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Adaptation of a zero-dimensional cylinder pressure model for diesel engines using the crankshaft rotational speed

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ABSTRACT

Tighter emission regulations are driving the development of advanced engine control strategies relying on feedback information from the combustion chamber. In this context, it is especially seeked for alternatives to expensive in-cylinder pressure sensors. The present study addresses these issues by pursuing a simulation-based approach. It focuses on the extension of an empirical, zero-dimensional cylinder pressure model using the engine speed signal in order to detect cylinder-wise variations in combustion. As a special feature, only information available from the standard sensor configuration are utilized. Within the study, different methods for the model-based reconstruction of the combustion pressure including nonlinear Kalman filtering are compared. As a result, the accuracy of the cylinder pressure model can be enhanced. At the same time, the inevitable limitations of the proposed methods are outlined.

1. Introduction

In parallel with the steadily increasing demands on passenger cars regarding emissions and fuel consumption, the requirements for the diagnosis of all emission-related subsystems are rising. The detection of misfire and electronic functions for torque balancing for example, is standard in today's engine control systems. Consequently, the more complex task of an accurate estimation of combustion features becomes the focal point of interest [1–3]. This represents the basis for the development of optimized engine control strategies required by modern combustion processes with high exhaust gas recirculation (EGR) rates. In this context, the cylinder pressure trace is the most prominent feedback signal since it is closely connected to the thermodynamic combustion process [4]. It allows for accurate calculation of corresponding quality criteria and the design of closed loop control strategies [5–7]. However, the use of pressure sensors in mass-production vehicles [7] is still affected by challenges such as durability and costs. Accordingly, the evaluation of alternative signals for combustion feature estimation is of special interest. A short review of existing methods is given in Section 2.

The present study is based on a newly developed empirical model for simulating the cylinder pressure in direct injection diesel engines [8,9]. It enables the representation of current combustion processes considering multiple injections, high EGR rates, and turbocharging accompanied by low resource demands and a fast adaptation to different engines. However, only a forward modeling using cycle-resolved, scalar variables from the electronic control unit (ECU) in

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