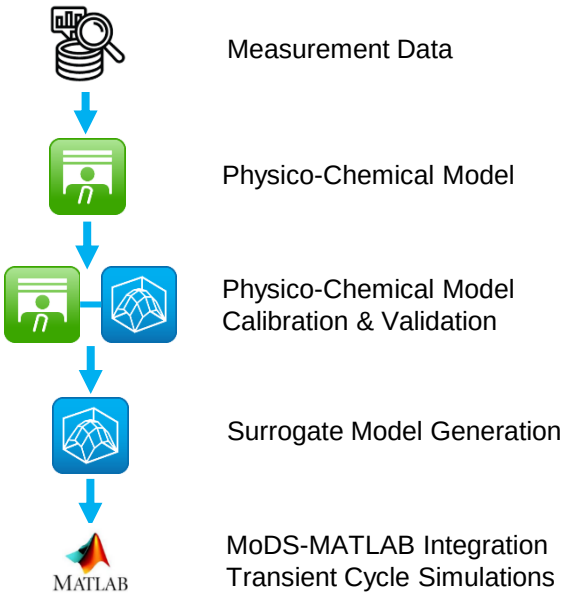
User Story

Digital Engineering Workflows for ARAI's Powertrain Development

CMCL's Digital Engineering Workflow



THE CHALLENGE

To build detailed physico-chemical engine models and a high dimensional, fast response surrogate model that are capable of high accuracy engine combustion characteristics and engine-out emissions evaluations for transient cycle simulations.

THE SOLUTION

- Use CMCL's *kinetics* & SRM Engine Suite to build a physico-chemical engine model
- Use CMCL's MoDS to calibrate and validate the physico-chemical engine model
- Use CMCL's MoDS to generate a surrogate model for transient cycle simulations in MATLAB

THE RESULTS

- Detailed physico-chemical models capable of high accuracy engine combustion characteristics and engine-out emissions evaluations are generated.
- A fast response, high dimensional surrogate model of a compression ignition diesel engine is generated to be integrated into MATLAB for transient cycle simulations.

"While using SRM Engine Suite or MoDS software I could feel the objectivity in every step. All methodologies are well designed and well documented and therefore, whoever operates the software will come out with same results. I really appreciate the efforts of development team to make such nice user experience."

Hitesh Chaudhari, Deputy General Manager
ARAI Powertrain Engineering

OVERVIEW

ARAI has applied CMCL's Digital Engineering Workflow to further enhance the predictive capabilities of existing in-house processes.

This use-case demonstrates the capability of *kinetics* & SRM Engine Suite in detailed physico-chemical engine modelling for combustion characteristics and engine-out emissions evaluations. This use-case also demonstrate the capability of MoDS in generating high-dimensional, fast response surrogate models for transient cycle simulations in MATLAB.

CASE DESCRIPTION

ARAI has collected a total of 72 operating points, covering various operating conditions with distinct engine speed and load across the entire operating window of a heavy duty compression ignition diesel engine from the measurement campaign.

kinetics & SRM Engine Suite is applied to set up detailed physico-chemical models of the engine. The physico-chemical models are calibrated (trained) using the advanced statistical algorithm within MoDS, where only 29 (40%) operating points are applied. Subsequently, the calibrated models undergo validation (blind test) by applying the remaining 43 (60%) operating points.

In addition, a high-dimensional, fast response surrogate model is generated using MoDS and applied for transient cycle simulations in MATLAB through API.

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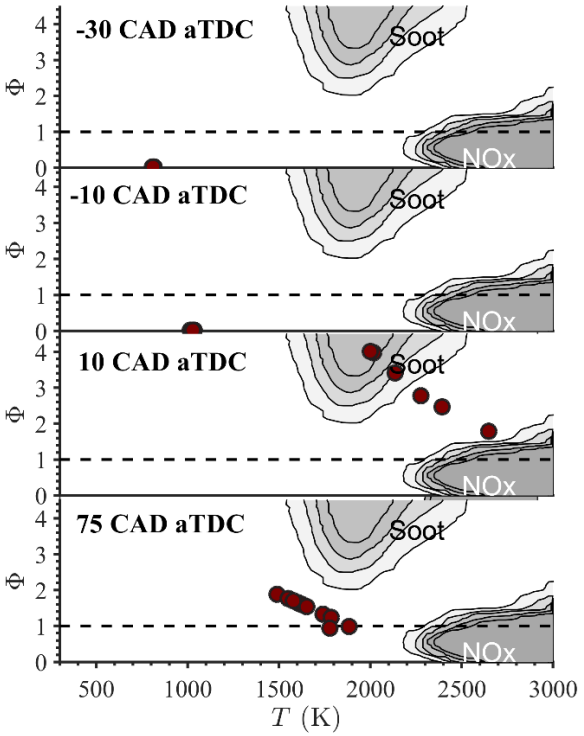
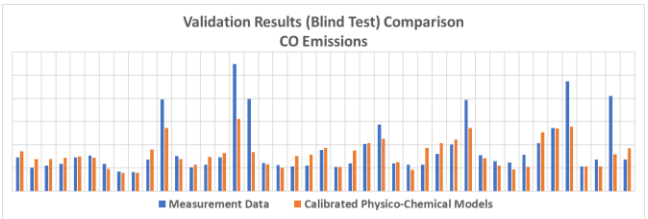
RESULTS

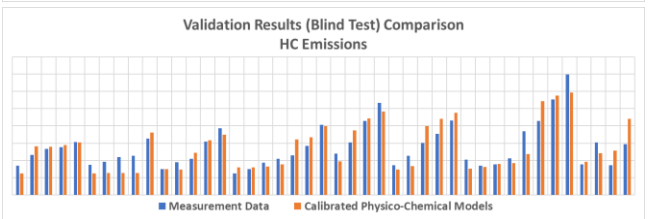
Once the physico-chemical models are calibrated, the models are applied to simulate the remaining 43 (60%) operating points as part of the validation process or blind test. The simulation results are compared against the measurement data.

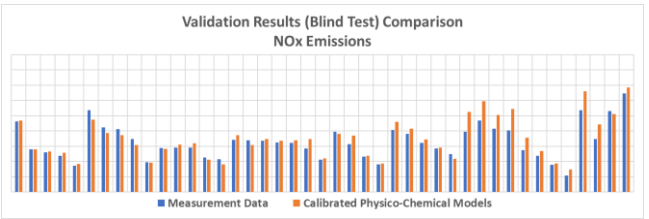
The calibrated models are able to simulate the validation points (blind test) with satisfactory accuracy, capturing the general trend across various operating conditions at every simulated emissions satisfactorily. For gas-phase emissions, 50%, 58% and 80% of the validation points are within 20% error in relative to the measurement data for CO, HC and NO_x respectively. For particulate emissions, 80% and 62% of the validation points are within 50% error in relative to the measurement data for soot and PN.

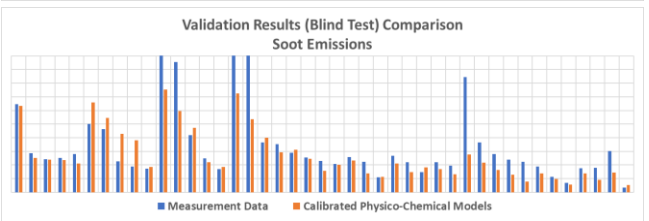
In addition, the MoDS generated data-driven surrogate model is applied to perform transient cycle simulations in MATLAB. Additional input variables and the option to augment measurement data with digitally populated data via validated physico-chemical models will be considered in future collaboration projects between ARAI and CMCL Innovations.

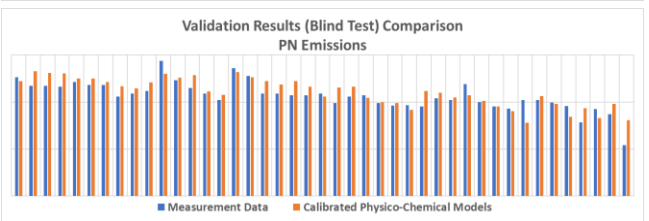


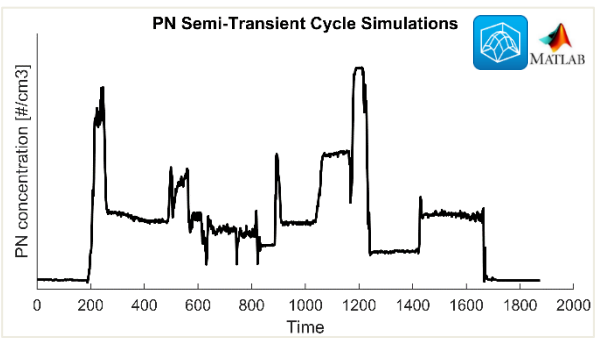












APPLICATION AREAS

- IC engines
- Reactors, devices, processes, etc.

PRODUCTS USED

- *kinetics* & SRM Engine Suite
- MoDS

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