Laser Diagnostics of Spray Flow with New Type Injection System

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1, Introduction

Laser Diagnostics of spray flow is regarded as an important part of engine design in terms of spray shape and fuel distribution observing and particle diameter-velocity field characteristics analyzing. In addition, the swirl pressure injector as the secondary generation injector for GDI engine has proved to offer lower fuel consumption and better combustion efficiency in the case of stratified part-load operation. However, from the point of view of the disadvantage of swirl injector, the spray cone angle is sensitive to the ambient pressure conditions, which can't provide enough ignition stability. In the same time, the wall wetting caused by the fuel in front of spray with larger momentum and worse particle diameter characteristic can't play a positive role to reduce HC and NO_x emissions.

The peizo outwards-opening pintle-type DI injector as the advantages of well atomization characteristics, faster mixture preparation and stable fuel/air equivalent ratio near the spark plug in the case stratified for spray-guided combustion was proposed as the new generation high pressure injector providing a hollow cone spray structure with limited penetration for stratified charge combustion strategy.

2, Experiment Setup and Main Condition Parameters

Two test piezo pintle-type injectors with the design spray cone angle of 94deg. and 98deg. were tested with a constant volume vessel. An electronic control fuel supply system is responsible for supplying different injection pressure conditions of 5MPa, 10MPa, 15MPa and 20MPa. The ambient pressure in the constant volume vessel can be adjusted from 0.1MPa and 1.1MPa. Moreover, the needle lift is also regarded as a primary variable parameter researched in experiments.

2, Experiment Results and Analysis

Laser Diagnostic methods were adopted for analyzing the hollow cone spray characteristics of piezo pintle-type injector adequately.

2.1 Visualization Researches

Visualization optical system with high resolution CCD camera was used for the observation of spray spatial characterize of new piezo test injectors. The results illustrated that the effects of injection pressure and ambient pressure conditions on spray penetration are obvious. As ambient pressure is increased, spray was effectively limited to concentrate in the center of combustion chamber, as shown in Fig.1. Furthermore, as needle lift is increased, the growth rate of penetration is reduced as presented in Fig.2.

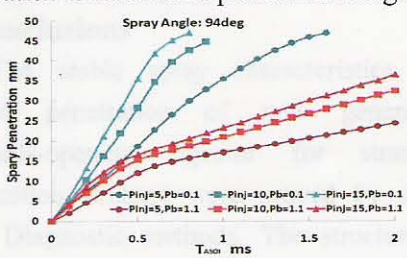

Fig. 1 Effect of Injection and Back Pressure on Penetration

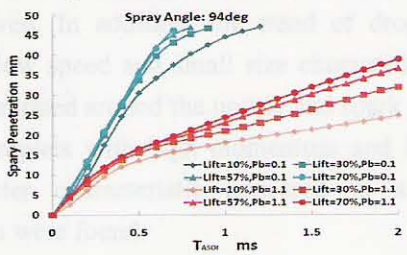

Fig. 2 Effect of Needle Lift and Back Pressure on Penetration

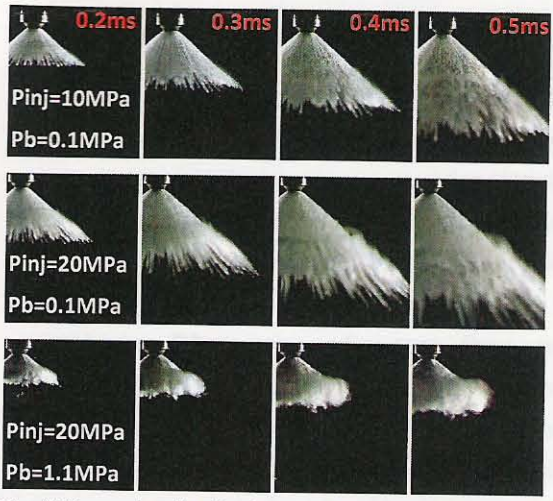

Fig. 3 Spray visualization images, for spray cone angle of 98deg and PWM of 57%

As shown in Fig.3, it has been noticed that instead of a continuous hollow cone spray, the spray from piezo outwards-opening injectors exhibits a structure of strings right from the injector nozzle exit.

2.2Velocity Field Distribution Based on PIV

For the case of hollow cone sprays, one of the main problems for PIV is the dense particles and strings of the sprays and the wide range of spray particle velocity. Therefore, decreasing injection pressure to 5MPa and ambient pressure to 0.1MPa was regarded as the primary solution way.

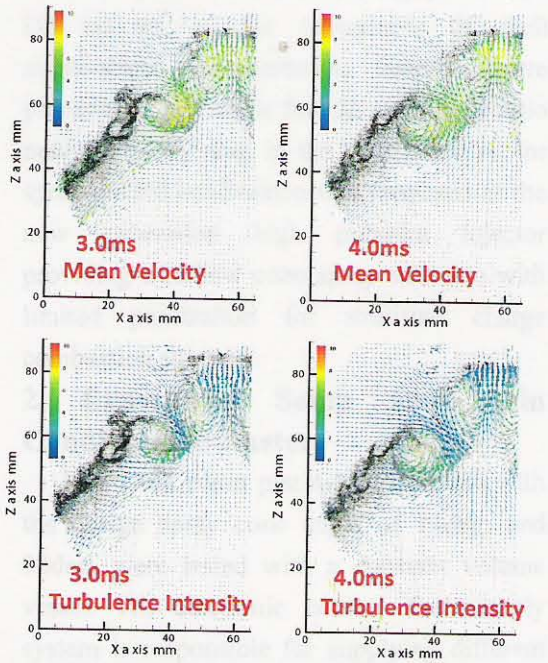

Fig. 4 The distribution of velocity field and turbulence intensity, for spray angle of 94deg, PWM of 30%

Under the condition of injection duration of 1.5ms, PIV results revealed that a large circumfluence region was observed right from the injector nozzle exit which provides proper fuel/air equivalent ratio around spark plug. As a function of time, the dissipation of eddy energy makes the circumfluence region expand, and the position variation is very small. Two high-speed regions appear in circumfluence region and nozzle region respectively, for T_{SOI}=3.0ms and 4.0ms.

2.3 Particle Size and Velocity Characteristics Based on PDA

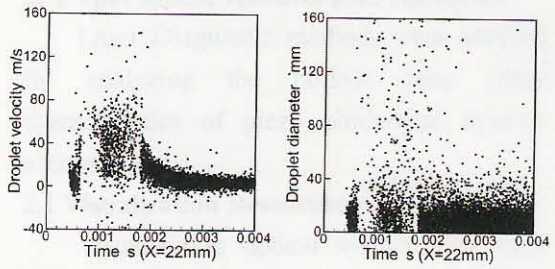

Fig. 5 Transient distribution characteristics of droplets size and velocity, X=22mm, Z=16mm, spray angle of 94deg, Pinj=20MPa, Pb=0.1MPa, PWM=57%

As shown in Fig. 5, the droplets size and velocity distribution are presented. Small gaps exit during the main of injection process due to the absence of valid measurement data. The non-spherical droplets shape and significant laser light attenuation caused by over-rich spray character were considered as the main reasons. The Time Dividing Method was adopted for analyzing the PDA results.

3, Conclusions

The stable spray characteristics and limited penetration of new generation outwards-opening injector for stratified combustion strategy were proved by using laser Diagnostic methods. The structure of strings and a large circumfluence region were observed. In addition, the trend of droplets with low speed and small size characteristics concentrated around the nozzle and spark plug, the droplets with high momentum and large diameter characteristic appeared in a far region were found.