User Story

Predictive HD Engine Modelling with the SRM Engine Suite and MoDS

Full in-cylinder pressure and emissions-modelling workflow of a CAT C4.4 engine including automatic calibration of the SRM Engine Suite with MoDS

Virtual engineering combining physico-chemical and advanced statistical algorithms provides a cost-effective means to optimise the design and integration of technologies aimed at the development of modern, low-emission energy-conversion powertrains for vehicular and stationary power generation applications.

THE CHALLENGE

Devising an end-to-end seamless workflow to apply digital engineering toolkits, instead of engine dyno testing, to predict in-cylinder pressure, NO_x, Soot, CO and uHCs in a comprehensive load-speed operating window and a range of engine calibration swings.

THE SOLUTION

Using the SRM Engine Suite software as the physico-chemical engine simulator coupled with the advanced statistical package MoDS for automatic model calibration

THE RESULTS

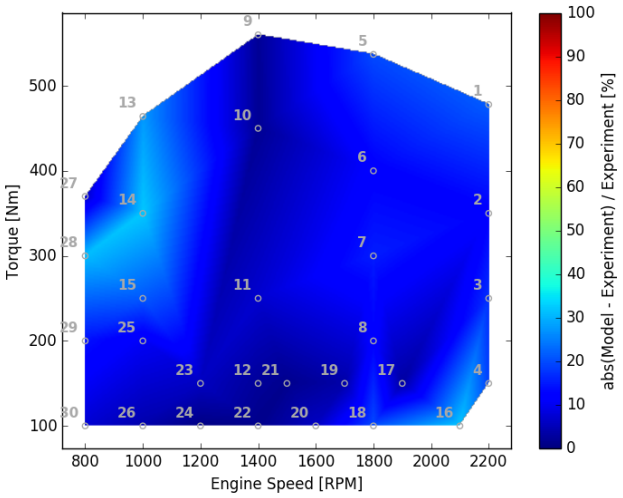
- Accurate emissions prediction (NO_x and Soot in particular) at a fraction of engine dyno cost
- SRM Engine Suite software coupled with MoDS automatically calibrated to experimental data

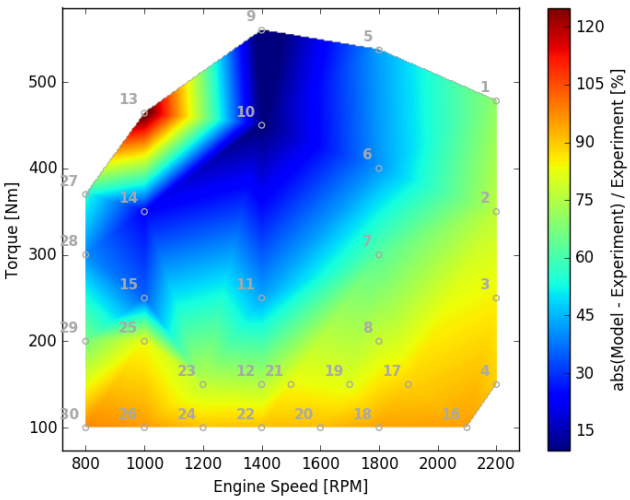
The probability density function (PDF)-based Stochastic Reactor Model (SRM) Engine Suite was applied to simulate a modern diesel-fuelled compression ignition heavy-duty engine. The SRM Engine Suite is coupled with the Model Development Suite (MoDS) to perform parameter estimation based on the engine measurements data at representative load-speed operating points. The fidelity of the SRM Engine Suite is further tested by carrying out blind tests against experimental measurements for combustion characteristics (heat release rate, in-cylinder pressure profile, etc.) and engine-out emissions: NO_x, Soot, CO and uHCs. Finally, parameter sweeps on engine calibration parameters were performed.

WORKFLOW

The full workflow utilised is described as follows:

1. Created the base engine model in the SRM Engine Suite, making sure that all geometry inputs are correct
2. Prepared process condition inputs from the experimental data to create all the child cases
3. Calibration: performed automatically by MoDS in less than a day
4. Blind testing: applied the calibrated model to the remaining of the experimental points and assess its accuracy and predictive capabilities.





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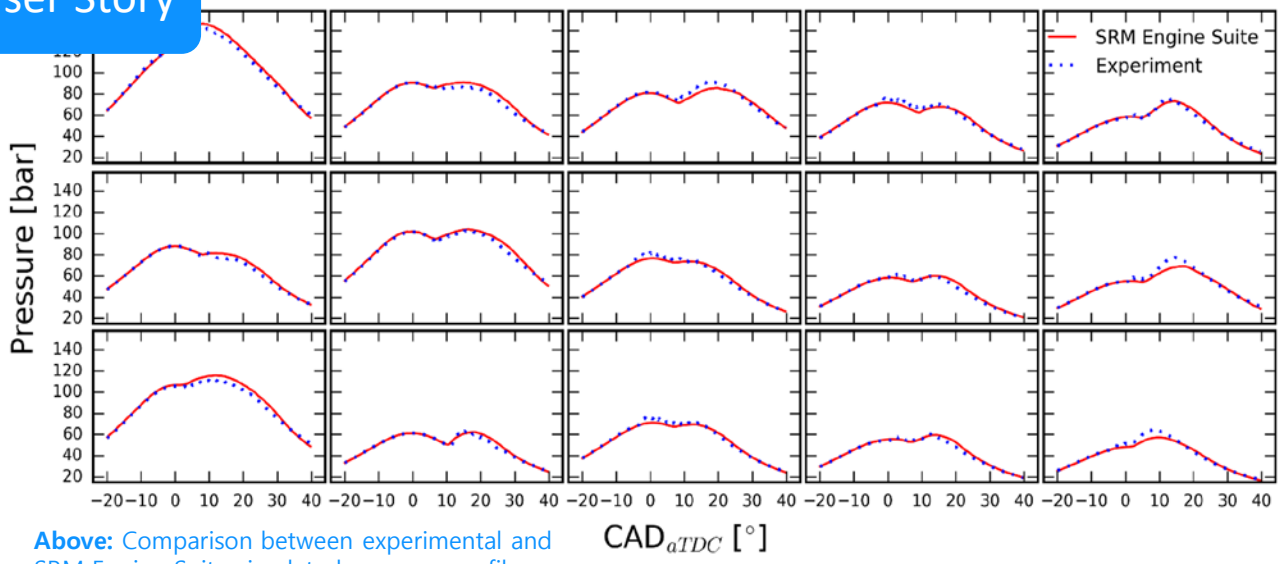
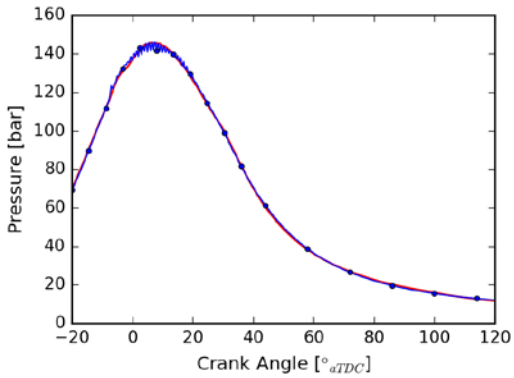


Above: Comparison between experimental and SRM Engine Suite simulated pressure profiles



Above: detail of the accuracy of the pressure profiles for pilot+main combustion

CALIBRATION

1. Select the representative points against which to calibrate the model.
2. Sample the parameter space using a Sobol sequence
3. Use a few local search algorithm runs to find the optimum inputs for the selected submodel parameters (affecting pressure and emissions)

Parametric sweeps

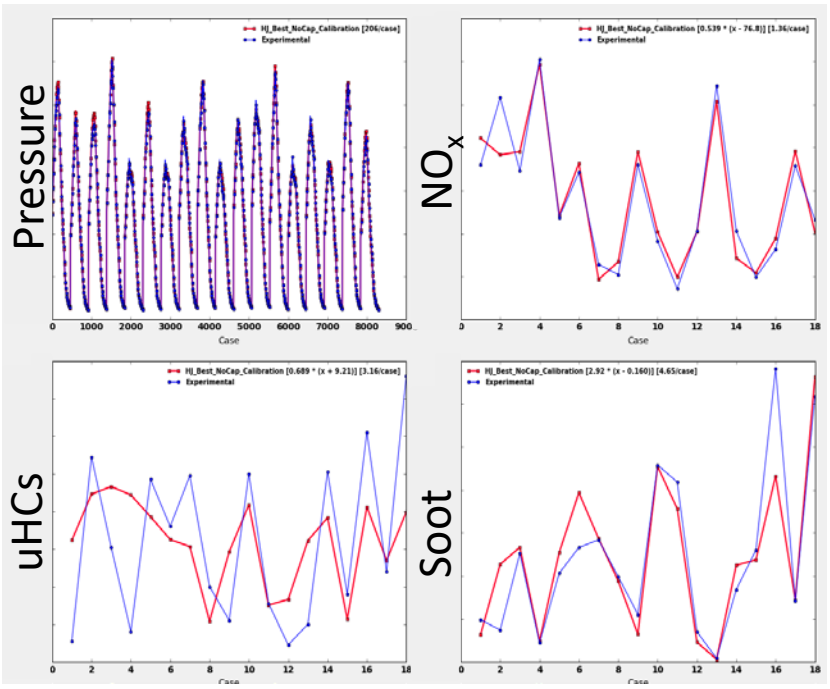
Parametric sweeps of the calibrated SRM Engine Suite were performed across a range of boost pressures, EGR rates and injection timing swings, and compared to experimental engine data for the four emissions considered.

APPLICATION AREAS

- Diesel engines
- Automatic calibration
- Predictive emissions simulation
- In-cylinder pressure and HRR

PRODUCTS USED

- SRM Engine Suite
- MoDS
- In-house N-Heptane + NO_x & Soot chemical model



Above: Pressure and emissions outputs from the parametric study.

Simulation end-users: Caterpillar, and CMCL Innovations

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