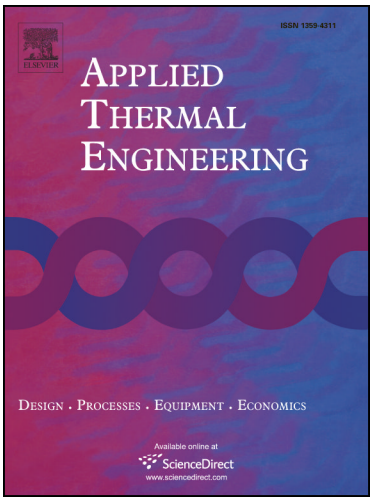

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Development of a skeletal mechanism for heavy-duty engines fuelled by diesel and natural gas

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Abstract

The purpose of this work is to develop a skeletal dual-fuel mechanism for heavy-duty engines fuelled by diesel and natural gas. With diesel fuel modeled as n-heptane, and natural gas modeled as methane, the skeletal mechanism was constructed by coupling the two skeletal mechanisms reduced detailed mechanisms: n-heptane and methane mechanisms. Directed relation graph error propagation and sensitivity analysis, computational singular perturbation and reaction rate adjustment methods were employed for mechanism reduction. The final skeletal dual-fuel mechanism is composed of 61 species and 199 reactions. So as to validate the fidelity of the novel skeletal dual-fuel mechanism, zero-dimension ignition delay testing against shock tube experimental results and 3-dimensional engine validation about in-cylinder pressures, heat release rates and NOx and CO emissions against engine testing results were performed under various operating conditions. The validation results indicate that the dual-fuel mechanism can accurately reproduce the ignition behaviors, combustion characteristics and emission trends in heavy-duty diesel/NG dual-fuel engines. Besides, a parallel computing method based on the round-robin algorithm was developed which can significantly save the time for calculating. Combined with the new developed skeletal dual-fuel mechanism, the 3D CFD simulation for the combustion in heavy-duty engines can be done in a reasonable computational time.

Keywords: Natural gas; Pilot diesel; Dual-fuel skeletal mechanism; heavy-duty engines

1. Introduction

Diesel engines are widely used in numerous applications throughout the world. With rapid depleting of fossil fuels and increasingly strict emission regulations, alternative fuels for diesel engines have attracted more and more attention [1-4]. Due to its abundant reserves, high fuel economy and relatively low emissions, natural gas (NG) has been emerging as a promising alternative fuel in recent years, especially in ship propulsion [5-7]. The diesel/NG dual-fuel engines adopt natural gas as primary fuel, while using a small amount of diesel as pilot fuel to ignite NG and air mixture [8-9]. Conventional diesel engines can be retrofitted to diesel/NG dual-fuel engines with some modifications, which make it possible for the dual-fuel engines to utilize the high compression ratios of original diesel engines, thus achieving high thermal efficiency as well as relatively lower nitrogen oxides (NOx) and particulate matter

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