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Study on Fuel Spray Impingement on Cylinder Wall with Post Fuel Injections

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Post fuel is injected for the DPF regeneration and it is empirically know that the late post fuel injection is one of the causes of the engine oil dilution, however the oil dilution mechanism and spray behavior of post fuel in the cylinder are not well know so far. In this paper, a constant volume chamber (ϕ110 mm diameter and 883cm^3 in volume) is introduced to simulate the post fuel injection phenomena in disel engines. A stage is in the chamber and a wall-impingement plate with 5 μm thickness of engine oil film, that is equivalent to the cylinder wall, is set on the stage. The post fuel injection environment is measured by the engine experiments, and a similar environment is formed in the chamber by the combustion of ethylene gas mixtures and the post fuels were injected at 30, 60, and 90 CA ATDC conditions in diesel engines. The quantities of adhered post fuel on the wall-impingement plate and splashed oil were measured by a precision balance and a chermostatic chamber, and the spray penetrations and motions in vapor and liquid phases were observed by the optical diagnostics of Shadowgraph and Mie scattering methods.

When the post fuel is injected at 30 CA ATDC condition, the post fuel vaporizes before the fuel impingemet on the plate, and the gas phase fuel condenses and forms a thin fuel film on the wall-impingement plate. As the fuel injection timing retarded, the temperature and pressure drop and the post fuel in liquid phase starts to impinge on the wall-impingement plate. On the wall-impingement plate, two rings were ovserved, inner and outer rings: the oil film inside the inner ring is rubbed off by the post fuel injection and flooding with engine oil occurs at the outer ring. Figure 1 shows (a) the fuel adhesion quantity and (b) adhesion ratio on the wall-impingement plate. Filled bars show the test results of wall-impingement plate with 5 μm thickness of engine oil film, and open bars show the test results of wall-impingement plate without engine oil film. In Figure 1 (a), the fuel adhesion quatity increases with the increase of fuel injection quantity and the retard of fuel injection timing, however the wall adhesion plate with engine oil film holds more fuel than the wall adhesion plate without engine oil, because the engine oil film on the wall-adhesion plate absorbs the thin fuel film formed after the fuel spray impingement. In Figure 1 (b), the fuel adhesion ratio does not increase with the increase of fuel injection quantity, ex. blue bars, and this suggests that there exists the maximum limit of fuel adhesion quantity that the wall-adhesion plate can hold. Futher, the splashed oil quantities were measured. As the retard of post fuel injection timing and increase of post fuel injection quantity, the splashed oil quantity increases.

The effects of multi stage post fuel injection on fuel adhesion on the wall-adhesion plate were investigated. The total fuel quantity was set at 0.98 mg, and single stage (0.98 mg/shot, one shot), two stages (0.49 mg/shot, two shots), and three stages (0.33 mg/shot, three shots) fuel injections were evaluated. As the increase of number of stages, the fuel adhesion quantity decreased, because the heat capacity of each fuel becomes smaller and much fuel vaporizes before impingement. However, in the multi stage injections in Figure 2, the length of liquid phase spray is getting longer as the number of injection increases, since the previous spray motion remains in the fuel spray path and affects the next fuel spray motion and vaporization.

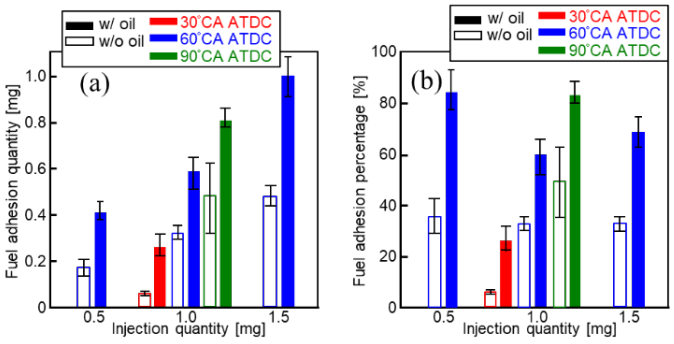

Fig. 1 (a) Fuel adhesion quantities and (b) fuel adhesion ratios with and without lubrinat oil on the wall adhesion plate

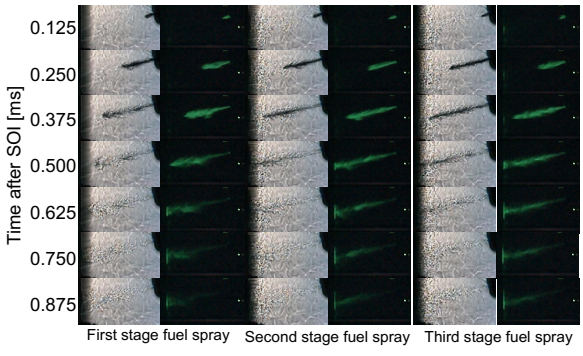

Fig. 2 Shadowgraph and Mie scattering images of first second, and third sprays of three-stage injections