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Blow-Down Supercharging in a HCCI engine using EGR

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Abstract

Blow-down supercharging by pressure wave (BDSCpw) was studied as a potential technique for boosting a homogeneous Charge Compression Ignition (HCCI) engine. The four-cylinder model, first, was built in the one-dimensional engine software GT-Power suite. Three different combustion models, namely SI-combustion, HCCI-combustion, and Stochastic Reactor Model (SRM) were investigated. The results show that the SRM combustion model, LOGEsoft software, well described the combustion event under the HCCI condition, which is highly dependent on the spatial distribution of in-cylinder pressure and temperature. Three detailed reaction mechanisms, namely LOGE, GT-Power, and SK171, of Primary Reference Fuel (PRF) were compared. The duplicate reaction is a critical factor for predicting the combustion phasing as it affects the formation rate of H_2O_2 an OH radicals, which control the auto-ignition event. The HCCI engine model with developed combustion object (coupled model) has an ability to predict the combustion process and engine's performance.

The coupled model was used to study the performance of HCCI engine of BDCSpw. Four different operation points running at 2000 rpm were studied by following the models proposed in [1]. The results indicate that the combustion phasing of low load operation is earlier than high load operation hence, controlling the ignition timing is challenging. The engine model fuelled with RON65, compression ratio of 12, 2000rpm, and intake air temperature 298K, can achieved the 8 bar IMEP with the maximum pressure rise rate of 6.34 bar/deg. The emission levels of NOx, CO, and unburned fuel are lower than from the convention Spark Ignition (SI) engine.

For the BDSCpw technique, the amount of EGR re-introduced can be varied by adjusting the valve lift and/or duration. However, it requires an attention as the in-cylinder gases will flow out if the in-cylinder pressure is higher than the exhaust port pressure hence, there is no benefit of the exhaust valve re-opening. The geometry of the exhaust manifold also affects the wave dynamics in the exhaust manifold.

In conclusion, the BDSCpw technique can boost a HCCI engine without the need for turbocharging. However, controlling the combustion is more complicated than suggested in [1].

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