user story

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Improving engine stability and exhaust emissions through optimisation of the control strategy

examining the SI to HCCI transition

THE CHALLENGE

Simulation and tabulation of the SI-HCCI transition, to enable optimisation of control parameters, with the aim of improving the stability and reducing emissions during the transition.

THE SOLUTION

Using srm suite, the transition was simulated and tabulated, and coupled with commercial software to enable optimisation of control parameters.

THE RESULTS

•SI-HCCI transition was simulated with srm suite.

•Tabulation of the srm resulted in extremely short simulation times.

•The tables were employed with an optimisation routine to improve the stability and reduce emissions during the transition.

•The key control parameters were optimised to achieve this.

Homogeneous Charge Compression Ignition (HCCI), also referred to as Controlled Auto-Ignition (CAI), is an IC engine operating mode with the potential to reduce emissions and improve efficiency compared with conventional engine operating modes. The main challenges for gasoline HCCI are the initiation of auto-ignition, the control of the heat release and the extension of the operating window.

The operating window may be increased by using a dual-mode engine that operates in HCCI at low, medium, and cruising loads and speeds, and in SI mode at start-up, idle and high loads and speeds.

As HCCI mode is already difficult to control, the transitions between SI-HCCI-SI are even more challenging.

Computational models are employed to improve control strategies through optimisation and testing. However these approaches require rapid computational times due to the large number of successive cycles to be simulated. The short computational times achieved by srm suite can be further improved by tabulating the model responses.

This document outlines some of the results obtained when the srm suite in-cylinder combustion software was applied to the SI-HCCI transition to improve its stability and emissions by varying several control parameters.

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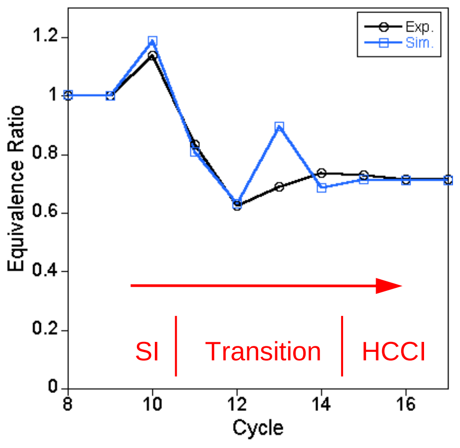
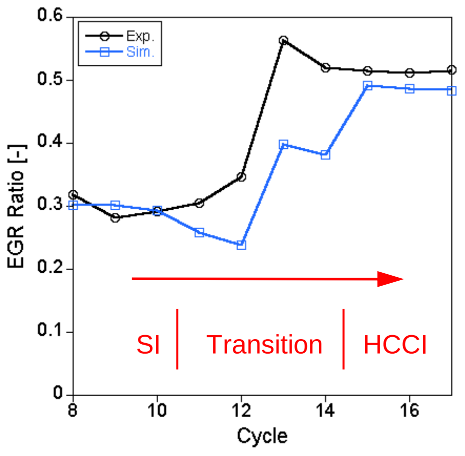


Above: Comparison of experimental and simulated equivalence ratios during transition over successive cycles. The final SI cycle is number 10.



Above: Comparison of experimental and simulated EGR ratios during transition. The final SI cycle is number 10.

APPLICATION AREAS

- HCCI/PCCI
- Conventional diesel
- Conventional spark ignition
- Direct injection spark ignition
- Soot modelling
- Emissions reduction

PRODUCTS USED

- srm suite

THE RESULTS

srm suite was used to simulate the complex transition from SI to HCCI. The reported experimental observations were simulated successfully using the model.

•Tabulation

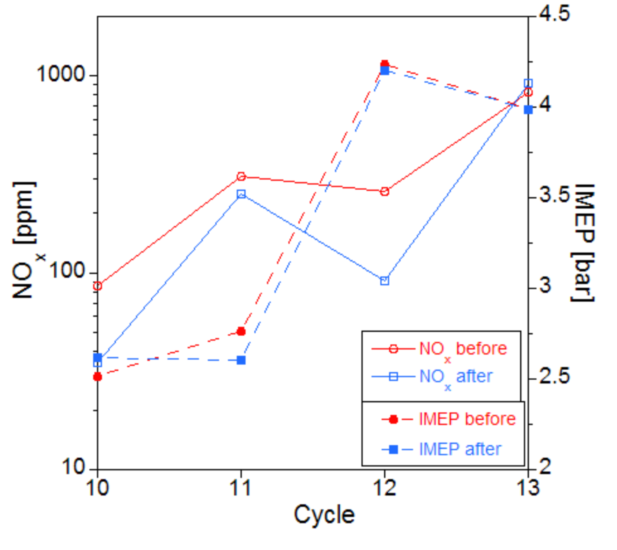
The detailed chemistry model was then tabulated to allow fast simulation of the transition. The tabulated transition was achieved by creating 6 different tables, each used for simulating a different part of the transition. Tables for the first NVO, transient valve timing NVO, transient valve timing HCCI, steady valve timing HCCI and NVO and SI combustion were required.

•Optimisation

The tabulated transition was optimised using industry standard tools. The tabulated model allowed fast simulation of the transition with emissions prediction. This enabled a cost function to be setup to penalise any deviations from the steady state IMEP and also any NO_x emissions. The optimisation took 34.5 hours, completing 553 transitions in all 4 cylinders. The result was a smoother transition and reduced net NO_x.

•Benefits

The technique is applicable to experimental design and identifying an engine control strategy prior to conducting experiments. One of the main advantages of the technique over conventional methods for fast simulation is the robust emissions prediction capability.



Above: Comparison of initial and optimised IMEP and NO_x emissions during transition. The final SI cycle is number 10. The IMEP target was 2.6 bar.

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