Hessisches Kompetenzzentrum
für Hochleistungsrechnen

LES of a Spark Ignition Engine Using Artificial Thickening and Flamelet Generated Manifols



Researchers
Chao He and Guido Künne

Principal Investigator
Prof. Dr.-Ing. Johannes Janicka

Project Term
2015 - 2015

Project Areas
Heat Energy Technology, Thermal Machines, Fluid Mechanics

Clusters
Lichtenberg Cluster Darmstadt

Institute
Fachgebiet Energie und Kraftwerkstechnik

University
Technische Universität Darmstadt

Introduction

The complexity of in-cylinder flow combined with chemical reactions involving a vast number of species render the modelling of spark ignition engines a challenging task. In this work the optical spark ignition engine built and measured at TU Darmstadt has been simulated. The experimental study of the engine have been presented in.[1,2]

Methods

The engine operates with homogeneous mixtures from port fuelled injection of iso-octane. Simulations have been performed using the code KIVA-4mpi extended with the Large Eddy Simulation (LES) turbulence model to capture the complex flow field behaviour and cycle-to-cycle variations. First, the cold flow simulations for this optical engine has been carried out. Since a new engine configuration was considered it was necessary to verify that the numerical grid represented correctly and accurately the engine’s geometry and that the experimental pressure curve could also be reproduced in the simulations. The numerical setup was assessed by comparing the predictions with a comprehensive set of velocity measurements for different spatial and crank-angle positions. The cycle parallelization technique was employed in this work. Each simulation was performed using 12 CPUs at the Lichtenberg-cluster. Thanks to its high performance, 64 engine cycles were simulated within three weeks. Statistics were evaluated over 50 engine cycles. A very good agreement with experimental data [1,2] was obtained

(Fig. 1). Finally the reacting operation using tabulated chemistry has been considered. The chemistry of iso-octane has been represented using the Flamelet Generated Manifold (FGM) technique which spans over the relevant temperature and pressure range of the engine. LES of combustion modelling has been performed adopting the thickened flame approach where the thickening factor automatically adapts to the local conditions of pressure and grid size to ensure a proper resolution of the chemical source term. In addition to the adaptive thickening, a flame sensor has been used to detect the flame.[3,4] To capture the spark ignition the mesh has been refined around the region of interest and the ignition model available in KIVA-4mpi has been improved consistently with the FGM approach. Also for the reacting case 50 cycles will be simulated and the predictions will be compared with the measurements. Figure 1: In-cylinder velocity field comparison at 90° crank angle bTDC (compression phase) .

Reference

1. E. Baum, B. Peterson, C. Surmann, D. Michaelis, B. Böhm, and A. Dreizler (2012), Investigation of the 3D flow field in an IC engine using tomographic PIV, Proc. Combust. Inst. http://dx.doi.org/10.1016%2Fj.proci.2012.06.123

2. E. Baum, B. Peterson, C. Surmann, D. Michaelis, B. Böhm, and A. Dreizler (2012), Tomographic PIV measurements in an IC engine, 16th Int. Symp. on Applications of Laser Techniques to Fluid Mechanics.

3. G. Künne, A. Ketelheun, and J. Janicka (2011), LES modeling of premixed combustion using a thickened flame approach coupled with FGM tabulated chemistry, Combustion and Flame. https://doi.org/10.1016/j.combustflame.2011.01.005

4. G. Künne (2012), Large Eddy Simulation of Premixed Combustion Using Artificial Flame Thickening Coupled with Tabulated Chemistry, Optimus Verlag.

Last Update: 2022-07-14 23:03