(2-15) Analysis of Cycle-by-Cycle Variation in a Direct-Injection Gasoline Engine Using Laser-Induced Fluorescence Technique

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ABSTRACT

Fuel mixture distribution has been measured during the mixture formation and the combustion period by the LIF technique in order to analyze the combustion fluctuation in a DI gasoline engine. Fig. A1 shows the cycle-by-cycle variation of the equivalence ratio at the spark position just before the spark timing and its effect on the initial combustion period and the IMEP value. From the figure, it can be seen that the equivalence ratio is highly fluctuated even in the same injection timing. At the advanced (-70°) or the retardant (-58°) injection timing, the initial combustion period tends to long and the IMEP value becomes low when the leaner cycles (φ<1) or the richer cycles (φ>2) appear. From these results, it has been revealed that the combustion fluctuation at both the advanced and retardant injection timing is dominated by the mixture concentration at the spark position and timing. In contrast to this, when the injection timing is set at the best combustion fluctuation condition (-63°), the initial combustion period is not affected by the fluctuation of the equivalence ratio. In this condition, the cycle-by-cycle IMEP value has a correlation not with the initial combustion period but with the main combustion period. Therefore, the combustion fluctuation is dominated by the latter stage of the combustion. Fig. A2 shows the fuel distribution during the combustion period. From the LIF image, the latter stage of the combustion occurs at the edge region of the piston cavity. Fig. A3 shows the cycle-by-cycle LIF intensity, which is mainly proportional to the fuel quantity, and its effect on the IMEP value. From this figure, it is evident when the unburned fuel remains much, the IMEP value is low; strong correlation can be seen in it. Therefore, it can be said that the combustion fluctuation near the best injection timing is due to the cycle-by-cycle variation of the unburned fuel existing at the cavity edges during the latter combustion period. Based on this analysis, it became possible to improve the combustion fluctuation by the procedure for the reduction of the over lean mixture at the cavity edge region.

Fig. A1 Cycle-by-cycle variation of the equivalence ratio at the spark position and its effect on the combustion period and IMEP
(Ne=1200rpm, Qf=12mm3/st, IT=-63°, ST=-31.5°, A/F=27, w/EGR)

Fig. A2 Fuel distribution during the combustion period (LIF images) Fig. A3 Relationship between the LIF intensity and IMEP value.