user story

Predictive combustion simulations for *"downsized"* direct injection spark-ignition engines:

solutions for pre-ignition *("mega-knock")*, misfire, extinction, flame propagation and conventional "knock"

THE CHALLENGE

Identify the sources of pre-ignition and knock in "downsized" DISI engines

THE SOLUTION

Using the srm suite software to simulate DISI engine combustion with detailed chemical kinetics

THE RESULTS

- A validated combustion model for DISI applications
- Knock onset times and heat release rates were obtained
- A source of pre-ignition was identified

One important means of improving DISI (Direct Injection Spark Ignition) engine efficiency has been through *"downsizing"* by utilizing exhaust gas turbo-charging to achieve equivalence engine performance with a smaller engine. In addition *"downspeeding"* enables the engine to be operated at an equivalent output at a substantially lower engine speed. The philosophy being that engine can be operated at higher loads in the part load range and therefore achieve a better part load efficiency, then cover the need for higher engine output with the aid of turbo-charging.

In order for the desired increase in efficiency to be achieved while at the same time attaining adequate drive performance values, a high compression ratio is needed for improved fuel consumption in the part load range, as well as high torque. This requires a correspondingly higher degree of turbocharging which unfortunately, in the lower revolutions range concerned, leads to sporadic irregular combustion events, referred to as pre-ignition as well as heavy knock for regular ignition times.

THE CHALLENGE

To simulate combustion events in a knocking DISI engine, then identify knock limits and the sources of pre-ignition.

THE SOLUTION

A series of computations using srm suite were carried out to validate the model. The ignition of a single oil droplet was simulated to determine whether it could cause a secondary ignition.

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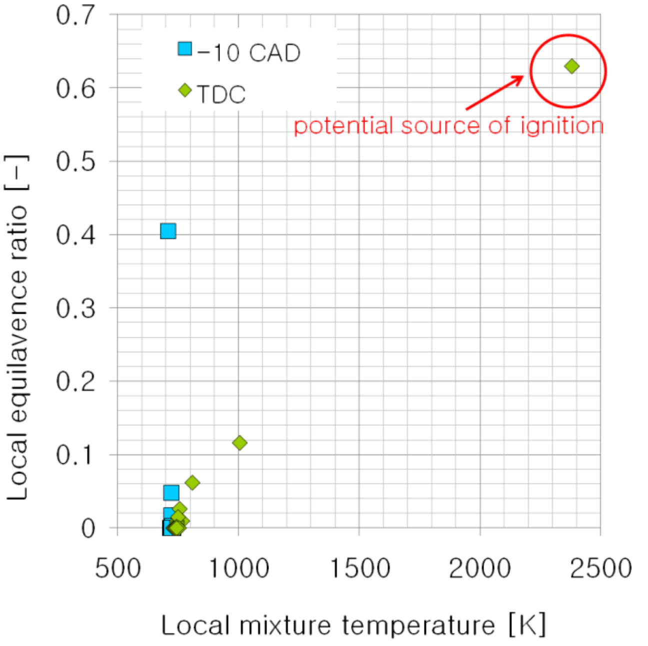


Corresponding in-cylinder local equivalence ratios and temperatures at 10 CAD bTDC and at TDC for a single oil droplet (here simulated as n-heptane). Results show that such a droplet could ignite forming a potential ignition source. This could "pre-ignite" the mixture prior to the spark, resulting in the mega knock cycle in the other graph

THE RESULTS

•The srm suite was used to simulate DISI combustion

The process of injection, fuel mixing and subsequent flame propagation and knock were simulated using srm suite. Results were consistent with those expected in such engines, including the heavy knocking events and high peak pressures.

•Further insight into pre-ignition or *"megaknock"* was obtained

This work has highlighted that *"downsized"* and *"downspeeded"* engines are susceptible to irregular pre-ignition or *"mega-knock"* as end gas temperatures are great enough prior to ignition such that an oil droplet (simulated by surrogate species) could autoignite resulting in a source for triggering ignition in the surrounding mixture.

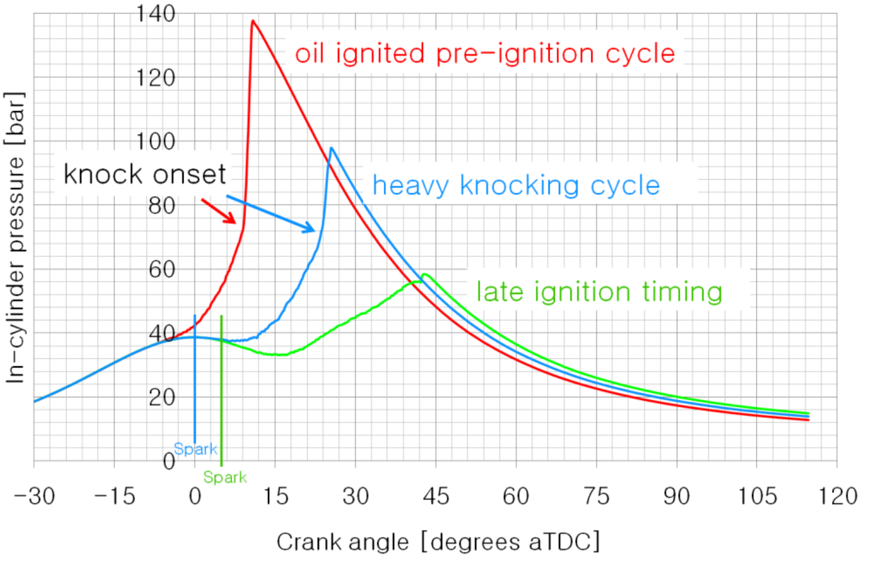
APPLICATION AREAS

- •DISI
- •Port injected SI
- •SI "knock"

- •emissions

PRODUCTS USED

- •srm suite



srm suite was used to simulate DISI combustion at high intake pressure (2.3bar). With an ignition timing of TDC, heavy knocking cycles were reported, however this was elevated by delaying the spark timing. Finally, an oil-ignited cycle was simulated – demonstrating similar characteristics to those observed in pre-ignition (*"megaknock"*) combustion cycles.