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Investigations on diesel engine characteristics with Pongamia biodiesel at dissimilar compression ratios

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ABSTRACT
Fuel price fluctuations and environmental degradation have developed interest in the area of biodiesel. In the present study, we investigated the performance and pollutant features of a DI diesel engine coupled with pollutant biodiesel blend B20. The characteristics considered for comparison are brake thermal efficiency, HC and NO_X with brake power of the engine. The engine was tested with dissimilar loads for various compression ratios ranging from 16.5, 17.5, 18.5 and 19.5:1 to assess the performance and pollutant parameters. From the results, a significant reduction in hydrocarbon (HC), a slight increase in NO_X and improved Brake thermal efficiencies for higher compression ratios to a biodiesel blend were evident.

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KEYWORDS
Diesel engine; biodiesel; brake thermal efficiency; brake power; compression ratio; emissions

1. Introduction

The requirement for global energy is constantly increasing, especially for gasoline energy. Global warming is associated with greenhouse gases which are usually released from the burning of gasoline fuels. Considering the energy situation and ecological concern, renewable energy with lesser ecological pollution effect should be made obligatory (Costa and Sodré 2011; Muralidharan and Vasudevan 2011; Karikalan, Chandrasekaran, and Sudhagar 2013). Biodiesel is a range of ester-based fuels resulting from usual, renewable organic bases such as plant oils. Its tag designates the usage of this fuel in the CI engine as a substitute to diesel. Biodiesel works in CI engines like diesel thus requiring no vital engine alterations. Furthermore, it can sustain the load capacity and choice of straight diesel. Biodiesel can be prepared from new/used plant oils and animal fats (Jindal et al. 2010; EL_Kassaby and Nemit_allah 2013; Karikalan and Chandrasekaran 2013). Unlike diesel, biodiesel is non-toxic, bio-degradable and basically sulphur free and free of aromatics. The selection of biodiesel feedstock is stated precisely and depends on readiness (Balki and Sayin 2014; Karikalan and Chandrasekaran 2015a). Many researchers reported that the performance and pollutant features of a single cylinder CI engine when powered with B20 Pongamia methyl ester with dissimilar compression ratios at a fixed engine speed of 1500 rpm, the brake thermal efficiency was found to be a maximum and less hydrocarbon, carbon monoxide and an increase in nitrogen oxides' emission (Bora et al. 2014; Karikalan, Chandrasekaran, and Sudhagar 2014; Karikalan and Chandrasekaran 2015b).

2. Materials and methods

The biodiesel resources are generally obtained from Jatropha oil, Pongamia oil, Palm oil, Mustard oil and Rubber seed oil, which are widely available in India. Biodiesel is generally costlier than petroleum diesel fuel unless and until there is a mass production of biodiesel takes place with government support. The cost of the biodiesel works out to be '1.5' times of that of the petroleum fuel in general and the cost can be reduced only through mass production of biodiesel. The by-products of the vegetable oil collected during processing of biodiesel could be used as animal foods and in soap industries.

Pongamia oil is utilised as a lubricant, pesticide, paint binder and in the soap producing and tanning industries. Transesterification is an effective way to diminish the viscosity of the plant oils. During the process of transesterification, the triglyceride of plant oil (Pongamia oil) reacts with methanol in the presence of NaOH compound and forms glycerol and vegetable oil ester. The resultant methyl ester is in liquid form and is in pale yellow colour. Experimentations were carried out using B20 blends of Pongamia methyl ester in the diesel engine. All the trials were carried at a continuous speed of 1500 rpm and the standard injection timing. During the experiments, the BTE, specific energy consumption and HC, CO, NO_X and smoke discharges were recorded. Engine tests were conducted with B20 Pongamia methyl ester blend at a rated speed and standard injection timing and with dissimilar compression ratios like 16.5:1, 17.5:1, 18.5:1 and 19.5:1 to get the performance, emission factors of the diesel engine.

3. Experimental set-up

Once the required biodiesel blend is prepared, it is tried in the KIRLOSKAR SV-1 direct injection diesel engine by varying the compression ratios to 16.5:1, 17.5:1, 18.5:1 and 19.5:1. The load cell activates the alternator load on the engine. The test engine is run with the varied compression ratios and the time taken for

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Table 1. Specification of engine.

Model/Make	SV1, KIRLOSKAR
Engine speed	1500 rpm
Rating power	5.2 KW
Bore × Stroke	87.5 mm × 110 mm
Compression ratio	17.5:1
Cooling method	Water

10 cc fuel ingesting is calculated. The calculations are done and the values are tabulated for estimating the brake thermal efficiency and specific energy consumption. AVL 444 gas analyser is utilised to compute the discharges from the tailpipe. The engine specifications are detailed in Table 1 and the experimental set-up is displayed in Figure 1.

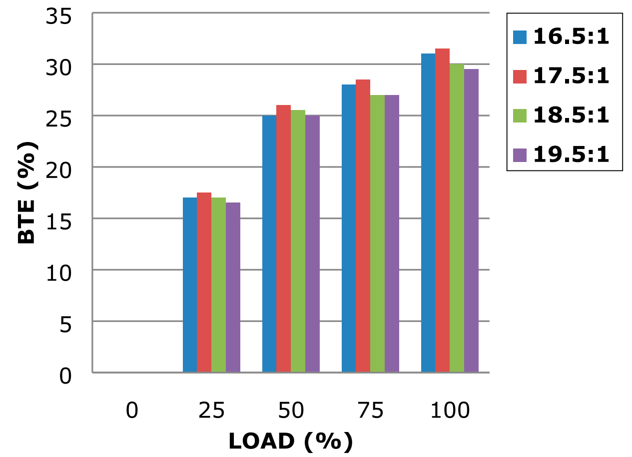

Figure 2. BTE against LOAD for dissimilar compression ratios.

4. Results and discussion

4.1. Brake thermal efficiency

The trial outcomes display that the brake thermal efficiency drops when the compression ratio is backward and increases when the compression ratio is increased. For biodiesel at 19.5:1, with three-fourths of the load maximum BTE was attained when equated to other compression ratios at three-fourths of the load. This could be due to better mixing of the fuel–air inside the combustion chamber which results in better combustion (Figure 2).

4.2. Specific energy consumption

The investigational results indicate that the specific energy consumption increases when the compression ratio is lower and decreases when the compression ratio is progressive. For all the compression ratios, specific energy consumption decreases up to part load and increases thereon. For biodiesel at 75% load, lower specific energy consumption was obtained when compared with other compression ratios for other loads for all the varied compression ratios. This may be due to the proper rate of evaporation of the biodiesel, which results in improved combustion (Figure 3).

4.3. Hydrocarbon emission

The trial results display that the hydrocarbon emission rises when the compression ratio is backward and decreases when the compression ratio is progressive. For all the compression ratios, hydrocarbon emission declines up to part load and increases thereon. For biodiesel at 17.5:1 and 19.5:1, at full load lesser HC emission was attained when equated to other compression ratios at full load. This might be owing to the homogeneity of the fuel–air mixture which results in better combustion (Figure 4).

4.4. Carbon monoxide emission

The investigational outcomes show that carbon monoxide emission rises when the compression ratio is backward and declines when the compression ratio is progressive. For all the compression ratios, carbon monoxide emission declines with an increase

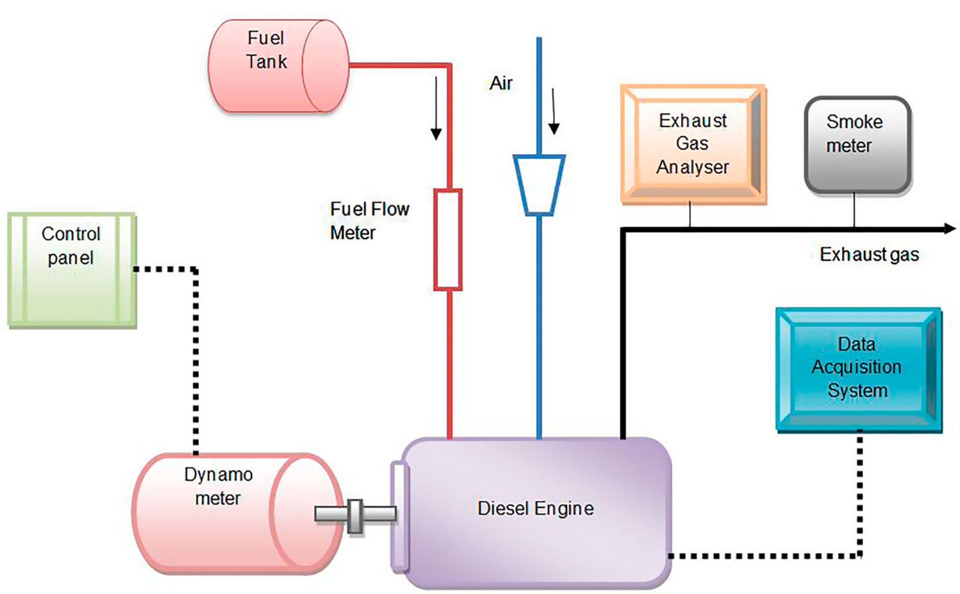

Figure 1. Experimental set-up.

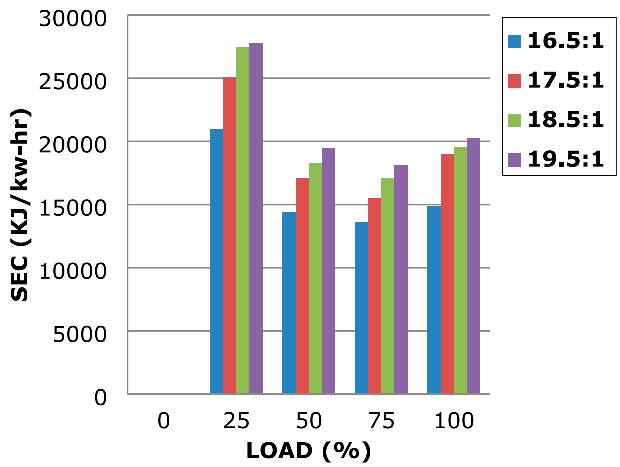

Figure 3. SEC against LOAD for dissimilar compression ratios.

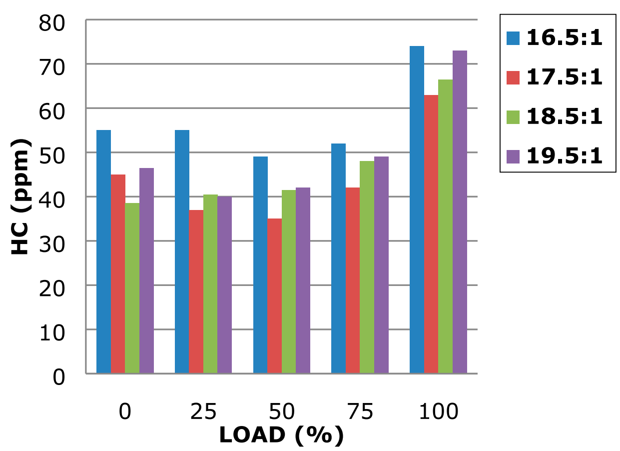

Figure 4. HC against LOAD for dissimilar compression ratios.

in brake power. For biodiesel at 18.5:1, at full load, lesser CO emission was gained next to 17.5:1 when equated with other compression ratios at full load. This can be due to the possibility of proper burning at this compression ratio (Figure 5).

4.5. Oxides of nitrogen emission

The experimental outcomes display that the oxides of nitrogen emission decrease when the compression ratio is backward and increases when the compression ratio is progressive. For all the compression ratios, oxides of nitrogen emission increase with an increase in brake power. For biodiesel at 17.5:1, at full load more NO_X emission was attained when equated with other compression ratios at full load. This might be due to the proper atomisation and better flammability, which cause larger amounts of NO_X formation (Figure 6).

4.6. Smoke emission

The trial results display that the smoke opacity emission increases when the compression ratio is backward and decreases when the compression ratio is progressive. For all the compression ratios, smoke opacity emission increases with an increase in brake power. At maximum load the lower smoke opacity was obtained at 16.5:1 and followed by 18.5:1 when equated with

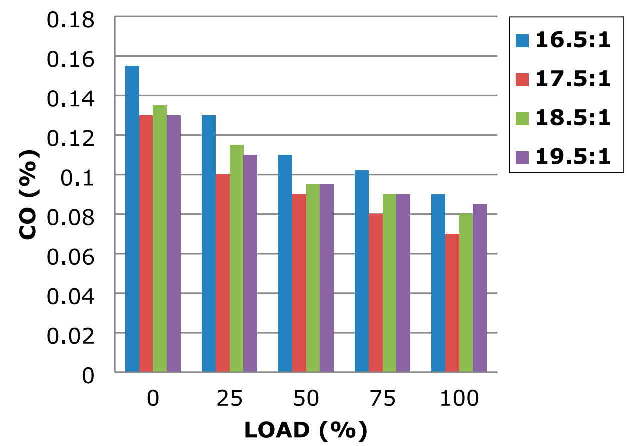

Figure 5. CO against LOAD for dissimilar compression ratios.

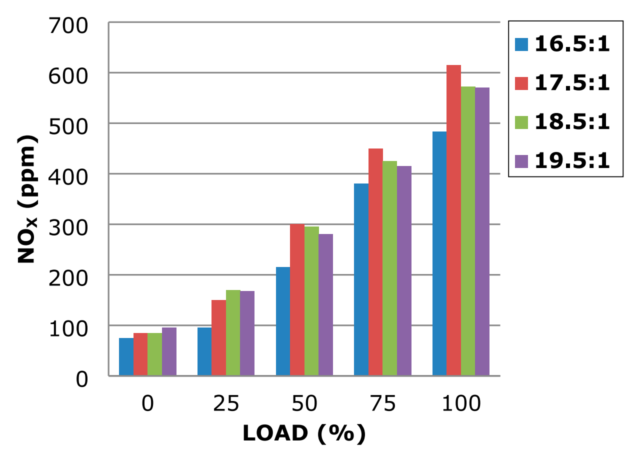

Figure 6. NO_X against LOAD for dissimilar compression ratios.

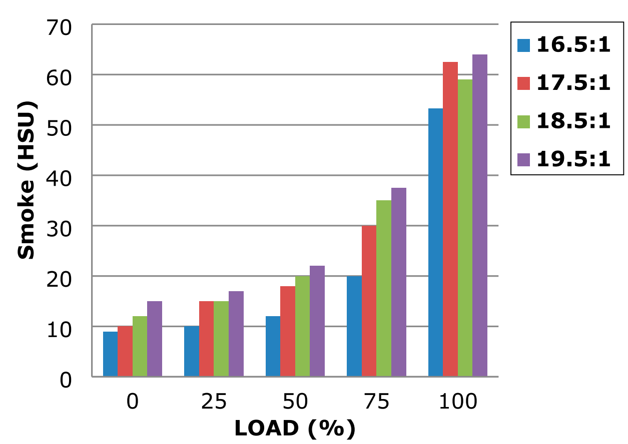

Figure 7. SMOKE against LOAD for dissimilar compression ratios.

other compression ratios at full load. This could be due to the rise of the O_2 content in the fuel providing ample oxidation in rich zones, leading to a noteworthy drop in smoke emissions (Figure 7).

5. Conclusion

Reducing the exhaust emission and improving the engine performance are the prime reasons for carrying out the work. The following results are obtained by variable compression ratios from 16.5, 17.5, 18.5 and 19.5:1 in a single cylinder CI engine using Pongamia B20 biodiesel blend.

- For biodiesel at 19.5:1, at three-fourths of the load maximum BTE was attained when equated with other compression ratios at three-fourths of the load.
- For biodiesel at 75% load, a lower specific energy consumption was obtained when equated with other compression ratios for other loads for all the varied compression ratios.
- For biodiesel at 17.5:1 and 19.5:1, at full load lesser HC emission was attained when equated with other compression ratios at full load.
- For biodiesel at 18.5:1, at full load lesser CO emission was attained next to 17.5:1 when equated with other compression ratios at full load.
- For biodiesel at 17.5:1, at full load the more NO_X emission was attained when equated with other compression ratios at full load.
- At full load, the lesser smoke opacity was obtained at 16.5:1 and followed by 18.5:1 when equated with other compression ratios at full load.

From the statement, it has been clear that Pongamia biodiesel blend B20 displays better emission features at high compression ratios with full load state.

Disclosure statement

No potential conflict of interest was reported by the authors.

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