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Research Paper

Investigations on the effect of ethanol blend on the combustion parameters of dual fuel diesel engine

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HIGHLIGHTS

- Ignition delay initially increases and then decreases by ethanol addition.
- Rate of pressure rise increases up to 16.79, 11.46 and 22.55%.
- Minimum and maximum net heat release was found to be 37.44 kJ and 92.7 kJ.
- Peak pressure increases by 19%.

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ABSTRACT

An experimental investigation has been performed on a 4 cylinder (turbocharged and intercooled) 62.5 kW gen-set duel fuel diesel engine. Maximum rate of pressure rise, peak cylinder pressure and heat release rate were observed at various load conditions with varying ethanol substitutions. Ignition delay at 20% substitution of ethanol at 10, 20 and 40% load conditions was 16, 14 and 10 °CA respectively. The rise in maximum rate of pressure was 16.79, 11.46 and 22.55% at 10, 20 and 40% load conditions as compared to diesel operation. The minimum and maximum net heat release was 37.44 kJ and 92.7 kJ at 20 and 40% ethanol substitution at 10 and 40% load conditions respectively. The peak pressure increases by 19% by 20–60% ethanol substitution at 10–40% load condition. A two factor, three-level full factorial design was employed, and the experimental results are in accordance with the results obtained.

1. Introduction

A lot of research has already been done on the subject of substitution of alcohol fuels for petroleum products. Diesel engines are an important part of the public and private transportation sector, and their use will continue and grow into the future. But their smoke has become biggest threat to health and environment. Diesel-fuelled engines have the disadvantage of producing soot, particles and nitrogen oxides and are presently subjected to increasingly severe legislation following revision of the standards [1]. The required levels are very difficult to achieve solely through engine design alone. With the shortage of conventional energy together with the increasingly stringent emission standards, it is very important to develop new and innovative internal combustion engines with minimum emissions, high fuel efficiency and high specific power [2]. Hodgson [3] demonstrated that higher brake thermal efficiency was obtained on ethanol than with gas oil on the corresponding standard engine. Nagalingam et al. [4] conducted experiment showing that alcohols have a high tendency to ignite when in contact with hot surfaces. Hansen et al. [5] reviewed the properties and a specification of ethanol blended with diesel fuel, and prominence is placed on the factors critical to the potential commercial use of these blends. Avinash [6] suggested the use of biodiesel in conventional diesel engines would result for substantial reduction in emission of unburned hydrocarbons, carbon monoxide and particulate. Hwanam and Byungchul [7] experimented and studied the engine performance and the formation of THC (total hydro carbon), CO (carbon monoxide), NOx (nitrogen oxides), smoke and PM (particulate matters).

De-gang et al. [8] experimentally evaluated the effects of different ethanol–diesel blended fuels and compared the results to find the optimum percentage of ethanol that gives simultaneously better performance and lower emissions. Huang et al. [9] conducted experimental investigation to study the performance and emissions of the engine fuelled with the blends compared with those fuelled by diesel. According to Bhattacharya and Mishra's [10] experimental results, ethanol blends have same power producing capability of the engine similar to that of diesel. Hansen et al. [11] studied the blends of ethanol and diesel fuel and found it to be technically feasible and reviewed the issues with particular reference to safety and

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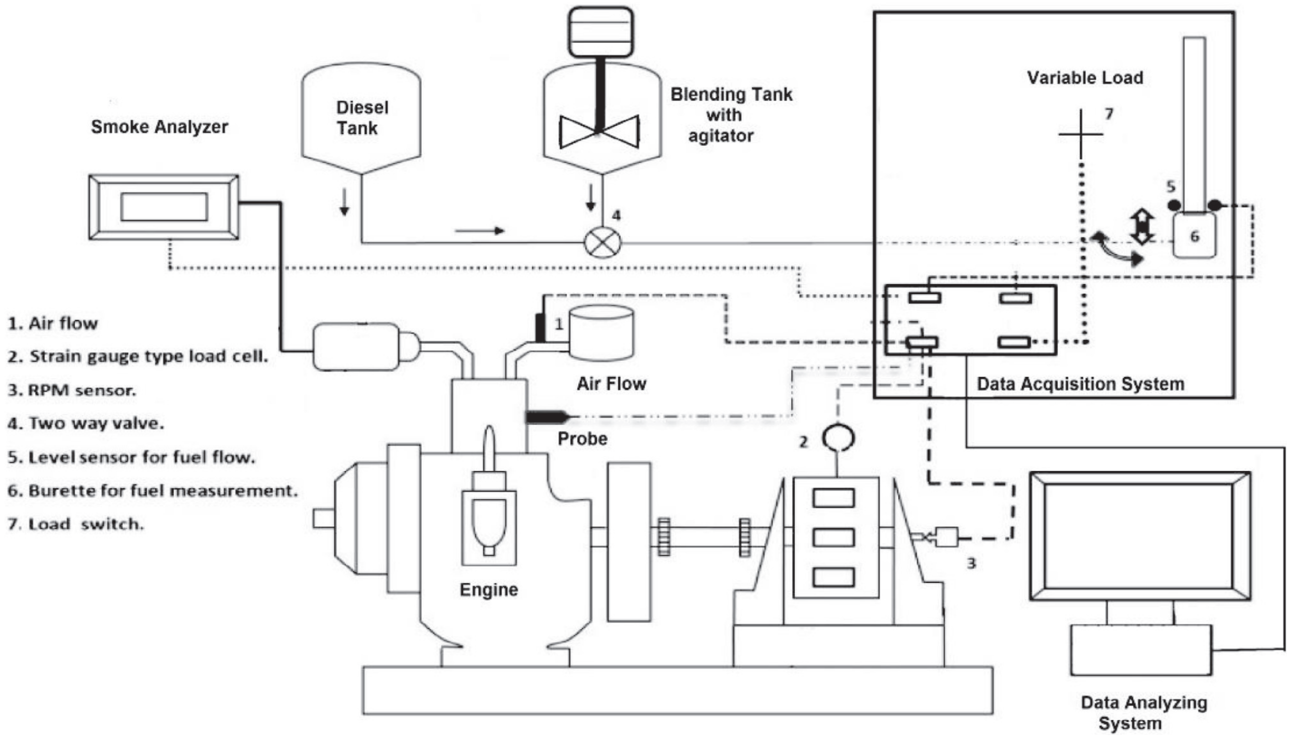

Fig. 1. Layout of test setup.

distribution, integrity of the fuel being delivered to the engine, emissions, engine performance and durability. Ajav and Akingbehin [12] experimentally obtained six blends of ethanol by volume with diesel. Siebers and Edwards [13] simulated diesel engine conditions, and results show that the ignition delays of the alcohol fuels are independent of the chamber pressure and are unaffected by the presence of 10% by volume of water in the fuel. Lahane and Subramanium [14] experimentally found that drastic decrease in CO, HC and smoke emissions occurs when fuelled with biodiesel–diesel blend (B20) in a diesel engine. They found that the nozzle modification could lead to reduction in emissions. Fang et al. [15] studied the effect of premixed low temperature combustion of ethanol on combustion and emissions in a four cylinder heavy-duty diesel engine and found that lower emissions of NOx due to lower combustion temperature and higher latent heat of vaporization were evident in the case of ethanol–diesel–biodiesel blends. Alberto Boretti [16] studied the need for conversion of a diesel engine to work as dual fuel with diesel and ethanol. He suggested the need to develop a dedicated dual fuel injectors for the diesel and the ethanol in small bore applications, or the simple addition of a second ethanol injector in large bore engines. Huang et al. [17] experimentally investigated on the application of the blends of ethanol with diesel to a diesel engine. Experimental tests showed that it is feasible and applicable for the blends to reduce the smoke emissions compared to fuelled by diesel.

Besides being a biomass based renewable fuel, ethanol has cleaner burning and higher octane rating than the various vegetable oils [18]. Alcohols burn more completely, hence improving combustion efficiency. As a renewable and oxygen-containing bio-fuel, ethanol is a prospective fuel for vehicle that could be blended with diesel or alternatively be injected into cylinder directly [19]. There are various studies on the utilization of ethanol on diesel engine, which concentrate on the three viewpoints: application systems of ethanol on diesel engine, fuel properties of ethanol–diesel mixtures, and consequences for the combustion and emission characteristics of ethanol–diesel mixtures, but along with it though studies on various combustion parameters like ignition delay, rate of pressure rise, heat release and temperature are equally important.

2. Experimentation

The experimental setup is same as used by Lata D.B. et al. [20,21] as shown in Fig. 1, with modifications made for the present experimentation (Table 1). The quantity of the diesel and fuel mixture was automatically controlled using control valves embedded with the fuel inlet. The predetermined amount of mixture of diesel and ethanol was introduced into the intake manifold through a fuel supply system. The amount of diesel and fuel mixture being consumed by the engine was measured by using a gravimetric principle, and was controlled by automatic control valves. The flow rates of the diesel and fuel mixture were also measured. After 15 min of stabilized operation and condition, the data are recorded for 100 cycles. The experiments were repeated five times to ascertain the reproducibility. The experiments were performed under the following conditions:

(i) Case I: engine runs on diesel only.
(ii) Case II: engine runs on mixture of 20% ethanol and 80% diesel.
(iii) Case III: engine runs on mixture of 40% ethanol and 60% diesel.
(iv) Case IV: engine runs on mixture of 60% ethanol and 40% diesel.

3. Results and discussion

3.1. Design of experiment

The experimental results at rated speed of 1500 rpm, injection pressure 260 bar and injection timing 16 BTDC are presented. The mixture of ethanol with diesel substitution is mainly presented at no load, 10%, 20% and 40% of full load condition. The 10% of full load was selected to represent engine performance at light load condition, whereas 20% of full load condition was selected for medium