Real-time Control of an SI Engine Using Ion Current Based Algorithms

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Akademisk avhandling som för avläggande av teknologie doktorsexamen vid Chalmers tekniska högskola försvaras vid offentlig disputation fredagen den 16 december 2005, klockan 10.15 i Wigforssalen, Högskolan i Halmstad.

Avhandlingen försvaras på engelska. Fakultetsopponent är Dr. Jean-Pierre Hathout, Robert Bosch GmbH, Corporate Research & Advance Engineering, Engine Management, Stuttgart, Germany.

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Abstract

Reducing emissions and improving fuel efficiency in automobiles are today important issues. New sensor techniques are developed to extract detailed combustion information to enable closed loop engine control. This thesis is about a *virtual* sensor; measuring an ion current inside the cylinder by using the already existing spark plug, followed by signal processing for estimation of combustion parameters.

First, the thesis aims to show that the ion current signal can be used for closed loop control of Exhaust Gas Recirculation (EGR). Use of EGR is very common in modern automobiles because of the potential reduction of NO_x emissions and fuel consumption, but using too much EGR can have the reverse effect (e.g. increased fuel consumption and driveability problems). Algorithms for estimating combustion variability are proposed and a closed loop scheme for controlling an EGR valve is demonstrated for driving on the highway in a SAAB 9000.

Estimation of the pressure peak position is treated for closed loop control of ignition timing. Such estimation can be performed with the ion current but may not work if a fuel additive is used. Different methods are compared and it is shown that using a fuel additive may even improve the estimation accuracy of the pressure peak position with about 25%. An algorithm is also proposed to estimate the pressure peak position even in presence of EGR.

Strategies for transient control of the air-fuel ratio are also compared. Air-fuel ratio control is important because even small deviations from the stoichiometric value can result in significantly increased emissions. It is found that a neural network based controller had the best performance with approximately 23% lower RMS error than the adapted standard control module.

Keywords: SI engine, Ion current, Real-time control, Exhaust gas recirculation, Location of pressure peak, Combustion variability, Fuel additive.