

Study on the Influence of Different Internal Exhaust Gas Recirculation Formation Modes on the Combustion Performance of Gasoline, Methanol, and Ethanol SI Engine

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Abstract

To promote the efficient and clean application of low-carbon alcohol fuels in internal combustion engines, this article compares and studies the effects of three internal EGR strategies, including exhaust valve lift strategy (EVVL), exhaust timing advance strategy (EVT), and intake valve timing advance strategy (IVT), on the combustion, performance, and emissions of gasoline, methanol, and ethanol. Under the same internal EGR rate, the internal EGR temperature generated by the three valve strategies is, from highest to lowest, as follows: EVT, EVVL, and IVT. With an increase in internal EGR in the cylinder, the ignition delay and combustion duration under the EVVL and IVT strategies increase progressively, whereas the ignition delay under the EVT strategy tends to first shorten and then lengthen. Methanol has the shortest combustion duration. Furthermore, methanol and ethanol have lower heat transfer and exhaust losses than gasoline. The thermal efficiency of methanol, ethanol, and gasoline can be raised by 7.7%, 7.5%, and 7.2%, respectively, using the IVT strategy; 3.1%, 3.9%, and 4.6% using the EVVL strategy; and 6.82%, 6.85%, and 7% using the EVT strategy. The combination of methanol and ethanol with internal EGR technology greatly reduces NO_x emissions, with an 84.5% reduction under the EVVL strategy.

Keywords Internal EGR · Gasoline · Methanol · Ethanol · Combustion performance

Abbreviations

EGR	Exhaust gas recirculation
IMEP	Indicated mean effective pressure
CA10	Ignition delay
CA10-90	Combustion duration
MBT	Minimum advance for best torque

1 Introduction

With the increasingly prominent issues of energy shortage and environmental pollution, energy conservation and emission reduction have become the development goals of internal combustion engines. The development of alternative

clean fuels has increasingly become a useful method for mitigating the energy crisis and reducing pollution. There are numerous forms of alternative clean fuels, with alcohol fuels being the most popular and widely used in China (Duan et al., 2018; Shiao et al., 2020; Zhou et al., 2020). Methanol, ethanol, and butanol are examples of alcohol fuels. Alcohol fuels have a higher oxygen content and H/C ratio than gasoline, which benefits power performance and emissions. According to research, methanol and ethanol have higher volatility and lower boiling temperatures than gasoline, making them more favorable to the formation of acceptable flammable combinations (Iodice et al., 2018). As a result, both as a single fuel and as a blended fuel, they have received much research (Iodice et al., 2018). According to studies, when used as a mixed fuel, an increase in the methanol/gasoline ratio in a mixed fuel can greatly enhance braking thermal efficiency while also lowering CO and NO_x emissions. M85 cuts CO and NO_x emissions by 25% and 80%, respectively. Similarly, adding ethanol to the engine can boost volumetric efficiency and brake specific fuel consumption by 12.89% and 6.59%, respectively (Ismail et al., 2022). When utilized as a single fuel in engines, methanol

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