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Effect of Nozzle Needle Motion on Fuel Spray and Combustion Flame Characteristics

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Fuel spray characteristics are known to have a significant effect on the combustion characteristics in diesel engines. Despite the extensive investigations on diesel spray, few experimental studies are found regarding the needle motion effect on the spray and combustion characteristics. In this report, a commercial injector was modified to vary its needle valve motion. Then, the needle valve motion, spray and combustion characteristics of the modified injector were compared to those of a base injector (non-modified). Results are discussed in detail to understand the needle valve motion effect on the fuel spray and combustion characteristics.

To create different neelde valve motion, the shim thickness in the upper part of the injector control chamber was modified. By changing this shim thickness, the discharge coefficient through the control chamber was suppressed, which was expected to be able to change the needle valve rising speed. Then, the mass flow measurement confirmed that the modified injector have a different mass flow rate compared the base injector. Furthermore, by taking advantage of the X-ray phase contrast imaging technique (XPCI) in Advance Photron Sourec in America, the needle motion of modifed injector and base injector was measured. The results showed that the modified injector have slower needle valve rising speed, whereas the full needle lift and the needle vale closing speed are almost identical for two injectors.

The spray characteristics were measured in the combustion chamber using visible light measuring technique. It is found that the modified injector, which has slower needle rising speed, have shorter the spray tip penetration and spray tip speed. This is likely because the decrease in the needle valve rising speed results in the extension of the transition period of the fuel injection. In addition, the spray angle, corresponding to the transitional period of the fuel injection, increases in the modifed nozzle. A similar tendency can be observed when the injection pressure is increased from 65 MPa to 160 MPa.

The fuel combustion flame characteristics were also measured and the OH chemiluminescence was imaged for the indication of combustion flame characteristics. It is found that the needle valve rising speed can change the start time of OH chemiluminescence. From this, it is known that spatio-temporal control can be achieved by altering the needle valve rising speed.

It can also be confirmed that the length of the OH chemiluminescence from the collision wall increases with the increase in injection pressure. This is thought to be due to the effects of the decrease in the needle valve rising speed. Slow needle rising speed has the reduced spray tip velocity, the enlarged spray angle during the transition period of fuel injection, and the improved mixing of the fuel spray with the ambient gas. Therefore, it was known that the formation range of the flame expanded due to the decrease in the needle valve rising speed.

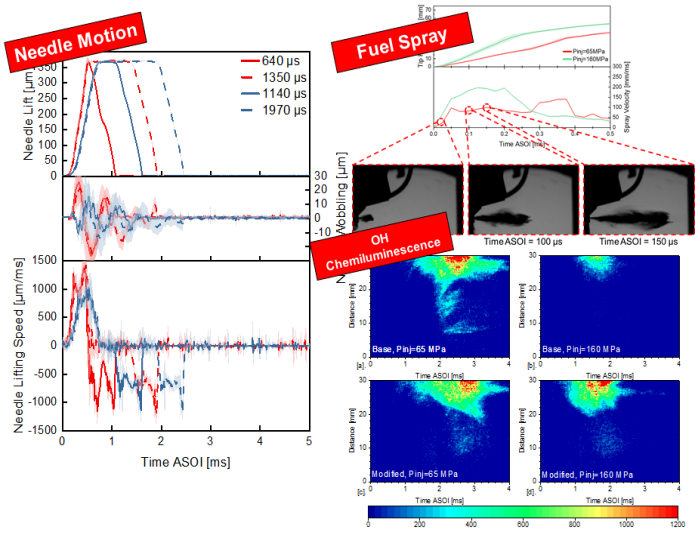

Fig. Needle valve motion effect on the spray and combustion characeteristics