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Significant CO_2 Reductions by Utilising the Synergies Between a Downsized SI Engine and Biofuels

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Abstract

This study explores the synergies between downsized direct injection engines and advanced gasoline fuels including those containing ethanol and butanol. It was shown that significant reductions in CO_2 emissions are possible with current technology levels across both the NEDC and more real-world (Artemis) drive cycles.

Replacing a proportion of gasoline fuel with a renewably sourced alcohol such as ethanol or butanol can directly reduce fossil fuel consumption in vehicle engines. Fuels containing ethanol and butanol in concentrations ranging from 10 to 85 % were tested together with two conventional gasolines. Further gains in efficiency can be made by downsizing the gasoline engine to increase the specific load and reduce the throttling inefficiencies at part load. To maintain full load performance, pressure charging of the intake system is required, often resulting in a reduction in the compression ratio and an increase in over-fuelling at full load to reduce exhaust temperatures and protect the turbocharger components.

Due to their superior evaporative cooling, splash blending alcohols into gasoline raises the RON rating of the blend and reduces the tendency of the fuel to 'knock' under high specific loads. Direct injection of these blends takes further advantage of the high latent heat of vaporisation of alcohols, cooling the exhaust gas and reducing the over-fuelling requirement. The combination of alcohol fuel blends, downsizing and direct injection are therefore mutually beneficial. However, blending alcohols with gasoline also reduces the calorific content of the blend, lowering the stoichiometric AFR and requiring higher volumetric fuel flows.

A current technology class D vehicle provided an accurate baseline for both drive cycles. The MAHLE downsized engine featuring an advanced boosting system and direct central injection was used to provide the data for drive cycle modelling. This paper concentrates on the process to obtain high quality modelled drivecycle data and the individual steps needed. Detailed testing was undertaken to understand the synergies between biofuels and downsizing and how they are best utilised. Comprehensive drive cycle modelling provides accurate data showing that CO_2 reductions of up to 34 % are possible under NEDC and more real world driving conditions by utilising biofuels in the downsized engine.