Effect of Cotton seed oil in Diesel Engine Performance Emission and Combustion Characteristics

Radha Krishna Gopidesi, V Ram Kishore Reddy, V Sai Sandeep Kumar, T Vishnu Vardhan, V Jeevan Reddy

Abstract: ***In the present situation, the stipulate for energy is escalating according to the growth of population and industrial development. Here, diesel engines are contributing more in power generation due to its reliable and energy efficient phenomenon. However, continuous diminishing of diesel fuel and environmental scenario researchers are trying to find alternative energy sources like biodiesel. In present investigation used the Cotton-seed oil has opted as biodiesel in various blends B5, B10, and B15. The increasing of cotton seed oil in the blend showed an increase of NO_X emissions when compared with the pure diesel operation. Here, observed the higher NO_X emission for B15 when compared to the other fuel samples. The HC emissions were reduced with the increase of cotton seed oil percentage. The blend 10 showed lower CO_2 emissions than the other samples. The peak cylinder pressure 68.2 bar was obtained at 366°crank angle of B10 and a higher heat release rate was found for B5 at 368°crank angle.***

Keywords: cottonseed, combustion, emission, performance

I. INTRODUCTION

Energy is a crucial input for the development of any source. The consumption of energy is increased during the last two decades due to industrial growth [1]. Diesel engine plays a essential role in the transportation sector due to high power to fuel ratio [2]. However, it contributes to major environmental pollutants like NO_X, HC, CO, and smoke. To reduce the pollutants diesel is replaced by biodiesel [3]. Here vegetable oil is preferred as biodiesel because of its renewable nature and quickly prepared. Vegetable oils like cottonseed oil, corn oil, soya bean oil, Karanja oil, jatropha oil, sunflower oil, etc. The choice of vegetable oils also depends on local conditions and availability. The consumption of fossil fuels leads to the increase of greenhouse gases in the environment [4]. Due to this problem alternative of fossil fuels is chosen, i.e. biodiesel. Biodiesel can be used as fuel in diesel engines [5]. Diesel engine plays a vital role in the transportation sector due to high power to fuel ratio. However, it contributes to major environmental pollutants like NO_X, HC, CO, and smoke. To reduce the pollutants diesel is replaced by biodiesel. Here vegetable oil is preferred as biodiesel because of its renewable nature and quickly prepared. Nitin et al. [6] worked on the preparation of cotton seed oil biodiesel and its effect on the diesel engine. They observed a higher efficiency for B20 and fewer emissions. Duple Sinha et al. [7] investigated the various low-cost catalyst for biodiesel production. The blends of biodiesel showed a diminution of CO and HC emissions and a slight increase in NO_X emissions. Nurun Nabi et al. [8] investigated the diesel engine performance and emission characteristics when fuelled with the cotton seed oil. From that, they found lower thermal efficiency for biodiesel mixtures compared to diesel fuel.

II. MATERIALS AND METHODS

A. Cottonseed Oil

Cottonseed has a related structure to other sources such as karanja, jatropha etc., having an oil kernel surrounded by a hard outer hull; by processing, the oil is extracted from the kernel. The cultivation of cotton fields is higher in India due to the suitable weather conditions. It leads to an interest in biodiesel production from cotton seed oil.

B. Transesterification Process

It is the exchange of ester ions. Esterification, it is only catalyzed by acid catalysts [9]. In the gateway of a base catalyst, the detrimental saponification reaction might take place. The free fatty acids content in the feedstock causes the hard downstream process in the removal of soaps.

C. Cottonseed Methyl Ester Preparation

Three blends of cotton seed biodiesels are prepared with various percentages of methyl esters and diesel composition. Initially, 5% of methyl ester is mixed with 95% of diesel (B5), similarly prepared the B10 and B15. The properties of fuels are shown in table 1.

Table 1: Fuel Properties

S.NO	Parameters	Diesel	B5	B10	B15
1.	Viscosity (mm^2/sec)	4.5	4.8	5.1	5.3
2.	Fire & flash point (°C)	56 & 64	65 & 71	68 & 74	72 & 81
3.	Calorific value (MJ/Kg)	42	41.22	40.85	40.52
4.	Density (kg/m^3)	830	835	840	842

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III. RESEARCH SETUP AND METHODOLOGY

In the present research work was carried out on 4-stroke single cylinder water cooled research diesel engine. This setup contains a computer interface for getting the automated data. It connected with AVL DI gas analyzer for analyzing the emissions like CO, CO_2, NO_X, HC, and O_2. Smoke was measured by using the AVL smoke meter. The engine setup was connected with crank angle encoder and a pressure transducer for the pressure analyzing. The engine setup was shown in Figure3.5.

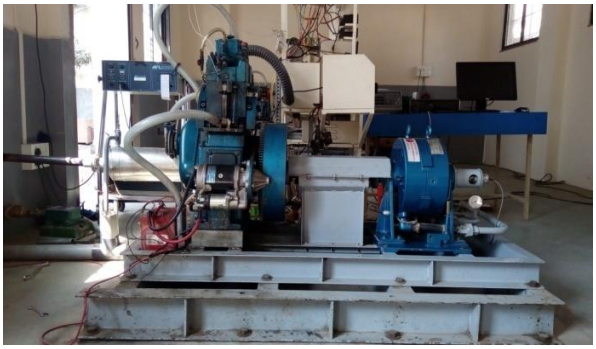


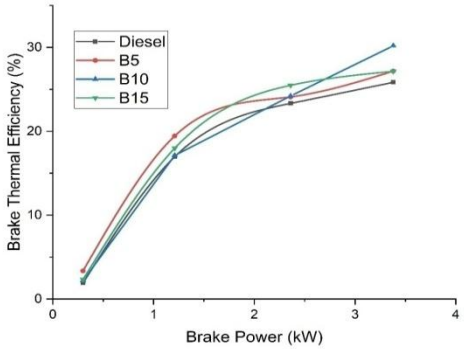
Fig. 1 Research Engine

IV. RESULTS AND DISCUSSION

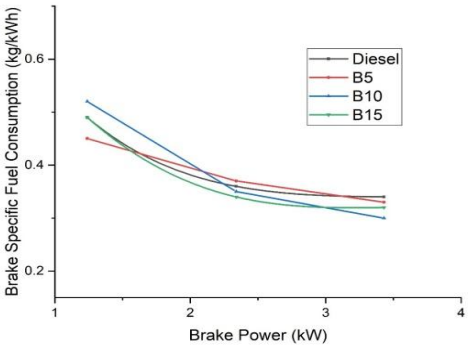
The present experimental investigation is run on a single cylinder, four stroke, and a water-cooled diesel engine. Firstly, the engine is run with the pure diesel and consecutively run with blends of B5, B10, and B15. In the present section deliberate the performance, emission, and combustion characteristics of diesel engine all the samples of fuels. The research diesel engine was run at a constant speed of 1500rpm from no load to full load condition [10]. Initially, operate the engine with pure diesel and later run with blends. From that obtained result observed the higher Brake thermal efficiency (Bthe) for blends when compared with the pure diesel operation.

A. Performance Characteristics

The Performance characteristics of Bthe and BSFC are analyzed by using graphs 1 & 2 respectively. The brake thermal efficiency is shown a continuous increase with an increase of brake power. Brake thermal efficiency of B-10 is 30.02%. Brake thermal efficiency of pure diesel is 25.84%. B10 showed 13.92% improvement than the diesel. This is due to the higher oxygen content of cotton seed oil. Brake specific fuel consumption of pure diesel is 0.32. B 10 showed 3.12% lower BSFC than diesel.



Graph 1 Brake power Vs. Brake thermal efficiency



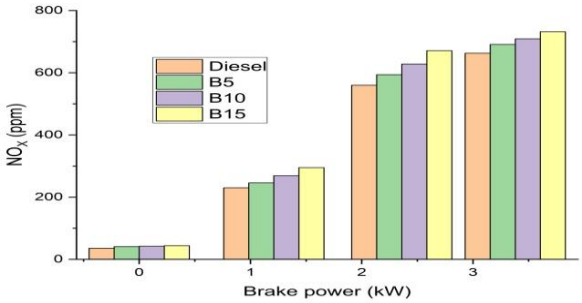
Graph 2 Brake power Vs. BSFC

B. NO_X Emissions

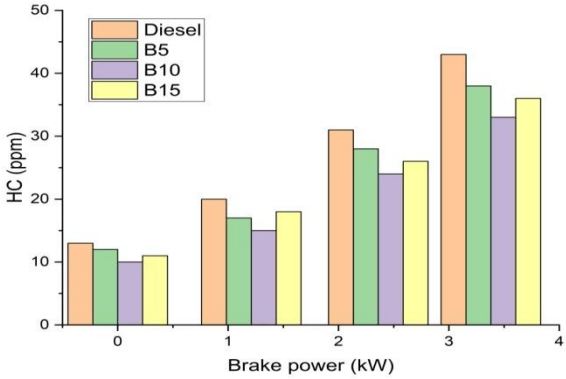
The diesel engines are causes major environmental pollutants. NO_X is the major environmental pollutant. The higher cylinder temperatures cause NO_X production. Graph 3 depicts the NO_X emissions at various brake power. Diesel showed lower NO_X emissions when compared to other samples. B15 showed higher NO_X emissions; it is about 7.1% lower than the diesel.

C. HC Emissions

The HC emissions are emitted due to incomplete combustion. HC emissions are shown in Graph 4. When Brake Power increases up-to 1.5kw HC emissions decreases compared to diesel. HC emission of pure diesel is 43ppm, and HC emission of B-10 blend is 33. The B10 blend showed 16.27% lower HC emissions when compared with diesel.



Graph 3 NO_X Emissions Vs. Brake power



Graph 4 HC Emissions Vs. Brake power

D. Combustion Characteristics

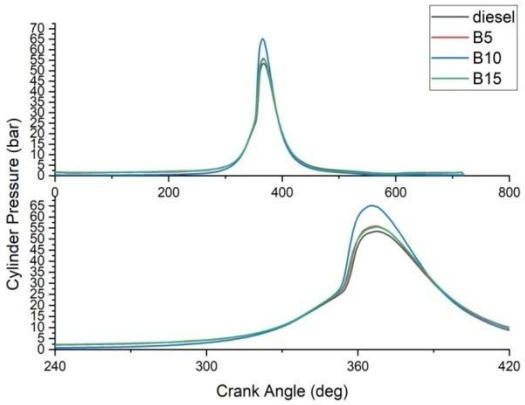
The piezoelectric transducer measures the combustion in the engine cylinder. It measures the cylinder pressure and crank angle encoder is used for crank angle measurement. In the present section deliberate the combustion characteristics of cylinder pressure and net heat release rate.

E. In-cylinder pressure

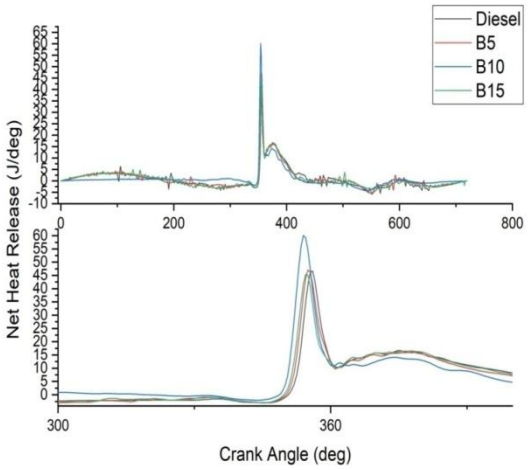
Graph 5 depicts the comparison between the cylinder pressure and crank angle. Observed the peak cylinder pressure for The B-10 Blend is 68 bars at a crank angle of 366°.

F. Net heat release rate

Graph 6 showed the comparison of Crank Angle &Net Heat Release. The B-10 Blend has exhibited the highest heat release rate of 66 J/deg at a crank angle of 365°.



Graph 5 cylinder pressure Vs. crank angle.



Graph 6 Net heat release Vs. Crank angle

V. CONCLUSIONS

The investigation is carried out on diesel engine fuelled with pure diesel, B5, B10, and B15 samples at various loads from no load to the full load condition. Based on the obtained results drawn the following conclusions.

The cotton seed biodiesel showed higher Bthe than the pure diesel operation. B10 showed 13.92% improvement than the diesel. HC emission of pure diesel is 43ppm, and HC emission of B-10 blend is 33. The B10 blend showed 16.27% lower HC emissions when compared with diesel. The pure diesel showed lower NO_X emissions when compared to the blends. B15 showed higher NO_X emissions; it is about 7.1% lower than the diesel. Observed the peak cylinder pressure for The B-10 Blend is 68 bars at a crank angle of 366°. The B-10 Blend has shown the highest heat release rate of 66 J/deg at a crank angle of 365°.

From the overall observation, B10 has opted as the optimal blend for replacing the diesel.

REFERENCES

1. P. S. S Vijaya Kumar Reddy, Radha, and N. U. Kautkar, “A Review on Nano Coatings for IC Engine Applications,” Int. J. Mech. Eng. Technol., vol. 8, no. 9, pp. 70–76, 2017.
2. N. Kumma, R. Krishna Gopidesi, T. Raja Rao, and K. Mohan Kumar, “Experimental Investigation on Diesel Engine Fuelled with Hythane Gas,” Int. J. Mech. Eng. Technol., vol. 10, no. 2, pp. 571–575, 2019.
3. P. S. Shelke, N. M. Sakhare, and S. Lahane, “Investigation of Combustion Characteristics of a Cottonseed Biodiesel Fuelled Diesel Engine,” Procedia Technol., vol. 25, no. Raerest, pp. 1049–1055, 2016.
4. Radha Krishna Gopidesi and P. S. R, “Review on effects of performance , emission and combustion characteristics of emulsified fuel in bifuel engine,” Prog. Ind. Ecol., vol. 12, no. 1–2, pp. 59–66, 2018.
5. S. R. Premkartikkumar, K. Annamalai, and A. R. Pradeepkumar, “Impact of ambient air temperature and injection timing on reduction of engine out emissions of DI diesel engine operating under the influence of oxygen enriched hydrogen gas,” Int. J. Oil, Gas Coal Technol., vol. 9, no. 1, pp. 109–127, 2015.
6. premkartikkumar S. Kautkar Nitin Uttamrao, “Production of biodiesel from refined cotton seed oil as well as its effects as fuel in diesel engine,” Int. J. Mech. Prod. Eng. Res. Dev., vol. 8, no. 3, p. 201886, 2018.
7. S. Suresh, D. Sinha, and S. Murugavelh, “Biodiesel production from waste cotton seed oil: engine performance and emission characteristics,” Biofuels, vol. 7, no. 6, pp. 689–698, 2016.
8. M. N. Nabi, M. M. Rahman, and M. S. Akhter, “Biodiesel from cotton seed oil and its effect on engine performance and exhaust emissions,” Appl. Therm. Eng., vol. 29, no. 11–12, pp. 2265–2270, 2009.
9. Radha Krishna Gopidesi, “Development of Polymer Polym Er Matrix Composites Reinforcing Reinforci With Al2Cumg a,” Int. J. Mech. Eng. Technol., vol. 8, no. 6, pp. 190–199, 2017.
10. P. S. & N. K. Datta Sai K, Radha Krishna Gopidesi, “Effects of Water Diesel Emulsion on Diesel Engine,” Int. J. Mech. Prod. Eng. Res. Dev., vol. 8, no. 1, pp. 675–680, 2018.

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