Heavy Duty SI Gas Exchange Requirements with Renewable Fuels

KTH CCGEX

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The project provides insights on diluted combustion of ethanol and methanol in HD SI engines. Experiments were performed to obtain the effect of excess air dilution on knock reduction and combustion stability. 0D combustion and knock models were developed to accurately reproduce combustion performance for a wide load range. Using the validated models, gas exchange requirements for high efficiency HD SI engines were explored

Introduction and Motivation:

Knock is one of the most important limiting factors for increasing specific torque in HD SI engines. The low engine speed and longer flame travel distance is critical for knock in HD SI engines due to the longer residence time available for the end gas to auto-ignite.

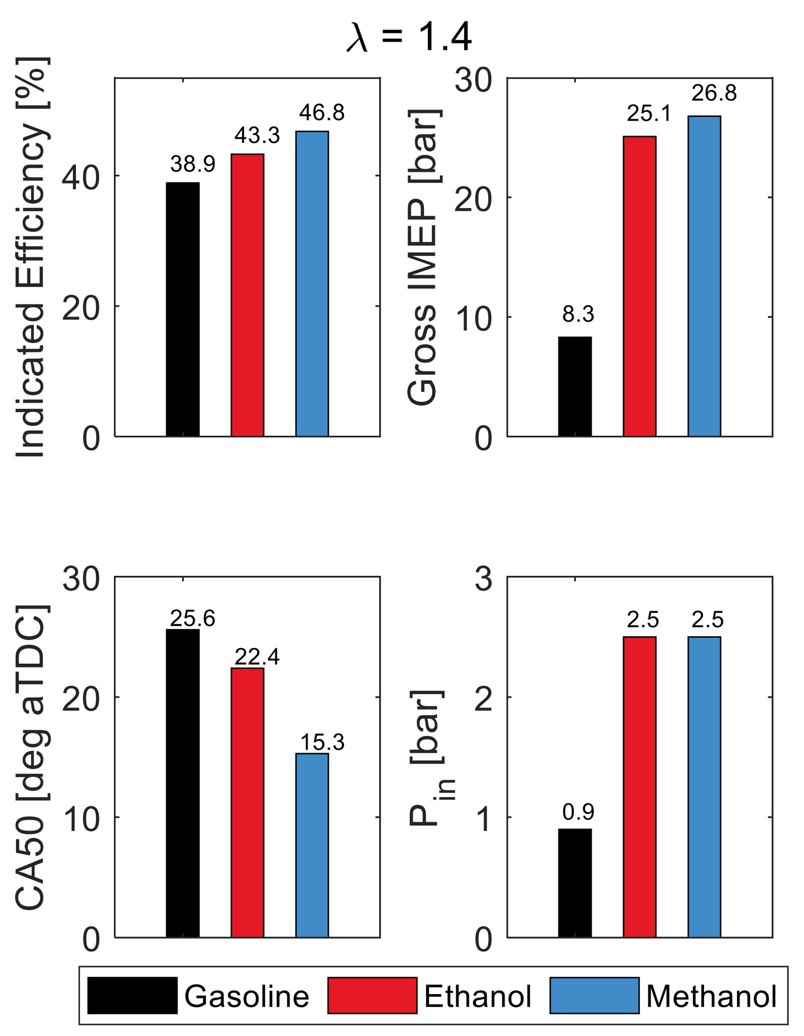
Four methods of reducing knock were seen to be promising based on literature and explored in this thesis:

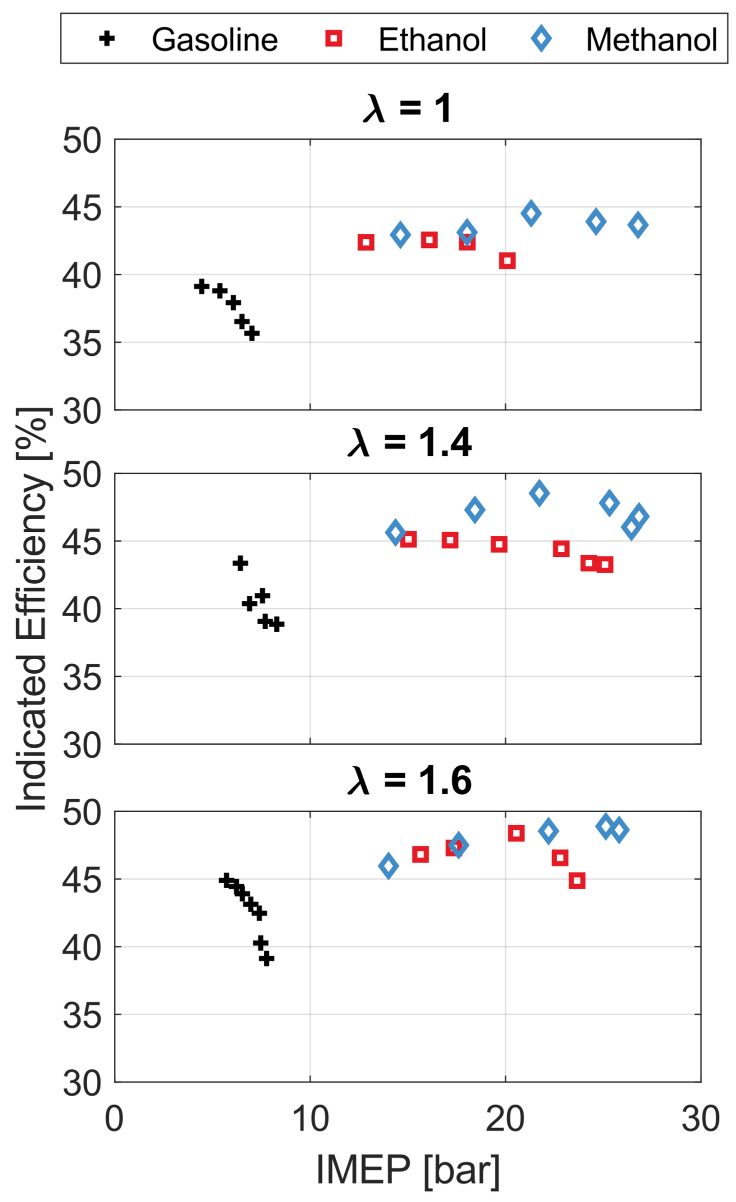
- Higher octane renewable fuels: ethanol and methanol
- Dilution using excess air ratio
- Miller valve timing
- Higher in-cylinder turbulence levels at spark timing

Experimental Results

Experiments – HD single cylinder engine, PFI, excess air dilution, full load and part load

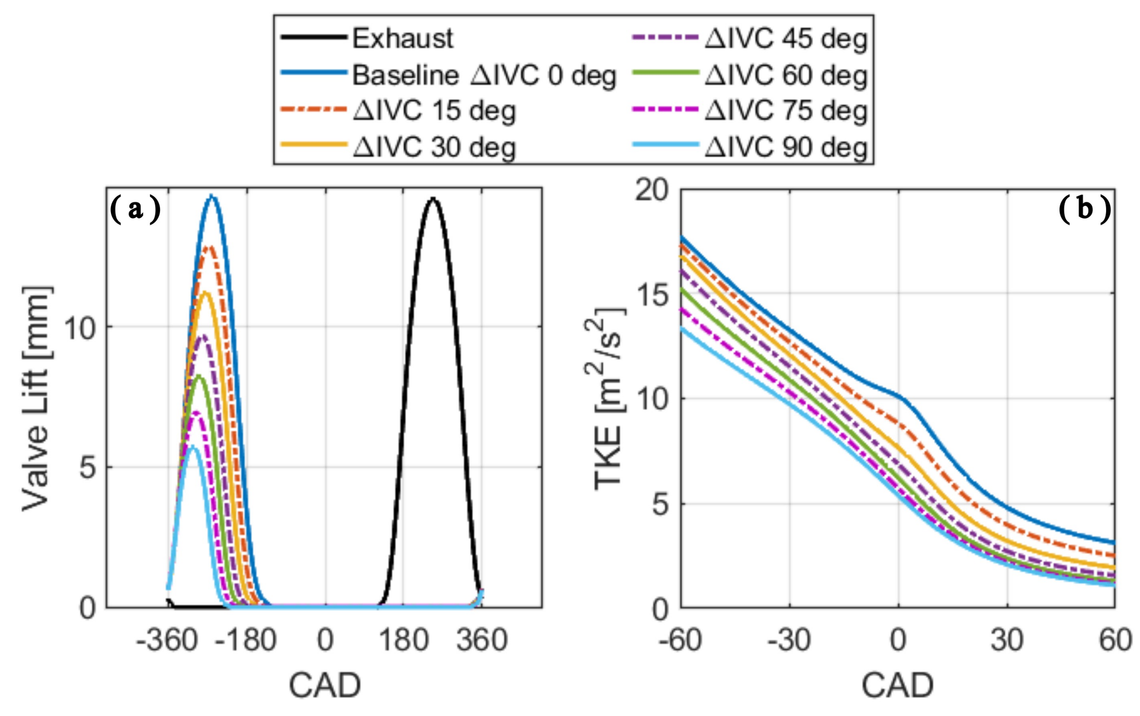
- Dilution reduced in-cylinder temperature and knock effectively
- 25 bar IMEPg successfully attained using ethanol and methanol at λ=1.4
- 48% peak indicated efficiency observed for ethanol and methanol at λ=1.6 at 21 bar IMEP



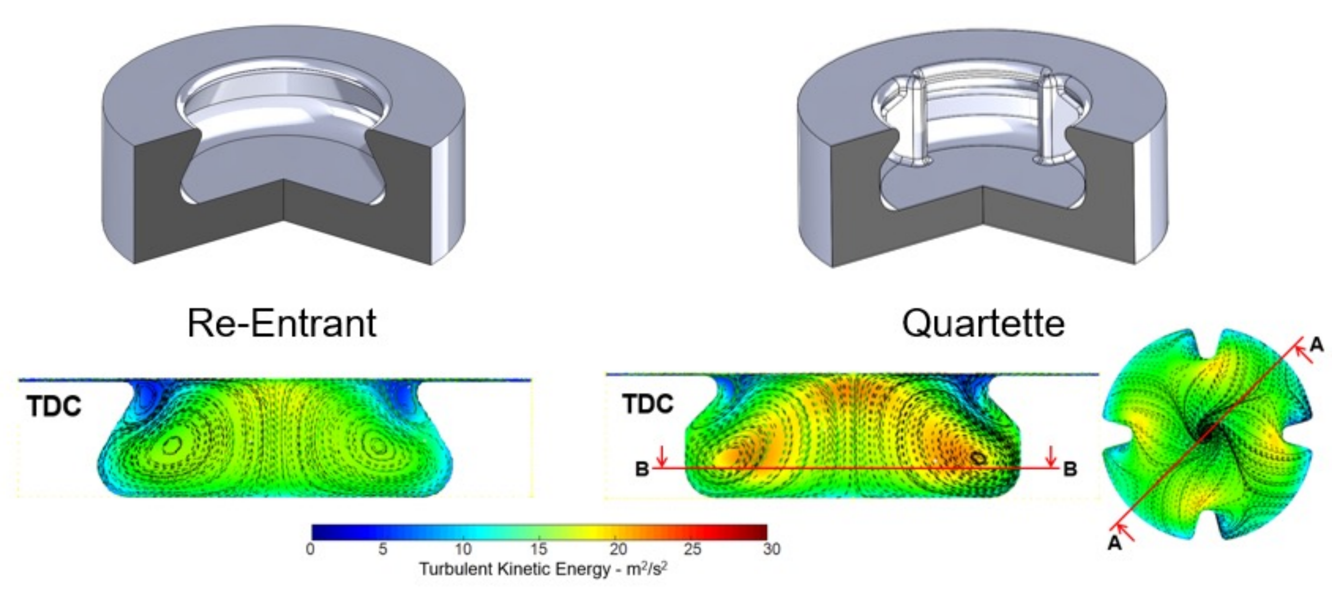


Simulation Results

- An improved laminar flame speed correlation and linear reduction of turbulent flame speed multiplier wer required to accurately predict combustion using the semi-predictive SITurb model in GT-Power
- Using simulations, Miller timing was effective seen to be effective in increasing brake thermal efficiency for stoichiometric operation. At lean conditions, turbocharger efficiency and the lower turbulence caused by Miller timing was a significant impediment in increasing efficiency
- Increasing turbulence close to TDC is important to increase combustion speed for lean burn and Miller timing engines. An exploratory pre-study was used to obtain the impact of piston geometries and squish in mitigating knock and improving efficiency. By combining CFD and 0D methods, simulation time was greatly reduced and the impact of in-cylinder flow features captured in a 0D combustion model.



Impact of (a) E-IVC Miller timing on (b) in-cylinder turbulence



High squish piston geometries evaluated

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