International Journal of Advances in Engineering Research http://www.ijaer.com

(IJAER) 2012, Vol. No. 3, Issue No. V, May **ISSN: 2231-5152**

PERFORMANCE, COMBUSTION AND EMISSION CHARACTERISTICS OF DI-CI ENGINE FUELLED WITH CORN METHYL ESTER AND ITS DIESEL BLENDS

K.Srinivasa Rao[1], P.V.Rao[2], Dr.B.S.K.Sunder Siva Rao[3]

[1]*Asso.Prof., Mechanical Engineering, Sai Spurthi Institute of Technology, Sathupally, India, 507303*
[2]*Asso.Prof., Mechanical Engineering, Andhra University college of Engineering, Visakhapatnam, India,530003*
[3]*Professor, Mechanical Engineering, Andhra University college of Engineering, Visakhapatnam, India,530003*

ABSTRACT

The aim of this study is to investigate the effect of corn biodiesel on engine performance, combustion and emission characteristics of single cylinder, 4-Stroke, direct injection, naturally aspirated, water cooled stationary diesel engine. Experiments were conducted on this at constant RPM with corn biodiesel (Corn Methyl Ester-CME), Petroleum Diesel (PD), B20 (20% CME+80%PD), B40 (40% CME+60%PD). The performance parameters like Brake specific fuel consumption (BSFC), Brake thermal efficiency (BTE), Brake specific energy consumption (BSEC), and Indicated mean effective pressure (IMEP) were evaluated at different engine loads. The cylinder pressure variation, heat release rate and mass fraction of fuel burnt were also studied. Emission characteristics like CO, HC and NO_x *were also investigated and compared all with diesel fuel values. From the test results it was observed that all the characteristics of the engine with CME and its blends are very closer to characteristics of engine with baseline petroleum diesel. BTE,EGT, IMEP decreased and BSFC,BSEC increased with increase in percentage of CME in blend. CO,HC emissions were reduced and* NO_x *was increased withCME.*

KEY WORDS: *Corn biodiesel, diesel engine, blends, Performance, emissions, combustion characteristics.*

INTRODUCTION

The continuous increase in price of crude oil and dangerous threat to environment due to exhaust emissions greatly affects the economical status of developing country like India. Due to this global problem there is a necessity to search for alternative fuel for internal combustion engines. The use of vegetable oil in diesel engine is not new but highly attractive in present scenario. This is because of continuous availability and renewable in nature. Many research works were carried out on the use of vegetable oils [1, 2] in diesel engines. Now due to energy crises, it has been necessity to seek alternate energy sources to conventional energy sources of petroleum based fuels. India being a agriculture based country produces tons of non-edible oils such as Jatropha[3], Linseed, Castor[4], Karanja[5], Neem etc., and edible oils such as Ground nut oil, Coconut oil[6], Mustard seed oil etc. These oils can be used as alternative fuels[7] in CI engines after modifying the fuel structure or properties (viscosity, specific gravity) without any major modifications of the engine[8,9]. There are number of methods to reduce viscosity of oils, among all, Trans esterification is one of the most used method to change the properties of oil nearer to diesel and ultimately to produce biodiesel.

In this study Corn oil Methyl Ester (CME) was prepared by using Trans esterification method [10]. All the performance, combustion, emission characteristic were studied with Petroleum Diesel-PD (B0), CME (B100), blends B20 (20% CME+80%PD by volume), B40 (40% CME+60%PD by volume).

II. PROPERTIES OFFUEL

The comparison of fuel properties of and Petroleum diesel, CME [11], and ASTM standard specifications for bio diesel [12] are given below in *Table 1*, it is observed that the properties of CME fuel are similar to diesel. This indicates that the CME fuel can be utilized in a diesel engine without any modifications and used as alternative fuel by blending. CME is a mixture of Methyl Ester and mainly contains Oleic (C 18:1), Linoleic (C 18:2), Palmitic (C 16:0) and Stearic (C18:0).

Property	**Unit**	**PD**	**CME**	**ASTM Standards.**
density@ $15^{0}C$	g/cc	0.831	0.87	0.87-0.89
Kinematic Viscosity at $40^{0}C$	Cst	2.58	4.26	1.9-6.0
Flash Point	^{O}C	50	158	130 min
Fire Point	^{O}C	56	163	-
Calorific value	kJ/kg	42500	40500	37500
Cetane number	-	48	-	48-70

Table.1: Properties of fuels

III. EXPERIMENTATION, INSTRUMENTATION AND PROCEDURE

Experiments were carried out on stationary water cooled naturally aspirated single cylinder 4-Stroke and direct injection compression ignition (DI-CI) engine at constant speed of 1500rpm. The engine specifications are described below in *Table.2.* Exhaust gas analysis was studied using exhaust gas analyser and details are given in*Table.3.*

Engine make	Kirloskar
Max Power	3.72 kw
Rated Speed	1500 rpm
Bore	80 mm
Stroke	110 mm
Compression Ratio	16.5 : 1
Method of cooling	Water cooled
Loading system	Eddy current dynamometer

Table.2: Engine Test Rig specifications

Exhaust Gas analyser make and model: INDUS make and PEA 205		
	RANGE	RESOLUTION
NO	0-5000 ppm	1 ppm
HC	0-15000 ppm	1 ppm
CO	0-15.0%	0.01%

Table.3: Exhaust gas analyser specifications

Fig.1 shows the image of engine testing and instrumentations with all attachments for measuring various parameters. The engine is tested with baseline petroleum diesel fuel, CME and blends to study performance, combustion and emission characteristics. The engine is allowed to warm up at constant speed of 1500 rpm until all temperatures reach a steady state. An Eddy Current Dynamometer is used to measure the torque or power, engine brake load was varied in four steps at 25% load, 50% load, 75% load, and 100% load (full load). Tech-Ed Bangalore, India, lab view software is used to record the cylinder combustion pressure heat release rate and all other parameters.

Figure.1: Image of engine test rig

IV. RESULTS ANDDISCUSSION

A. PERFORMANCE ANALASYS

The performance of a single cylinder diesel engine was evaluated in terms of Brake Specific Fuel Consumption (BSFC), Brake Thermal Efficiency (BTE), Exhaust Gas

Temperature (EGT), Indicated Mean Effective Pressure (IMEP) and Brake Specific Energy Consumption (BSEC) which were discussed as follows.

(i) BSFC

Fig.2 shows the variation of Brake Specific Fuel Consumption (BSFC) of various blends of Diesel & CME, pure diesel and pure CME as a function of % of full load. BSFC decreases with increase in the engine load. It is observed that BSFC was almost same for all blends, pure diesel and pure CME at 50% load on the engine, but at full load pure CME has slight higher BSFC (14%) than pure diesel.

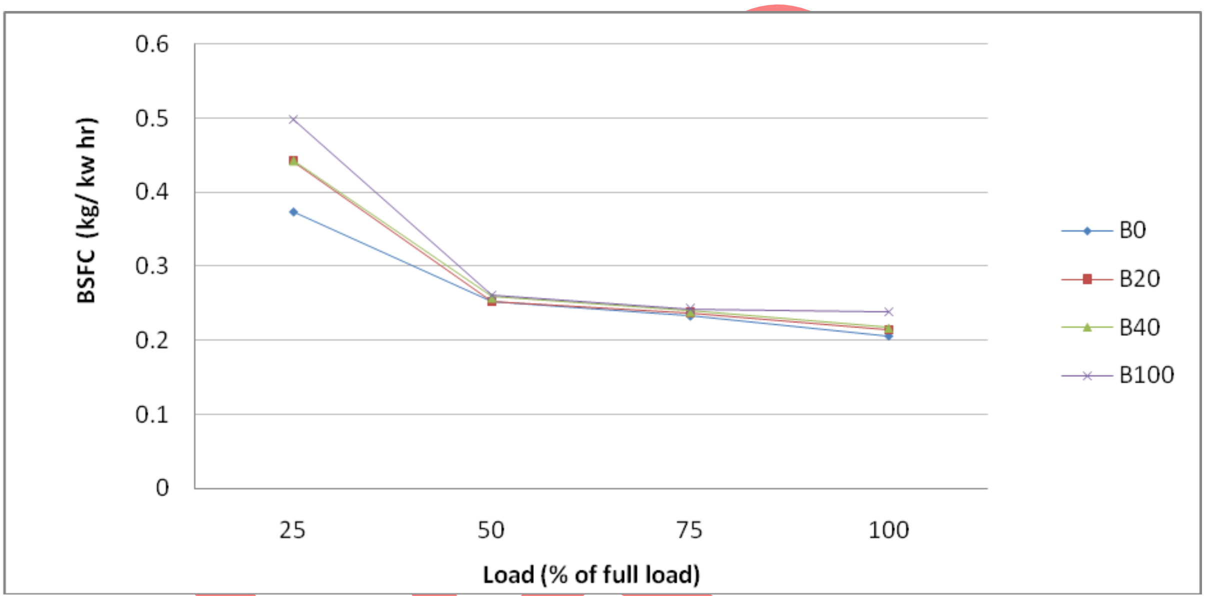

Figure.2: Variation of BSFC with Engine Load

(ii) BTE

BTE calculated for CME and its blends with diesel fuel are shown in *Fig.3*. BTE of B20 was better than B40 and B100. The reduction in viscosity of B20 leads to improved atomization, fuel vaporization and combustion. It may also be due to very close properties of B20 to that of diesel. The efficiency of B20at full load is 36.52%, where as for diesel it is 38.13%.

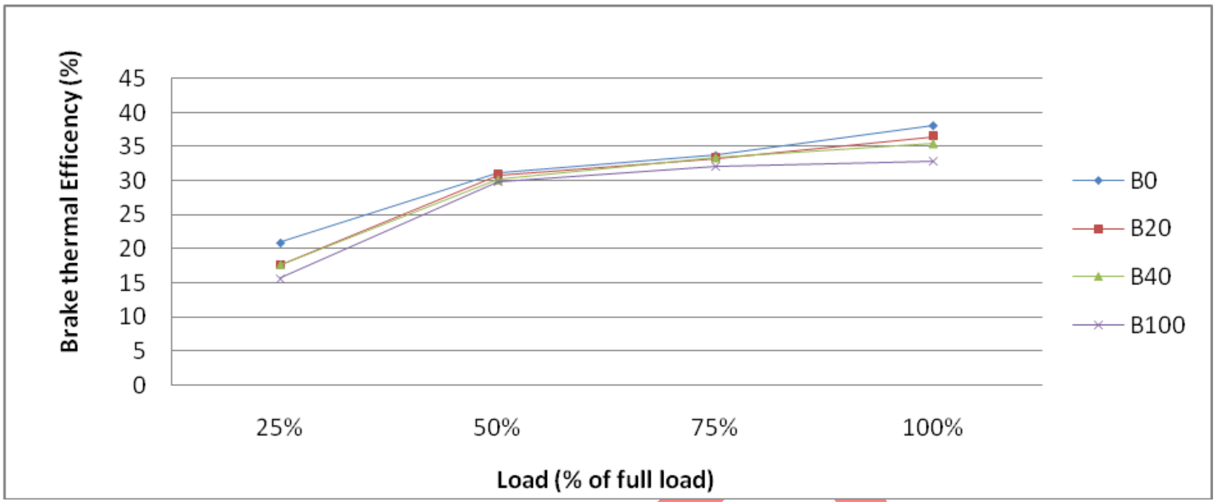

Figure.3: Variation of BTE with Engine Load

(iii) EGT

Fig.4 shows the variation of exhaust gas temperature (EGT) with % of load for CME and its blends with diesel in the Engine. EGT increases with increase of engine load for all blends. The EGT of B100 (Pure CME) had lower value compared to all blends at all loads and is well comparable with diesel. The EGT of B100 is 356^{O}C at full load which is 5.8% less than pure diesel. This may be due to the calorific value of pure diesel is more than that of CME(B100)

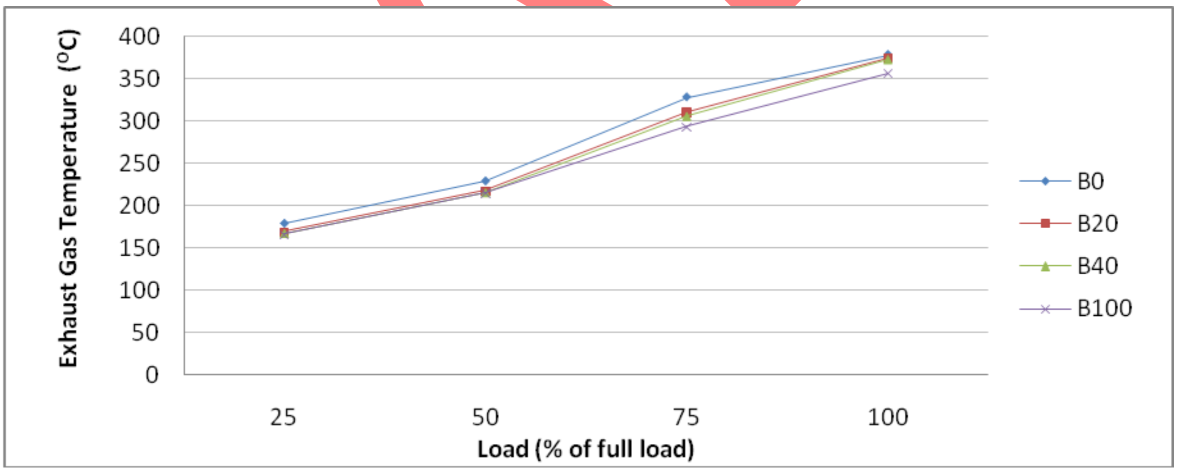

Figure.4: Variation of EGT with Engine Load

(iv) IMEP

Indicated Mean Effective Pressure (IMEP) variation with engine load for CME and its blends in diesel compared with pure diesel are shown in *Fig.5*. IMEP indicates the availability of mean pressure of the gas in engine cylinder for development of brake power. IMEP increases with increase in engine load for CME, its blends and pure diesel. IMEP at fullloadofpurediesel(B0)is8.945barswhichis0.695barshigherthanpureCME(B100).

This may be due to low viscosity of diesel and it leads effective atomization of fuel and better combustion.

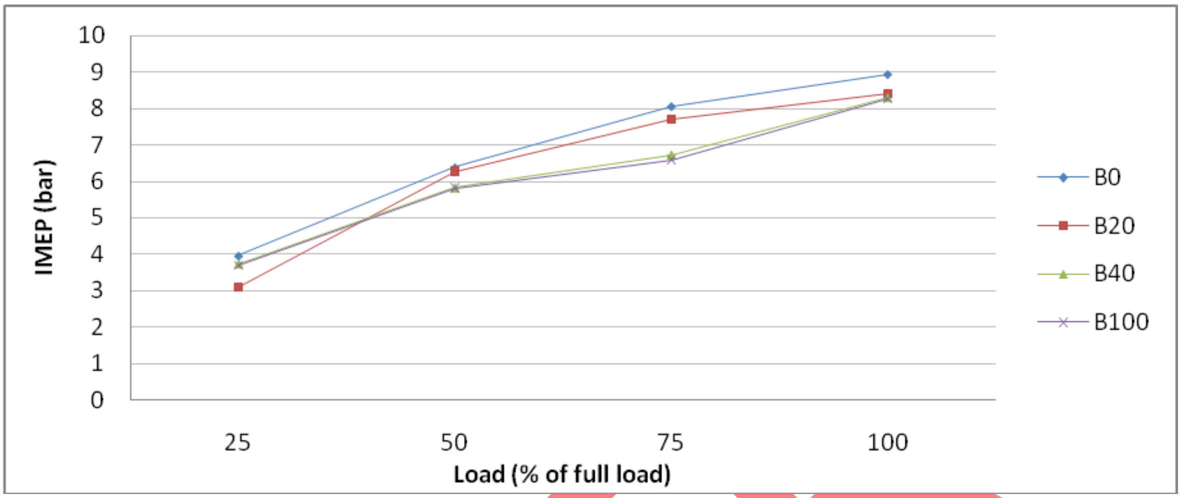

Figure.5: Variation of IMEP with Engine Load

(v) BSEC

Brake Specific Energy Consumption (BSEC) is the input fuel energy required to produce a unit brake power output. *Fig.6* shows the variation of BSEC of CME and its blends compared with pure diesel B0 at different loads on the engine. It is observed that BSEC of CME is higher at all loads of power output compared to diesel. This is presumably due to low value of calorific value and higher value of kinematic viscosity of CME.

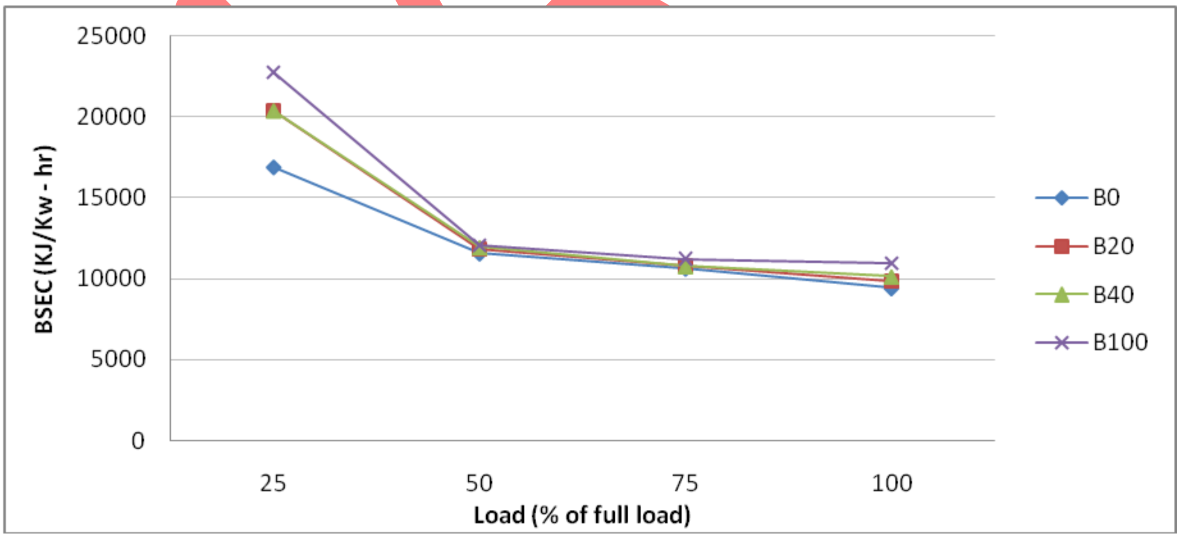

Figure.6: Variation of BSEC with Engine Load

B. COMBUSTION ANALASYS

Combustion analysis was made based on cylinder pressure, net heat release rate and mass fraction burnt at 75% of engine load condition at constant speed at 1500 rpm. The results were discussed asfollows.

(i) CYLINDER PRESSURE

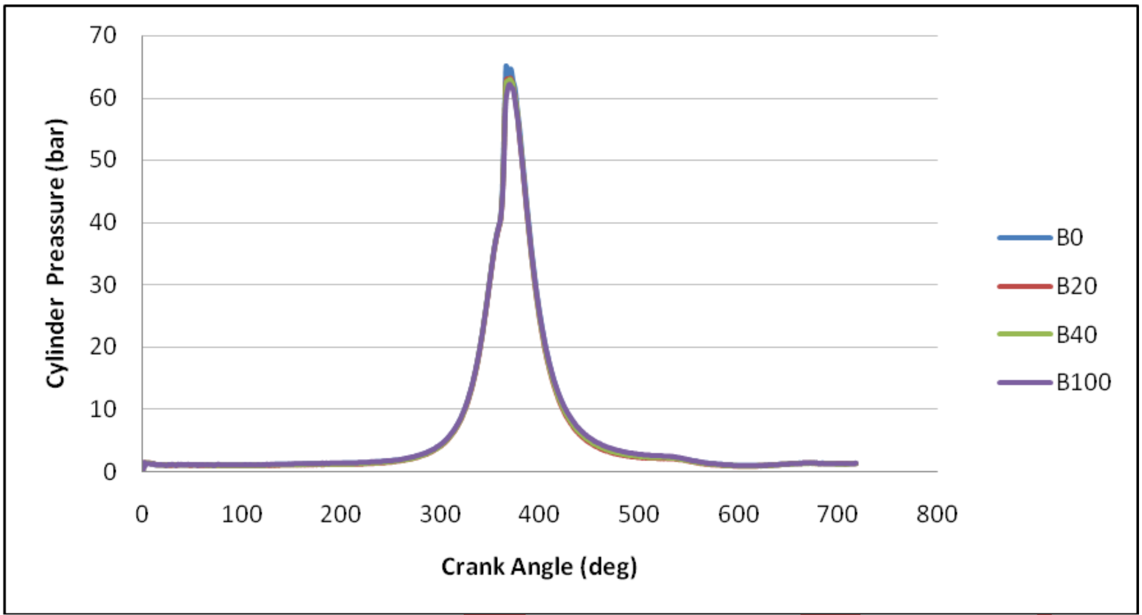

Figure.7: Variation of Cylinder pressure with crank angle at 75% load

Fig.7 shows the variation of cylinder pressure with crank angle at 75% load on the engine for complete cycle for pure CME its blends and diesel. Almost overlapped curves were observed except peak pressure near to TDC. *Fig.8* shows cylinder pressure variation for the crank angle range between 340^{O} to 440^{O}.From the graph it is observed that the peak pressure of pure CME is 62.9 bars which was lower than the Diesel for which peak pressure is 65.1 bar. *Fig.9* show the variation of cylinder peak pressure of various fuel blends with % load on the engine. Peak pressure increases with increase in engineload.

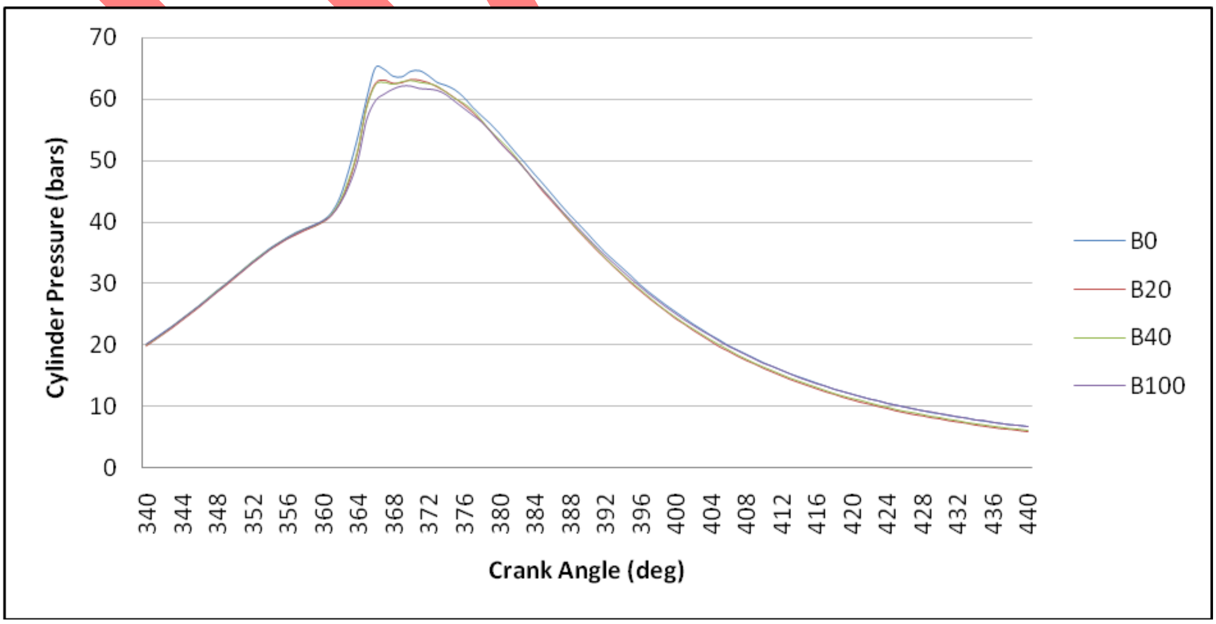

Figure.8: Variation of Cylinder pressure with crank angle nearer to TDC at 75% load

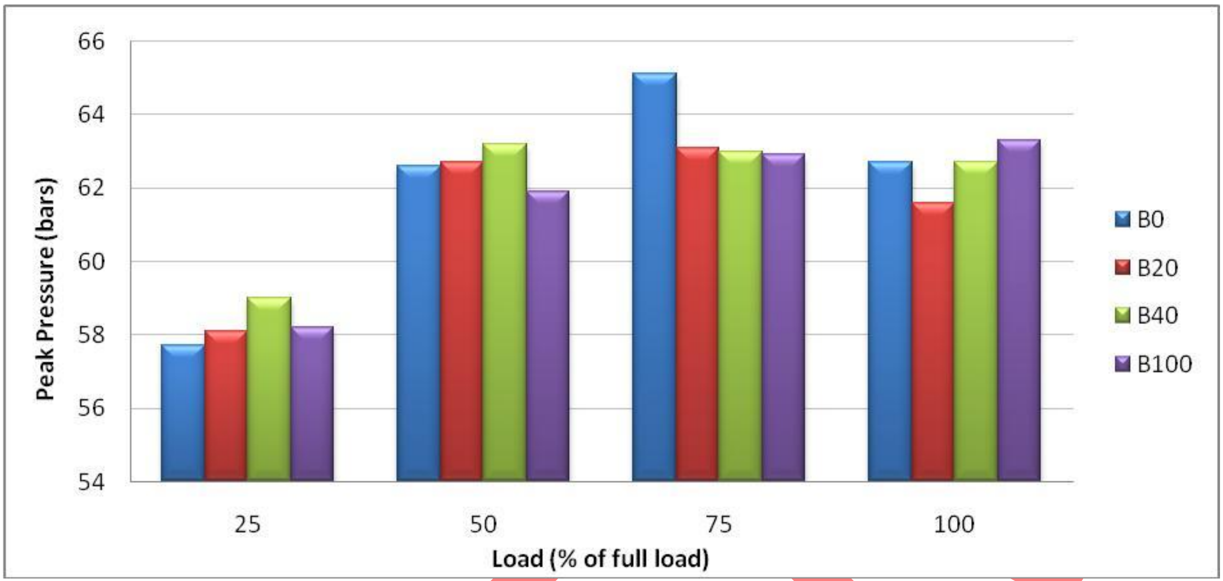

Figure.9: Variation of Peak Pressure with load

(ii) HEAT RELEASERATE

A thorough knowledge of heat release pattern of fuel is very important for cooling system requirement. The comparison of heat release rate, variation of CME and its blends with diesel at 75% of engine load is shown in *Fig.10*. It is observed that the maximum heat release rate of 36.8 J/deg CA is recorded for diesel at 30^{O} ATDC while CME records its maximum heat release rate of 35.16 J/deg CA at 30^{O}ATDC, and *Fig.11* shows the cumulative heat release rate variation with respect to crank angle range from 370^{O} to 440^{O} at 75% engine load. It is observed that the cumulative heat release rate was higher for diesel (B0) than CME (B100). This may be due to higher calorific value and effective combustion of diesel.

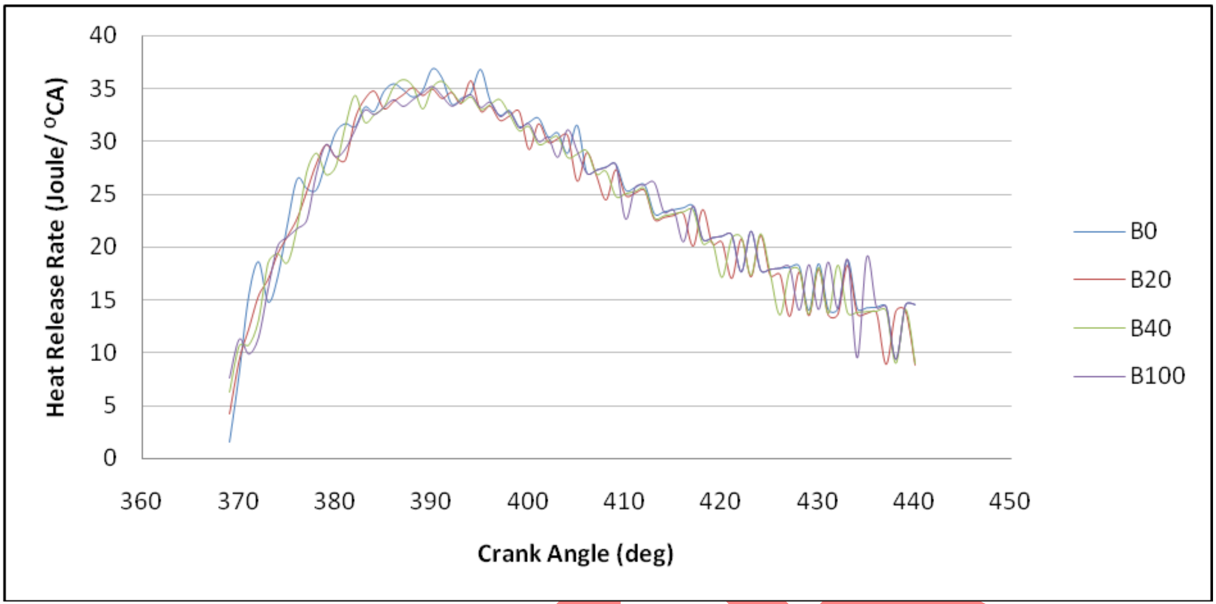

Figure.10: Variation of heat release rate with crank angle at 75% load

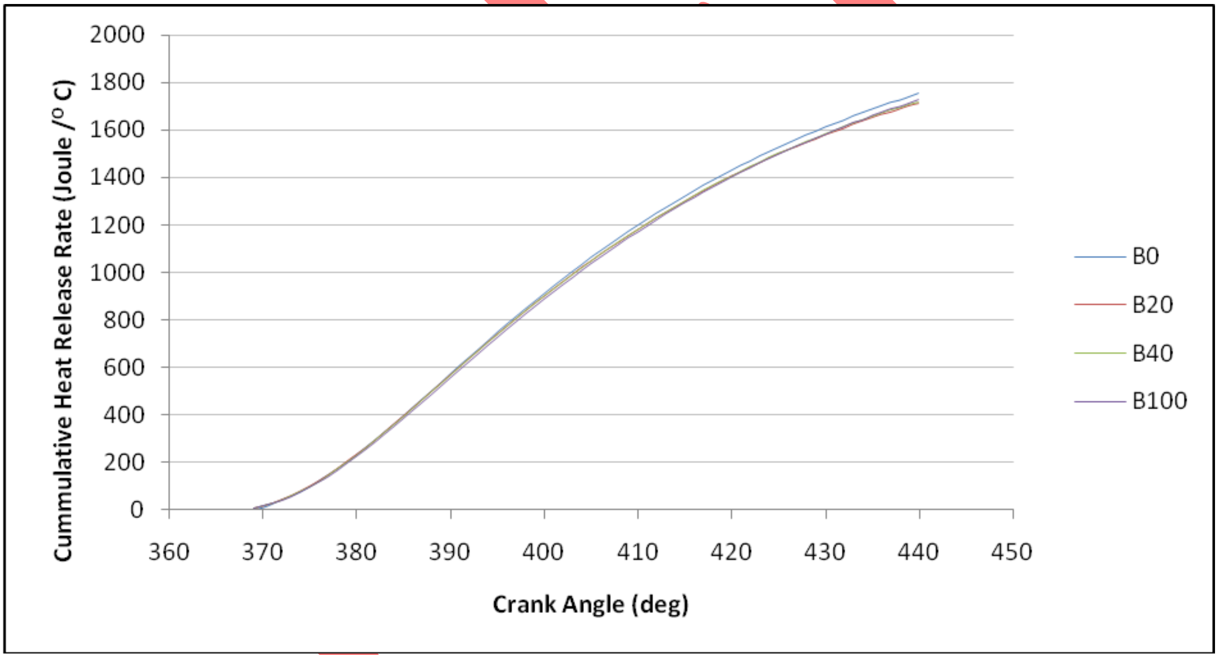

Figure.11: Variation of cumulative heat release rate with crank angle at 75% load

(iii) MASS FRACTION BURNT

Fig.12 shows the rate of mass fraction burnt with respect to crank angle at 75% of engine load for CME and its blends compared with diesel. It is observed that the process of burning is initiated at 10^O BTDC and is completed at 38^O ATDC. The length of the burning process was same for all fuel blends but burning rates were slightly different. Though the burning was initiated at 10^O BTDC but rapid increase in burning rate was observed immediately after TDC only.

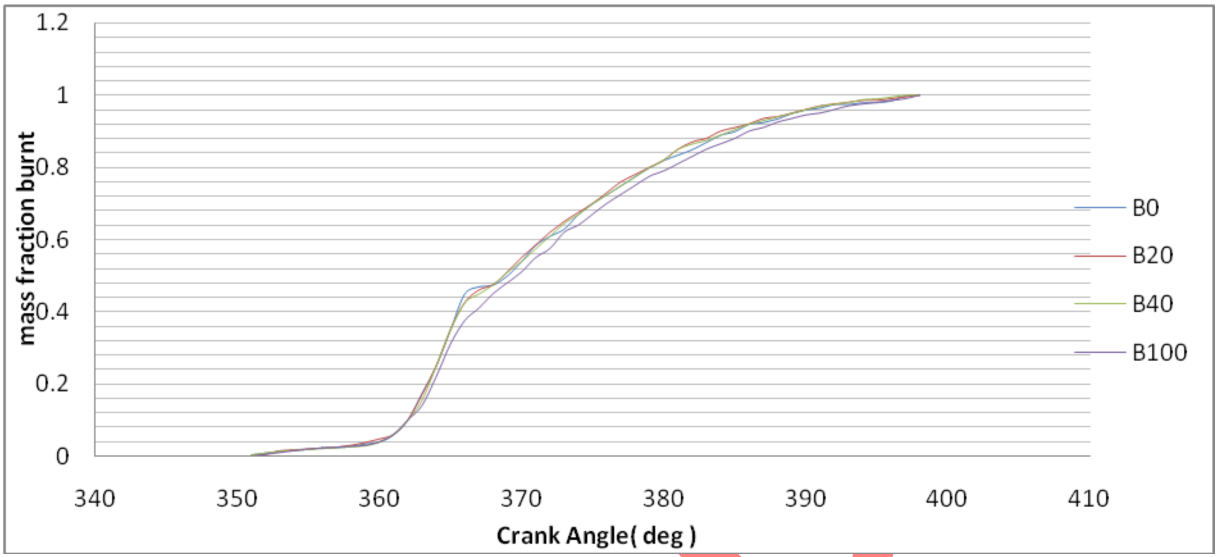

Figure.12: Variation of mass fraction burnt with crank angle at 75% load

C. EMISSIONANALASYS

Exhaust gas emission was analysed based on variation of HC (ppm), NO_X(ppm) and CO (%) with respect to % load on the engine.

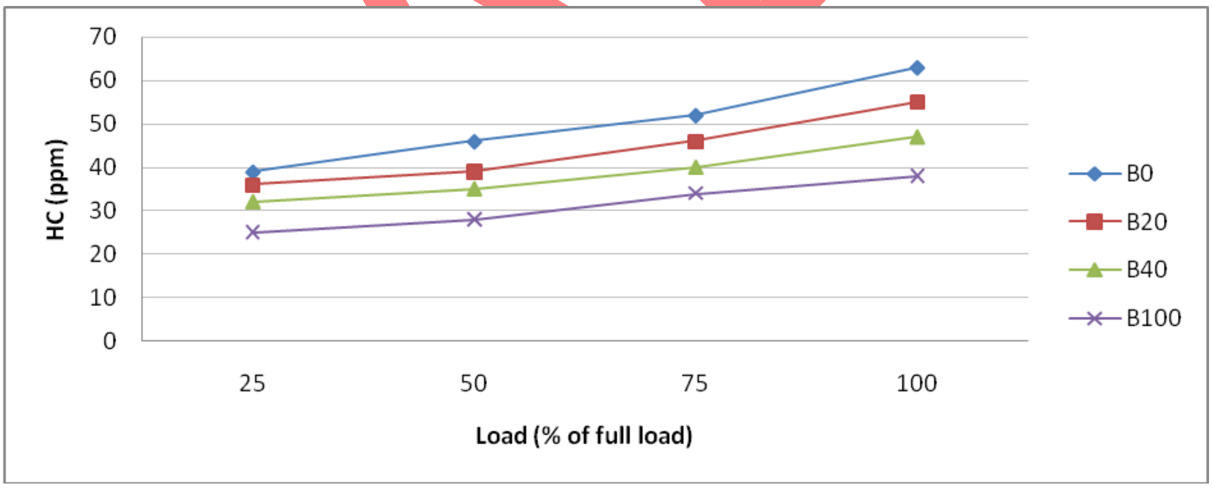

Figure.13: Variation of HC emissions with Engine load

The variation of hydro carbon emission with % of engine load is shown in *Fig.13*. The addition of CME in diesel decreases the HC emission when compared with pure diesel. The use of oxygenated fuel (CME) promotes complete combustion, is the cause for hydro carbon emission reduction. But, HC emission increases with load.

Fig.14 shows the variation of carbon monoxide emission with % of engine load. The CO emission increases with increase in engine load. But, it is observed that addition of CME in diesel decreases the CO at constant load.

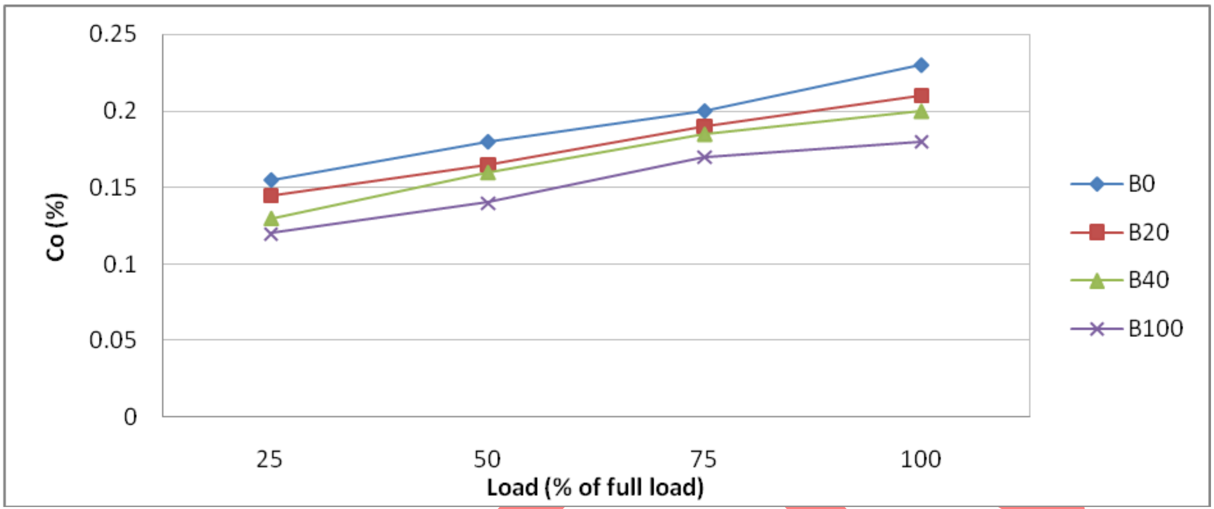

Figure.14: Variation of CO emissions with Engine load

The variation of Oxides of Nitrogen with respect to engine load is shown in the *Fig. 15*. The NO_X emission is lower for pure diesel when compared with pure CME and its blends with diesel.

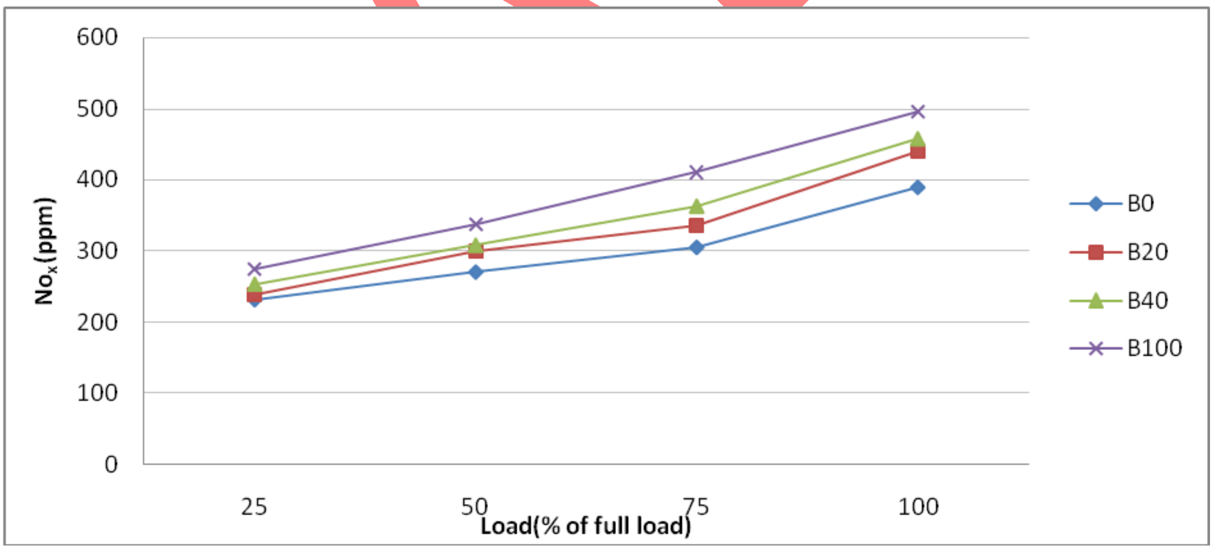

Figure.15: Variation of NO_X emissions with Engine load

V. CONCLUSIONS

The performance, combustion, and emission characteristics of 3.72 kW DI-CI engine fuelled with CME and its blends have been analysed and compared to baseline diesel fuel. The results of present work are summarised asfollow.

- The BSFC and BSEC increases with increase in % of CME in the blend due to lower calorific value ofCME.
- The BTE decreases with increase in % of CME in itsblends.
- EGT, IMEP decreases with % of CME in theblend.
- Higher oxygen content in the CME diesel blend as compared to pure diesel results in better and complete combustion. This leads to decrease in CO, HC and increase in$NO_{X.}$
- The engine develops maximum rate of pressure rise and maximum heat release rate for diesel compared to CME and itsblends.
- The CME satisfies the important fuel properties like Kinematic Viscosity, Calorific value and Flash point as per ASTM specification of biodiesel and obtained significant performance, combustion and emissioncharacteristics.

VI. ACKNOWLEDGEMENTS

Authors thank the management of Sai Spurthi Institute of Technology, Sathupalli for providing the necessary experimental setup to perform this research.

VII. REFERENCES

[1] Rakopoulos CD , Antonopouls KA, Rakopoulos DC, Hountalas DT, Giakournis EG. "*Comparative Performance and emission study of DI diesel engine with vegetable oil*", Energy Conserve Manage 2006:47:3272-87.

[2] Bueno AV velasquez JA, Milanez LF. "*Heat Release and engine Performance effect of soyabean oil ethyl ester blending into diesel engine*" in proceedings of 22nd International Conference on ECOS 2009, Brazil Aug 31- Sep 3 2009P2009-18.

[3] Amba Prasad rao, P.Rama Mohan "*Performance evaluation of DI and IDI engines with jatropha oil based bio diesel*" Journal of the institutions of engines (INDIA), Vol 86 july2005

[4] N.L Panwar Hemant Y shrirame , NS Rathore, Sudhakar Jindal and A.K Kurchania "*Performance evaluation of a diesel engine fuelled with methyl ester of castor seed oil*" Appled thermal Engg,30,245-249,2010

[5] Rehman H, A.G Phadatare "*Diesel Engine emission and performance from blends of karanja methyl ester and Diesel*" Biomass and Bioenergy vol27,pp:393-297,2004.

[6] Shaheed A and Swain E "*Performance and exhaust emission evaluation of a small diesel engine fuelled with coconut oil methyl ester*". SAE paper981156,1998

[7] Kowalewicy And Wojtyniak M, 2005 "*Alternative fuels and their application to combustion engines*" , journal of Automobile Engineering. 219(1);103-125

[8] Recep Altin Selim Cetinkaya, Huseyin, Serdar, Yecesu " *The Potential of using vegetable oil fuels as fuel for diesel engines*" Energy Conversion And Management, 42, 529-538,2001

[9] Arjun B Chhetri, Martin S Tango, Suzanne M Budge, K.Cheris, Watts and M.Rafiqul Islam "*Non Edible plant oils as new sources for Bio Diesel production, International Journal of Molecular Sciences* " ISSN 1422-0067,8,169-180,2009

[10] A.P Sathiyagnanam and C.G Saravanan "*Experimental Studies on combustion and performance of .ADI engine fuelled with biodiesel*", proceedings of the world congress on engineering 2011 Vol III, ISSN:2078-0958.

[11] Mariceli Da Silva Machadoand Virginia Colimbra zuvanov "*Themo physical properties of bio diesel obtained from vegetable oils, corn, soy, canola and sunflower*" centro cientific conhecer – Goiania, V 8, N.14, pg917-926,2012

[12] *ASTM American Society for Testing and Materials (2002) standard specification for biodiesel fuel (B100) blend stock for distillate fuels*, designation D6751-02, ASTMInter.