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The Full Cycle HD Diesel Engine Simulations Using KIVA-4 Code

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ABSTRACT

With the advent of the KIVA-4 code which employs an unstructured mesh to represent the engine geometry, the gap in flexibility between commercial and research modeling software becomes more narrow. In this study, we tried to perform a full cycle simulation of a 4-stroke HD Diesel engine represented by a highly boosted research IF (Isotta Fraschini) engine using the KIVA-4 code. The engine mesh including the combustion chamber, intake and exhaust valves and helical manifolds was constructed using optional O-Grids catching a complex geometry of the engine parts with the help of the ANSYS ICEM CFD software. The KIVA-4 mesh input was obtained by a homemade mesh converter which can read STAR-CD and CFX outputs. The simulations were performed on a full 360 deg mesh consisting of 300000 unstructured hexahedral cells at BDC. The physical properties of the liquid fuel were taken corresponding to those of real diesel #2 oil. The spray atomization and droplet dynamics models were described by the KH-RT hybrid model which is a modified replica of the ERC model; the droplet collisions were modeled by the droplet trajectory based method with a reduced grid dependency. The original KIVA-4 droplet evaporation model was replaced by the KIVA-3V model. Chemical kinetics (71 species, 323 reactions) was based on the mechanism for diesel oil surrogate represented by a blend of n-heptane (70%) and toluene (30%) coupled with the EDC (eddy dissipation concept) model to simulate turbulent combustion. The emission (soot and NO_x) formations were described in terms of sub-models based on the evolution of soot precursors, A2R5, and the extended Zel'dovich mechanism, respectively. All stages of the engine cycle were successfully calculated. Due to a small amount of experimental data available for the research IF engine, predictions were successfully compared with experimental data on the in-cylinder pressure and RoHR (rate of heat release) histories only. Comparisons of the predictions produced on the full and sector meshes were also made.

INTRODUCTION

Prediction of combustion and emission formations in ICEs using advanced CFD codes becomes an important tool to facilitate the engine development and optimization process. Regardless of the presence of commercial CFD engine codes (STAR-CD, FIRE, etc), the simulations based on the KIVA-3V [1] code are still popular in research community due to a more simple procedure of implementation of advanced spray combustion sub-models coupled with the improved chemistry/turbulence interaction modeling and new formulations of complex combustion kinetics for surrogates of practical hydrocarbon fuels. With the advent of the KIVA-4 [2] code which employs an unstructured mesh to represent the engine geometry, a gap in flexibility between commercial and research modeling software becomes more