**Model Reference Adaptive Control of a Marine Diesel Engine Combined with Electric PTI/PTO Motor**

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**Abstract:** This paper investigates the applicability of robust Model Reference Adaptive Control (MRAC) for the control of speed in a marine diesel engine combined with an electric Power-Take-In/Power-Take-Out (PTI/PTO) motor. Results of numerical simulations with a mean-value engine model (MVEM) are given where realistic loading is applied. These showed good performance of the engine control system: a satisfactory adaptive control system could be designed without necessarily having accurate information about the engine parameters, and consequently, configuration changes could be easily accounted.

**Keywords—**model reference adaptive control, marine diesel engines.

1-Introduction

The aim of this work is to investigate the applicability of Model Reference Adaptive Control (MRAC) for the control of speed and load in marine diesel engines. Of particular interest is the use of low-order models that will represent the plant, preferably of first order, while keeping the control algorithm as simple as possible. There is continuous interest in speed engine control problem, through the use of model based control approach, in order a) to eliminate the requirement for precise engine model, as in classical or optimization algorithms and b) to reduce the conservatism inherent to robust control algorithms. The speed control problem is to ensure that the engine rotational speed \( \omega \), tracks the desired reference speed, within the frame of operation of a marine engine, which includes the application of sudden external loads. The present work was carried out in two directions: a) the derivation of suitable engine models for adaptive control and b) the selection of appropriate MRAC methodologies. The brief literature review which follows focuses on these two areas.

In [1], a mathematical model of a turbocharged diesel engine was developed which was further linearized and provided transfer functions for use in control studies. The transfer functions varied over the operating range from low load and low speed to high load and high speed. Their type was second order with zero and delay. With a similar aim, in [2] a model of a large turbocharged 2-stroke marine diesel engine is presented, providing relations for engine speed and turbocharger speed in the form of transfer functions, based on first principles. In [3, p. 282-295] the application of self-tuning to a turbocharged diesel engine for the regulation of engine speed is presented. The diesel engine was modelled by a first order model relating the fuel rack position to engine speed. Experimental results verified the control methodology, considering various parameters like pole placement polynomials, forgetting factors, sample rates, controller order. In [4] a pole assignment and a PI self-tuning algorithm were applied for the control of engine speed and smoke in a diesel engine during transients. Experimental results showed that objectives were met. Two self-tuning algorithms were compared in [5], as were applied for the idle speed regulation in a heavy-duty diesel engine. Recursive least squares were used for parameter identification while minimum variance and pole placement were developed and tested on a nonlinear engine model. Both self-tuners were able to converge quickly in controller parameters, the first type achieved faster settling times with slightly higher overshoot. Not many publications exist for work relating MRAC and internal combustion engines. An early work can be found in [6], where the application of MRAC with identification for the control of speed in a diesel engine is presented. The algorithm was similar to self-tuning, it was implemented in discrete form and stability was based in hyperstability concepts. Recently [7], presented a successful extension of the standard MRAC method, for systems with time delay, called posicast, which was applied to the idle speed control problem in a spark ignition engine. Simulation and experimental results demonstrated the improvement by employing such an adaptive controller. Finally, in [8], the work of the authors in model-based engine control system design is presented, with the aim to reduce smoke from marine diesel engine exhaust emissions, during transient operation, by injecting compressed air in intake manifold, with compressor surge avoidance at the same time. Model Predictive Control was employed in experiments with a marine diesel engine, while models for exhaust smoke opacity and intake pressure were derived with system identification, in a multivariable formulation.