Effect of Fuel Injection Pressure on the Engine Performance Characteristics of Direct Injection Single Cylinder Engine operate with Argemone biodiesel

[1] Avinash.Shabadi, [2] Dr.C.H.Biradar
[1] M-TECH PG Studies ,Thermal Power Engineering,[2] HOD,Dept of Automobile Engineering Poojya Doddappa Appa College Of Engineering, Kalburgi, Karnataka, India.

Abstract— *In the present work, the effect of FIPs on engine performance characteristics of a Argemone biodiesel-diesel fuelled 4S, direct injection, single cylinder engine with a constant speed (1500rpm) was considered. The experimental test were conducted for three different FIPs (180, 200 and 220bar) and varying loads. Blend B10 showed highest BTE of 27.21% at 220bar FIPs. Argemone oil was tested for FTIR. The frequency range and wave number of dominant peak were obtained from absorption spectra, various functional groups like carboxylic acid, alkanes, ester, amines and mono substituted aromatic compounds were identified.*

Keywords: Argemone biodiesel, Two-step transesterification, Varying injection pressure, FTIR analysis, Performance characteristic.

I. INTRODUCTION

A diesel fuelled engines are broadly used dominating high power sources for transportation due to higher efficiency, operational accuracy, durability, low operating cost, lower exhaust emissions such as UHC, CO and CO_2 emissions. Total oil consumption of our country is 2.5-2.8 million barrels/day. The demand of fossil fuel will rise day by day with every passing decade and is anticipated to reach nearly 250 million tons by the year 2024 [1]. Biodiesel is treated clean fuel since it has almost no aromatic, no sulphur and has about inbuilt oxygen concentration which helps it to burn fully. Biodiesel properties mainly depend on the soil type, climate conditions, plant growing, type of plant feed stock, plant maturity. These parameters affect the physico-chemical properties of the biodiesel [2]. Trans-esterified biodiesel fuel has very stringent potential in CI engines, hence has many as countries uses the varieties of edible and non-edible oils such as soyabean, palm, pongamia pinnata, jatropa and argemone biodiesel to produce the power out from CI-engine [3].

Previous to transesterification, oils were usually extracted from oil seeds through different methods such as soxhlet apparatus, mechanical expeller, solvent extraction, aqueous enzymatic oil extraction, ultrasonic extraction, stirring and shaking extraction [4]. Methanol is used for biodiesel production due to its shorter chain, low cost, more polar nature.

The engine performance and emission parameters of diesel fuelled engine mainly depends on several factors such as combustion chamber geometry, fuel injection pressure, injection timing, injection nozzle diameter, air-swirl, spray pattern and compression ratio etc.

The standard FIPs in diesel engine in the order of 200-1700atm it's mainly depending on type of combustion and engine geometry. When the FIPs is increased fuel particle diameters will become small. The mixing of fuel-air becomes improved during ignition delay period which causes low CO and smoke emissions. But, if the FIPs is too high ignition delay becomes shorter. So, possibilities of homogeneous mixture decreases and combustion efficiency falls down [5].

When FIPs is low, diameters of fuel particle increases and ignition delay period during the combustion will increases. This may leads to incomplete combustion in the engine chamber and causes the increase in CO and NO_x emissions.

Mexican prickly poppy (Argemone mexicana) is a family of papaveraceae family. It is a biennial plant and growing up to a height of 1500mm. The seeds are brownish black and about 1mm in diameter. Its seeds are enclosed in a egg shaped capsules and around 400 seeds can be produced in one capsule

1.1.Literature reviews

P.Somasekar et al [6] in his study on effect of injection pressure on emission and performance characteristics of DI diesel engine fuelled with mango seed oil methyl ester at three different FIPs at constant speed engine. Their results reveal that, BTE increases for B20 blend at 230bar FIPs. Study also reported that exhaust emissions reduces for MSME/diesel blends.

Avinash kumar et al [7] in his study on effect of injection timing and injection pressure on combustion, emission and performance characteristics of CRDI engine fuelled with karanja biodiesel blends at varying FIPs. Their results illustrate that BTE improves slightly for KB10 blend. Also, exhaust emissions reduces for KB20 blend.

II. MATERIALS AND METHODS

2.1 Materials used

The Argemone Mexicana seeds were collected from both agricultural and waste fields in vijaypur, Karnataka, India. Methanol, propanol, phenolphthalein indicator, H_2So_4, NaoH were purchased from ''Shree venkatesh scientific system'' store, Kalburgi, Karnataka, India.

2.1.2 Oil extraction

A mechanical press oil extraction is the most regular technique. Argemone seeds were dried in the sun for about 5days. A motor drive screw press can be used to extract oil from Argemone seeds. A motor driven screw press can extract 68-80% of the oil. The oil extracted by mechanical presses needs further treatment of filtration and degumming in order to produce pure Argemone crude oil.

2.1.3 Two-step transesterification

The technique to produce biodiesel from Argemone oil is two step transeterification due to its very high acid value. For esterification, crude Argemone oil was mixed with sulphuric acid and was taken into a 3-necked flask filled with water cooled condenser and stirred mechanically by magnetic stirrer at 200rpm at 60°c for 3hr for esterification. After completion of esterification process, two layers were separated within 1hr. The bottom layer was discarded. The neutral oil was then mixed with sodium hydroxide and methanol and stirred mechanically at 200rpm at 50°c for 4hr. After transesterification, oil was separated from glycerine layer by separating funnel and washed with hot distilled water 5-6 times to remove some unreacted residues such as alcohol, catalyst and some impurities. Even after washing oil was heated around 30min at 110°c in order to remove water particles from the prepared biodiesel. The obtained pure Argemone biodiesel was added to neat diesel fuel volumetrically to obtain B10, B20, B30, B40, B100 and B00 blends.

2.2. Biodiesel analysis

2.2.1 Fourier transform infra-Red spectroscopy (FTIR)

FTIR spectrum was used to identify the functional group of the active components based on peak value in the region of infra red radiation. The results of FTIR peak values and functional groups were represented in Table.1 and FTIR spectrum profile is illustrated in the fig.1.

The peaks at value 2923 and 2853 predicts the long chain of alkanes, with added functional groups of COOH, O-H. However, these are few C=O groups found at peak 1743 and C=N at peak value of 1161. The value of 721 clearly states the aromatic structure with multiple bonds which states a glycine backbone for the long chain.

The intense bands occurring at 2923.24 cm-1, 2853.81 cm-1, 1743.45 cm-1, 1461.24 cm-1, 1161.84 cm-1 and 721.47 cm-1 corresponding to O-H str / C-H/ C=O/ C-H/ N-H/ C-H. This confirms the presence of functional groups in Argemone oil like , carboxylic acid, alkanes, esters, amines and mono substituted aromatic compounds etc in Argemone crude oil. The peaks after 1500cm-1 depicts long chain fatty acid presence with glycine moiety.

There is no absorption in between the region 2220-2260 cm-1 indicates that there is no cyanide groups in Argemone oil sample and it does not contain any toxic substances [8]. A carboxylic acid presents in Argemone oil is responsible for treatment of disease like headache, Fever, joint pain, jaundice, wound and lever pain [9].

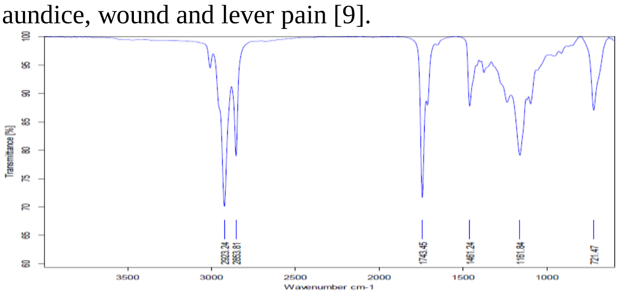


Fig.1. FTIR spectra of Argemone Mexican crude oil

Frequency range	Functional group	Bond type	Type of vibration
2923.24	Alkane	C-H	Stretch
2853.81	Alkane	C-H	Stretch
1743.45	Carbonyl	C=O	Stretch
1461.24	Alkane	C-H	Bending
1161.84	Amines	C-N	Stretch
721.47	Alkene	=C-H	Bending

2.3 Fuel blends

In the present investigation following fuel blends were analyzed.

1. B10- 10% Argemone biodiesel with 90% diesel.
2. B20- 20% Argemone biodiesel with 80% diesel.
3. B30- 30% Argemone biodiesel with 70% diesel.
4. B40- 40% Argemone biodiesel with 60% diesel.
5. B100- 100% pure Argemone biodiesel.
6. B00- 100% neat diesel.

2.4 Thermo-Physical properties

Table.2 represents the physico-chemical properties of Argemone biodiesel and diesel blends (B10, B20, B30, B40, B100 and B00) based on ASTM standards. The fuel properties like density, viscosity, flash point, fire point increased for all prepared test fuel blends than diesel. The C.V of Argemone biodiesel blends higher than pure biodiesel (B100). Due to its higher oxygen concentration.

Table .2 Physical properties of Argemone biodiesel and diesel blends.

Properties	unit	B10	B20	B30	B40	B100	DIESEL	CRUDE OIL
Density	kg/m^3	839	844	850	856	886	808	921
Viscosity	cst	2.97	3.22	3.30	3.40	5.07	2.63	35
Flash point	°c	75	83	95	102	130	65	--
Fire point	°c	78	87	105	110	138	68	--
Calorific value	Mj/kg	42.3	41.36	40.56	39.66	39.41	43	--

2.5 Experimental setup

Experiments were carried out at engine test laboratory of “Apex lab pvt lmtd”, sangli. Test were conducted on single cylinder, 4-stroke, water cooled, direct injection, compression ignition engine. The detailed specification of the engine are shown in Table.3.

Table .3 Engine specification

Make and model	Kirloskar
No. of cylinders	One
Bore	87.5 mm
Stroke	110 mm
Swept volume	661 cm^3
Clearance volume	36.87 cm^3
Compression ratio	17.5:1
Rated output	5.2 kW :7 HP
Rated speed	1500 rpm
Injection system	Direct injection
Injection pressure	20-21Mpa
Fuel injection timing	23° (BTDC)
Fuel injection duration	20-30° CA BTDC
Valve timing	
Intake valve opening (BTDC)	4.5°
Intake valve closing (ABDC)	35.5°
Exhaust valve opening (BBDC)	35.5°
Exhaust valve closing (ATDC)	4.5°

2.6 Experimental procedure

Before starting the engine, leakage of fuel, lubrication and water supply must be analyzed. The FIPs can be increased or decreased by rotating the screw in cw/ccw-direction respectively. Located on top of the injector and one complete rotation of screw in cw-direction increases the FIPs by 40bar. Initially, the engine was run at zero (no-load) load condition and at constant speed (1500rpm). Then test were performed at three different FIPs (180, 200 and 220bar) and varying loads (0%, 25%, 50% and 75%) with different blends of Argemone biodiesel with neat diesel (B10, B20, B30, B40, B100 and B00). After initial warm up of engine for more than 25min, when engine exhaust gas temperature were stabilized. The engine was run at different FIPs and the readings were taken after study temperature was reached. For each load engine was allowed to operate for about 10min and last 4min were used for data recording purpose.

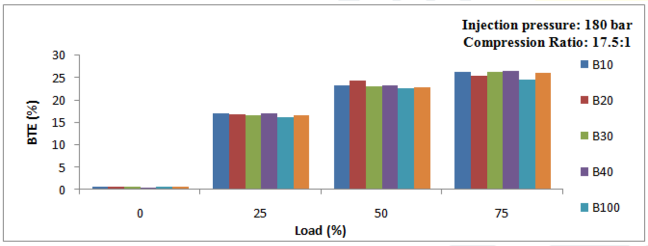
III. Results and Discussion

Engine test were calibrated at different engine load (0%, 25%, 50% and 75%) with corresponding fuel injection pressures of 180, 200 and 220 bar respectively. Argemone biodiesel were used as a fuel for compression ignition engine without any engine modification. The performance characteristics of the engine with six different blends (B10, B20, B30, B40, B100 and B00) are presented and discussed.

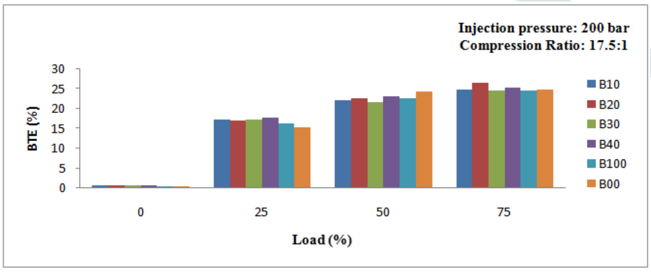
3.1. Performance characteristics

The performance parameters like brake thermal efficiency and break specific fuel consumption obtained with B10, B20, B30, B40, B100 and neat diesel at different engine load (0%, 25%, 50% and 75%) at three different FIPs (180, 200 and 220 bar) respectively. They are discussed as fallows.

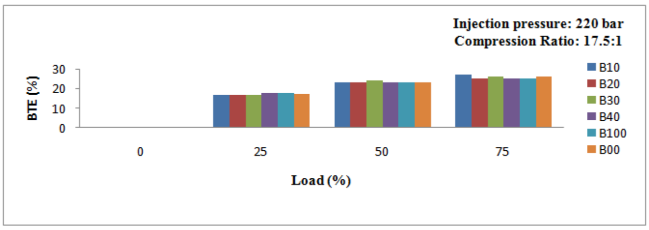
3.1.1 Brake thermal efficiency



(a)



(b)



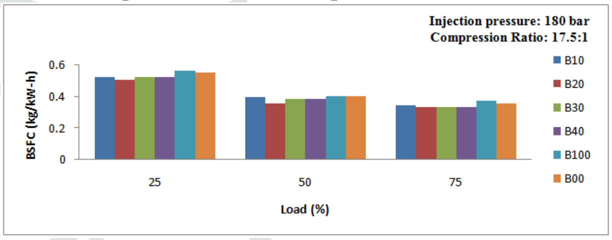
(c)

Fig.1 Variation of BTE with respect to engine load (a,b,c)

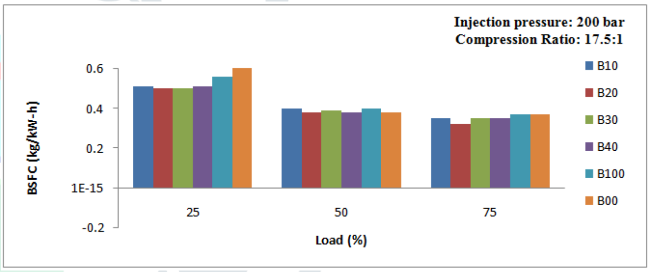
Figure 1[a-c] compare the BTE of different fuel blends at 0%, 25%, 50% and 75% load as depicted in figures. The BTE increases for lower biodiesel blend. As the biodiesel percentage (%) increase in blend, BTE decreases due to a increase in fuel consumption. At 180bar and full load, the BTE of B100 was 24.55% lower than diesel, while for B10, B30 and B40 were only 26.27, 26.25, and 26.55% higher, than neat diesel. This may be due to poor atomization of biodiesel blend because of higher density and viscosity. Furthermore, Brake thermal efficiency of biodiesel (B100) is lower than neat diesel because of higher viscosity, density and lower heating value of the fuel [10]. The highest BTE, 24.81, 26.50 and 25.34% observed for B10, B20 and B40 at 200bar FIPs at 75% load. The increase in injection pressure, injection timing and right atomization results in increase in brake thermal efficiency [11].

The BTE for B10 (27.21%) blend was maximum than that of all prepared test fuel blends at 220bar FIPs at 75% load due to its higher oxygen concentration in the biodiesel blend. This value indicates that increase in engine power output and decreases in heat loss with maximum load conditions. However, the lower BTE obtained for pure biodiesel due to the increase in fuel consumption and lower in calorific value.

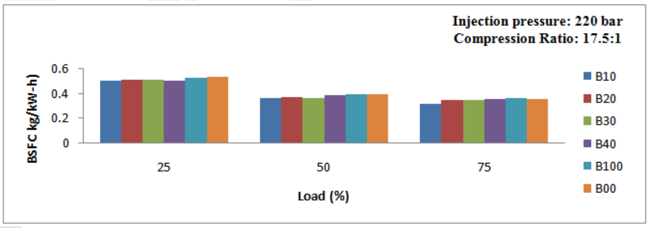
3.1.2 Brake specific fuel consumption



(a)



(b)



(c)

Fig.2 Variation of BSFC with respect to engine load (a,b,c)

Figure 2[a-c] compare the BSFC of different fuel blends at 0%, 25%, 50% and 75% load as depicted in figures. The BSFC decreases with respect to engine load due to its higher output power per unit fuel consumption. According to recent literature [13] found many reasons for higher BSFC is higher density, viscosity, and lower heating values of biodiesel compared to neat diesel. Furthermore, the injection pressure plays a dominant factor which leads to increase in BSFC.

The BSFC was decreases with increase in engine load. From fig.2(a-c), the BSFC for B10, B20, B30, B40 and neat diesel value was lower because of higher oxygen content in the biodiesel blend they lead to decrease in the fuel consumption and better combustion characteristics. At 220bar FIPs, the mean BSFC for B10, B20, B30, B40,B100 and diesel were found to be 0.31, 0.34, 0.34, 0.35, 0.36, and 0.35kg/kW-h respectively, as compared with 0.35, 0.32, 0.35, 0.35, 0.37 and 0.37kg/kW-h at 200bar injection pressure. It is observed

that BSFC is highest for B100 and lowest for diesel. This is due to low volatility, high viscosity, lower C.V and density of pure biodiesel (B100) when compared with that of diesel.
1)

CONCLUSION

The fallowing conclusions are drawn from the present work:
1. A two-step transesterification process the fuel properties are closer to ASTM standard.
2. A comparison of fuel properties of argemone biodiesel and diesel fuel indicated that argemone biodiesel and diesel fuel blends are quite similar in nature to diesel fuel. However, viscosity and density were higher and C.V were lower for pure biodiesel (B100).
3. The BTE of the engine for argemone biodiesel blends (B10, B20 and B30) is high compared to neat diesel at three different fuel injection pressure (180, 200 and 220bar).
4. BSFC were slightly higher in case of pure biodiesel (B100) compared to neat diesel. It increased from 0.37% with B100 to 0.35% with neat diesel at all FIPs.

REFERENCES

[1] Srinath Pai, Abhishek Rao, Dr. Abdul Sharief, Dr. Shiva Kumar, Dr. Shreeprakash B, "A comparative study of injection pressure impact on performance and emission of a diesel engine fuelled wioth neat diesel and Jathropa biodiesel blends". Advances in Mechanical Engineering Science, ISSN: 2231-5381.
[2] K.V.Yatish, H.S. Lalithamba, R.Suresh & B.R. Omkaresh, "Synthesis of biodiesel from Garcinia gummi-gutta, Terminalia belerica and Aegle marmelos seed oil and investigation of fuel properties". Biofuels, 2016.
[3] Mahantesh.S. Shivasimpi, Nagaraj R. Banapurmath, S.A. Alur, "Effect of Injection parameters: Injection timing and Injection pressure on the performance, emission and combustion characteristics of CRDI Diesel engine operate with Palm oil methyl ester (POME). European Journal of Sustainable Development Research, 2019, 3(3), em0091.
[4] T.F. Adepoju, B. E. Olatunbosun, O.M. Olatunji, and M.A. Ibeh, "Brette Pearl Spar Mable (BPSM): a potential recoverable catalyst as a renewable source of biodiesel from Thevetia Peruviana seed oil for the benefit of sustainable development in West Africa". Energy, Sustainability and Society (2018) 8:23.
[5] M L S Devakumar, M venakata Ramudu and K Vijaya Kumar Reddy, "Effect of injection pressure on the performance and emission characteristics of DI Diesel engine running on Nelli oil and Diesel fuel blend". International Journal of Mechanical Engineering and Robotics Research, Volume 3, No.1, January 2014.
[6] P.Somasekar Babu, V.Pandurangadu "Effect of injection pressure on engine performance and emission characteristics of diesel engine using Mango Seed oil methyl ester" ISSN: 2393-8374, 2394-0697, volume-5, 2, 2018.
[7] Avinash Kumar Agarwal, Atul Dhar, Jai Gopal Gupta, 6 Woong Il Kim, Kibong Choi, Chang Sik Lee, Sungwook Park " Effect of fuel injection pressure and injection 1 timing of Karanja biodiesel blends on fuel 2 spray, engine performance, emissions and 3 combustion characteristics".
[8] Lethika D Nair, Santhosh K Sar, Arun Arora, Deepak Mahapatra, "Fourier Transform Infrared Spectroscopy Analysis of Few Medicinal Plants of Chhattisgarh, India". Journal of Advanced Pharmacy Education & Research. July-September 2013, Volume 3, Issue 3.

[9] A.K.Agarwal, L.M.Das, "Biodiesel development and characterization for use as a fuel in compression ignition engines". Transactions of the ASME, Voume 123, April 2001: 440-447.
[10] Sehmus Altun, Husamettin Bulut, Cengiz Oner, "The comparison of engine performance and exhaust emission characteristics of sesame oil-diesel fuel mixture with diesel fuel in a direct injection diesel engine". Renewable Energy 33 (2008): 1791-1795.
[11] G.R.kannan, R.Anand, "Effect of injection pressure and injection timing on DI diesel engine fueled with biodiesel from waste cooking oil". Biomass and Bioenergy 46 (2012): 343-352.
[12] Mithun Das, "Performance and emission Characteristics of biodiesel-diesel blend". Encyclopedia of Renewable and sustainable Materials.
[13] P.K.Sahoo, L.M.Das, M.K.G.Babu, S.N.Naik, "Biodiesel development from high acid value Polanga seed oil and performance evaluation in a CI engine". Fuel 86 (2007): 448-454.
[14] Bhupendra Singh Chauhan, Naveen Kumar, Haeng Muk Cho, "A study on the performance and emission of a diesel engine fueled with Jatropha biodiesel oil and its blends". Energy 37 (2012): 616-622.
[15] Ekrem Buyukkaya, "Effects of biodiesel on a DI diesel engine performance, emission and combustion characteristics". Fuel 89 (2010): 3099-3105.