user story

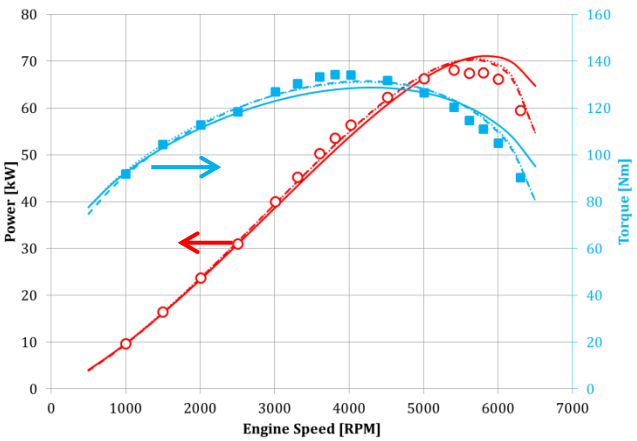
automated model calibration and parameter estimation

A case study based on IC engine peak performance measurements

Practically all numerical models include some simplification of real-world physical processes. It is common that these models include "tuneable" model parameters which must be estimated or calibrated using real-world data. If carried out iteratively by hand, these kind of projects can be time-consuming and unrewarding. Automation offers a systematic and repeatable result (independent of the user skill or experience) and results can be quantified to meet pre-agreed targets.

THE CHALLENGE

A common example of parameter estimation is carried out routinely in IC engine design and development. In this simple example, we seek to calibrate a IC engine model and complete a parameter estimation using measurements of engine power and torque as a function of engine speed (see Figure).



Power and torque at full load for the experimental data and the numerical models. The solid lines represent the optimal point from the Sobol analysis and the broken lines are the results associated with the parameters obtained through the two optimisation algorithms.

AUTOMATED CALIBRATION

Key engine geometric information were used to build a model using a mean-value engine approach. All other parameters were fixed to default values. The details of the "unknown" parameter estimation and bounds are listed in the Table. The bounds were defined based typical values from previous analysis. The targets for the optimisation were set as those experimental observations presented in the Figure.

A set of 2000 Sobol points were run across 12 cores to map out the design space (optimum result presented in the figure). Next the top ten best fits (minimum sum of squares) were used to initiate two optimisation algorithms. The best estimate of the parameters are presented in the table with results presented in the Figure.

SUMMARY

•A numerical model of an 1.6 litre gasoline engine was built-up

• A set of model parameters and reasonable bounds were identified

•The model was calibrated against experimental measurements using MoDS

Unknown parameter	Lower bound	Upper bound	Best estimate
Intake duct diameter [m]	0.03	0.06	0.041
Exhaust duct diameter [m]	0.03	0.06	0.053
Intake manifold temperature [K]	300	400	351
Vol. efficiency parameter 1	0.02	0.15	0.013
Vol. efficiency parameter 2	0.01	0.05	0.04
Vol. efficiency parameter 3	0.1	0.5	0.31

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