NOX emissions and Smoke opacity
The Fig 7. Shows the variation of CO_2 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 NOx emissions. Here for all JSME biofuels NOx emissions will be high when compared with pure diesel. The NOx will be increases with increase in the load. The obtained NOX 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 NOX when compared with the JSME100 blend.



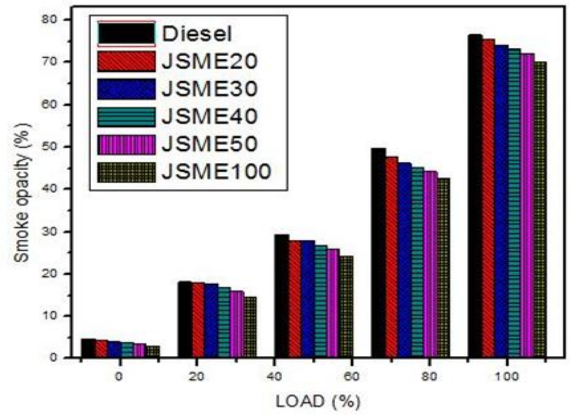


Figure 7Variation of nitrogen oxide emissions and Smoke opacity with load

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 hea1th issues if inha1e 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.

5. CONCLUSION

Present investigation going on, the specialized or technical possibility of utilizing JSME biofuel 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 NOX when compared with the other JSME blends.
- The blend JSME100 will give lowest 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 biofuel 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.

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