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CLEANER COMBUSTION IN COMPRESSION IGNITION ENGINES: RSM-BASED OPTIMIZATION OF WASTE COOKING OIL BIODIESEL BLENDS

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Abstract

This study explores the performance and emission characteristics of a compression ignition (CI) engine fueled with biodiesel blends derived from waste cooking oil (WCO) and optimizes the blend composition using Response Surface Methodology (RSM). Biodiesel was produced through transesterification and blended with diesel in proportions of D90B10 and D85B15 for experimental evaluation. Tests were carried out on a four-stroke, water-cooled diesel engine operated at constant speed under varying loads. RSM-based predictive models were developed and validated using ANOVA, confirming statistical significance at a 95% confidence level. Optimization results indicated that the optimal blend, B1.157 (98.843% diesel, 1.157% WCO biodiesel), achieved values of 0.46 kW brake power, 11.59% brake thermal efficiency, 0.043% CO, 0.0804% CO₂, 14.117 ppm unburned hydrocarbons, and 331.215 ppm NO_x, with an overall desirability index of 0.425. The findings revealed that incorporating WCO biodiesel slightly increased brake power for biodiesel blends, while brake thermal efficiency decreased but contributed to notable reductions in CO, CO₂, UHC, and NO_x emissions compared with diesel fuel. The optimization framework effectively identified the key operating variables, offering a reliable approach to improving CI engine performance and emissions with alternative fuels.

Key words: ANOVA, engine exhaust emission, response surface methodology, waste cooking oil

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