Bio- and Mineral-Fuel Spray Evolution in Non-Evaporating and Evaporating Conditions by Image Processing Techniques

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Abstract

Fuels from renewable resources have obtained an increasing interest for transport application in the last decade because of their biodegradability, potential improvements on exhaust emission and benefits on virtuous CO_2 cycle of the earth. Within this framework, the paper presents the influence of biodiesel fuels on the injection process and their impact on the air-fuel mixture preparation. The results of an experimental investigation on the fuel spray from a multi-jet common rail injection system both under non evaporative and evaporative conditions are illustrated. The characteristics of the investigated spray include the fuel delivery and instantaneous flow rate and the jet visualization, both within a high pressure vessel at ambient temperature and in an optically accessible single cylinder diesel engine for the evaporative conditions.

The injection profiles appear similar for all the used fuels in terms of pulse slopes and timing distributions. Images recorded in the evaporating system show a negligible variation of the tip penetration for the different fuels dependent on engine condition rather than on fuels properties. Nevertheless a comparison of the tip penetration in evaporative and non evaporative systems has been made. Finally a different spatial distribution of the liquid fuel has been noted analysing the luminous intensity spatial distribution along the jet direction.

Introduction

Alternative fuels for diesel engines are becoming important due to the decrease of petroleum reservoirs and the increase of environment pollution problems [1]. The biodiesel is technically competitive with conventional petroleum-derived diesel fuel and requires virtually no changes in the fuel distribution infrastructure. For this reason and its biodegradability, the use of biodiesel is considered a good alternative to fossil fuels [2]. Moreover, there is evidence that biodiesel, fuelling the engine, can have a strong impact on performances and pollutant emissions. In particular, the last generation electronically controlled diesel engines using biodiesel have shown a decrease in the emission of particulate matter and unburned hydrocarbons. Vice versa, although many researches show a slight increase in NOx emissions when using biodiesel fuel, some others have been found different effects [3]. The feedstock used for the biodiesels production interferes with the human food chain and the production costs are very high. These are the two main problems of the first generation biodiesel. For this reason, researchers are making considerable efforts in the development of an alternative production path, leading to the so-called second generation of biodiesel. The 1st generation is essentially a blend of methyl-esters while the 2nd are paraffin hydrocarbons [4].

Materials and Methods

The injection process characterization has been carried out under non evaporative conditions injecting the fuel within stagnant inert gas in a high-pressure optically-accessible cylindrical vessel in order to measure the spatial and temporal distribution of the fuel. Moreover, the injection process has been studied in an optically accessible single cylinder Common Rail diesel engine representing evaporative conditions similar to the real engine. The selected engine working condition has been extracted from the ECU map of a commercial EURO 5 engine. They are 1500 rpm at 2 bar of break mean effective pressure (BMEP) and 2000 rpm at 5 bar of BMEP, respectively. The corresponding injection pressures are 50 and 73 MPa. The implemented injection strategy consists of pilot + main pulses and has been fixed for all fuels. First generation of biodiesel, Soybean Methyl Ether (SME), and second one, Gas To Liquid (GTL), have been used and their behaviours have been compared to the reference diesel fuel.

Results and Discussion

The comparisons of the tip penetration under evaporative and non evaporative conditions for the pilot and main injection, are reported in Figure 1 for both engine conditions. The curves relative at the injection pressure of 50 MPa are split into two segments both for the pilot and the main pulses. In the first part, a good partly cov-

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ering occurs for the spray penetrations for all the fuels except for the pilot of the diesel fuel. Later a less penetrating trend for the engine evaporative conditions is shown due to the vaporization process. At the injection pressure of 73 MPa the effects of the vaporization process on the main penetrations are more evident.

In Figure 2 are reported the liquid spatial distribution of the jets detected in the non evaporative system at two times from the start of main injection for the high load condition (P_{inj}=73 MPa). In the graph, all jets show a liquid core and a decreasing liquid density moving towards the jets boundaries. Moreover, the SME fuel shows a denser liquid core with respect to the other ones at 400 μs and a higher penetration because of the highest density/viscosity. These results fairly agree with literature data [5].

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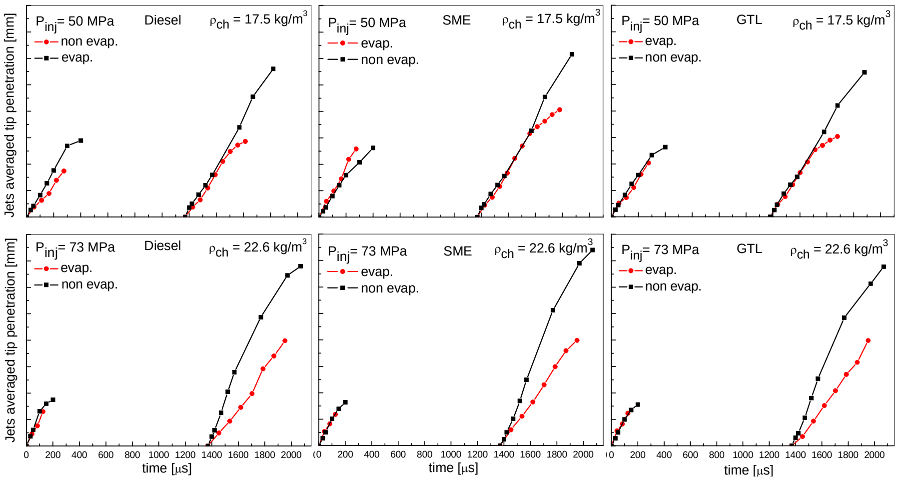

Figure 1. Comparison of liquid jet penetration profiles under evaporative and non-evaporative conditions.

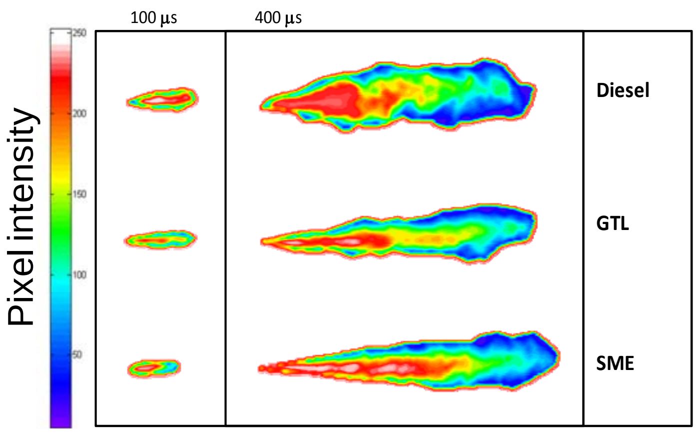

Figure 2. Jet liquid densities for the investigated fuels in non evaporative system for the high load condition (P_{inj}=73 MPa) at 100μs and 400μs after the SOI