INVESTIGATE THE IMPACT OF COMPRESSION RATIO ON PERFORMANCE AND EMISSION OF VARIABLE COMPRESSION RATIO DIESEL ENGINE FUELED WITH MICRO ALGAE BIODIESEL

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Abstract : In this present research, investigate the performance, combustion and emission characteristics of variable compression ratio (VCR) engine fuelled with spirulina micro algae biodiesel(SMABD) (Arthrospira platensis and A. maxima) blends(B9, B18 and B27)for different compression ratio(14, 16 and 18) and loading conditions are studied. Different performance parameters such as brake power(BP), brake thermal efficiency(BTHE), brake specific fuel consumption(BSFC), emission parameters (CO,CO_2,HC,NO_x) has been compared with petro-diesel. BTHE is increased with compression ratio (CR) but it is higher for blend B18 at CR18 compared to other blends and diesel. BSFC is reduced when CR increases however it is lower for biodiesel blends than diesel. Emissions are greatly reduces for biodiesel blends. Finally it reveals that blend B18 at CR18 shown best results.

Key words: spirulina micro algae biodiesel, performance, emissions, compression ratio, variable compression ratio engine.

I.INTRODUCTION

Retaining in view of the depleting oil reserves, increasing crude prices and growing international temperature, a collection of well matched marketers, scientists, bureaucrats and social workers have fashioned a society to sell using biodiesel. The objective of the society is to promote the intake of bio-diesel. Because of availability of excessive yielding varieties, this could additionally results in discount in import of petroleum products. At present, biodiesel becomes an adequate alternative choice to researchers for supplementing conventional diesel fuel. The properties of biodiesel are very close to diesel and it can be blend at any portion with diesel and can be used in existing engine without any modification. But at present biodiesel costs 1.5-3 times more than diesel due to the higher cost of raw feed stocks and unavailability of oil crops that serves as a source of biodiesel production. Bio-diesel is easy to apply, biodegradable, secure, and essentially freed from sulphur and aromatics. Biodiesel is the mono-alkyl esters of lengthy chain full of fat acids extracted from vegetable oils or fat of animals which verify to ASTM D6751 specifications for use in diesel engines. Bio-diesel is the name of the clean burning fuel, made out of domestic, renewable resources [1]. Rahman et al.[2] investigate the optimization of process of extracting biodiesel from micro algae spirulina maxima, for this they used two-step process was developed for the production of biodiesel from microalgae Spirulina maxima and determined finest operating conditions for the steps. In the initial stage, acid esterification was carry out to reduce acid value of the feed stockpile and most positive conditions for maximum esterifies oil yielding be found at molar ratio 12:1, temperature 60^0C, 1% (wt%) sulphuric acid(H_2SO_4), and mixing intensity 400 rpm for a reaction time of 90 min. The next stage alkali transesterification was carry out for maximum biodiesel yielding (86.1%) and best situation were found at molar ratio 9:1, temperature 65^0C, mixing intensity 600 rpm, catalyst concentration 0.75% (wt%) potassium hydroxide (KOH)for a reaction time of 20 min. Madkour et al.[3] did research on production and value of Spirulina platensis in reduced cost media, This research aimed to afford a cost effective medium to huge scale production of Spirulina platensis. This aim was implemented by alternate all the nutrients present in Zarrouk's medium (SM) with cheaper and locally available profitable fertilizers and chemicals. The reduced cost restricted single super phosphate (SSP), commercial sodium bicarbonate, Muriate of potash (MOP) and basic sea-salt, (Syahat salt). Mostafa et al.[4] studied the viability of biodiesel production from microalga Spirulina platensis has been investigated. The different physical and chemical characteristics of the produced biodiesel were studied according to the standard methods of analysis (ASTM) and evaluated according to their fuel properties as compared to petro-diesel. Different blends of microalgae biodiesel and diesel were prepared on a volume basis and their physio–chemical properties have been also studied. The obtained results showed that; with the increase of biodiesel concentration in the blends; the viscosity, actual density, total acid number, boiling point, calorific value, flash point, Cetane number and diesel index increase. Whereas the pour point, cloud point, carbon residue and sulfur, ash and water contents decrease. The experiential properties of the blends were within the suggested. As observe in the literature review, both biodiesel-diesel blends and operating parameters impact the diesel engine performance (such as BSFC and BTHE) [5-12] and exhaust emissions (such as OP, HC, CO and NOx). Conversely, the effects of working conditions such as compression ratio, injection timing and injection pressure on the exhaust emissions and engine performance of diesel engine using biodiesel-blended diesel fuel have been studied, in thorough with experiments conducted on the same engine. Contrast of performance and emission data from the same engine using different fuel blends and operating conditions is more meaningful [12-18] .

In this study, the biodiesel extracted from spirulina (blue-green algae) (Cyanophyceae) are also referred to as microalgae, this applies for example to Spirulina (Arthrospira platensis and A. maxima) is used as a fuel for VCR engine to study the performance, combustion and emission characteristics at different compression ratio.

II. MATERIALS AND METHODS

2.1 Physiochemical properties of Spirulina algal oil

The results of the GC-analysis of the algal oil are listed in Table 1. The algal lipids consisted of fatty acids between 16 and 20 carbon chain length. The higher concentration fatty acids were stearic, palmitic, oleic and linolenic acid. Table 2 also shows some of the most important physicochemical properties of Spirulina algal oils which were used for simulating an engine test running with the two fuels. Algal oil has a lower carbon content compared to vegetable oils while at the same time having a larger amount of oxygen, which both justify the lower heating value of Spirulina algal oil. The difference in the composition of the two oils is explained by the higher amount of phospholipids, pigments (like chlorophyll) and waxes in algal lipids compare to commercial vegetable oils which have higher purity in triglycerides.

Table-1 Gas Chromatography Mass spectroscopy Analysis

S.no	Carbon number	Name of fatty acid	GCMS of spirulina oil
1	C14:0	Myristic acid	0.245
2	C16:0	Palmitic acid	11.932
3	C18:0	Stearic acid	4.26
4	C22:0	Behenic acid	6.870
5	C23:0	Tricosanoic acid	0.215
6	C18:1n9c	Oleic acid	22.738
7	C20:1	Cis -11 Ecosenoic acid	0.821
8	C18:2n6c	Linoleic acid	46.330
9	C18:3n3	Alpha- Linoleic acid	2.890
10	C20:3n6	Cis -8,11,14- Ecosatrienoic acid	0.635
11	C20:4n6	Arachidonic acid	0.889
12	C22:2	Cis -13,16, Docosadienoic acid	0.120
Total identified fat			97.945

Table 2 Fuel Properties of diesel and bio-diesel.

S.no	Test description	Ref .Std. ASTM 6751	Algae Bio-diesel (Spirulina)	Diesel
1	Density in kg/m3	D1448	871	830
2	Cetane number	D613	46.10	51
3	Flash point in ^{0} C	D93	138	60
4	Fire point	D93	147	63
5	Viscosity in mm2/sec	D445	4.46	3.26
6	Calorific value in KJ/kg	D6751	39000	42500
7	Cloud point in ^{0} C	D2500	5.80	-8
8	Pour point in ^{0} C	D2500	1.0	-40
9	Carbon residue in %	D4530	0.5	0.5
10	Ash in %	D4812	0.05	0.05

2.2. Experimental Design

Fig. 1 shows that the photographic view of experimental set up. The set up consists of single cylinder, four stroke, and variable compression ratio multi fuel engine coupled with eddy current dynamometer for loading. The detailed specification of the engine is shown in Table 3. Engine performance analysis software package "IC Enginesoft" is employed for online performance analysis. The tests have been conducted at the rated speed of 1500 rpm at different loads and compression ratio (14, 16, 18). Standard diesel is used to start the variable compression ratio engine and is allowed to warm up. The warm up period ends when cooling water temperature is stabilized at 60 C. Then the engine operating parameters such as brake thermal efficiency (BTHE), brake power (BP), brake specific fuel consumption (BSFC), mechanical efficiency and exhaust gas temperature with respect to different loads and different blends are measured. The exhaust emissions by combustion of biodiesel were measured by AIRREX HG-540, 4Gas Emission gas analyzer. In this analyzer, the zero setting function sets the sensor to zero using fresh air. The analyzer first being turned ON a zero will be requested automatically at 7, 15 and then 25 min time intervals. Subsequent request will be every 25 min. The zero air port allows the gas analyzer to zero without removing the sampling probe from the exhaust tail. The ambient air from the zero port drawn through a charcoal filter helps in setting HC to zero. The zero key on the keyboard enables to set zero for CO, CO_2 and NO_x values to zero with ambient air and is calibrated to 17.84% oxygen by volume.

A computerized data acquisition system (IC Enginesoft) is used to collect, store and analyze the data during the experiment by various sensors. Same procedures were repeated for different blends of Spirulina biodiesel and conventional diesel

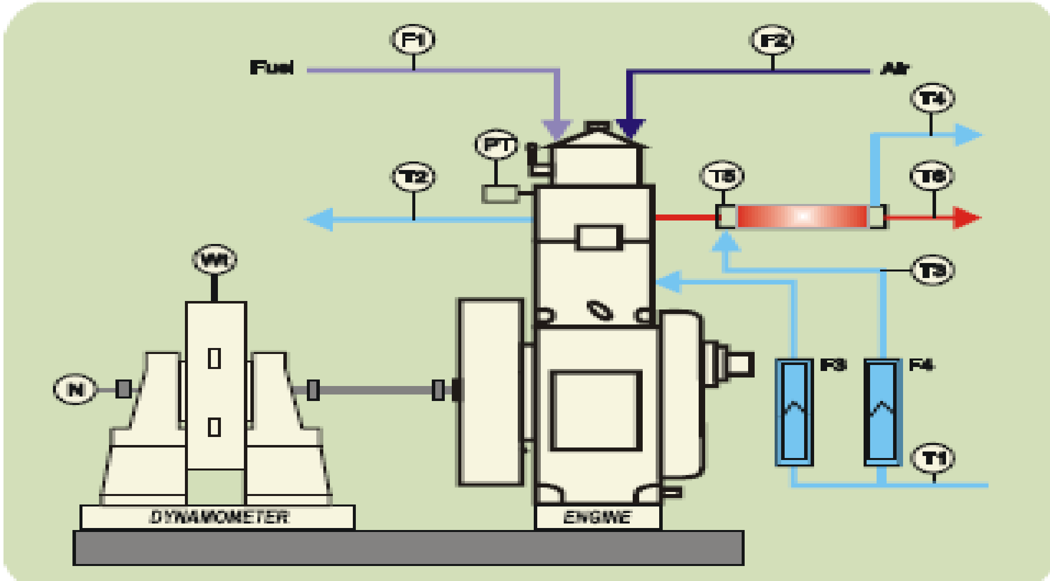

Fig.1 Experimental setup

Table .3 Specifications of the variable compression ratio engine and features

Engine parameters	**Specifications**
Make	Kirloskar
Model/Type	TV1/Four stroke
Number of cylinders	Single
Bore/Stroke	87.5 mm/110 mm
Rated power	5 HP(3.5 kW) @ 1500 rpm
Capacity(cc)	661
Type of cooling	Water cooled
Compression Ratio range	12–18
Injection timing range	0- 25^0 BTDC
Loading	Eddy current dynamometer
Data acquisition device	NI USB-6210, 16-bit, 250kS/s.
Temperature sensors	Type RTD, PT100 and Thermocouple, K-Type
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	“Engine soft” Engine performance analysis software
Rotameter	Engine cooling 40-400 LPH; Calorimeter 25-250 LPH

III. RESULTS AND DISCUSSIONS

3.1 Performance characteristics

The different performance parameters for example brake power, BTHE, BSFC are assessed for spirulina micro algae biodiesel, in which BSFC is an idle parameter for comparing the engine performance of fuels having different calorific values and densities.

(A) Brake thermal efficiency: Fig.2 (a) shows the variation of BTHE with different compression ratios of 14, 16, and 18 for different blends of SMABD and conventional diesel. BTHE is linearly increasing with increasing compression ratio for all the blends of SMABD and conventional diesel. It is clearly observed that the BTHE is increasing for blends of B9, B18, and B27, moreover, B18 (28.1%) and B27(27.91%) shows the higher values than base diesel(27.84) at CR18 with full load. In addition, B18 shows better BTHE than all the blends for all CR values. The possible basis for higher BTHE for biodiesel blends is may be having a few amount of oxygen in the molecules of biodiesel, which takes part in combustion and improves the complete combustion.

(B) Brake Specific Fuel Consumption: Fig.2 (b) shows the variation of BSFC with CR at full load. BSFC as a function of load obtained during the operation on SMABD-diesel blends and for all fuel is tested, in which, BSFC is higher at lower CR and load for all blends and decrease with increasing CR. For blend B18, the BSFC at full load for CR14, CR16, and CR18 are 0.32, 0.31, and 0.31 kg/kWh, respectively whereas for diesel at full load for CR14, CR16, and CR18 are 0.33, 0.32, and 0.32 kg/kWh, respectively. The BSFC reduction in the biodiesel blends may be density is higher for biodiesel then conventional diesel.

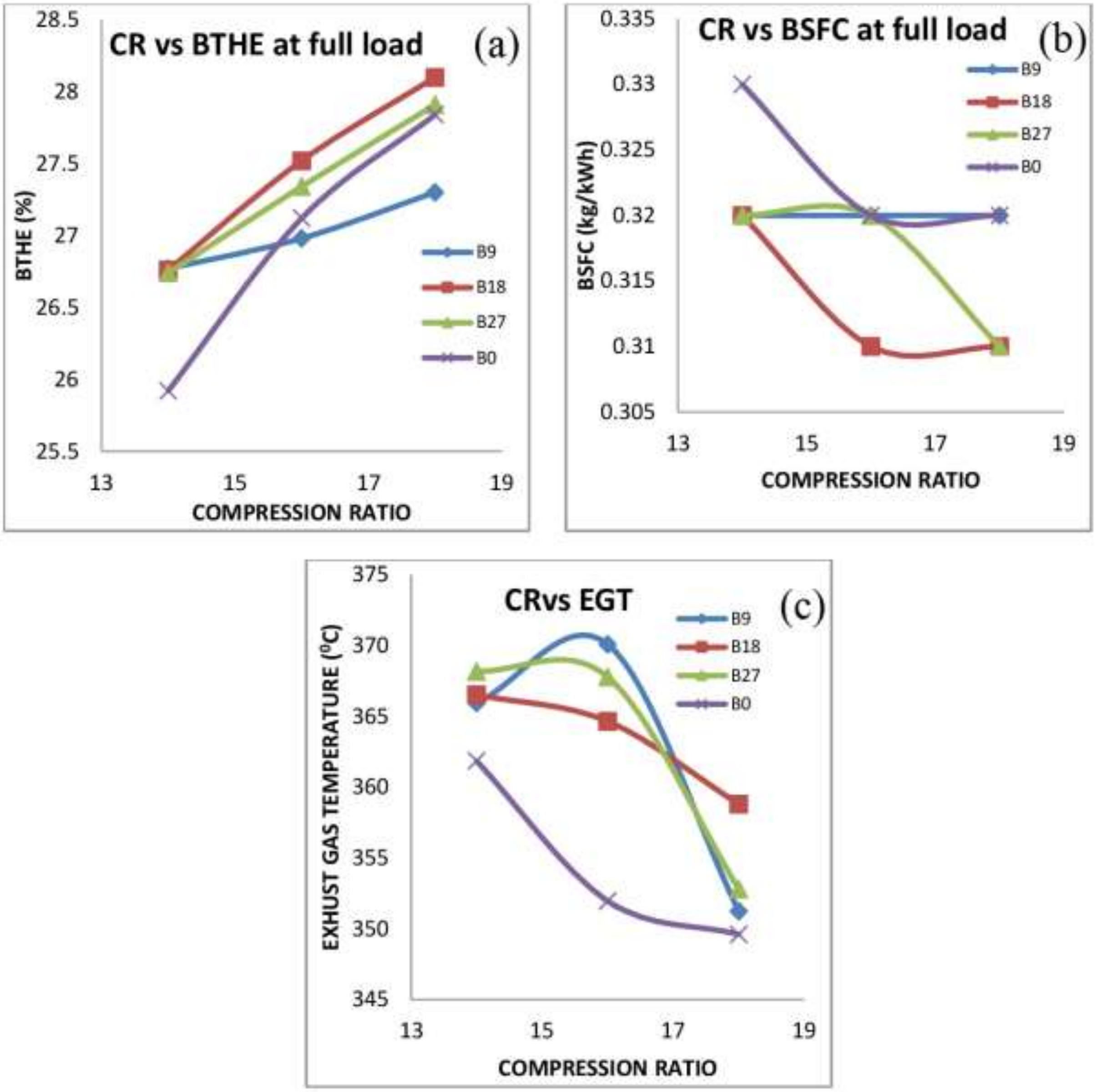

Fig.2 (a-c) shows the variation of brake thermal efficiency, specific fuel consumption and exhaust gas temperature with compression ratio at full load.

(C) Exhaust gas temperature: Fig.2 (c) shows the variation of EGT with CR at full load for different blends of SMABD and diesel .EGT decreases while increasing the CR. In this EGT is higher for biodiesel blends than diesel, at CR18 all the blends of biodiesel and diesel having lower value may be utilization of heat of combustion is when compare to other compression ratio.

3.2. Emission Characteristics

(A) Hydro carbons (HC): Fig.3 (a) shows the variation of hydro carbon emission with different compression ratios of the different blends at full load. HC emissions are decreasing with increasing CR for all blends of SMABD. The effect of CR is very less on HC for biodiesel blends and diesel. However, the HC value of B18 blend seems to be very less at CR18.

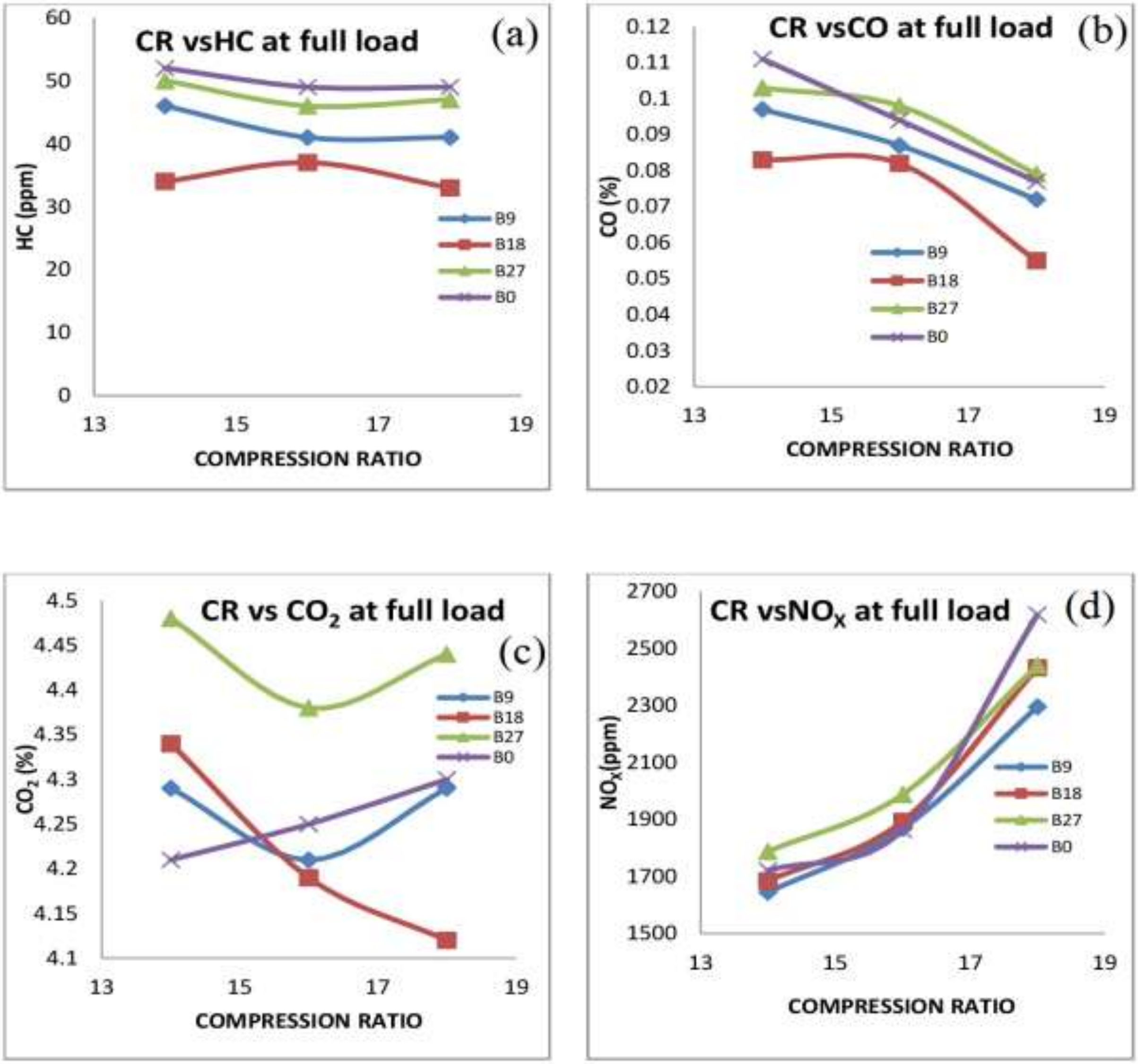

Fig.3 (a-d) shows the variation of HC,CO, CO_2 and NO_X emissions with compression ratio at full load.

(B) Carbon monoxide (CO): Fig.3 (b) shows the variation of CO emissions with CR at full load for all the blends of SMABD and diesel. The CO emissions are decreasing while CR increases. The blend B18 and B27 shows lower value than Diesel at all compression ratios. However, CO emission exhibited lowest value than Diesel for B18 at CR18.

(C) Carbon dioxide (CO_2): Fig.3 (c) shows the variation of CO_2 emissions with CR at full load for all the blends of SMABD and diesel. The CO_2 emission variation exhibited different manner for different blends. For instance, blend B9 and B27 first decreases upto CR16 subsequently increases, blend B18 decreases while increasing CR and reaches lower value at CR18. However blend B18 having lower CO_2 emissions.

(D) Nitrogen oxides (NO_x): Fig.3 (d) shows the variation of NO_X emissions with CR at full load for all the blends of SMABD and diesel. NO_x emissions are increased with CR and all blends of SMABD shows lower than Diesel. However, B9 and B18 blend at CR18 having lower NO_x emissions.

IV. CONCLUSIONS

The fallowing conclusions are presented in VCR engine with functions of fuel blends and CR.

- The BTHE of blend B18 is higher than that of standard diesel and other biodiesel blends at higher compression ratio and full load condition.
- BSFC is lower for biodiesel blends then diesel but it is lowest for blend B18.
- There is a significant reduction in CO, HC, and CO_2 for blends of SMABD at CR 18.

For the above observation, it has been found that the blend B18 shows better performance and emission characteristics than other blends and Diesel at compression ratio 18:1 and full load condition.

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