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Effect of Biodiesel-water-air derived from Biodiesel Crude Palm Oil Using Premix Injector and Mixture Formation in Burner Combustion

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Abstract

The prospects of fossil oil resources and strengthen of future emission regulation had raised keen attention together with the issue of alternative fuel especially in burner combustion of boiler or incinerator system. In order to investigate the solutions for these problems, rapid mixing of biodiesel-water-air is one of the most appropriate techniques to be used with the significant approaches to reduction in emissions, such as nitrogen oxides (NOx) and particulate matter (PM). Biodiesel fuel is predicted as the solution of alternative fuel issue especially from crude palm oil (CPO) base due to the most economical option and biodegradable properties of biodiesel production. Besides, the properties of biofuel will affect the spray characteristic [14]. Moreover, higher fuel's viscosity could contribute to the high penetration length and low spray angle, thus predominantly the lower combustible mixture and lower the flame length [15]. Therefore, the aim of this study is to focus on the effects of biodiesel-water-air premixing and mixture formation by observing the real images of spray and flame characteristics at different equivalence ratio and water content using direct photography method. The parameters measured are spray penetration length, spray area and spray angle. Meanwhile, parameters measured for flame characteristics are flame lengths, flame angle and flame area. The percentage of water emulsion is up to 15vol% and blending biodiesel ratio varies from 5vol% to 15vol%. The results from the biodiesel are compared to the diesel fuel. The result showed that the percentage of biodiesel and higher water content contributed to the higher penetration length, bigger area and lower spray angle due to their viscosity.

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Keywords: Renewable fuel; rapid mixing; mixture formation; emissions

1. Introduction

In the future, the growth of population and economic require more energy and natural resources. The rise in environmental issues and cost of the fossil fuel has encouraging research on alternative fuel such as biodiesel.

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Biodiesel as the renewable resource continue to be an interest research in order to achieve a sustainable energy economy as well as reducing the dependency on fossil fuels. Moreover, worldwide demand on the biodiesel as an alternative fuel is increasing due to the energy sources crisis.

Biodiesel is an environmentally friendly fuel, which is one of the clean and renewable energy resources. Biodiesel fuels are usually made from animal fat or vegetable oil revenue trans-esterification reaction. The oxygen content in biodiesel is about 11% to 15%, which results in improvement of combustion process and notable reduction in the emission from diesel combustion [1][2]. The development for crude palm oil (CPO) transform to biodiesel is increasing particularly due to CPO is readily available, safe to store and handle, and the most important, it is totally renewable. The sulphur content of CPO biodiesel is negligible compared to the diesel which results less possibility of acid rain caused by sulphur dioxide emissions [3-5].

Besides, CPO can be made into a biodiesel through the process of trans-esterification of triglycerides with methanol. The product of this process is known as palm oil methyl-ester (POME), or palm oil diesel. Studies conducted on POME [6-8] had showed promising results compared to the diesel fuel based on both engine performance and emission respectively. However, POME is more expensive than CPO due to the chemical and mechanical processing involved. The interest on CPO as a diesel substitute stems from its simple production process, which makes it less expensive than POME.

Spray combustion is commonly used in the process of industries for the purpose of gaining energy and power. Meanwhile, effervescent nozzle of burner and fuel properties plays a significant role in spray atomization and formation of fuel-air mixture in order to improve combustion performance, and reduce some pollutant products [10, 12, 19]. Apart from that, many investigations have been conducted experimentally and numerically on combustion and emissions using biodiesel, mainly by the emission reduction standpoint. However, detailed studies of spray characteristics are less frequent found in literature for biofuels, despite their fundamental importance is recognized [17]. Higgins *et al.* [16] used different fuels like diesel, biodiesel, methanol, gasoline, and n-hexadecane to measure the maximum spray penetration. They discovered that the spray penetration of biodiesel is higher than diesel fuel. Moreover, they also attributed that the biodiesel has higher heat of vaporization and boiling point. Payri *et al.* [18] found that the higher density and viscosity of biofuel is significantly affected to the spray, which characterized by higher penetration and lower angle, especially for long injection.

Nevertheless, emission is the main issue of investigation in the external combustion characteristics, specifically nitrogen oxide (NOx) [9-10]. NOx emission could emit into the atmosphere during the combustion process, while it can react with water and other compounds to form various acidic compounds, fine particles and ozone. These pollutants can remain in the air for days or even years. Apart from that, side effects of NOx on human body are decreasing the lung function, results in difficulty breathing, shortness of breath, and other symptoms [11-12]. Diesel fuel releases toxic emissions is still a global issue, concerning NOx and carbon monoxide (CO). NOx is known to be immediately dangerous to the human health and environment. Besides that, NOx could react with other pollutants to form toxic chemical as well as contribute to the formation of acid rain [13].

Rapid premixing in the combustion process is a new concept advanced technique for the purpose of gas emission reduction especially on flame temperature which is the main factor to produce NOx emission. Besides, the premixing also influences on flame propagation phenomena which contributed to the reduction of PM [1, 15, 20]. Water-emulsified fuel could lower the flame temperature and it also reduces PM [1, 2, 21-24]. The main reason of PM reduction is micro-explosion which enhances spray atomization in result of PM reduction [1, 2, 25-27]. Therefore, the objective of this paper is to investigate the influence of biodiesel-air-water premixing with the respect of spray mixture formation through spray characteristics, such as spray penetration, spray area and spray angle. In addition, spray combustion criteria investigated through the flame length, flame area and flame angle which is directly proportional to the spray characteristics. Nonetheless, the reduction of emission is predicted from the performance of spray combustion.

Nomenclature

CPO	Crude Palm Oil	W5	5% water content
POME	Palm Oil Methyl-Ester	CPO5	5% of CPO blends with diesel fuel
NOx	Nitrogen Oxide	PM	Particulate Matter
HC	Hydrocarbon		