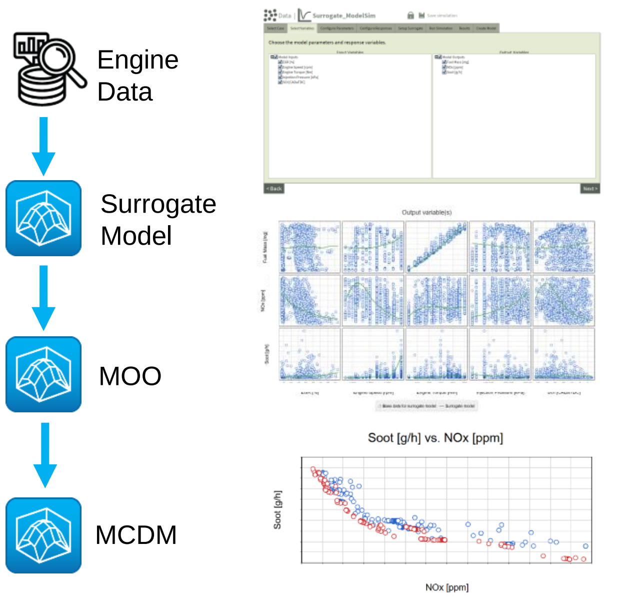
User Story

Multi-Objective Optimisation (MOO) with Multi-Criteria Decision Making (MCDM)

MoDS MOO-MCDM Workflow



OVERVIEW

Digital engineering approaches such as Multi-Objective Optimisation (MOO) and Multi-Criteria Decision Making (MCDM) are receiving increasing attention in today's industry. MOO and MCDM enable engineers and researchers to further optimise their existing engine without relying extensively on measurement data, hence saving time and costs.

The **use case** demonstrates the capability of MOO within MoDS (Model Development Suite) in minimising fuel mass, NO_x and soot emissions of a compression ignition engine. Subsequently, MCDM is applied to select the optimal combination of the engine variables from the pareto front at every operating point, while meeting the output boundary conditions.

THE CHALLENGE

To optimise the engine variables of a compression ignition engine to minimise the fuel mass (consumption), NO_x and soot emissions.

THE SOLUTION

- Use CMCL's MoDS to build a data driven surrogate model of the engine
- Use CMCL's MoDS to run MOO and select the optimal engine variables combination via MCDM

THE RESULTS

- A fast response, high dimensional surrogate model of a compression ignition diesel engine is generated
- The engine variables are optimised to produce minimum fuel mass, NO_x and soot emissions

CASE DESCRIPTION

A data-driven model is set up in MoDS to generate a fast-response, high-dimensional surrogate model of a compression ignition engine. The input variables of the surrogate model include engine speed, engine torque, injection pressure, start of injection (SOI) and EGR mass fraction. The surrogate model produces output for fuel mass, NO_x and soot emissions.

Subsequently, the MOO-MCDM workflow within MoDS is applied at every operating point for a given engine speed and engine torque to optimise the engine variables such as the injection pressure, SOI and EGR mass fraction, in order to minimise the corresponding fuel mass, NO_x and soot emissions.

The fuel mass, NO_x and soot emissions data before and after the optimisation are compared to demonstrate the effectiveness of the MOO-MCDM digital workflow within MoDS.

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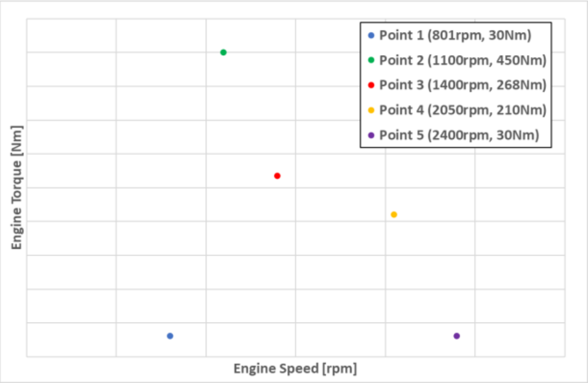
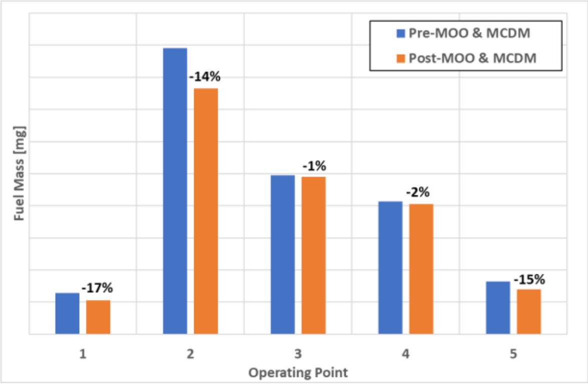
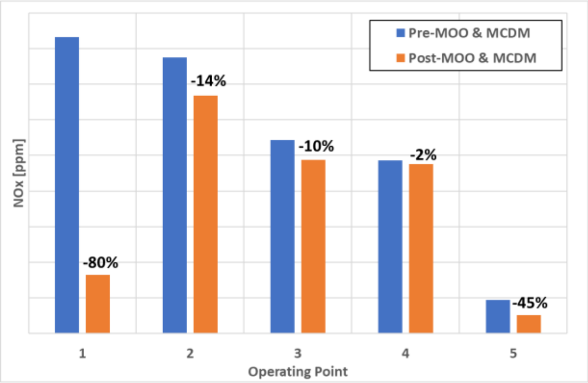
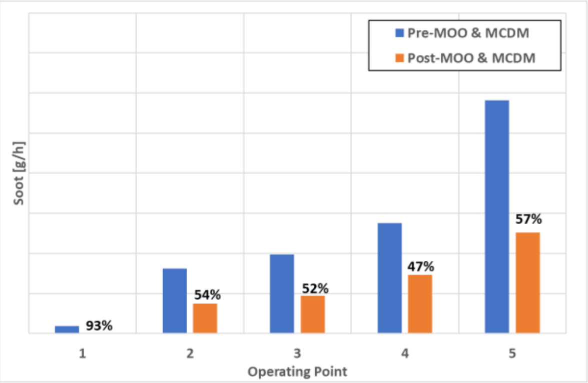






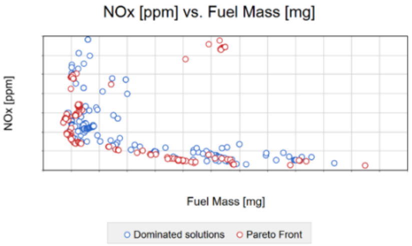


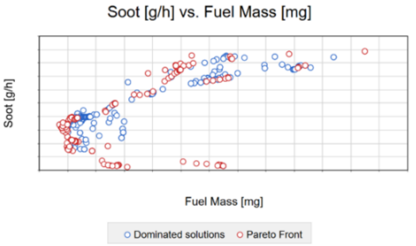
RESULTS

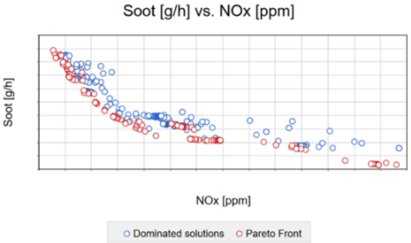
The fuel mass and engine-out emissions outputs before and after the optimisation tasks at five different operating points are compared in this use-case. These five operating points are selected from different regions across the operating window to demonstrate the effectiveness of the MOO-MCDM digital workflow within MoDS.

Following the completion of MOO, MCDM is applied to select the optimal combination of engine variables from the pareto front while meeting the output boundary conditions at these five operating points. The output boundary conditions are set up to ensure MCDM only selects the optimal combination of engine variables that lead to reduced fuel mass, NO_x and soot emissions. MoDS is able to reduce fuel mass, NO_x and soot emissions by as much as 17%, 80% and 93% respectively across the five operating points.

PARETO FRONTS







APPLICATION AREAS

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

PRODUCTS USED

- MoDS

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