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Combined impact and coating on diesel engine using diesel-biodiesel blends

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Abstract

The purpose of this study is to determine the optimal fuel injection pressure and the split injection technique by comparing the performance, combustion, and emission characteristics of biodiesel blends made from jatropha and karanja at a variety of fuel injection pressures. Both jatropha and karanja are combined with diesel in a ratio of 20 (biodiesel makes up 20% of the mixture, and diesel makes up 80%). J20 had a lower BSFC and a higher thermal efficiency than diesel, with the exception of when it was operating at full load. Additionally, increasing and decreasing the injection pressure as well as performing split injection helped reduce emissions. The information gathered from the pressure sensor located inside the cylinder was measured, and then the lab view programme was used to calculate the combustion characteristics. These characteristics included the mass fraction burned and the rate of heat release. the peak in-cylinder pressure increased by 5–6 bar because the split injection helped to improve the combustion behaviour of the engine. Splitting the injection reduced NO emissions at all loads, with the exception of full load, where it had no effect when the fuel injection pressure was raised to

1200 bar. Split injection achieves a marginally higher efficiency of 25% even when working with light loads. The split injection techniques help to improve the performance and emissions in CI engines using biodiesel mixes.

Introduction

As a result of global pollution, tighter emission standards, rising demand, and increasing prices for petroleum products, there is a demand for alternative fuels for surface transportation that are both effective and friendly to the environment [1], [2]. Several studies have shown that the use of vegetable oil biofuels as a viable alternative to diesel fuel does not call for significant engine modifications to achieve the same level of performance. India is able to cultivate and develop its own biodiesel fuels, as well as supply those fuels to other countries, because it is one of the major developing countries in the world that has access to agricultural resources. In most cases, biodiesel obtained from feedstocks such as jatropha and karanja are mixed with diesel in order to be utilised in internal combustion engines [3], [4], [5], [6], [7], [8]. In contrast, the combustion, performance, and emissions characteristics of this blended diesel are inferior to those of neat diesel.

In a world moving towards electronics where 30% of the engine is controlled by electronics, there is a way where these electronics can be used to increase the performance of blended biodiesel fuels [9], [10], [11], [12], [13], [14], [15]. The pressure with which the gasoline is injected is a crucial factor that significantly impacts performance, combustion, and emissions. Fuel atomization and subsequent mixture formation are influenced by fuel injection pressure. Varying this parameter has a major influence on the engine's behaviour. For changing the above parameters, the field of electronics is utilised where an open-ECU whose engine mapping can be altered is utilised to change the injection parameters and control the fuel injection pressure and carry out multiple injection strategies [16], [17], [18], [19], [20].

In the process of developing a new engine, conducting a thermodynamic analysis before prototyping can cut down on the amount of time needed for performance and emission optimization in a later stage. In addition to power, specific fuel consumption, peak combustion pressure, and pollutants, the rate of heat release (ROHR) is probably the most important factor in determining the performance of an engine. During the combustion process, the rate at which the chemical energy contained in the fuel is released is what the HRR measures [21], [22], [23], [24]. In light of this, HRR aids in determining the beginning and end of combustion as well as the mass of fuel burned at each crank degree, which can be selected from the amount of energy generated by combustion. HRR also helps in identifying the need for post and pilot injections that help in reducing emissions and increasing fuel efficiency.

Understanding the idea of heat release rate is required in order to comprehend the combustion process in engines. The HRR defines four distinct phases of combustion for diesel combustion, each of which is governed by a different physical and chemical characteristic. They are.

- Ignition delay
- Pre-mixed combustion (or) rapid combustion
- Mixing controlled combustion
- Late combustion

Additionally, HRR assists in establishing a direct link between pressure fluctuations and the quantity of chemical energy released during the combustion process of the fuel.
The next most important parameter that needs to be analysed is the fuel injection pressure. Greater air–fuel mixing and quick combustion are produced by higher fuel injection pressure (FIP), which has a direct impact on pollutant production. Understanding droplet size, spray angle, spray tip penetration, and droplet velocities are essential when investigating fuel injection pressure since these variables improve combustion efficiency and lower exhaust levels of harmful emissions [25], [26], [27]. Spray droplet size distribution has a significant impact on the combustion process in CI engines. The size distribution needs to be optimised since smaller fuel droplets have a shorter penetration time yet evaporate more quickly than bigger droplets do. According to studies, the quality of the fuel–air combination is improved by small droplets and a high penetration depth of the fuel jet, which results in shorter ignition delays and more complete combustion. Larger droplet sizes produced by lower FIPs lengthen the time it takes for combustion to ignite [28], [29], [30]. Additionally, this results in higher cylinder pressures, which ultimately raise NOx emissions. Due to better mixing during the ignition delay, this results in enhanced fuel–air mixture generation, which lowers smoke and CO emissions. Thus, there is less chance for homogenous mixing, which lowers combustion efficiency. In order to maximise combustion, performance, and tailpipe emissions in diesel engines, the fuel injection technique is a crucial variable.

Another important parameter analysed in this paper is the multiple injection schemes. Multiple injection schemes produce a perpetual decline in the brake thermal efficiency

(BTE) due to an increase in heat loss through the cylinder wall because of the longer duration of the combustion process, which results in less generation of useful mechanical work. But in the case of emissions, they produce good results by reducing the amount of NOx emissions. The peak heat release rate was decreased as a result of the injection being divided into many sections. Lowering the combustion temperature also helped to lower the NOx emissions. The presence of several injection strategies affects the location of the combustion starts, the occurrence of the first peak heat release rate (HRR), and the crank angle position of the peak pressure. In order to reduce particulate matter and smoke, control the amount of NOx, manage engine combustion noise, and handle exhaust pipe after treatment equipment in diesel engines, multiple injection approaches made up of pilot and post injections are frequently utilized.

Along with its advantages over diesel, biodiesel also has a number of drawbacks that must be taken into consideration, including its reduced calorific value, high flash point, more viscosity, less oxidation stability, and increased emissions of nitrogen oxides. Biodiesel fuels that have been studied in depth include Calophyllum inophyllum, canola, Citrullus colocynthis, castor oil, Karanja oil, Simarouba oil, jatropha oil, coconut oil, used cooking oil, and cottonseed oil.

The aim of this study is to determine the optimal fuel injection pressure and the split injection technique by comparing the performance, combustion, and emission characteristics of biodiesel blends made from jatropha and karanja at varied fuel injection pressures.

Section snippets

Experimental setup and procedure

The engine's setup schematic is depicted in the image (Fig. 1), and the engine's specifications are listed in the Table.1. Using an AG80 saj 80kw Eddy current Dynamometer, the engine was loaded. KS Automation Systems TORNADO software was used to control the dynamometer.

In order to obtain the crank angle and TDC reference from the engine, a separate crank angle encoder was attached to the engine pulley, and a Kistler pressure sensor was mounted to the engine cylinder head in order to collect

Procedure

By altering the injection pressure and employing split injection techniques in conjunction with open ECUs, a series of experiments were carried out with the purpose of determining the combustion characteristics and emissions of diesel and jatropha biodiesel. Performance, emission, and combustion parameters were all recorded after a single injection was used to adjust the injection pressure to three different values: 400, 500, and 1200 bar. Both types of J20 (Jatropha 20 % and Diesel 80 %)

Results and discussions

The engine was initially run-on baseline diesel before being permitted to run at any load until the water temperature reached 70 °C and remained there for the duration of the experiment. The temperature of the water was maintained at that level throughout the experiment. At a speed of 2300 revolutions per minute, the motor was subjected to loads of 0 %, 10 %, 25 %, 50 %, 75 %, and 100 %. After that, the injection pressure was raised to 400 bar, then 500 bar, and finally 1200 bar; this was done

BSFC

Fig. 2 gives the comparison of brake-specific fuel consumption for diesel and J20. At low load conditions, J20 seems to produce lower BSFC than diesel. The lowest BSFC for J20 was 0.2458 kg/kW-hr at 50 % load compared to diesel. Diesel seems to produce lower BSFC at high loads. The lowest BSFC for diesel was 0.2679 kg/kW-hr at 100 % load when compared to J20. This is a result of the less density of diesel compared to J20, which results in a less efficient fuel discharge for a given plunger

Conclusion

The experimental investigation was carried out in order to determine the effect of split injection and injection pressure on a DI engine that with neat Diesel and J20 as fuel. According to the findings, J20 possesses lower BSFC and a higher thermal efficiency as compared to neat Diesel at all loads, with the exception of full load.

- Both the increasing the injection pressure to 1200 bar and decreasing to 500 bar had a negative impact on the BSFC and the thermal efficiency.
- At full load, however,

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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