Aalto University
School of Engineering

Dissertation Release 5.11.2019

Multiscale numerical simulation of combustion using computational fluid dynamics and chemical kinetics

Title of the dissertation	Numerical modeling of ignition and flame propagation in gas engines.
Contents of the dissertation	Using natural gas in internal combustion engines (ICE) is gaining worldwide attention particularly in marine propulsion. Natural gas usage promotes cleaner combustion compared to e.g. longer hydrocarbons with lower CO2, NOx and unburned hydrocarbon emissions. The present dissertation utilizes high-performance computing and advanced 3D multiscale modelling methods to provide detailed description of turbulent ignition characteristics and combustion processes in compression and spark ignited gas engines, respectively. The major challenge in natural gas combustion is the non-repeatability of different combustion cycles i.e. the so called cycle-to-cycle variation (CCV). CCV has been shown to lead to undesired phenomena in ICEs such as misfire, knock, methane emissions, power fluctuations and increase in fuel consumption. In the present dissertation, ignition characteristics of dual-fuel natural gas/diesel blends is studied using detailed chemical kinetics. Such a study improves the combustion community to understand how the ignition of low-reactivity natural gas can be improved by addition of small amounts of diesel. In addition, CCV is studied in a spark ignited lean gas engine using advanced 3D simulations at a new level of detail. A major finding of the study is to demonstrate, that the outcome of a combustion cycle can be connected to the local flow field conditions around the spark at early times after ignition. Such findings clearly encourage the experts to focus on controlling ignition at early stages of combustion process advocating development of robust natural gas ignition technologies such as dual-fuel combustion.
Field of the dissertation	Energy Technology, Computational fluid dynamics and chemical kinetics
Doctoral candidate	Mahdi, Ghaderi Masouleh, Mechanical Engineering, M.Sc. (Eng) Born in 04.01.1987
Time of the defence	15.11.2019 time 12:00-15:00.
Place of the defence	Aalto University School of Engineering, lecture hall 215 (K1), Otakaari 4, Espoo
Opponent	Professor Xue-song Bai, Lund University, Sweden, Lund
Supervisor	Professor Ville Vuorinen, Aalto University School of Engineering, Department Mechanical Engineering
Electronic dissertation	http://urn.fi/URN:ISBN:978-952-60-8769-6
School of Engineering electronic dissertations	https://aaltodoc.aalto.fi/handle/123456789/40967
Doctoral candidate's contact information	Mahdi Ghaderi Masouleh, Department of Mechanical Engineering, Mahdi.GahderiMasouleh@aalto.fi, 0504463309