OPTIMUM IGNITION TIMING CONTROL OF SI ENGINE USING ARTIFICIAL NEURAL NETWORKS

by

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Advanced combustion engine control systems require accurate feedback from the combustion chamber. Whereas the in-cylinder measurements are the most straightforward mean of obtaining combustion process information, their drawbacks in terms of implementation costs and durability are the main obstacles to their mass production implementation. Model based, virtual sensing approach has some advantages by offering high-quality information on the combustion process relying on the information provided from the commonly available engine signals, at the same time.

Models of the thermodynamic and mechanical process, within a combustion engine, are substantially nonlinear, which makes them, particularly interesting to the viewpoint of Artificial Neural Network (ANN) modelling approach. With a brief review of the thermodynamic fundamentals of combustion engine efficiency, combustion process indicators and general ANN modelling approach, commonly used in combustion engines, this thesis deals with an experimental study of ANN applications in virtual sensing of combustion process indicators based solely on the engine crankshaft speed and acceleration measurements. Focused on combustion process information extraction, measured angular speed is pre-processed in order to minimize the inertial effects by a detailed lumped-mass crankshaft model and calculation of new synthetic signals. This method provided ANN with combustion process rich information input signal.

The research presented, focuses on the combustion process phase estimation sublimated in the sensing of the angular position of the 50% of fuel mass fraction burned (MFB50). Two ANN approaches are compared with regard to MFB50 estimation accuracy and real-time control algorithm implementation suitability. The first one, based on Radial Basis Function implementation and trained by Orthogonal Least Squares algorithm, demonstrated its capabilities not only in a single combustion indicator sensing, but in complete MFB curve reconstruction. The second one, based on a Local linear neuro-fuzzy model (LLNFM) approach and trained with Local linear model tree algorithm (Lolimot), provided a compact and fast neural-network-like model for virtual MFB50 sensing. Both models are trained and tested on experimental data acquired from 140 engine testing points (with 50 cycles, each) of a test-bench four cylinder SI engine. Trained with the 30% of available data only, and tested with the rest of the data set, both models demonstrated good generalization capabilities with MFB50 estimation error 3% deviation within acceptable ±1,6° crank angle range.

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