

Effects of Fuel Physical Properties on Shape of Spray from a Diesel Nozzle

Kodai Aritomi ¹⁾ Keisuke Komada ¹⁾ Shohei Yamamoto ²⁾ Yasuyuki Takatsu ¹⁾

1) Fukuoka Institute of Technology

3-30-1 Wajiro-higashi, Higashi-ku, Fukuoka 811-0295, Japan

2) Osaka Electro-Communication University

18-8 Hatsu-cho, Neyagawa, Osaka 572-8530, Japan

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The use of synthetic fuels and biofuels has been considered as a means of achieving carbon neutrality in diesel engines. Previous studies have reported that changes in fuel type alter the spray tip penetration, droplet size distribution, and exhaust characteristics. However, because changing the fuel causes multiple physical properties to change simultaneously, it has been difficult to isolate and identify the individual effects of each property. The present study creates test fuels by mixing multiple liquids such that only one of the physical properties—kinematic viscosity, surface tension, or density—differs significantly from the others, with the purpose of clarifying the effects of each physical property on spray tip penetration and spray angle.

In this study, six types of test fuels were formulated. The kinematic viscosity of Fuel A is approximately 17.0 times that of Fuel B, the surface tension of Fuel C is approximately 1.56 times that of Fuel D, and the density of Fuel E is approximately 1.44 times that of Fuel F. On the other hand, the differences in the physical properties intended to be matched were within 4%. The temperature of the test fuel when the physical properties were measured was 20 ± 0.1 °C. A 10-hole injector with a nozzle diameter of 0.133 mm was used to inject the fuel into the atmosphere. The injection pressure was set to 60 MPa, and the injection duration was 0.765 ms. Spray images were captured using a high-speed camera. The spray angle was defined as the angle formed by two straight lines: one extending from the edges of nozzle orifice and the other connecting the two ends of the spray width at a position 40 times of nozzle orifice diameter (approximately 5.3 mm) downstream from the orifice.

Figure 1 shows the time variations of spray tip penetration and spray angle for the six test fuels. Fuel B, which has a lower kinematic viscosity than Fuel A, had an earlier injection start time and a higher spray tip velocity. It is thought that the injection rate increased more rapidly due to a decrease in viscous resistance inside the injector. Furthermore, Fuel B had a larger spray angle than Fuel A. It is thought that this was due to increased flow turbulence inside the nozzle, thereby promoting the radial spread of the spray. Although Fuel C, which has higher surface tension than Fuel D, began injection earlier, the time variation of spray tip penetration and spray angle were nearly identical for both fuels. The effect of surface tension on these parameters was therefore minimal. Fuel F, which has a lower density than Fuel E, had an earlier injection start time and a greater spray tip penetration. It is thought that the injection velocity increased due to the decrease in fuel density. The spray angle tended to be smaller for Fuel F than for Fuel E. It is thought that the increase in injection velocity resulted in a relatively greater development of the spray in the axial direction than in the radial direction.

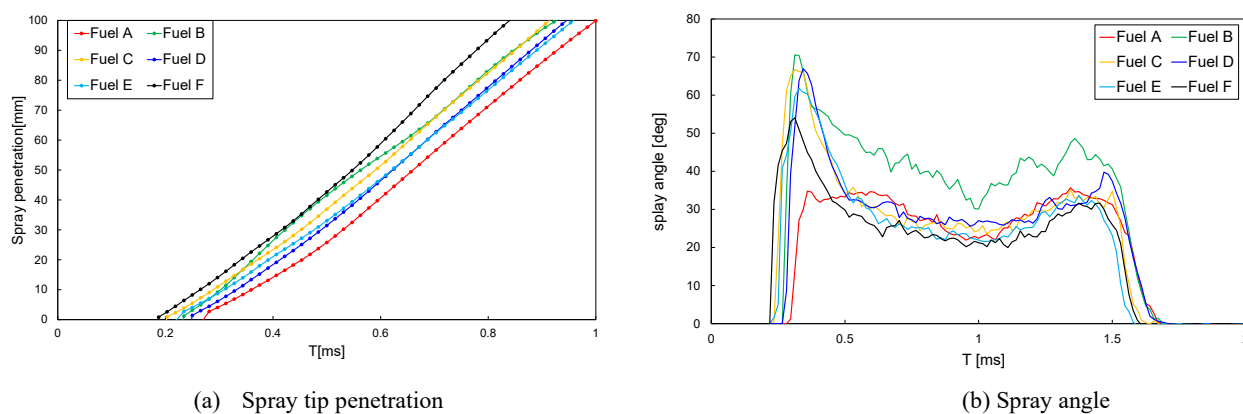


Fig. 1 Time variations of spray tip penetration and spray angle