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EFFECT OF INJECTION PRESSURE ON THERMAL EFFICENCY AND BSFC OF 4-STROKE DIESEL ENGINE WITH ESTERIFIED NEEM OIL AND BIOGAS AS A FUEL

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ABSTRACT
This study deals with the effect of injection pressure on thermal efficiency and BSFC of 4-stroke diesel engine. The engine was fueled with NOME biogas having operated with constant engine speed of 1500 RPM, injection pressure of 180 bar, 200 bar, and 220 bar and injection angle of 23º with varying electrical loads. Performance characteristics like brake thermal efficiency, specific fuel consumption, and emission characteristics like CO, NOX, have been investigated. From the results it is observed that 200 bar injection pressure yields better performance and improved emission characteristics, for all the fuel blends.

Keywords: Bio-Gas, C I engine, esterified neem oil (NOME)

I. INTRODUCTION
Since the dependence on traditional fuels like coal, wood and petroleum fuels involves deterioration of the environment, alternative fuels are being sought by many countries. The alternative energy sources may be hydro, biomass, wind, solar, etc., which are renewable and have the ability to solve many of current problems such as, air pollution, global warming and sustainability issues. From last century, many scientists have suggested that the bio-fuels are good alternatives to fossil fuels [1]. Biodiesel is one of the renewable, non-depleting sources of energy, the properties of biodiesel being close to diesel fuel properties. Currently vegetable oils have become more attractive because of their advantage over petroleum fuels. The vegetable oil is not directly used in diesel engine because of high viscosity, low volatility, incomplete combution and formation of deposits in fuel injector and combustion chamber. This problem can be eliminated by subjecting oil to trans-etherification with ethanol which yelds low viscous ethyl esters known as biodiesel (BD). The BD can be prepared by using several types of

vegetable oils such as honge, soybean, rapeseed and neem oil. Neem is one of the plant species that possesses the combination of most of the pest control properties like anti-feedant, repellent and chemo-sterilant. Neem is a renewable source of various useful products, seeds and leaves being of particular interest. A fully-grown Neem tree yields about 50 kg fruits and about 350 kg leaves annually. From about 14 million Neem trees that grow in India, 0.7 million metric tones of fruits and about 5 million metric tones of leaves, besides, 83,000 tones of Neem oil and 3,30,000 tones of Neem cake are expected to be produced annually. Neem fruit consists of 30% greenish brown kernels and 70% shell, pulp. Neem Kernel consists of 48% of oil. In composition, Neem oil is much like other vegetable oils, composed primarily of triglycerides of oleic, stearic, linoleic, and palmitic acids [1].

In India, abundance of raw materials are available for producing biogas such as municipal sewage, cow dung, and agriculture waste. Biogas can be produced from the decomposition of biomass. Biogas obliquely replaces the fossil fuels, which contain 55-60% methane, 30-40% of carbon dioxide and rest being the impurities (H2, H2S, and some N2). It is a clear but slow burning gas and usually has calorific value between 5000-5500 kCal/kg. Tthe gas can be used to operate a diesel engine with dual-fuel mode with little modification [2,3].

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II. METODOLOGY

The engine was started by manual cranking with diesel fuel and ran above the idling RPM for few minutes without load, which allows the warming up of engine and also to stabilize all the parameters. The required engine speed was achieved by altering the governor

mechanism. Then biogas was introduced into inlet manifold ensuring that no parameters are altered. Subsequently the different loads were applied gradually in steps, and the salient parameters were recorded. The recorded parameters for diesel is treated as standard base line. A biogas flow rate of 0.5 LPM is maintained by adjusting the knob of rotameter meter. The time taken to consume 10 cc of biodiesel blends for different loading was recorded with other parameters such as voltage, current and temperature. The experiment was conducted for constant engine speed of 1500 RPM, speed of engine being ensured by digital contact type tachometer. Temperature was monitored using thermocouples and also air consumption was measured using the air box method.

The above procedures were repeated for biodiesel blends of 25% BD, 100% BD with biogas. The work used esterified Neem oil blends. Exhaust gas was analyzed by using AVL gas analyser. The experimental set up is shown in Fig. 1 and technical specifications are listed in Table-1. The properties of NOME are determined by different testing procedure sand which is tabulated in Table- 2. Similarly, the composition of biogas is shown in Table-3.

Table- 1: Technical Specifications of Engine

Engine	4-Stoke, Direct injection, Engine
Rated Power	3.6KW
RPM	1500
Compression Ratio	16.5:1
Manufacturer	Kirloskar

Table -2: Properties of NOME

Fuel properties	Neem oil	Neem oil methyl ester(NOME)	Diesel
Density (gm/cm^3)	0.920	0.868	0.830
Viscosity CST	35.83	3.8	2.9
Calorific value MJ/Kg	44.65	39.81	43
Cloud point °C	19	09	-2
Flash point °C	100	73	58
Fire point °C	109	78	63
Pour point °C	10	02	-16

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Table - 3 Properties of Biogas

Sl. No	Biogas Composition	Percentage	Testing Procedure
1.	Methane, %	90.64	By Gas Chromatography
2.	Carbon dioxide, %	5.96	By Gas Chromatography
3.	Oxygen, %	0.10	By Gas Chromatography
4.	Hydrogen sulphide, ppm	BDL	By Gas Chromatography
5.	Nitrogen, %	2.48	By Gas Chromatography
6.	Hydrocarbons(C 2 to C3),ppm(other gases)	BDL	By Gas Chromatography
7.	Moisture, ppm	2.0	By Gas Tube Analyzer

III. RESULTS AND DISCUSSIONS

The thermal efficiency and BSFC of diesel engine was studied using NOME and biogas as a fuel with varying, load, pressure, and angle. The behavior of the engine for various operating conditions are discussed below.

Brake Thermal Efficiency (BTE)

Generally break thermal efficiency increases with increased load. From Fig.2, it is clearly seen that the maximum BTE was observed for diesel at a load of 60% than biodiesel blend. This is because at higher load fuel undergoes complete combustion and compared to biodiesel blend, and also diesel fuel has higher heating value [4].

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The variation in brake thermal efficiency at varied injector opening pressures like 180 200 and 220 bar when diesel and blends of NOME fuels used as a injected fuel with 0.5 lpm biogas as supplement fuel Is shown in Fig.3.

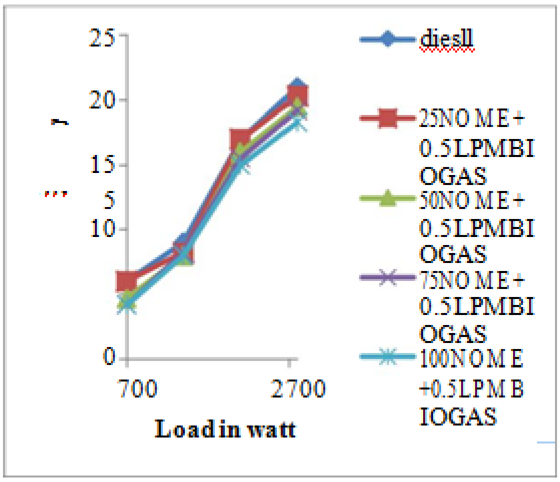

Fig.- 2: variation of BTE with load (IP-200bar, IA-23°)

From this plot, it is observed that considerably similar brake thermal efficiency is obtained for NOME blend at 200 bar pressure compared with diesel at 60% load. When increasing the load up to 80%, the efficiency is decreased due to improper combustion and very fine droplets of fuel have less momentum. Since viscosity of the bio-diesel is high, it requires large heat source for combustion of fuel at 180 bar opening pressure. But at 200 bar opening pressure, atomization and

penetration of injected fuel is good and hence the injector opening pressure of 200 bar results in higher brake thermal efficiency at 60% of full load, further increase in injection pressure decreases the BTE. Increase of injection pressure beyond 200 bar decreases the fuel droplet size thereby increases the momentum got impinging on cylinder walls leading to loss of heat through cylinder wall.

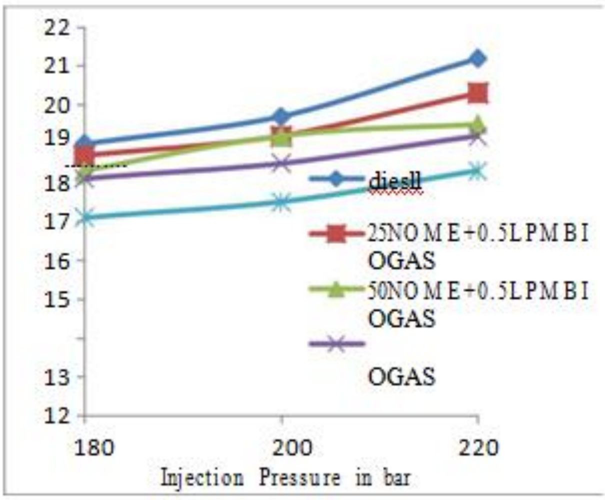

Fig-3: Variation of BTE with Injection Pressure (load-60%, IA-23°).

Brake Specific Fuel Consumption

Experimental results reveal that BSEC decreases as the load on the engine was increased and was minimum at full load. Fig.-4 shows the variation of BSEC with load for NOME. BSFC is more because of low heating value

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than diesel. The variation of BSFC with injection pressure is shown in Fi-5. Increasing fuel injection pressure decreases the BSFC for all fuel blends up to 200 bar. Increasing the injection pressure increases the atomization of fuel leading to formation of homogenous mixture resulting in complete combustion and decreases the BSFC. Engine when operated at injection pressure above 200 bar pressure shows the trend in increasing BSFC for all blends. This may be mainly due to fine atomization of fuel at higher injection pressure reduces the fuel droplets size and increased momentum leads to escaping from combustion space results to waste of fuel . This trend was increased further at very high injection pressures [5,6].

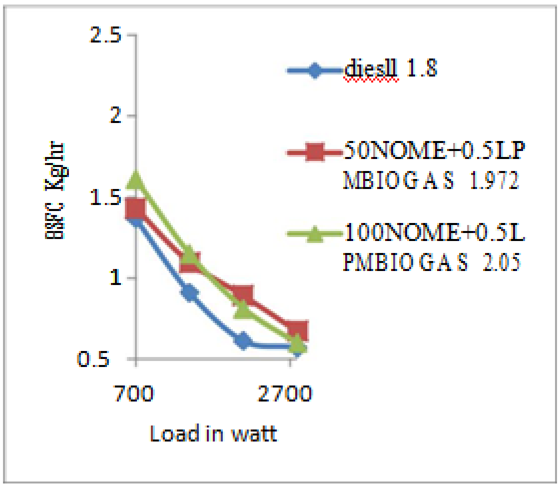

Fig.- 4: Shows the Variation of BSEC with Load (IA-23°).

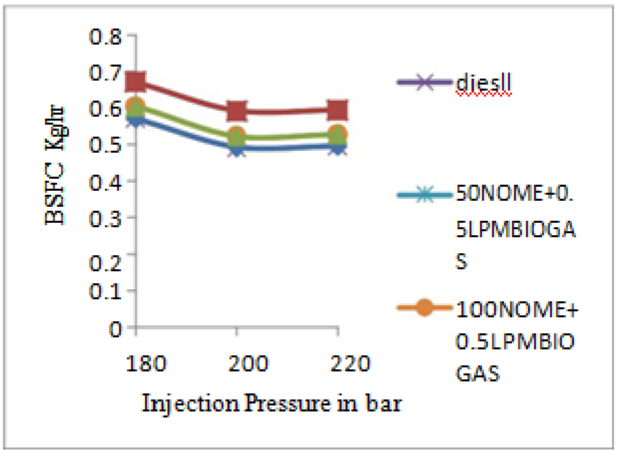

Fig.-5: Variation of BSFC with Injection Pressure (IA-23°, load-60%)

NOX Emission

Fig.-6 shows that NOx emission reduces as the proportion of the NOME oil increases; this is an encouraging fact for usage of NOME as an alternate fuel as NOx emission is considered to be one of the most harmful emissions. Similarly as the injection pressure increases temperature also increases resulting in increased NOX emission [8].

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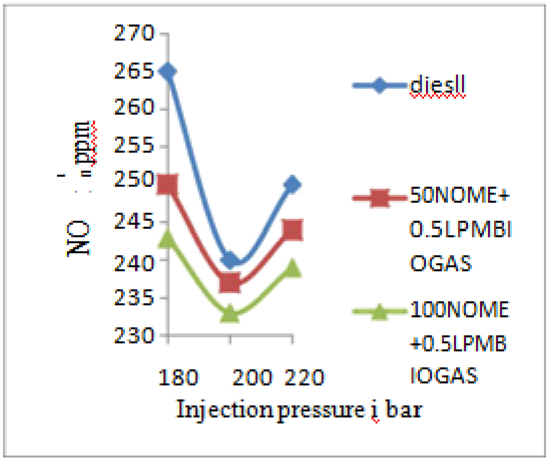

Fig.-6 NOx Emission vs. Injection Pressure

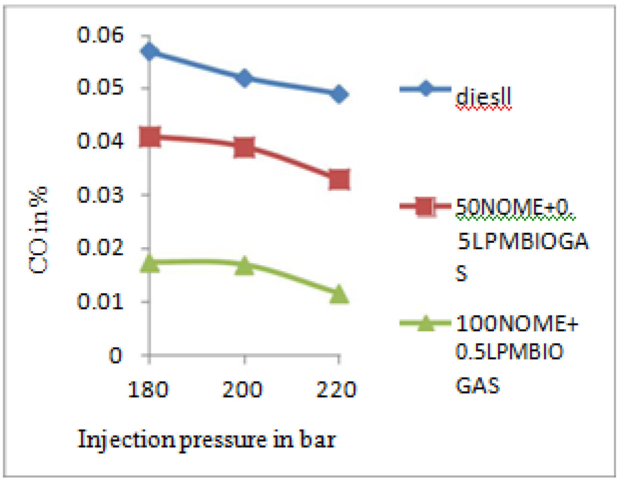

Fig.- 7 CO Emission vs. Injection Pressure

CO Emission

Fig.-7 describes the variation of CO emission with fuel injection pressure. Decreased CO emissions are observed up to 200 bar injection pressure. Beyond 200 bar, increasing the injection pressure increases CO emission for all fuels. CO emission depends mainly on the combustion process. When there is complete combustion, lower CO emissions result. At 200 bar injection pressure the CO emissions are observed to be minimum for all the fuel blends due to complete combustion. CO emission for biodiesel and its blends are observed lower than those for pure diesel. This is also because of more oxygen content of biodiesel leads to effective combustion and resulting lower CO emissions[7,8,9].

IV. CONCLUSIONS

The engine was made to run with all different blends at different injection pressures successfully and the following conclusions are drawn from experimental investigations:

1. Brake Specific fuel consumption is low at 200 bar and with increase of injection pressure BSFC increases. At higher injection pressures BSFC is increased because of higher momentum of fuel got impinges on cylinder walls leads to wastage of fuel and improper combustion
2. BTE of NOME+biogas combination is high at 200 bar injection pressure which are higher compared to other injection pressures. This was mainly due to complete combustion of entire fuel which was admitted without any wastage with higher momentum
3. NOx emissions increases for all fuels with increase of injection pressure beyond 200 bar.

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4. The lowest CO emissions were observed at 200 bar compared to other pressures.
5. The lowest CO emissions were observed for 100% NOME+0.5lpm biogas

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