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"Experimental Investigation of the Effects of Jet A-1/Biodiesel Blends on Lean Pre-vaporized Pre-Mixed Combustion Characteristics"

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ABSTRACT

The world faces a crisis of energy demand and environmental threats from exhaust emissions and global warming. Utilizing biodiesel produced from waste cooking oil is considered to be a potential solution to both issues and a promising alternative to diesel and jet fuels. It is estimated that 500,000 tons of waste cooking oil are annually available in Egypt from many sources like food factories, restaurants, hotels, and homes. Biodiesel is produced via transesterification of raw waste cooking oil into waste cooking oil methyl ester.

Biodiesel has several attractive features, such as having a high cetane number, oxygen content, flash point, no sulphur content, and the ability to be produced from renewable resources. It also has some drawbacks, such as higher viscosity, surface tension, and lower volatility compared to diesel, which hinder its spray and atomization from meeting diesel levels. This could lead to poor performance in the formation of an ignitable mixture. Therefore, adding a less viscous fuel to biodiesel, such as diethyl ether, can improve its viscosity, density, and surface tension. Also, diethyl ether is an oxygenated additive that can help reduce exhaust emissions if blended with biodiesel.

A premixed flame over a diffusion flame is recommended for complete and clean combustion. The use of the swirl-stabilized lean pre-vaporized premixed combustion technique may achieve these targets.

The current study aims to evaluate the effect of the addition of diethyl ether to waste cooking oil biodiesel on its physicochemical properties, emissions, and flame characteristics for use as an alternative fuel in gas turbines. Test fuels considered in this study are B20 (20% biodiesel+80% Jet A-1), B20D10 (20% biodiesel+10% diethyl ether+70% Jet A-1), B20D20 (20% biodiesel+20% diethyl ether+60% Jet A-1), B20D30 (20% biodiesel+30% diethyl ether+50% Jet A-1) as well as pure Jet A-1. These blends are applied in the lean pre-vaporized premixed system with preheated air of 350 ℃ at a fixed equivalence ratio of 0.85 (lean condition).

The results showed a 68, 38.4, 14.5, and 43.4% decrease in CO, NO_x, CO_2, and UHC emissions, respectively, for the B20D30 blend compared with pure Jet A-1 fuel at the combustor outlet. The B20D20 blend also indicated a 61.4, 12.5, 20.6, and 69.6% drop in CO, NO_x, CO_2, and UHC levels, respectively. The B20D10 blend also indicated a 15.8, 8.9, 6.17, and 51.4% drop in CO, NO_x, CO_2, and UHC levels, respectively. The B20 blend showed a relative variation in flame temperature distribution, while diethyl ether blends share a similar temperature distribution compared with Jet A-1. The B20 blend exhibited the lowest pattern factor (0.146) compared with Jet A-1 (0.151) at the combustor outlet, indicating a 3.3% more uniform temperature distribution throughout the combustor than Jet A-1. In general, all blends had the ability to reduce emissions. Overall, the B20D30 blend was better for NO_x and CO levels, while the B20D20 blend was better for CO_2 and UHC levels and flame temperature profiles. Therefore, it is concluded that the recommended diethyl ether blending ratio is 20%, regarding emission levels and flame temperature profile.