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Impact of Various Factors on the Performance and Emissions of Diesel Engine Fueled by Kerosene and Its Blend with Diesel

Wenming Yang[a*], Kun Lin Tay[a], Kah Wai Kong[a]

[a]*Department of Mechanical Engineering, Faculty of Engineering, National University of Singapore 9 Engineering Drive 1, Singapore 117576, Singapore. Email: mpeywm@nus.edu.sg*

Abstract

As a response to the single fuel concept introduced by the North Atlantic Treaty Organization (NATO) as well as increasing cases of adulteration of diesel fuel with kerosene, it is important for us to have a better understanding on the performance of diesel engine fueled by kerosene and its blend with diesel. An extensive numerical investigation on the combustion and emission formation of a diesel engine fueled by kerosene and its blend with diesel is presented in this paper. The impact of various factors such as the fuel blend ratio and the fuel injection angle on the performance of the engine was examined. The results indicated that the fuel with a higher percentage of kerosene tend to give higher maximum power output, lower carbon monoxide emission. It is also found that for each fuel, there is an optimum fuel injection angle that gives the highest maximum power output and relatively low emissions.

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Keywords: Kerosene, combustion, fuel injection strategy

1. Introduction

The North Atlantic Treaty Organization (NATO) introduced the Single Fuel Concept in 1986 in order to maximize equipment interoperability and therefore in general to improve the organization's logistic efficiency. An agreement was reached on a common aviation turbine fuel for land based military aircraft, F-34 (JP-8) to replace F-40 [1]. The proposal and implementation of the Single Fuel Concept has resulted in the use of a single fuel, namely the Jet-Propellant 8 (JP-8) kerosene-based fuel in all its engine including the diesel ones. In addition to the Single Fuel Concept, there is the problem of increasing cases of diesel fuel being adulterated with kerosene due to kerosene's excellent miscibility with diesel [2]. This consequently requires the need for more investigations to be done on the operation of diesel engines fueled by kerosene and its blend with diesel. Fuel properties such as cetane number, density and viscosity are factors affecting the combustion, subsequently on the performance and emission

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characteristic of diesel engine. To address this issue, some investigations on the combustion and emission characteristics involving different fuel blends have been conducted. For example, Aydm et al [3] experimentally investigated the performance of a diesel engine fueled by kerosene fuel and its blend with biodiesel [3]. Lee et al [4] investigated the performance of JP-8 in a heavy duty diesel engine under different injection pressure and injection timing. Uyumaz et al [5] tested the performance of a diesel engine fueled by JP-8 and biodiesel blends under different fuel blend ratio and engine load. However, compared to experimental testing, rare works have been done in terms of numerical simulation due to the lack of a short and robust chemical reaction mechanism for kerosene. To bridge this gap, most recently, a skeletal chemical reaction mechanism for the combined oxidation of kerosene and diesel fuel was developed by our group [6]. In this work, a more comprehensive investigation has been conducted to examine the impact of various factors on the performance of the diesel engine fueled by kerosene and its blend with diesel such as kerosene and diesel blend ratio and the fuel injection angle.

Nomenclature

CAD	Crank angle degree
DOI	Duration of injection
ICE	Internal combustion engine
JP-8	Jet propellant 8
NATO	North Atlantic Treaty Organization
SOI	Start of injection

2. Methodology

3-dimensional numerical simulations will be carried out in this work to investigate the combustion process and emissions formation in a diesel engine fueled by kerosene and its blend with diesel fuel. Since diesel engine combustion is a complex process involving both physical and chemical processes, it is important to capture these processes during the engine simulations. The KIVA4 code coupled with CHEMKIN will be used for the simulations. The physical processes that occur in the combustion chamber, such as in-cylinder turbulence and spray breakup, will be modelled by the KIVA4 code which contains all essential physical models such as the KHRT spray breakup model and the RNG k-e turbulence model. On the other hand, the chemical processes which occur during the entire combustion process will be captured by CHEMKIN which calculates the heat-release and the species evolution at every crank angle. This enables the KIVA4-CHEMKIN code to predict engine combustion with high accuracy. For more details about KIVA 4 and CHEMKIN coupling, please refer to our previous publication [7]. A 2KD-FTV Toyota car engine is employed for the experimental test of the base case and for validation of the numerical simulation results. The engine specifications and operating parameters are described in Table 1.

Table 1: Engine Specifications and operating conditions

Engine Specifications	
Engine Type	Four stroke, direct injection, 4 cylinder in line
Bore × Stroke	92 × 93.8 mm
Connecting Rod	158.5 mm
Compression Ratio	18.5:1
Base case engine speed	2400 rpm
Aspiration Type	Turbocharged
Fuel Supply System	Diesel common rail system
Fuel Injector	Denso 6-hole injector
Fuel injection duration	15.5 CAD