user story

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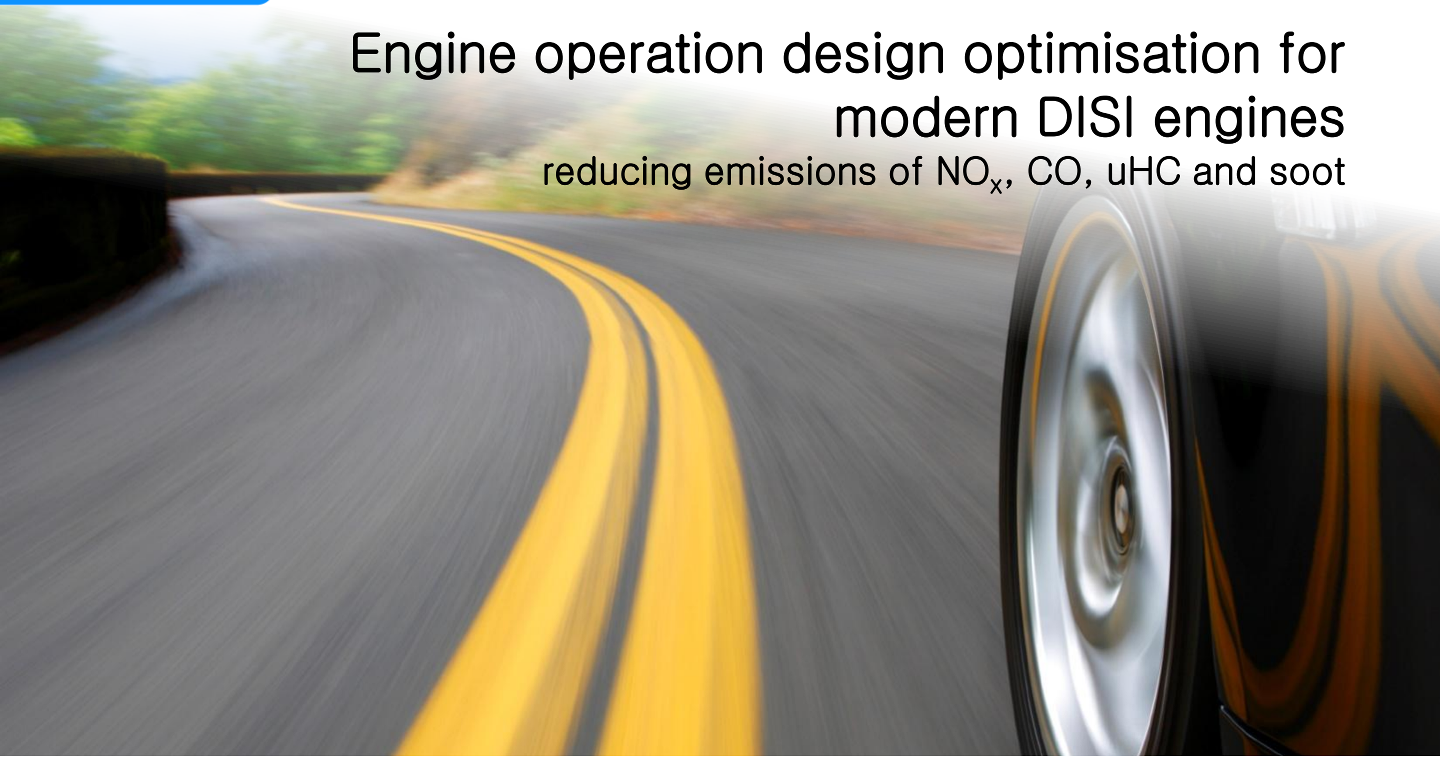
Engine operation design optimisation for modern DISI engines

reducing emissions of NO_x, CO, uHC and soot



THE CHALLENGE

To simulate the NO_x, CO, HC and soot emissions produced by a DISI engine, optimise fuel injection timings.

THE SOLUTION

Using srm suite in SI mode with fuel injection sub model, detailed chemical kinetics and integrated soot model.

THE RESULTS

- Flame propagation can be simulated
- When coupled with a 1D cycle code, cycle-to-cycle variations can be simulated.
- Emissions were predicted which mimicked those reported experimentally.
- The impact of injection timing on soot size distribution was determined.

Direct injection stratified charge (DISC) Spark Ignition (SI) engines can offer up to 25% improvement in fuel economy compared with port-fuel injected (PFI) SI engines. This is mainly achieved through reductions in pumping and heat losses when operated unthrottled at low-mid loads. One of the drawbacks however is the increase in particulate emissions formed by combustion of fuel rich regions in the cylinder.

CFD models are an important tool for investigating in-cylinder mixing and the effects of spray and cylinder geometry in DISI combustion. However, incorporating detailed chemical kinetics into these models remains computationally expensive making design optimisation and parametric studies impractical.

The challenge is to simulate the combustion characteristics and emissions produced by direct injection spark ignition models. Specifically, this means the ability to determine whether flames can be ignited and can propagate over wide ranges of local air-fuel mixture compositions and produce the concentrations of gaseous emissions such as NOx, uHC and CO. In addition, the progress of the soot formation should also be included.

This document outlines some of the results obtained when the srm suite in-cylinder combustion software was applied to meet these challenges.

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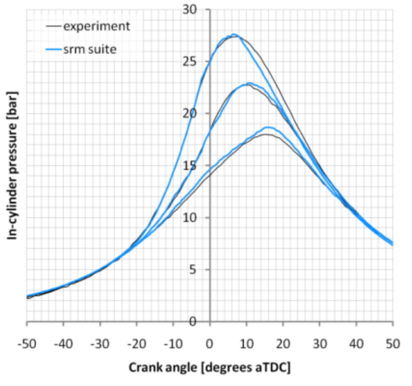
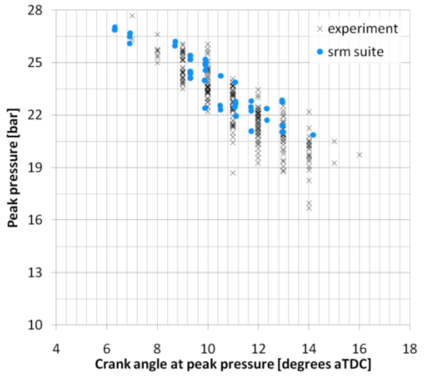




Above top: Pressure crank angle of the cycle-to-cycle variation noted in a spark ignited engine

Above bottom: Scatter of peak pressure and time of peak pressure for both model and experiments

THE RESULTS

•Flame propagation was simulated

The flame propagation was simulated, mimicking equivalent experimental observations. Aspects such as local flame extinction (due to a lean mixture) reduced the combustion rate.

•Cycle-to-cycle variations

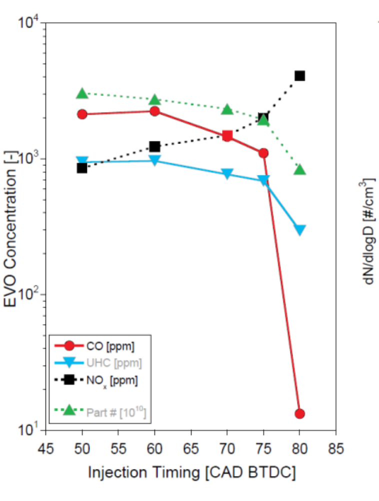
When coupled to a 1D cycle simulation code, cycle-to-cycle variations were simulated. This enabled engineers to identify sources of NOx, which were significantly greater for those faster burning cycles due to increased flame temperatures.

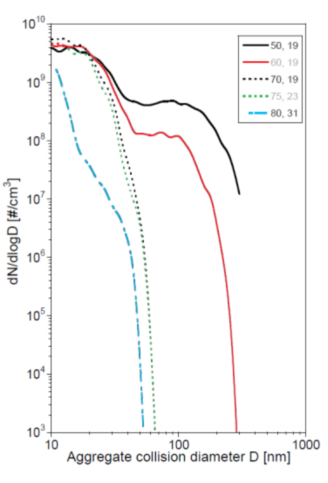
•Emissions prediction

As presented below, emissions of soot mass as well as NOx, uHC and CO concentrations were computed, these agreed qualitatively with those reported in the experiments.

•Impact of injection timing

As presented below right, the influence of injection timing is presented with respect to the soot size distribution, demonstrating that the larger soot particles are formed by a later injection event.





Above left: The exhaust gas emissions with respect to fuel injection timing at EVO.

Above right: Aggregate collision diameter, D (loosely the soot particle size distribution) for injections at 50, 60, 70, 75 and 80 deg bTDC.

APPLICATION AREAS

- •Direct Injection Spark Ignition engines
- •Emissions
- •Conventional and alternative fuels

PRODUCTS USED

- •srm suite
- •srm soot model