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Original article

The effect of castor oil methyl ester blending ratio on the environmental and the combustion characteristics of diesel engine under standard testing conditions

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ABSTRACT

In current work, ultrasonicator was used to produce Castor Oil Methyl Ester (COME) from raw castor oil to properly reduce the production period. GC-MS and FT-IR analyses were used to confirm the conversion of raw oil into esters. Blended fuel of COME and diesel fuel with blending ratio up to 40% (symbolized as B40) were used to experimentally investigate the influence of COME blending ratio on diesel engine combustion and on engine emissions flow as per ISO 8718 steady state test cycle. The in-cylinder pressure records were applied through zero-dimensional thermodynamic model to compute the variation of heat release rate and accumulated heat released. Results of engine measurements revealed that (i) best effective utilization of fuel energy is attained for B30, (ii) best fuel economy with best brake thermal efficiency was identified for B20, and (iii) lowest emission flow of nitrogen oxides (NOx), carbon monoxide (CO), and unburned hydrocarbons (HC) with lowest calculated particulate matter (PM) were observed for B10 while minimum opacity level in engine exhaust was attained for B30. It can be concluded that, B20 would be recommended to get the best engine mechanical performance and emission characteristics with slight deterioration in the in-cylinder combustion parameters.

Introduction

Diesel engines are widely used in heavy duty applications with high fuel consumption among that is consumed by transportation sector with annual increase rate of 1.4% [1]. In this regard two urgent issues are raised; limited fuel resources and environmental pollution. Use of biofuels would resolve both of them, so its production is increased by 9.7% in the last decade [2]. The produced biofuel suitable for diesel engine is

Abbreviations: AC, Air cooled diesel engine; AHRR, Accumulated heat release rate, J; ASTM, American society for testing and materials; ATDC, After top dean center °C.A.; Bxx, Fuel blend containing xx COME v/v and (100-xx) base diesel fuel; BxxLyy, Engine operated by fuel blend Bxx at engine load percentage yy from its full value; BR, Blending ratio is the volumetric percentage of biodiesel in fuel blend; CR, Compression ratio; BMEP, Brake mean effective pressure bar; BSEC, Brake specific energy consumption kJ/kW.h; BSFC, Brake specific fuel consumption kg/kW.h; BTDC, Before top dean center °C.A.; BTE, Brake thermal efficiency; CHNOS, Carbon, Hydrogen, Nitrogen, Sulfur and Oxygen elemental analysis of hydrocarbon fuel; CO, Carbon monoxide emissions ppm; CO_2, Carbon dioxide emissions mole fraction; COME, Biodiesel of Castor Oil Methyl Ester; DI, Direct injection diesel engine; IP, Injected pressure bar; IT, Injection timing °C.A.; IL, Ignition lag; HC, Unburnt hydrocarbon emissions ppm; HRR, Heat release rate J/°C.A.; K, Optical absorption factor; KOH, Potassium Hydroxide; N, Engine speed rpm; n, Exhaust opacity level; NA, Not available/applicable; NaOH, Sodium Hydroxide; NO_x, Nitrogen oxide emissions ppm; P, Instantaneous cylinder pressure bar; PM, Particulate matter emissions; P_{max}, Peak in-cylinder pressure bar; RP, Rate engine power at given engine rated speed (rpm) kW; rpm, Revolutions per minute; T, Mean cylinder gas temperature, K; TC, Turbocharged diesel engine; T_{exh}, Exhaust gas temperature °C - degree centigrade; TGA, Thermogravimetric analysis; Smoke, Smoke mass fraction in exhaust Smoke (in g/m^3); V, Instantaneous cylinder volume m^3; WC, Water cooled diesel engine; °, Crank angle or °C.A.; ΔP, Pressure rise rate MPa/°C.A.; ΔP_{max}, Peak cylinder pressure rise rate; MPa/°C.A.θ, Crank angle position °C.A.; θ_{max}, Crank angle where peak pressure exists °C.A.; $\Delta\theta_{max}$, Crank angle where peak pressure rise rate exists °C.A.; $\Delta\theta_{Ig}$, Ignition lag °C.A. increment; γ, Specific heat ratio kJ/kg.K.

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