

Study on Modeling of Combustion Chamber Deposits in High-efficiency Gasoline Spark-Ignition Engines

- (Forth Report) Evaluation of Deposit Formation under Carbon-Neutral Fuel Conditions Using an Autoclave-

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Achieving carbon neutrality in gasoline-based fuels, which have high energy density, is an important challenge. In Japan, research and development of next-generation fuels, including synthetic fuels targeted for introduction by 2050, has been promoted. Action plans have also been formulated to expand the use of bioethanol and introduce gasoline containing 20% ethanol (E20). Overseas, the production of carbon-neutral fuels derived from hydrogen produced using renewable electricity, including methanol-to-gasoline (MTG) fuels, has also been advancing. Meanwhile, high-efficiency spark-ignition engines employing high compression ratios and ultra-lean combustion are being investigated as utilization technologies for synthetic fuels. Combustion chamber deposits (CCDs), which may affect abnormal combustion associated with increased compression ratios, are also an important trade-off issue. Therefore, this study aims to clarify the mechanisms of CCDs formation, establish methods for suppressing deposit formation, and ultimately develop a predictive model. In this report, simulated deposit formation experiments were conducted in an autoclave using carbon-neutral and ethanol-blended fuels, and the experimental results are presented.

Simulated deposit formation experiments were conducted in an autoclave using premium gasoline (PG), PG blended with 10% and 20% ethanol (PG+E10 and PG+E20), and MTG+E20. The resulting residues were subjected to solvent extraction with hexane, and the hexane-insoluble fraction was defined as the deposit. This fraction was further extracted with tetrahydrofuran (THF) and separated into THF-soluble and THF-insoluble fractions.

Fig. 1 compares the amount of deposit formed from each fuel. The deposit mass was calculated from the measured residue mass and the solvent extraction ratio, assuming that the deposit was uniformly distributed within the residue. At a heating temperature of 150 °C, the deposits consisted predominantly of THF-soluble fractions, whereas THF-insoluble fractions, which are considered to include polymerized products, were scarcely detected. In addition, the amount of deposit formed decreased with increasing ethanol blending ratio, while no appreciable difference was observed between MTG+E20 and PG+E20.

The reduction in the amount of deposit formed with increasing ethanol concentration is likely attributable to changes in the liquid-phase composition and in the concentration of deposit precursors during the heating of gasoline as a multicomponent mixture. These changes may result from near-azeotropic volatility behavior among several components and the associated increase in vapor pressure. The MTG+E20 fuel used in this study contained approximately 15% fewer aromatics than PG+E20; therefore, a reduction in deposit formation was expected. However, the resulting deposit mass was comparable to that obtained from PG+E20, although the reason for this remains unclear.

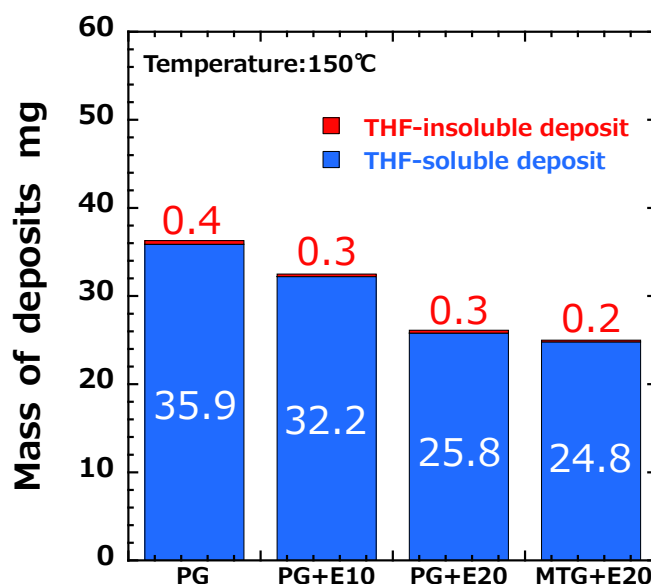


Fig.1 Comparison of Simulated Deposit Mass Derived from Different Fuels