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Effect of injection timing to performance of a diesel engine fuelled with different diesel–ethanol mixtures

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HIGHLIGHTS

- Engine performance parameters have been improved with ethanol addition.
- Engine performance parameters have been improved with the increase of the injection advance.
- The optimum performance values have been obtained for 5% ethanol addition for the injection advance of 35 KMA.

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ABSTRACT

The aim of this study is to determine the effect of injection timing to performance of a single cylinder diesel engine. The fuel mixtures have been prepared by addition of ethanol to HC based diesel fuel at the ratios of 5%, 10% and 20% by volume. To change the injection timing an adjustable cam mechanism has been connected to the test engine. The results showed that; the maximum engine power has been obtained in 2400 rpm for 5% diesel–ethanol mixture at the injection advance of 35 CA. The maximum engine torque has been obtained in 1200 rpm for 5% diesel–ethanol mixture at the injection advance of 25 CA. The minimum brake specific fuel consumption has been obtained in 1000 rpm at the injection advance of 35 CA for the same mixture.

1. Introduction

The sources of energy have gradually decreased while increased need for energy in the world. A major part of decreasing these sources of energy has been fossil based fuels. Besides running out of these fuels, their damages to environment have reached to significant level. One of the usage areas of fossil-based fuels is transportation which is done by motor vehicles. Thanks to this, mankind has been reached to its current standard of living. Today, increasing of combustion efficiency of vehicles which reduces fuel consumption and exhaust gas emissions has become a necessity for the countries and users [1–5].

Internal combustion engines use fossil based fuels. Using alternative fuels in internal combustion engines has the potential to reduce the dependency on fossil based fuels. Further, development of efficient and eco-friendly combustion systems, alternative fuels becomes increasingly important. Alcohols have been considered as alternative fuels for diesel engines [6–8]. Ethanol has potential to become the most significant alternative fuel for the motor vehicles.

Ethanol is a colorless and transparent liquid which's chemical formula is C_2H_5–OH. Ethanol is a biodegradable fuel, which can be produced from vegetable materials, such as potato, corn, sugar and barley. It has higher miscibility with diesel fuel. Although both methanol and ethanol reduce emissions in diesel engines, ethanol has the advantages of being a renewable fuel and having a higher miscibility. Besides ethanol addition to diesel fuel results in different physico-chemical changes in diesel fuel properties, particularly reductions in cetane number, viscosity and heating value. With increase of ethanol in diesel fuel, there is an increase in both the ignition delay and the rate of heat release while there is a decrease in diffusion combustion, total combustion duration and combustion temperature. For emissions, there is a reduction in smoke and particulate matter (PM). Therefore, the use of ethanol in compression ignition (CI) engines has received considerable attention in recent years [8–11].

At present, spark-ignition and compression-ignition engines are not seemed to achieve the desired combustion efficiencies and emission level. For this reason, a new combustion technology

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Table 1
The specifications of the test engine.

Engine Type	Lombardini / LDA450
Bore × stroke (mm)	85 × 80
Displacement (l)	0.454
Compression ratio	17.5/1
Max. engine power (kW)	5.5@3000 rpm
Max. engine torque (Nm)	28.5@1800 rpm

was needed. Nowadays the researchers are trying to develop new combustion concepts for internal combustion engines. Homogeneous charge compression ignition (HCCI) is a new combustion and advanced concept which is explored by engine makers as the next-generation of internal combustion engines. In HCCI the fuel and air should be mixed homogeneously just before combustion starts. And combustion occurs spontaneously at multiple points throughout the charge volume by the end of the compression stroke. HCCI engines offer higher thermal efficiency than diesel engines, while particle matter (PM) and nitrogen oxides (NOx) emissions are ultra-low [6,7,12].

One of the most important parameters which affect to combustion process of a diesel engine is injection timing. The injection timing changes, physical conditions of air which the fuel is injected. If the fuel is injected away from top dead center (TDC) into the cylinder, the ignition delay period increases due to reduction of temperature and pressure levels of the air before the mixing proses. If the fuel is injected close to TDC into the cylinder, the temperature and pressure levels will be higher before the mixing of fuel and air. As a result the ignition delay duration varies with the changing of injection timing which affects strongly to engine performance [13].

On the other hand, use of diesel ethanol fuel mixture in diesel engine needs some modifications like optimization of injection timing. Advanced injection timing enhance premixed combustion period and decreases the fuel consumption [13,14]. In this study, the effects of diesel–ethanol mixtures and injection timing to engine operating parameters of a single cylinder, naturally aspirated, air cooled, direct injection diesel engine have been investigated. The test fuels were injected into the cylinder of test engine before the standard injection timing (25 CA BTDC) of the test engine with increment of 10 CA BTDC.

2. Material and method

A single cylinder, naturally aspirated, direct-injection (DI) and air cooled diesel engine has been used for the engine tests. Technical specifications of the test engine are given in Table 1.

The engine tests were performed at full load conditions. An electrical dynamometer was used to load the engine. The overview of test system is given in Fig. 1.

The test engine was coupled to an electrical dynamometer to determine the performance characteristics. A strain gauge load cell was used to measure the dynamometer load. The load cell on the dynamometer was calibrated with standard weights. An optical sensor was used for determining the engine speed. The data were recorded by hand after stabilizing the exhaust gas temperature of the test engine. The tests were done at injection pressure of 203 bar. The fuel injection pump regulator was not employed during the engine tests. Thus the engine power exceeded its standard value of 5.5 kW.

Ethanol (purity of 96%) and petroleum based diesel fuel have been used as test fuels. Test fuels were prepared by blending method at room temperature just before the experiments. So there were no engine modifications needed [13,15,16]. To obtain a

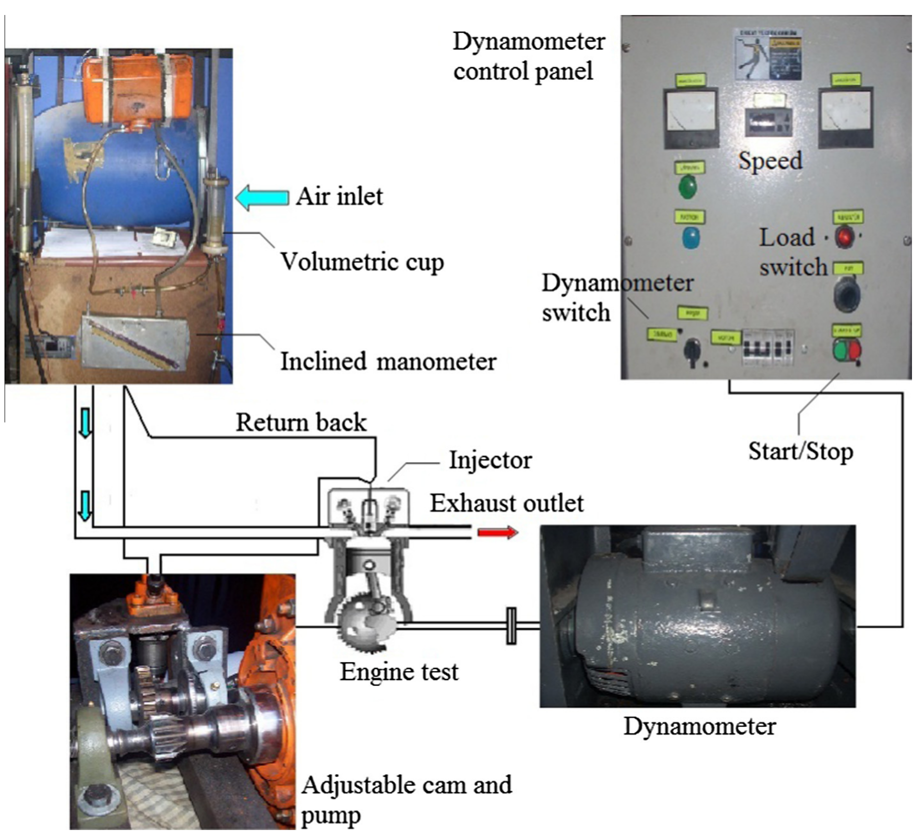

Fig. 1. The schematic layout of test system.