Multi-objective Optimisation of the Combustion Process in a Compressed Natural Gas Direct Injection Engine

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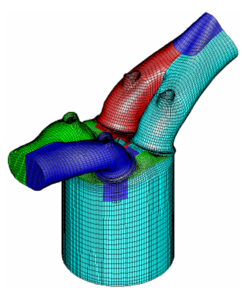
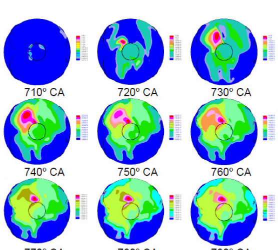
With increasing concerns in energy availability in the world, efforts have been focused on the development of alternative carbon-based oil fuels. One of the feasible solutions to address the important problem is through the use of natural gas. Several advantages related to its utilisation are higher thermal efficiency and lower exhaust emissions including CO_2 due to the higher octane level as well as lower ratio of carbon and hydrogen ratio. In this aspect, spark-ignition direct injection mono-fuel engines using compressed natural gas are capable in fulfilling this demands and its performance is comparable to those of gasoline and other mono-fuel engines.

Using STAR CD in Design and Modelling

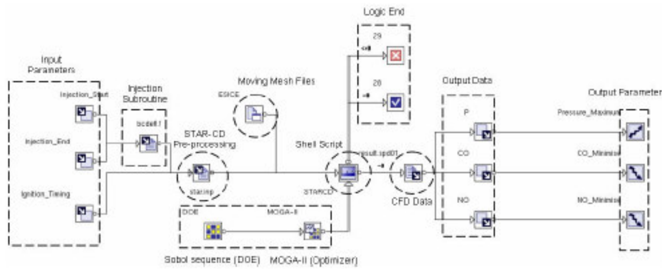


In order to meet a more stringent emission regulations, the success in the increase in performance with reduced exhaust emissions is very critical and has to be optimized using the multi-objective genetic algorithm (MOGA) optimisation. During the internal combustion simulation, three combustion parameters affecting engine performance and the corresponding emissions are the timings for start of injection (SOI), end of injection (EOI) and spark advance (SA). The multidimensional engine modelling and combustion simulation was carried out using the computational fluid dynamics (CFD) code, namely Star-CD.

Using modeFRONTIER in Optimisation Process

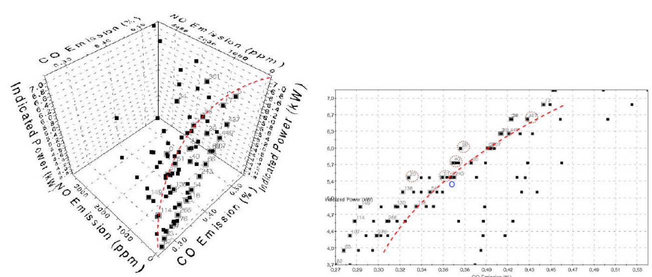


During the optimization process, the multiobjective optimisation tool, namely the Gaussian processes (GP) and MOGA was coupled with the CFD code in order to raise engine power and emissions level up to the acceptable standard level comparable to the gasoline-fuelled engine. Based on the comparisons performed, ten Pareto designs were chosen to represent the improved engine parameters for improvement on performance increase and reduction in emission.

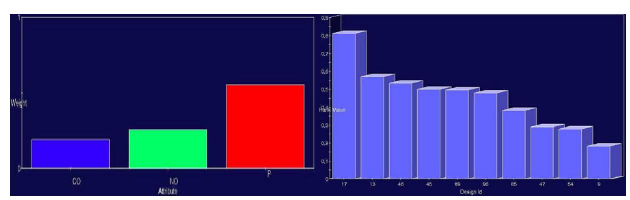


The multi objective optimisation workflow

Furthermore, the multicriteria decision making (MCDM) analysis was carried out to select one optimum Pareto design at an engine speed. The implementation of artificial intelligence for the optimisation of engine parameters in the internal combustion engine could reduce of the role of experimental test rig to verification and validation only. In addition, the computational time and resources required for in-cylinder combustion simulation can be optimized and reduced dramatically.



Pareto optimum solutions



MCDM analysis

Why modeFRONTIER?

The clear advantage of using MOGA available in modeFRONTIER for an internal combustion simulation is that it is possible to obtain the optimized engine critical parameter based contradicting objectives (performance vs. emission). By doing this, the work can be further extended to predict the optimized tork and power curve for the full engine which can eventually represents the performance of the whole vehicle.