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Macroscopic spray characteristics of wide distillation fuel (WDF)

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HIGHLIGHTS

- Spray behaviours of piezoelectric and solenoid injectors were compared.
- The effects of fuel pressure fluctuation on multiple injections were illustrated.
- With a piezoelectric injector, the spray optical experiment has been done.
- The spray characteristics of WDF were investigated.

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ABSTRACT

In this study, the performance of piezoelectric and solenoid injectors were compared. With a piezoelectric injector, the spray characteristics of kerosene and G50 (gasoline/diesel blend fuel), which are kinds of WDF, were investigated and compared to diesel. The characteristics such as spray penetration, spray velocity, spray angle and air entrainment were used to understand the spray behaviour of the test fuels. The results indicate that the piezoelectric injector shows significant improvement over the conventional solenoid injector in injection response and needle opening speed, which enables precise and rapid control of injection. The trade-off effects of charge density and injection pressure on spray penetration and spray velocity are quite clear, while spray angle is almost insensitive to injection pressure. Kerosene and G50 give smaller but similar spray penetration and velocity compared to diesel. The spray angle of kerosene and G50 are larger compared to diesel. The spray volume and mass of entrained air for kerosene and G50 are higher compared to diesel, which indicates kerosene and G50 can form better fuel–air mixing, which is very important for the performance of engine when fuelled by WDF.

1. Introduction

In internal combustion engines, diesel and gasoline have been proved to be the two most commonly used fuels. In addition to the difference in the length of carbon chain in their major components, the distillation temperature ranges are also different, which is 40–180 °C for gasoline and 180–360 °C for diesel. Based on the physical and chemical differences between gasoline and diesel, researchers have proposed various engine combustion concepts: low temperature combustion (LTC) and premixed charge compression ignition (PCCI) with diesel [1–4], partially premixed combustion (PPC) with gasoline [5,6]. However, it is proved that these new combustion concepts cannot solve all the problems faced by engines. And also due to separate production for diesel and gasoline, engines fuelled with diesel and gasoline must be designed differently and manufactured separately, which results in high cost for petro-based transportation.

In order to integrate the advantages of gasoline and diesel fuels to get lower emissions as well as high thermal efficiency, researchers have proposed some other ideas, like dual-fuel reactivity controlled compression ignition (RCCI) (two fuels mix in cylinder) [7–13] and premixed compression ignition (blend fuel) [14–25]. Based on these studies, a concept called wide distillation fuel (WDF) has been surfaced, which refers to fuels with distillation range from initial boiling point of gasoline to final boiling point of diesel. Gasoline/diesel blend fuel, which is obtained by mixing the two most commonly used fuels, is considered as one kind of WDF. Besides, the idea of using a single fuel was also proposed by many experts in order to simplify the logistic supply chain for petroleum products [26]. This novel idea was called the single fuel concept (SFC). Kerosene is such a kind of WDF.

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A lot of researches have been carried out on engine performances and emissions when fuelled by gasoline/diesel blend fuel and kerosene [14–25,27–31], but there is few work focusing on spray characteristics of WDF. Therefore, in this paper, based on a piezoelectric injector, an extensive investigation has been conducted on the spray characteristics of WDF like gasoline/diesel blend fuel and kerosene and compared with the conventional diesel fuel. The characteristics such as spray penetration, spray velocity, spray angle and air entrainment were analysed which can help us to better understand their effect on the combustion process and emissions formation in the engine.

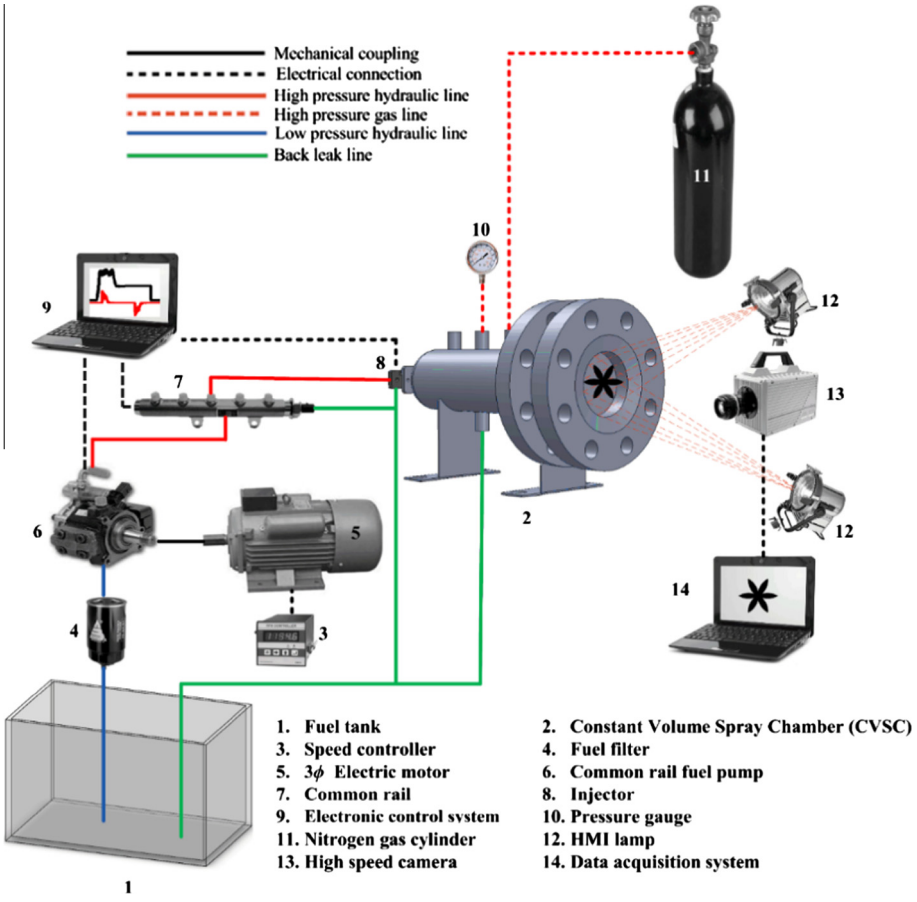

Fig. 1. Schematic of experimental setup for spray measurement.

Fig. 2. Built-in-house electronic control system for spray study.

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