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Effect of Fuel Preheating on Engine Characteristics of Waste Animal Fat-Oil Biodiesel in Compression Ignition Engine

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Abstract: The present study aims at understanding the effects of fuel preheating on engine characteristics of waste animal fat-oil (WAF-O) biodiesel in a single-cylinder CI engine, with the preheating technique proposed as an effective means for enhancing the fuel properties. To understand the effects of the preheated fuel, the WAF-O biodiesel was preheated at 60, 80, 100 and 120 °C and tested along with neat diesel and unheated WAF-O biodiesel. For this purpose, biodiesel was produced from different animal wastes by means of KOH-assisted ethanol-based transesterification, reporting its maximum yield as 96.37 ± 1.8%, with significant distribution of unsaturated oleic acid, saturated palmitic acid and stearic acid. Upon evaluating its fuel characteristics as per ASTM D6751 standards, a rise in preheating temperature by 1 °C reduced the density and kinematic viscosity of WAF-O biodiesel by 0.383 kg/m^3 and 0.025 mm^2/s, respectively, and was explained by the weakening of intermolecular forces between its fatty acid ester molecules. Preheated samples reported superior combustion characteristics by exhibiting increased in-cylinder pressure (2.24%, on average) and heat release rates in addition to their shortened ignition delay (1–4 °CA). Furthermore, preheating of WAF-O biodiesel reduced its specific fuel consumption and increased its brake thermal efficiency by 7.86% (on average) and 9.23% (on average), respectively. However, higher preheating temperatures (>120 °C) resulted in increased fuel consumption owing to its varied flow characteristics. In addition to the changes in combustion characteristics, preheating WAF-O bio-diesel also resulted in reduced carbon monoxide, nitrous oxide and hydrocarbon emission by 13.88%, 7.21% and 26.94%, respectively, and increased carbon dioxide emission by 7.58%. Summing up, the enhancements in overall engine characteristics of preheated samples were accounted for by their improvised fuel injection characteristics due to their reduced density and viscosity, which ensured for their effective combustion.

Keywords: animal wastes; waste animal fat-oil biodiesel; fuel preheating; engine characteristics; flow characteristics; atomization and vaporization

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1. Introduction

The increased usage of biodiesel as an effective alternative biofuel for both industrial and transportation sectors has made many researchers and scientists focus on producing