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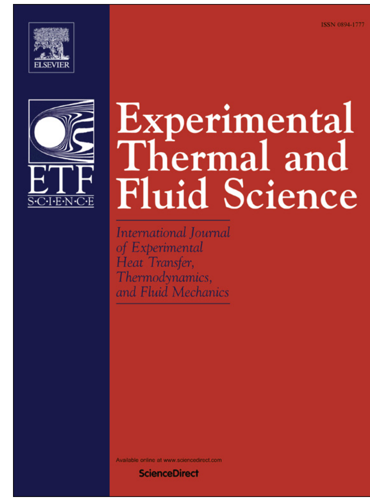

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Effects of cavitation flow and stagnant bubbles on the initial temporal evolution of diesel spray

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Abstract：This study focuses on the in-nozzle flow characteristics and the primary spray breakup of diesel at the near-nozzle region under atmospheric conditions. A long working distance microscope and a Canon EOS 700D CCD Camera were employed to study the cavitation flow in the nozzle and the spray structure at near-nozzle region via photographic technique with backlighting. Images were obtained with short exposure time and sufficiently high spatial and temporal resolutions which allowed a detailed observation of the early phase of fuel injection from the nozzle orifice to near nozzle region. The images revealed that the formation of a variety of complex two-phase flow regimes. Stagnant bubbles were present inside the nozzle at the start of injection. The stagnant bubbles may have originated from the last injection because they have not been evacuated from the nozzle or sucked into the nozzle orifice as the needle valve opened. During the opening and closing stages of the needle valve, the cavitation occurred in the valve seat area. Subsequently, free cavitation was observed at the inlet orifice followed by film cavitation, cloud cavitation and string cavitation in the orifice. A dimensionless number *S* derived from the images of transparent nozzles was adopted to evaluate the cavitation intensity, which increased monotonically with the increase of injection pressure. In addition, mushroom shaped spray head was also found at the nozzle exit. A close inspection revealed that the stagnant bubbles or the fuel trapped in the injector orifice at the end of injection had an appreciable impact on the near nozzle spray structures. The spray angle, penetration length and the spray area also increased for every 10 MPa rise by about 20%, 10% and 15%respectively.

Key words：Stagnant bubbles; Cavitation; Spray structure; Optical-injection nozzle tip design

1. Introduction

The increasingly stringent emission regulations have driven and continue to drive the development of clean combustion and emissions control techniques for diesel engines. It is well established that adopting high injection pressure could promote the fuel breakup and atomization, and hence improve the combustion efficiency and reduce the engine-out emissions. In a diesel engine, the design of fuel injection nozzle is an important factor for the spray characteristics and air/fuel mixture preparation. A number of studies have been conducted to investigate the effects of the nozzle characteristics on the internal and external spray performances [1-6]. One of the most primary factors that influence the nozzle flow characteristics is cavitation. Cavitation is formed from the liquid to vapor in the low static pressure flow regions when the local pressure is less than the saturated pressure, and cavitation has a great influence on the fuel injection (especially the disintegration of liquid jet) and the subsequent combustion process. The fuel jet normally experiences the primary breakup at the exit of the nozzle and the breakup determines the spray structure and macro characteristics. Better primary breakup will provide better secondary dispersion quality, thus generate smaller droplets and quicker evaporation. There is a need to better understand the in-nozzle flow characteristics and the near-nozzle spray primary breakup, because many previous researches were hindered by the difficulties of directly observing the high speed flow in the tiny space between the seat and the spray nozzle hole.

Utilizing visualization experiments on in-nozzle

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