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A Review of the Concept of Fuel-water Internally Rapid Mixing Injector in Burner System

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Key Words: Biodiesel, Water Emulsion, Mixture Formation, Combustion Process, Combustion Characteristics, Emissions, Flame

Abstract
This paper reviews the effects of premix fluids between biodiesel, air, and water for external combustion especially open burner. During burning process, biodiesel combustion involves the fuel-air mixing characteristic such as oxidation stability, stoichiometric point, bio-fuel composition, antioxidants and viscosity that influences more NOx emissions than diesel fuel. The strategies to reduce NOx emission are acquired with water additional in biodiesel fuel mixing during early stage of burning process. The method to mix biodiesel-water with injector was acquired in burner system. A vast majority of author reported that the variation in mixing of blending biodiesel ratio and water was found to enhance the burning process and mixture formation thus predominantly reducing the NOx emissions.

Introduction

Global warming is one of the environmental issues since 1958. Definition of global warming is referring to increased temperature of earth surface and it gives effect to green house[1-6]. The main gas in green house is CO2. It is a necessary product for economic activities and human's life [7-12].Green house gasses are carbon dioxide (CO_2), carbon monoxide (CO), methane (CH_4), water vapor (H_2O), nitrous oxide (N_2O) and ozone (O_3).

A flame stabilizer equipped with a new injector will be used to investigate the rapid BDF-water-air premixing and burning process related phenomena. Using this injector, the new approach to introduce water into burner combustion could be reproduced within the range high load combustion and different composed of three-fluid injected. The new injector is employed to create the fuel-air internally rapid mixing inside the injector nozzle, thus maximing the atomizing air for BDF-air mixing prior to ignition and burning process.

The potentially of global warming are from burning of fossil fuel, deforestation, transportations, etc. Transportation emissions especially from diesel engine can contribute direct warming impact (carbon dioxide) and indirect Impact (Nitrogen oxide, carbon monoxide etc). Effects of global warming are rise in global temperature, rise in sea level, impact on weather, food production, and the economy. So, one of the solution is reduce the use of fuel especially diesel change to biodiesel as a renewable energy [13]. Internal or external combustion use biodiesel as alternative fuel. Compared to conventional diesel fuel, biodiesel can reduce emissions of Carbon monoxide (CO), Carbon dioxide (CO2), hydrocarbons (HC), and particulate matter (PM) but for Nitrogen oxides (NOx) depending on percent of biodiesel [14-16].

Biodiesel as a Renewable Energy

Biodiesel is defining by ASTM as "a fuel comprised of mono-alkyl esters of long-chain fatty acids derived from vegetable oils or animal fats, designated B100". Another name for biodiesel is fatty acid methyl esters (FAME).The main advantages of using biodiesel are lower dependence on crude oil, renewable fuel, favorable energy balance, reduction in green house gas emission, lower harmful emission, biodegradable and nontoxic, use of agricultural surplus and safer handling (higher flashpoint than conventional diesel fuel) [17-18].

Palm oil Biodiesel is free from sulfur and produced by esterification and transesterification reaction of vegetable oil with low molecular weight alcohol, such as ethanol or methanol. It is also biodegradable and non-toxic fuel. This fuel is obtaining from vegetable oils (typically palm oil, soybean, rapeseed, or sunflower) with changing the properties of the oil significantly[19-21].

Malaysia is a country that produces palm oil producers in the world and the main raw stock for biodiesel. Palm oil biodiesel gives advantages and disadvantages for the economical and environmental issue in Malaysia. Since 1982, Malaysia had developed palm oil as renewable fuel and use palm oil biodiesel blend (B5) for industrial and transportation sector [22-23].

Biodiesel fuel can use for external and internal combustion because less of emission and pollutant. Biodiesel also uses in transportation for reduction of pollutant emissions of automotive Diesel engines. It has proven by research "Biodiesel as alternative fuel: Experimental analysis and energetic evaluations" by Carraretto [21].

Biodiesel Properties

Chemical properties of biodiesel are carbon, hydrogen, and oxygen. Common chemical name of biodiesel is Fatty acid (m) ethyl ester and chemical formula range C_{14}–C_{24} methyl esters or C_{15-25} H_{28-48} O_2 [22]. Definition of Density is mass per unit volume and kinematic viscosity is the ratio of absolute or dynamic viscosity to density. There are different types of biodiesel Kinematic viscosity, it can be obtain by dividing the absolute viscosity of a fluid with its mass density[23].

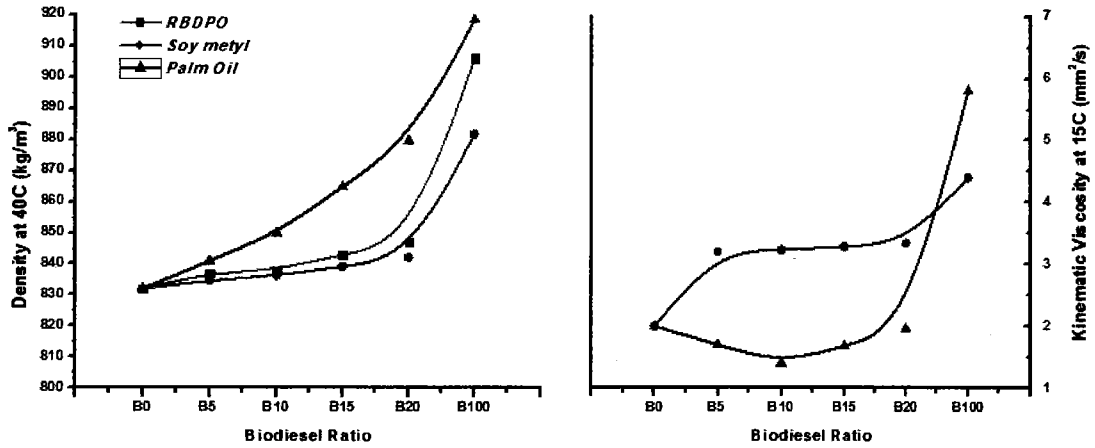

Figure 1: Density, Kinematic viscosity vs Biodiesel ratio for RBDPO [13] [14] [16]

Figure 1 shows biodiesel blends such as B5, B10, B15, and B20 have different values of density and kinematic viscosity [24-28]. B0 stands for diesel fuel and B100 for pure biodiesel. B5 is 5% biodiesel and 95% diesel fuel, B20 is 20% biodiesel and 80% diesel. Refined, Bleached and Deodorized Palm Oil (RBDPO) has higher value of density at 40°C compared with soy methyl and palm oil, but has lower value of kinematic velocity. If the temperature increase, the density of fuel will decrease[29] . Density of biodiesel depends on the type of feedstocks. Example, the density of Palm oil biodiesel is 853.3 kg/m^3 (100°C), Soybean 885.6 kg/m^3 (100°C), Cotton seed 876.2 kg/m^3 (100°C), and Jatropha 880.32 kg/m^3 (100°C).

Figure 2 compares the water additional into hydrocarbon fuel such as methane, kerosene, diesel, and biodiesel has potential to reduce pollutant emission (NOx, Sox and soot) depend on the type of experiment methods. Almost researcher studied the fuel emulsions. The benefits of water emulsions are improve the combustion efficiency, reduction of the particular matter (PM) and NOx emission. Water-emulsification is one of easier and lower cost solution of toxic emission in burner combustion. Water-emulsified fuel reduces the flame temperature, leading to NOx reduction that had been tested by Kidoguchi, Yatsufusa, and D. Nakagawa 2011[30-31].

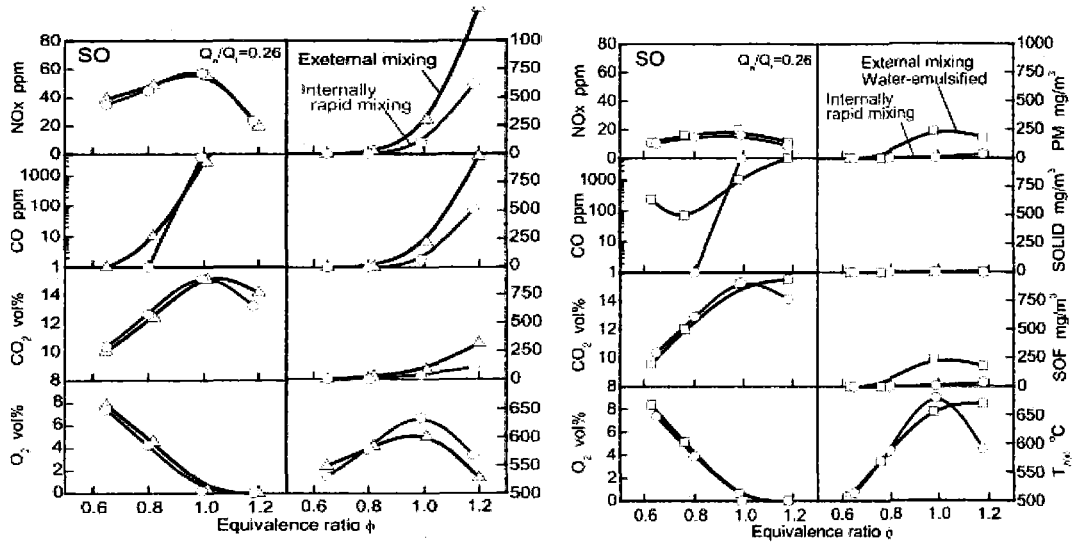

Figure 2: Comparison of emissions between two types of injector [31]

Water particles vaporize and explode spread when emulsion fuels are igniting in an internal combustion engine and a boiler. The oil particles surrounding the water particles are also scattered and become finer with smaller particle sizes. Oil particles have more contact area with oxygen, and as a result, incomplete combustion suppressed and combustion efficiency is improved. Combustible limits in pure gas oil and water-emulsified gas oil determined by smoke in high atomizing air ratio.

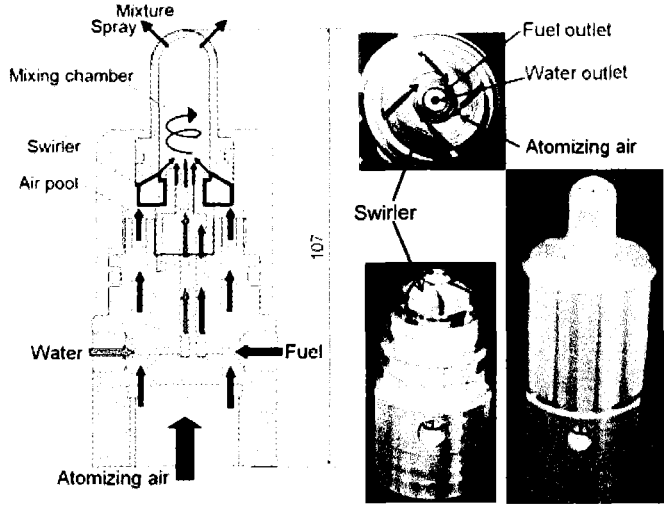

Figure 3: Fuel-water internally rapid mixing type,[30]

Water -fuel mixing and mechanism

In most recent studies, Y. Kidoguchi et al. [31] measured the emission between two types of injector using fuel with water-mixing. Figure 3 show a new injector has been developed in order to use water with free of emulsification is used to reduce toxic emission[30-31]. Water, atomizing air, and fuel are mixing inside the mixing chamber. The mixture composes of three-fluids injected as spray into a flame stabilizer of burner. This research has burner with an injector, pilot flame ignite, a chimney and flame stabilizer. In both research, use secondary air into the combustion area and supplied oxygen to the flame stabilizer. The ignition of burner combustion was started by Liquefied petroleum gas (LPG). After LPG flame was stable, fuel supply line can open and replace LPG. Then analyze the exhaust gas concentration by emission analyzer.

Effect of combustion on emission with biodiesel water emulsion

Water content mixed with diesel or biodiesel for combustion processes such as W30 and W50 has a positive effect to resolve global warming issue. Water fuel emulsion is widely used to control pollutant emissions in large and medium diesel engines. W30 is defining as 30% water and 70% fuel. The differences of water content mixing with fuel can give advantages such as reducing NOx and PPM. The advantages of water-fuel combustion process showed the reduction of contaminants. Water that is used independent of emulsification to reduce toxic emission. Water mix with biodiesel can use for burner combustion. This was proved by Kidoguchi et al.[30] creates new injectors to solve global warming issue. Biodiesel fuel used is soybean. The external mixing type of injector applies water-emulsified soybean oil as fuel, and internally rapid mixing type of injector blends soybean oil and water together with atomizing air inside of the injector. Water content is 50% in volume and use of water in both water emulsified and water mixing; further, PM is reduce dramatically at high load condition by using water as seen in Figure 4[30].

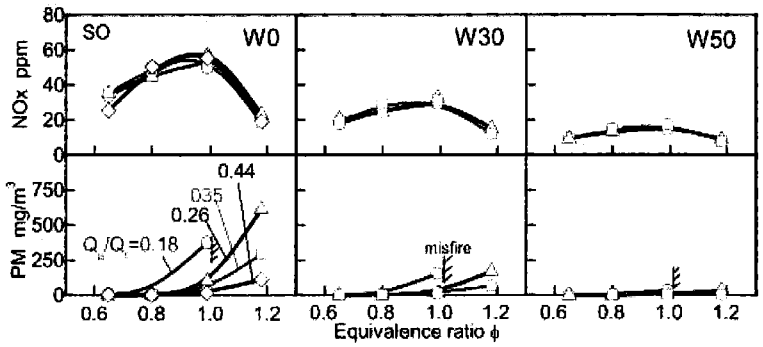

Figure 4: Effect of atomizing air ratio on emissions with changed water content [30]

CONCLUSION

Biodiesel flame, emission, and emission of biodiesel-water emulsions have been studied in the literature review. Based on the previous researchers, the following conclusion can be drawn:

1. Spray angle for diesel or B0 is larger compared to the blend of biodiesel but the penetration is vice versa. In addition, red, orange, and yellow colors of diesel flame are more compared to the blend of biodiesel. The effect of Biodiesel-water emulsion can burn lightly.
2. Ignition delay period of biodiesel higher than diesel. However, biodiesel will increase the NOx but not other gas. Biodiesel-water emulsion can reduce NOx and other gas.

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