Study on Applying Machine Learning to Calibrate Turbocharger Model Parameters for Workload Reduction and Accuracy Improvement (Second Report)

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Model-based design/development (MBD) has been remarkable. In the automotive power-train development process, one-dimensional computational aided engineering (1D-CAE) is widely prevalent, in addition to the conventional three-dimensional computational aided engineering (3D-CAE). 1D-CAE requires far less computational cost than 3D-CAE, which has greatly contributes to minimizing the development lead time and to reduce the cost. However, calibration of parameters is required and is not always simple and easy, even in 1D models. Therefore, in this study, a machine learning was applied to optimize the parameters of a 1D turbocharger model for workload reduction and accuracy improvement. The concept is shown in Fig. 1. The first report showed that the prediction accuracy with the model optimized by machine learning had the same accuracy as the model optimized by the engineer. The result is calibrated at only one operating condition, turbine operating temperature (T_3) was fixed at 600°C, and has not been calibrated at other operating temperatures [1)]. In face turbochargers in IC engine are practically used in a wide operating temperature from a motoring condition where T_3 = 100°C to the full load condition where T_3 = 600°C, a robustness for the temperatures is required to the model. In this report, test results with two levels (400°C/ 600°C) of different operating temperature are prepaired for the model accuracy calibration, and a turbocharger model that can be useful under a wider operating temperature condition is attempted to built. Table 1 shows the index of the analysis results, which consists of the combination with the model types and the condition temperature to be predicted. Models calibrated with the training data of T_3 = 400°C, 600°C, and 400°C + 600°C were designated as Model 4, Model 6, and Model 0 respectively. As a result, the following conclusions were obtained.

1. A model adjusted by a certain operating temperature as learning data has low prediction accuracy for other operating temperatures.
2. By adding the test results of different operating temperature to the learning data, there is a possibility to build a robust model for the wider operating temperatures. (Fig. 2 and Fig. 3).

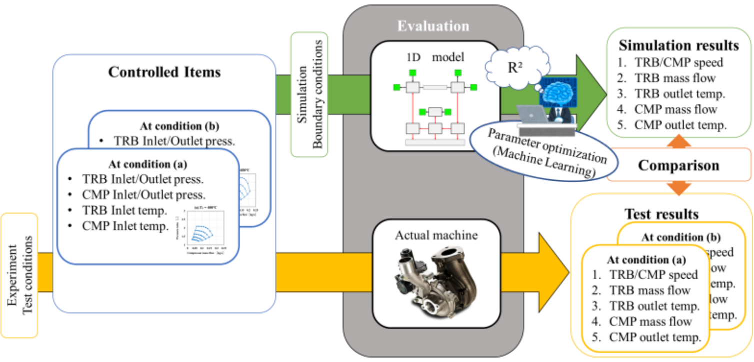

Fig. 1 Schematic flowchart for applying Machine Learning in this study

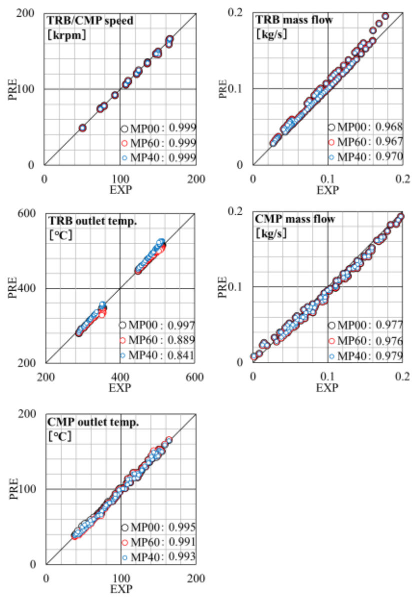

Fig. 3 Comparison of correlation between experimental and simulation results with MP00, MP40 and MP60

Table1 Simulation result index which consist of optimized model type and simulation condition (T3)

Model type \ Predict for	400°C	600°C	400°C and 600°C
Model 4	MP44	MP46	MP40
Model 6	MP64	MP66	MP60
Model 0	MP04	MP06	MP00

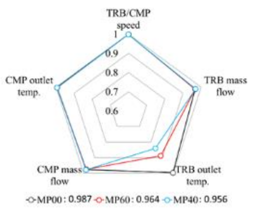

Fig. 2 Comparison of MP00, MP60 and MP40 accuracy expressed as the coefficient of determination

(1) Taiki Sakamoto, Study on Applying Machine Learning to Calibrate Turbocharger Model Parameters for Workload Reduction and Accuracy Improvement (First Report) (2020)