Internal Flow Visualization of a Large-Scaled VCO Diesel Nozzle with Eccentric Needle

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Valve-covered-orifice (VCO) diesel nozzles are usually employed in order to reduce unburned hydrocarbon emissions of diesel engines. Radially eccentric location of needle markedly influences formation of cavitating bubbles inside nozzle and atomization. This result suggests that flow patterns inside the nozzle strongly affect production of cavitating bubbles and primary breakup of liquid jets. Therefore flow visualization was carried out to investigate the effects of eccentricity of a needle inside a VCO diesel nozzle on flow structure of internal flow and primary atomization.

A 10 times large-scaled VCO nozzle had two nozzle holes as shown in Fig. 1. The diameter of both the nozzle holes was 2mm and the length was 8mm. Reynolds number of the flow inside the nozzle hole of the large-scaled VCO nozzle achieved maximum value of approximately 40000, which was nearly the same as that of real-size diesel nozzles. The needle, which was incorporated into the nozzle, was manipulated by a three-dimensional traverse with micrometers. Fine polymer particles were employed as tracer particles for flow visualization, so that photographs of stream lines of the particles are obtained.

Most of discussion in this study focuses on the behavior observed at relatively low needle lift, and the needle is manipulated vertical to both the holes. The visualization shows that flow pattern strongly depend on radial location of the needle, and two modes of flow patterns are observed. On the contrary the flow pattern is almost independent of injection pressure. Flow visualization for first mode of internal flow, which causes the solid cone spray, indicates almost straight stream with weak swirl motion inside the hole when the eccentric needle is located close to the nozzle center. High injection pressure leads to cavitating bubbles at both contraction regions while vortex cavitation is not observable. On the other hand, the second mode of internal flow is encountered when the distance of the needle from the nozzle center is further increased beyond the radial location of the first mode. The flow pattern of the second mode shows strong swirl motion, so that the hollow cone spray is mainly appeared. The upperside contraction region at the hole entrance remains in the second mode although the lowerside contraction region at the hole entrance becomes undetectable. High injection pressure causes a vortex cavitation inside of the hole. Spray cone angle is compared with the swirl angle of flow inside the hole which is obtained from a flow pattern as shown in Fig. 2. The swirl angle was defined as the angle between a centerline of the hole and a stream line across the center line by using the photograph obtained in order to evaluate swirl motion along the hole. This result shows a similar trend to that of the spray cone angle.

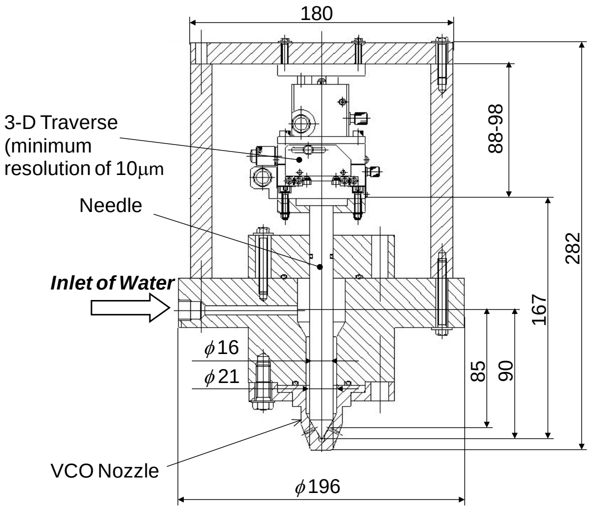

Figure 1 Schematic of nozzle holder with 10 times large-scaled VCO nozzle.

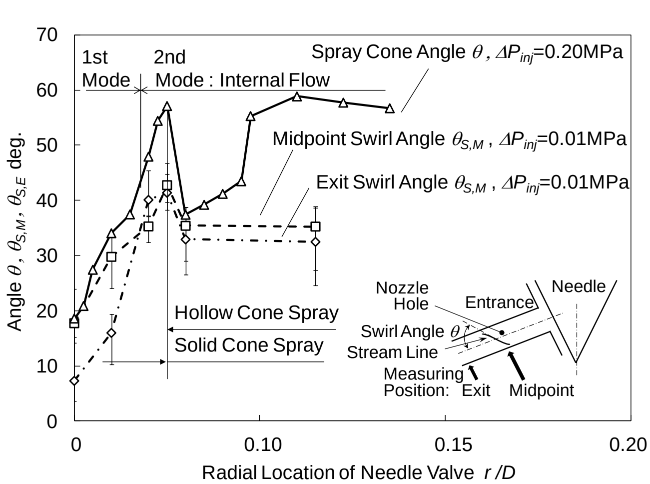

Figure 2 Comparison between spray cone angle and swirl angles. (L_h=0.3mm, ϕ=90^o)

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