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Experimental Investigations of a Variable Compression Ratio Diesel Engine Fuelled with Neem Methyl Ester (NeME).

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***Abstract* - Investigations are carried out to verify the performance and emission of a variable compression diesel engine operated with pure Neem oil Bio diesel (NeME), and pure Diesel at various compression ratios starting from 15:1, 17:1, 19:1 and 21:1 to compare the results at each compression ratio considering pure diesel as base line. The experiment has been conducted at fixed engine speed of 1500 rpm and engine tests have been conducted to get the comparative measures of Specific Fuel Consumption (SFC), Brake thermal efficiency (BTh) and emissions such as CO, CO_2, HC, and NO to study the impact of pure NeME, with respect to Compression ratio and its implementation. A notable improvement in between NO and HC was observed maintaining a high thermal efficiency by a suitable combination of Neem biodiesel and compression ratio. The results of pure NeME operated under compression ratio 17:1 were found encouraging in all respects of performance and improved emission characteristics.**

Keyword - Biodiesel, Neem Methyl Ester, Variable compression ratio engine, emissions, performance.

1. INTRODUCTION

The limited availability and fast retreating resources of petroleum fuels, increasing day by day prices of crude oil, and environmental aspects are the reasons for the use of biodiesel obtained from vegetable oils as alternative to petro diesel [1-3]. Methyl/Ethyl Esters of Vegetable oils offer almost the same output with slightly lower thermal efficiency when used in diesel engines [4 & 5]. Reduction of tailpipe emissions plays a major role in the field of biodiesel application and also research aspect in engine development. [6-10] shows the environmental protection and pollution norms of the application of biodiesel. The use of neat vegetable oils posses some problems when operated long run of the engines due to high viscosity, low volatility and poly-unsaturated character of vegetable oils [11].

The main problems are trumpet formation on the injectors, carbon deposits, oil ring sticking and thickening and gelling of lubricating oil as a result of contamination by the vegetable oils [12 & 13]. In the present work, bio-diesel (Methyl Ester) is prepared from Neem oil. The fuel properties of the test bio-diesel were determined and their performance and emission were studied on a four-stroke, single cylinder, variable compression ratio direct-injection diesel engine to evaluate suitability as alternative to Diesel.

2. EQUIPMENT AND EXPERIMENTS

2.1. Bio diesel (Neem Methyl Ester)

The Pure diesel used in the Experimentation is obtained from nearest filling station. The biodiesel prepared from Neem oil by a method of alkaline-catalyzed transesterification. The lower calorific value of biodiesel is approximately 7 % lower than that of pure diesel. The viscosity of Neem methyl ester is evidently higher than the pure diesel. In the experimentation, four compression ratios are provided by the screw adjustment for the test engine starting 15:1, 17:1, 19:1, and 21:1. The test values were named as 15 BD to 21 BD for biodiesel run at particular C.R and 15 PD to 21 PD for pure diesel run at particular compression ratio. Transesterification of Neem oil was carried out by heating of oil, addition of KOH and methyl alcohol, stirring of mixture, separation of glycerol, washing with distilled water and heating for removal of water traces. The NeME so produced was used for the experimentation along with pure diesel at above said compression ratios for comparative study. Fuel properties such as flash point, fire point, kinematic viscosity and calorific value were determined for Neem methyl ester and are compared with the pure diesel.

Properties	Diesel	Biodiesel (NeME)
Density(kg/m^3)	860	910
Kinematic viscosity at 40oc(Cst)	3.03	4.6
Calorific value (kj/kg)	42500	39000
Cetane number	48	50
Flash point ◦C	84	124
Surface tension N/m at 20°C	0.023	0.024
Molecular weight	170	205
Stoichiometric air to fuel ratio Wt/wt	15	13.5
Boiling point ◦C	188-344	-
Carbon content % weight	84-87	-
Oxygen content (%) weight	0	10

Table 2.1 Properties of Diesel and NeME.

2.2. Experimental setup and Procedure

The experimental set up consists of a single cylinder four-stroke, water-cooled and constant-speed (1500 rpm) compression ignition engine. The detailed specification of the engine is given below.

Product	Research Engine test setup 1 cylinder, 4 stroke, Multifuel, VCR, Code 240
Engine	Single cylinder, 4 stroke, water cooled, stroke 110 mm, bore 87.5 mm, 661 cc. Diesel mode: 3.5 KW, 1500 rpm, CR range 12-18. Injection variation:0- 250 BTDC Petrol mode: 4.5 KW@ 1800 rpm, Speed range 1200-1800 rpm, CR range 6-10,
Dynamometer	Type eddy current, water cooled, with loading unit
Fuel tank	Capacity 15 lit, Type: Duel compartment, with fuel metering pipe of glass
Calorimeter	Type Pipe in pipe
ECU	PE3 Series ECU, Model PE3-8400P, full build, potted enclosure. Includes peMonitor & peViewer software.
Piezo sensor	Combustion: Range 350Bar, Diesel line: Range 350 Bar, with low noise cable
Crank angle sensor	Resolution 1 Deg, Speed 5500 RPM with TDC pulse.
Data acquisition device	NI USB-6210, 16-bit, 250kS/s.
Temperature sensor	Type RTD, PT100 and Thermocouple, Type K
Temperature transmitter	Type two wire, Input RTD PT100, Range 0–100 Deg C, Output 4–20 mA and Type two wire, Input Thermocouple,
Load sensor	Load cell, type strain gauge, range 0-50 Kg
Fuel flow transmitter	DP transmitter, Range 0-500 mm WC
Air flow transmitter	Pressure transmitter, Range (-) 250 mm WC
Software	“Enginesoft” Engine performance analysis software
Rotameter	Engine cooling 40-400 LPH; Calorimeter 25-250 LPH
Overall dimensions	W 2000 x D 2500 x H 1500 mm

Table 2.2 Test Engine Specification

2.3. Specification of diesel engine

The setup consists of single cylinder, four stroke, Research engine connected to eddy current dynamometer. It is provided with necessary instruments for combustion pressure, crank-angle, airflow, fuel flow, temperatures and load measurements. These signals are interfaced to computer through high speed data acquisition device as in fig.2.2. The set up which is shown in fig. 2.1 has stand-alone panel box consisting of air box, twin fuel tank, manometer, fuel measuring unit, transmitters for air and fuel flow measurements, process indicator and piezo powering unit. Rota meters are provided for cooling water and calorimeter water flow measurement. In petrol mode engine works with programmable Open ECU, Throttle position sensor (TPS), fuel pump, ignition coil, fuel spray nozzle, trigger sensor etc The setup enables study of engine performance for both Diesel and Petrol mode and study of ECU programming. Engine performance study includes brake power, indicated power, frictional power, BMEP, IMEP, brake thermal efficiency, indicated thermal efficiency, Mechanical efficiency, volumetric efficiency, specific fuel consumption, Air fuel ratio, heat balance and combustion analysis. at the constant speed. During each trial, the engine was started and after it attains stable condition, important parameters related to thermal performance of the engine including the time taken for 20 cm^3 of fuel consumption, applied load, the ammeter and voltmeter readings were measured and recorded. Also, the engine emission parameters like CO, CO_2, HC, and NO, from the exhaust gas analyzer, which is shown in Fig.2.3 were noted and recorded.

Fig.2.1.Test Engine for this work


Fig.2.2.Computerised data logging system


Fig.2.3.Exaust gas analyzer

3. RESULTS AND DISCUSSIONS

3.1. Thermal Efficiency

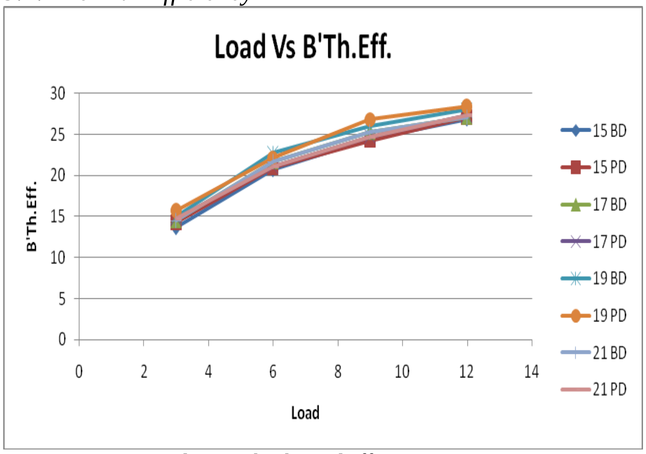

Fig.3.1.Load Vs Brake thermal efficiency at varying CR.

Engine operation at full Load, the Brake thermal efficiency of Neem biodiesel is 1% lesser than Pure diesel at the CR 15 to 21 and for biodiesel thermal efficiency increasing while compression ratio increasing .at lower loads the increment shows as 7% where as for pure diesel the increment is 3% and full load operation both are having nearly same increment.

3.2. Specific Fuel Consumption

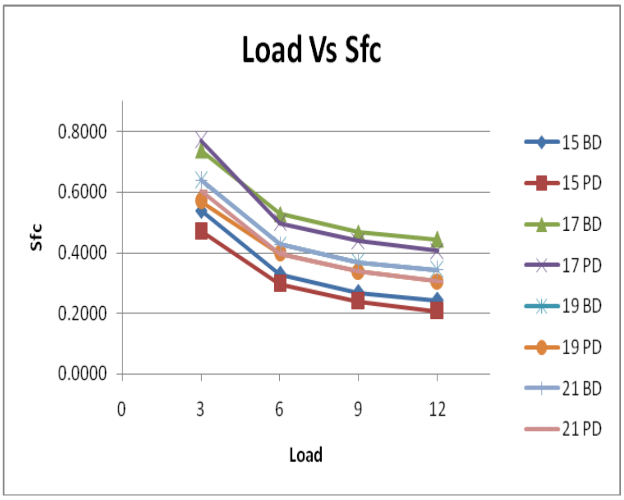

Fig.3.2.Load Vs specific fuel consumption at varying CR

Engine full Load run, the specific fuel consumption of B.D. is more than P.D. 15%, 8%, 11% respectively at the CR 15, 17, 19 & 21 where as at lower loads biodiesel to pure diesel the increment varies 4% to 11% only. In case of Neem biodiesel operation with CR increment s.f.c decreases and nearly 50%.

3.3. Emission analysis

3.3.1. HC emission

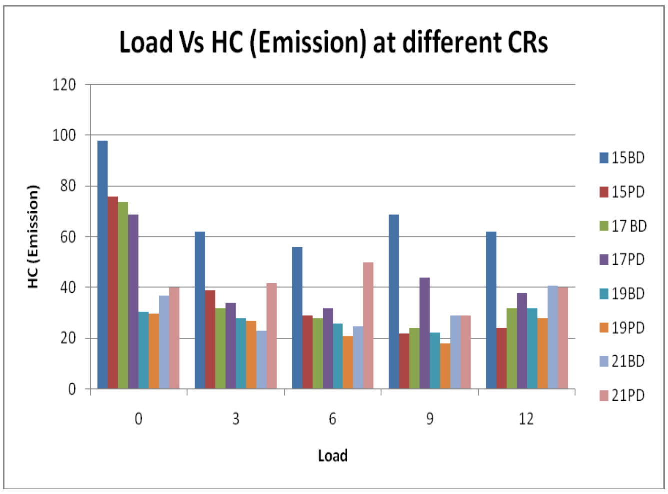

Fig.3.3.Load Vs Hydrocarbons at varying CR

At Full Load, the HC Emission of Neem biodiesel is 61% more than Petro diesel at CR 15:1, 13 % more at CR 19 but lesser than pure diesel at CR 17 & 21, i.e 18% and 8% respectively .Compression ratio increasing the HC emission of Neem biodiesel also increasing where as for pure diesel decreasing. Lower loads both the fuels are increasing HC emission with respect to increment in CR.

3.3.2. NO emission

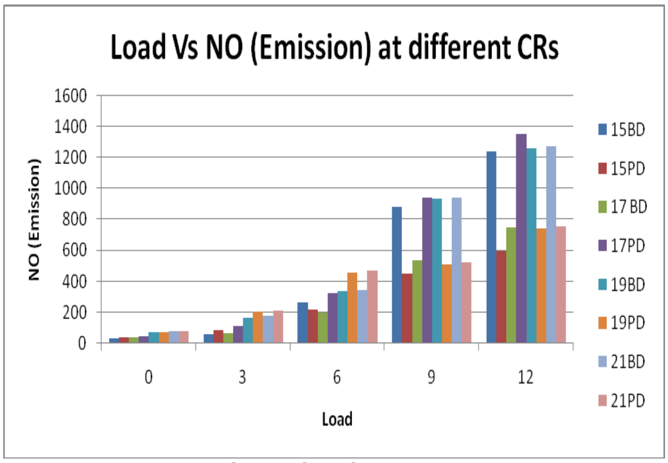

Fig.3.4.Load Vs Hydrocarbons at varying CR

Engine Higher Load operation, the NO Emission of Neem biodiesel is 50% more than P.D. at the CR 15:1, 80 % less than purediesel at CR 17 but agin increasing morethan pure diesel at CR 17 & 21, nearly 40% .Due to compression ratio increment, NO emission of Neem biodiesel also slightly increasing where as pure diesel increment is notable. At lower loads both the fuels are increasing the NO emission with respect to increment in CR.

3.3.3. CO emission

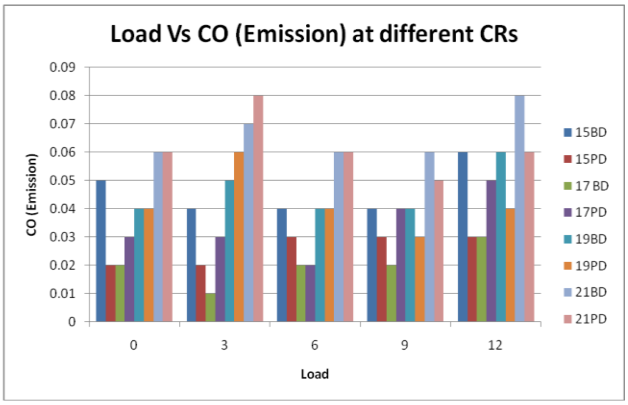

Fig.3.5.Load Vs Carbon monoxide at varying CR

At Full Load, the Carbon monoxide Emission of neem biodiesel is 50% more than P.D. at the CR 15, but it is 67% lesser at CR 17. Similarly at higher Loads, the CO Emission of B.D. is more than pure diesel nearly 30%. The CO Emission of NeME is increasing while increasing in CR 15 to 21.

3.3.4. CO_2 emission

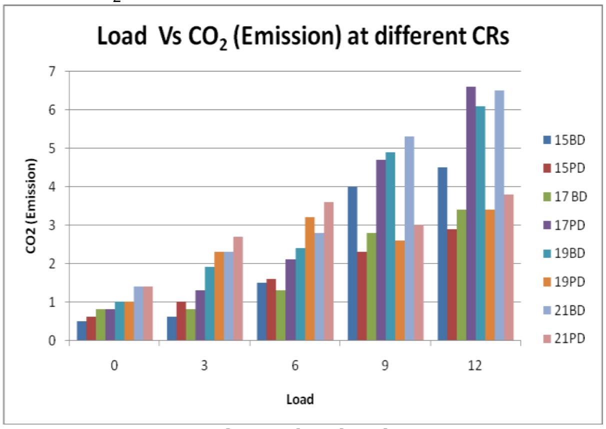

Fig.3.5.Load Vs Carbon dioxide at varying CR

At Full Load, the Carbon dioxide Emission of Neem biodiesel (NeME) is 30% more than pure diesel at the CR 15, but it liberates more emission at CR 17. Lower loads it shows lesser and at CR 17 CO_2 emission almost equal. Similarly at higher Loads, the CO_2 Emission of B.D. is more than pure diesel nearly 30%. The CO Emission of NeME is increasing while increasing in CR 15 to 21. Both are showing increment of the emission while CR increasing.

4. CONCLUSIONS

The experimental conclusions of this investigation can be summarized as follows:

- Brake specific fuel consumption was found to have minimum for pure diesel as compared to biodiesel at all loads and compression ratios at CR 17 part loads nearly equal both biodiesel and petro diesel.
- The brake thermal efficiency was found to increase with increase in compression ratio and there is no large difference in the brake thermal efficiency of bio diesel and neat diesel at full load condition of compression ratio 17 and NeME have the maximum thermal efficiency equal to pure diesel at CR 17.Hence implementation of Neem biodiesel at CR17:1 recommended.
- Exhaust emissions like HC, NO, CO, and CO_2 are all comparable with pure diesel and Neem biodiesel run at compression ratio 17:1 shows a better emissions. Hence recommended.

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