MIMO System Identification of Four-Stroke SI Engine Dynamic Research

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ABSTRACT

This study proposed a methodology to identify the dynamic characteristics of a four stroke SI engine which are important for system control and performance evaluation. Since the engine performance parameters are complicated correlated with the control parameters and operating variables, the engine system plant becomes a random, time-varying, nonlinear and multi-input and output dynamic relation. Engine simulation models used to explore the internal flow and thermal field are multidimensional complicated codes, which are not proper be used in engine real-time control purpose. This motivated study to establish proper engine plant models by MIMO system identification methods for engine performance evaluation and controller design. The experiments were compared under two different engine control modes, which are constant-load and constant-speed mode. The engine load was applied by an eddy current dynamometer, and the engine throttle position was controlled to maintained constant engine speed or load condition. This study also developed a graphic user interface for data acquisition and measurement monitor for different engine and dynamometer control operation modes. The measured data from dynamometer and engine sensors were acquired by user graphic interface and were used to find the system dynamic response behavior. The output performance variables including the engine speed, manifold absolute pressure were correlated with the input operating variables which were engine load and throttle position. The system identification process were adopted and viiicompared by different approaches and validated by the same data sets taken at later acquisition time. The observed different engine dynamic performance during acceleration and deceleration were compared with the simulation identification results. System identification models from the measured dynamic performance data correlation can be used for future reference of the engine design and engine management controller settings. In order to improve the system identification model prediction result, several engine experiments and different simulations were validated and compared. The comparison showed that the measured engine data needs to have proper variation to get better system identification result. In addition, the identification range chosen the whole experimental data range attained better model predicted result than those partly chosen data to identified. This study used the parametric identification methods such as Automatic Regression eXogenious (ARX), Automatic Regressive Moving Average eXogenious (ARMAX), Output Error (OE), Box-Jenkins (BJ), etc., and nonparametric identification methods, such as frequency and impulse response model. Different system identification parameters and order effects on the identification results were compared and validated by the real engine experimental data. From these results, it was observed that the ARX model predictions were not diverged the MIMO engine dynamic response in most of the engine operating conditions. As for the accuracy, the OE predictions were validated to be the most effectively method to follow the engine step response. As mention to the identification order effects, results showed that not necessarily the higher order the better, by proper adjusting identification parameters might get better approximated ixmodel. Divergence and separation happened when the nonlinear MIMO engine plant models which were identified and transformed into linear transfer functions. In order to solve this problem, frequency response must be judged in advance and zero-pole plot be checked to assure system stability requirement. Among the two engine constant-load and speed control modes experiments, OE showed better fit result under engine higher throttle opening variation conditions. The constant-load mode results were fitted better than the constant-speed control mode cases. The engine data before using filter were used in the identification could derived more stable and not distorted result compared to those filter data. Although results showed that OE attained better fit while when the transfer function results were compared, ARX model gained best result, thus these two methods are suggested for the MIMO engine identification plant model.

Keywords : Engine Dynamic Model Testing, MIMO System Identification.

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