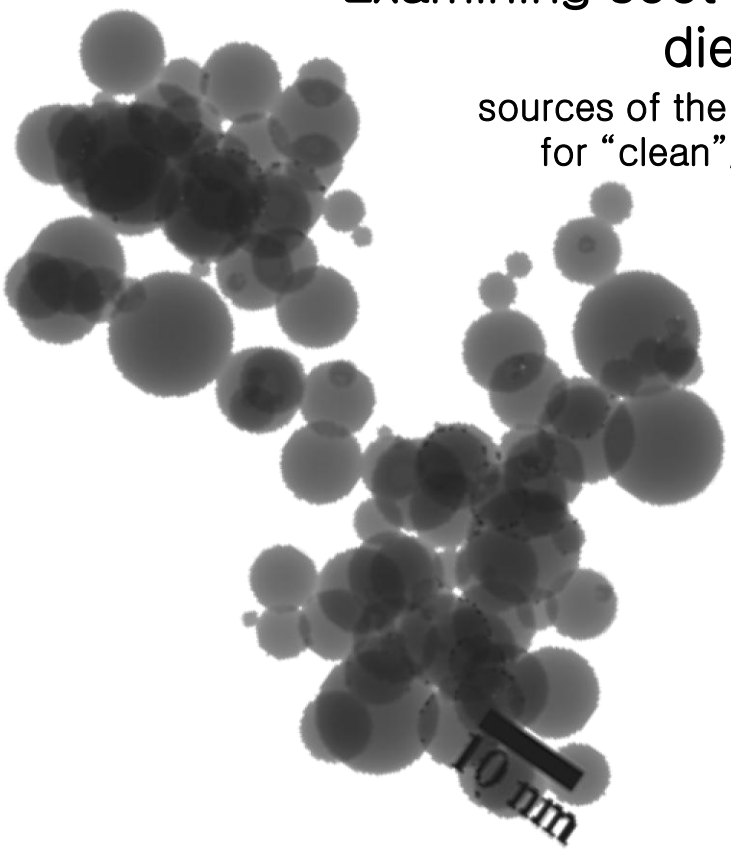
user story

Examining soot emissions from boosted diesel engines at high EGR

sources of the larger soot particles and solutions for “clean”/ “dirty” recirculated soot particles



The formation of soot and other particulate matter in internal combustion engines is a common problem. While soot formation is usually associated with conventional Diesel, i.e. Compression Ignition Direct Injection (CIDI) engines, soot can also be shown to be relevant in engines with other (multiple) Direct Injection (DI) strategies such as partially premixed Diesel, partially stratified Homogeneous Charge Compression Ignition (HCCI), and Direct Injection Spark Ignition (DISI) engines.

Given the importance of direct injection technology for mixture preparation and combustion control in modern engines, and the fact that stratified operation bears the possibility of locally fuel-rich mixtures, the formation of soot is an important factor in the design of cleaner engines. Such development is assisted by detailed understanding of the processes involved, to which modelling and simulation can contribute significantly.

THE CHALLENGE

To gain a deeper understanding of the sources of soot observed in diesel fuelled IC engines when high rates of EGR are employed. Further insight into the fundamental differences between “dirty” and “clean” EGR are sought.

THE SOLUTION

The srm suite combustion software was employed to examine the sources of soot formation over a cycle using detailed chemical kinetics and a soot population balance model.

To investigate the influence of “dirty” and “clean” EGR, the simulation tool was run over a number of cycles.

THE CHALLENGE

Compute the size distribution, composition and morphology of soot formed in IC engines.

THE SOLUTION

Using the srm suite software to simulate diesel fuelled combustion

THE RESULTS

- The distribution of soot particles were shown to evolve during the cycle
- The EGR composition is critical to the soot formation process
- Trapped soot particles grow in size in subsequent cycles

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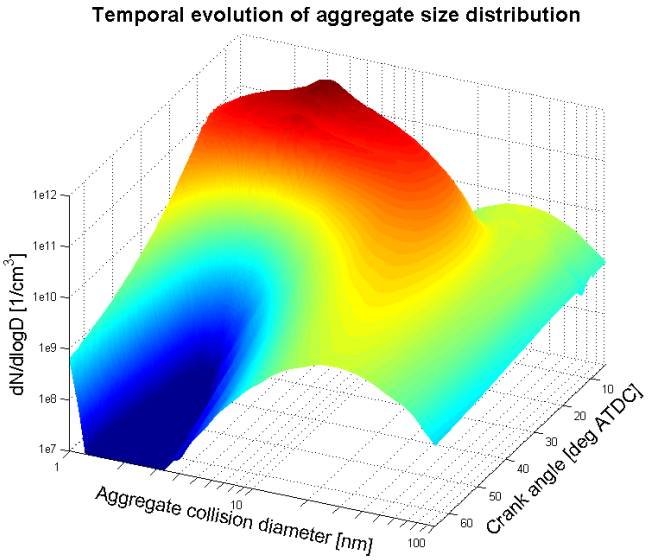


This diagram shows the evolution of the soot particle size distribution with respect to crank angle.

APPLICATION AREAS

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

PRODUCTS USED

- srm suite
- srm suite soot model

THE RESULTS

•Soot develops during the combustion cycle

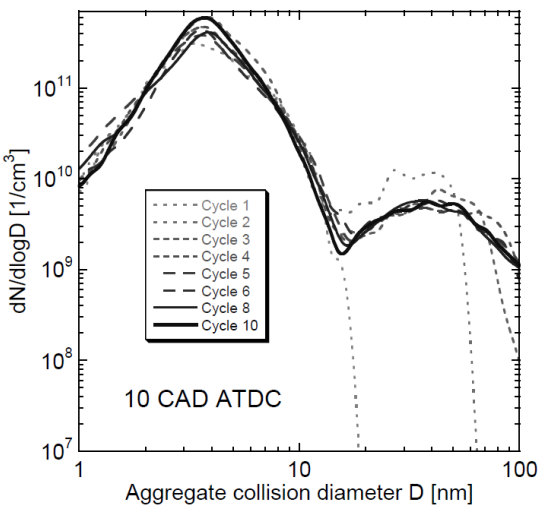
As shown in the diagram, the soot size distribution evolves during the cycle, with the larger particles forming later in the combustion event and into the exhaust stroke.

•Soot formation is highly sensitive to EGR

Flame temperatures are influenced by EGR due to dilution and temperature effects but chemical aspects proved highly influential.

•Recirculated soot particles grow in size during subsequent cycles

As shown in the diagram, the soot size distribution is sensitive to the cycle number. The first cycle is a mono-distribution; once this distribution is recirculated a bi-modal distribution forms – consistent with that observed experimentally. i.e. the larger soot particles are formed over a series of cycles. Hence in order to carry out robust soot simulations multi-cycle modelling is a pre-requisite.



Size distribution at 10 CAD aTDC for ten consecutive cycles. The recirculated aggregates can be clearly identified as those larger than about 20 nm.

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