

Effects of Ethanol Adding to MtG (Methanol to Gasoline) Fuel on Engine Performance

Haruto Morimoto ¹⁾ Chihiro Kishimoto ¹⁾ Ratnak Sok ¹⁾

Kou Osada ²⁾ Ryota Yamada ²⁾ Jin Kusaka ¹⁾

1) Waseda University, Graduate School of Creative Science and Engineering, Department of Modern Mechanical Engineering
Room 226, Building 58, 3-4-1 Okubo, Shinjuku-ku, Tokyo, 169-8555, Japan

2) Toyota Motor Corporation,
1200 Mishuku, Susono-city, Shizuoka, 410-1193, Japan

KEY WORDS: Heat engine, Spark ignition engine, Combustion analysis, e-fuel, Ethanol adding (A1)

To achieve carbon neutrality by 2050, reducing greenhouse gas emissions is imperative, making the utilization of sustainable liquid fuels such as bioethanol and carbon-neutral synthetic fuels a key focus. Previous literature has demonstrated that blending ethanol into gasoline effectively reduces carbon monoxide, unburned hydrocarbons, and nitrogen oxides emissions in spark-ignition engines. Furthermore, studies on synthetic fuels like Methanol to Gasoline (MtG) and Ethanol to Gasoline (EtG) have shown that ethanol addition linearly increases the research octane number (RON) and enhances laminar burning velocity according to detailed chemical kinetic simulations. However, the impact of ethanol blending into synthetic fuels on actual engine performance and exhaust characteristics remains insufficiently explored in practical engine experiments.

To address this research gap, this study investigated the effects of ethanol blending into regular base gasoline and MtG fuel. Engine experiments were conducted across seven engine load conditions from low load to high load. In each load, experiments were conducted in seven ignition timings, including MBT (Minimum advance for Best Torque) or TK (Trace Knock) point. The ethanol blending ratios were varied at 0%, 10%, and 20% by volume to systematically evaluate key parameters including thermal efficiency and exhaust gas composition.

The experimental results indicated that the brake thermal efficiency increased from low load to medium load region across all fuels. For ethanol concentrations of 0 vol% and 10 vol%, the brake thermal efficiency peaked at approximately 37% around a brake mean effective pressure (BMEP) of 0.7 MPa. In contrast, the 20 vol% ethanol blend achieved a higher peak thermal efficiency of approximately 38% at a higher load of BMEP 0.9 MPa. In the low to medium load range (BMEP 0.4 to 0.7 MPa), variations in ethanol blending ratio resulted in negligible differences in thermal efficiency. However, at higher loads exceeding BMEP 0.8 MPa, the 20 vol% ethanol blend demonstrated a thermal efficiency improvement of 1% to 2% compared to the 0 vol% and 10 vol% blends. At BMEP of 0.7 MPa, knocking occurred with 0% ethanol addition, while no knocking was observed at 10% and 20% ethanol addition. Increasing the ethanol blending ratio improved fuel octane number, which led to some benefits, such as knock suppression and enhanced thermal efficiency in high load due to ignition timing advancement. Under high-load conditions (BMEP 0.95 MPa), ethanol addition enabled the TK ignition timing to advance by 4.5 degrees crank angle from 0.5 deg. ATDC to -4.0 deg. ATDC, leading to a marked improvement in thermal efficiency due to enhanced charge cooling from ethanol's high latent heat of vaporization. In conclusion, these thermal efficiency trends were consistent for both gasoline and MtG fuels, confirming the effectiveness of ethanol addition in synthetic fuels.

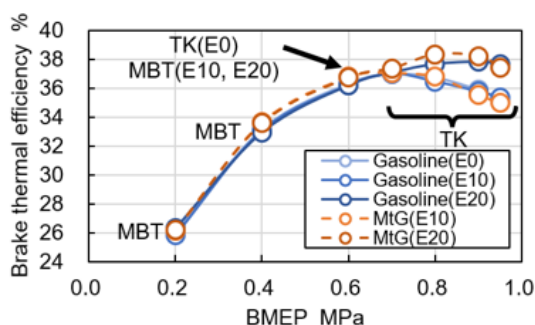


Fig.1 Comparison of break thermal efficiency (2000 rpm, $\lambda=1$, EGR 0%, Ign. timing : MBT or TK)

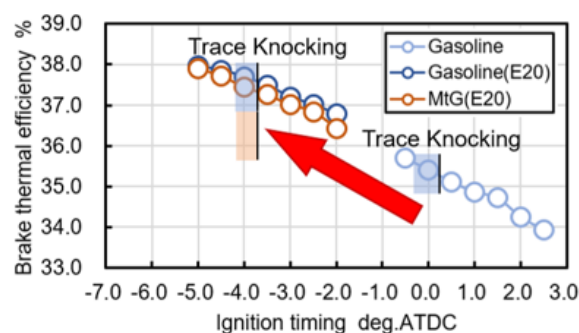


Fig.2 Thermal efficiency improvement (2000 rpm, BMEP=0.95 MPa, $\lambda=1$, EGR 0%)