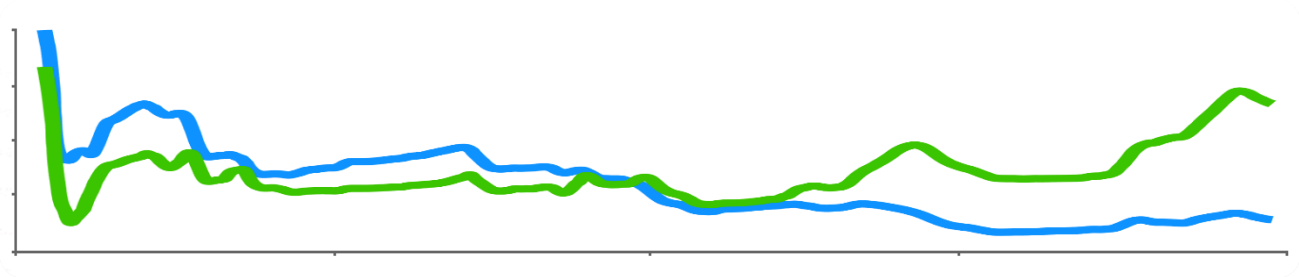
User Story

Transient Particulate Emissions Simulation

"Digital Engineering workflow comprising SRM Engine Suite and MoDS applied to model engine-out PM and PN; a key enabler for simulating transient particulate emissions"



THE CHALLENGE

To simulate particulate matter (PM) and particle number (PN) emissions for transient (e.g. drive cycle) conditions.

THE SOLUTION

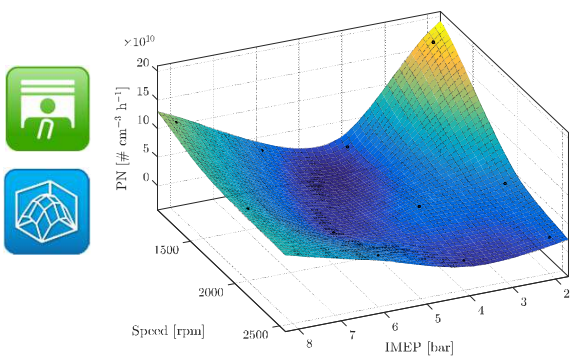
A detailed physio-chemical model combined with advanced statistical algorithm are applied to calibrate and validate PM and PN emissions.

SRM Engine Suite is calibrated and validated against steady-state emissions measurement data.

MoDS is applied to construct a fast-response high-dimensional surrogate to generate engine performance and emissions maps which feed into a 3rd party industry-standard vehicle transient simulation software.

THE RESULTS

A fast-response high dimensional surrogate for PM and PN enables simulation of vehicle emissions for transient drive cycles.



Fast-response Particle Number (PN) surrogate model

The Euro 6 emissions standards regulate the PM and PN emissions for passenger car, on-road applications (as tabulated below). These emissions are also regulated for on-road heavy duty (Euro VI) as well as for non-road (Stage V) applications.

Table: Euro 6 emissions standards for passenger cars

	CO g/km	HC g/km	NO_x g/km	PM g/km	PN #/km
Euro 3	2.3	0.20	0.15	-	-
Euro 4	1.0	0.10	0.08	-	-
Euro 5	1.0	0.10	0.06	0.005	-
Euro 6	1.0	0.10	0.06	0.005	$6x10^{11}$

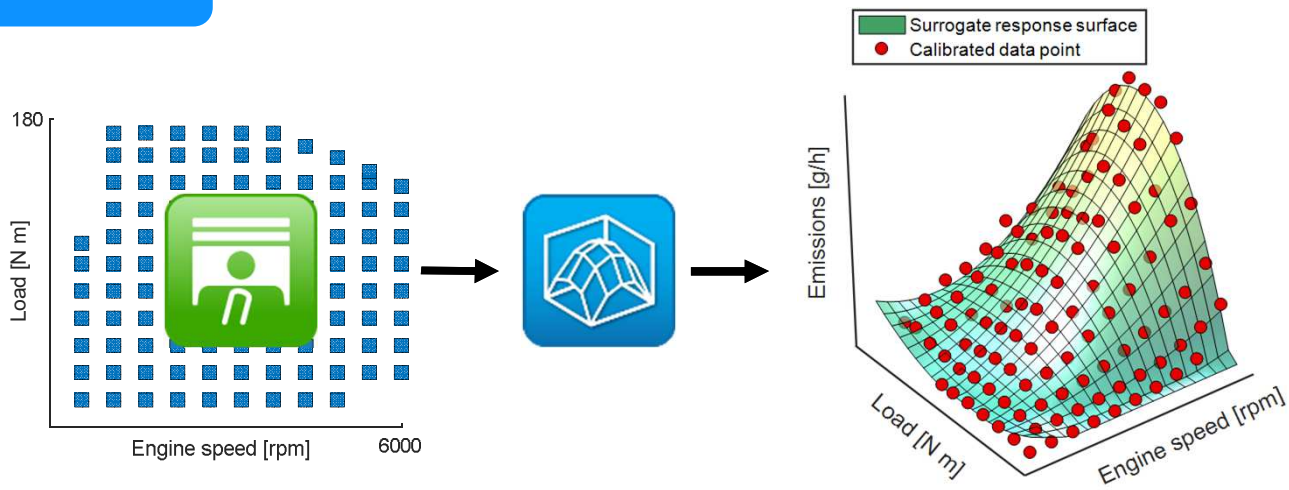
Furthermore, given the high dimensional design variable space, powertrain optimisation and control for emissions reduction, relies upon large data sets from measurements. "Maps" based on surrogate models and interpolations from steady state measurements are used to feed transient simulations.

A digital engineering workflow that calibrates and validates a detailed physico-chemical model based on measurements data and then populates and augments the data for the purpose of producing emissions "maps" offers a robust methodology to simulate transient conditions observed during randomised Real Drive Emissions (RDE) conditions.

enquiries@cmclinnovations.com
cmclinnovations.com

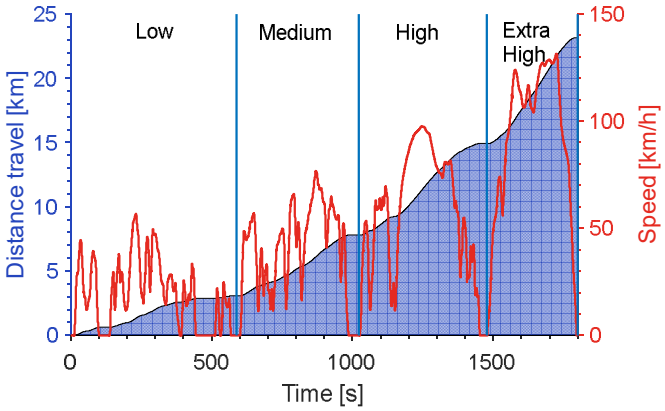
CMCL Innovations

User Story

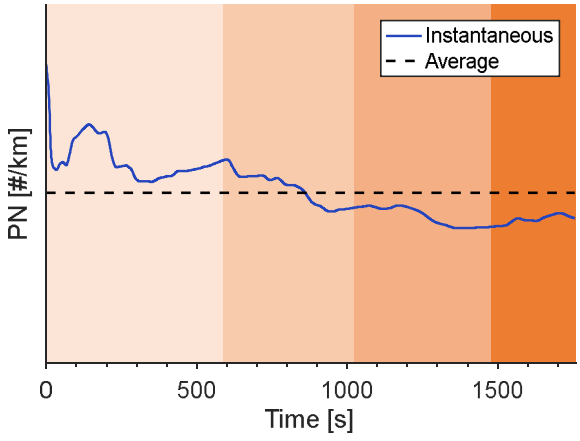


Surrogate model generation in MoDS based on a calibrated SRM Engine Suite and steady state measurements data

- A vehicle containing a powertrain configuration based on a 4-cylinder gasoline direct injection (GDI) Spark ignition (SI) engine was used.
- Digital workflow based on MoDS and SRM Engine Suite were applied to calibrate and validate steady state data for in-cylinder pressure, gas phase (CO, HC and NO_x) and soot emissions from the engine.
- MoDS software was used to produce fast-response surrogate models based on higher-order polynomials.
- The emissions maps were fed to a commercial 3rd party vehicle simulator for a variety of transient drive cycle configurations.
- Post-processing performed to generate probability density function (PDF) plots and cumulative emissions.



Imposed drive cycle (vehicle speed vs. time profiles) and distance travelled



Instantaneous and average PN emissions (#/km) as the output

APPLICATION AREAS

- Vehicles run with IC engine powertrains
- Particulate emissions
- Steady state and transients

PRODUCTS USED

- SRM Engine Suite
- MoDS
- 3rd party industry-standard vehicle simulator

enquiries@cmclinnovations.com
cmclinnovations.com