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Title: A Design Tool to Analyse Homogeneous Charge Compression Ignition (HCCI) engines.

Abstract

Homogeneous Charge Compression Ignition (HCCI) technology is a potential candidate for the sustainability of internal combustion (IC) engines. The technology alternatively termed as Controlled Auto-Ignition (CAI) arouses great interest due to its high thermal efficiency and very low emissions of nitrogen oxides (NOx) and particulates [1,2]. Critical issue of the HCCI combustion is the control of the engine since the combustion process is mostly dominated by chemical kinetics. Therefore the accurate assessment of the chemical kinetics is fundamental in numerical simulation of this kind of engines. Experimentally it has been demonstrated that even in HCCI engine the charge within the cylinder is not fully homogeneous, but many quantities, such as temperature, density and equivalence ratio, vary along the combustion chamber. These inhomogeneities influence the combustion process and yield the conventional homogeneous reactor model to be not completely adequate to simulate HCCI combustion.

This poster focuses on the use of a probability density function (PDF) based stochastic rector model coupled with a commercial 1-D CFD engine cycle simulator. The coupling enables the modeler to account for the interaction between engine performance parameters such as BSFC, IMEP and the combustion parameters such as ignition timing, emissions, in-cylinder pressure etc. The model is based on a detailed chemical kinetics description and accounts for inhomogeneities in composition and temperature. Turbulent mixing is modelled using Curl's coalescence-dispersion model and the convective heat transfer is modeled as a stochastic jump process.

The model is applied to simulate the HCCI operation in two different engines running in HCCI mode:

1. The first one is a multi-cylinder, turbocharged HCCI engine. The model is first validated against measurements and then applied to investigate the effect of variation in octane number on combustion and engine parameters.
2. The second one is a single cylinder engine with exhaust gas recirculation (EGR). Here as well, the model is validated against measurements and then used to investigate the effect of EGR and residual burnt fractions on in-cylinder pressure and emissions. The HCCI operating window (range) with respect to air/fuel ratio and EGR is predicted.

The integrated model presented, agrees satisfactorily with the measurements and clearly out-performs the single zone based engine cycle models.

References:

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2. L Montorsi, F. Mauss, G. M. Bianco, A, Bhave, M. Kraft: Analysis of the HCCI engine combustion of a turbocharged truck engine using a stochastic reactor model, Paper No. 2003-ICE-681, ASME Technical Conference ASME 2003.