Adaptive power-split control design for marine hybrid diesel powertrain

Sergey Samokhin *
Postgraduate researcher
School of Electrical Engineering
Aalto University
Otaniementie 17, 02150
Espoo, Finland
Email: sergey.samokhin@aalto.fi

Sotiris Topaloglou
Postgraduate researcher
School of Naval Architecture
and Marine Engineering
National Technical University of Athens
Zografou Campus-15780, Athens, Greece
Email: akis@lme.ntua.gr

George Papalambrou
Assistant professor
School of Naval Architecture
and Marine Engineering
National Technical University of Athens
Zografou Campus-15780, Athens, Greece
Email: george.papalambrou@lme.ntua.gr

Kai Zenger
Senior lecturer
School of Electrical Engineering
Aalto University
Otaniementie 17, 02150
Espoo, Finland
Email: kai.zenger@aalto.fi

Nikolaos Kyrtatos
Professor
School of Naval Architecture
and Marine Engineering
National Technical University of Athens
Zografou Campus-15780, Athens, Greece
Email: nkyrt@lme.ntua.gr

It is known that mechanical wear and tear of components of large marine engines throughout their lifetime can cause the engine dynamics to alter. Since traditional control systems with fixed parameters cannot deal with this issue, the engine performance may degrade. In this work, we introduce adaptive control algorithms capable of adapting the control system in order to preserve the engine performance once its dynamics deviate from the nominal ones. Particularly, direct and indirect model reference adaptation mechanisms are studied. In this work, the case of degraded oxygen sensor is investigated as an example of engine components deterioration throughout its lifetime. The controllers are implemented in Simulink and their performance is evaluated under both nominal and degraded sensor conditions. Specifically, the sensor degradation is imitated by altering its time-delay. In such conditions, adaptive controllers demonstrate a notable improvement in tracking performance compared to the fixed parameters PI controller. Finally, the designed controllers are validated on the hybrid marine engine testbed using dSpace rapid prototyping system.

*Corresponding author

1 Introduction

During the last decades, marine diesel engine emission regulations have become increasingly stringent due to stricter environmental requirements imposed by the International Maritime Organization (IMO) [1]. As a result, achievement of near-zero emissions has recently become one of the key targets for marine engine manufacturers [2, 3].

Recently, the combination of an internal combustion engine with an electric motor has emerged as a powerful approach for reducing emissions within the automotive industry [4]. A large number of research papers has been devoted to evaluating various aspects of hybrid electric vehicles (HEVs), including components sizing, control systems design and topologies investigations. The control of HEVs is usually categorized into rule- and optimization-based algorithms [5]. Various optimization-based algorithms have been proposed for HEVs control, including model-predictive control [6], optimal control based on Pontryagin's minimum principle [7, 8], and genetic algorithms [9]. Typ-