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Effective utilization and optimization of waste plastic oil with ethanol additive in diesel engine using full factorial design

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Abstract

Hydrocarbons, which are found in plastic, are an excellent energy source due to their high energy density. The disposal of plastic waste presents significant energy saving and recovery opportunities. The purpose of this study is to determine how much energy can be recovered from waste plastics as a possible alternative fuel source for cars. This research aims to assess the performance of waste plastic pyrolysis oil (WPO) generated by polyethylene pyrolysis. Ethanol is an appealing alternative fuel since it is made from renewable bio-resources and works as an oxygenated fuel in diesel engines, allowing for emission reductions. Three different percentages of WPO were combined with ethanol to create a tertiary fuel blend. This research examines the performance and emission requirements of a single-cylinder direct injection diesel engine. With diesel, D70W20E10's specific fuel consumption reduces by about 7.5 %. Carbon monoxide emissions from D70W20E10 were about 6.5 % lower than diesel and 13.5 % lower than hydrocarbon at various loadings. The most optimum running condition was further examined using the Full Factorial Design method.

Introduction

When it comes to a developing country like India, energy security and the transition to a low-carbon economy are critical. Local ethanol in gasoline may assist India in improving its energy security by increasing its energy independence. It promotes small companies and farms to produce energy, thus lowering emissions from automobiles and other transportation vehicles. A target of 10 % ethanol in gasoline by 2022, 10 % ethanol in diesel by 2030, and a target of twenty-percentage ethanol in gasoline by 2035 has been set for India. Due to their high volatility and latent heating properties, oxygenates such as methanol and ethanol are suitable as prime movers in combustion engines. Indian pollution will be reduced when the use of ethanol in fuels increases. Reiterating its commitment to achieving the goals it set for itself in 2015 on climate change.

Oxygenated Additives have been examined, and it has been found that increasing the amount of diesel alcohol in the fuel reduces pollution by boosting premixed combustion. Taquira et al. (2018) evaluated steady-state engines using analytical and experimental methods. Ethanol-gasoline mixes have an impact on power and torque output, fuel consumption, and exhaust emissions [1]. Numerous studies have optimized diesel, biodiesel, and alcohol blends for use as a fuel substitute in CI engines. While ethanol in its pure form cannot be utilized in diesel engines directly, it may be

blended with diesel [2]. Its low viscosity, high oxygen concentration, high hydrogen-to-carbon ratio, low sulfur content, and rapid cooling rate contribute to its volumetric efficiency [3]. When mixed with diesel, its decreased viscosity promotes atomization and mixing with air. Due to the high latent heat of evaporation of ethanol, its combination with diesel may improve volume efficiency by cooling the intake and compression strokes [4].

However, widespread plastic use generates enormous amounts of trash and contributes to other environmental problems. Pyrolysis of discarded plastic debris may be used to fuel diesel engines in place of diesel fuel. Pyrolysis is a method for reusing waste plastic as an energy source for fuel generation that is ecologically friendly. Pyrolysis is widely regarded as the only method for permanently eradicating plastic waste from the environment [5]. Mangesh et al. (2020) investigated the properties of four different pyrolysis oils derived from polymers, including HDPE, LDPE, Polypropylene, and Styrene. They examined waste plastic oil mixtures synthesized using the Zeolite-A catalyst. The engine research showed a 20% increase in brake thermal efficiency while operating at full load [6]. Singh et al. (2020) studied the pyrolysis of pure plastic. According to engine tests, using 50 % plastic oil mixtures resulted in a slight loss of efficiency and a negligible increase in pollutants [7]. A.K. Das et al. (2020) investigated the use of WPO and ethanol to increase performance while lowering emissions. Taguchi was utilized for both performance and emissions. Increased compression ratios and loads increased brake thermal efficiency and reduced emissions when 20 % WPO and 20 % ethanol blended diesel were used [8]. Ravi and Karthikeyan (2019) claim that a propanol-plastic oil blend beats diesel in performance and emissions and that pollution restrictions may be relaxed [9]. Selvam et al. (2020) examined the performance of a diesel engine with and without DEE additives. Engine emissions may be reduced by using a fuel mixture of plastic oil and DEE [10].

Multiple laboratory investigations have been conducted to use alcohols as oxygenated additions in recent years. It was studied that alcohols may be added to ternary blends to prevent the density and kinematic viscosity of the fuel from rising while at the same time improving the fuel's properties and yielding a significant decrease in emissions. Amounts of ethanol up to 20% are often blended with diesel fuel (by volume). A stabilizer is added to the blend, which adds to its stability and, more significantly, to the cetane number and lubricity of the mixture [11]. Tertiary fuel blends are created by mixing a fixed volume of twenty percentage WPO with ethanol concentrations of 10%, 15%, and 20 %, respectively, as an oxygenated additive. The performance and emission requirements of a single-cylinder direct injection diesel engine are evaluated to determine the suitability of tertiary fuel blends for effective utilization. The findings are compared to those obtained using base diesel and then assessed using a full fractional design to determine the optimum operating state to be used in future operations.

Section snippets

Materials and methods

Waste polymers are transformed to alternative energy in the form of diesel engine fuel during the pyrolysis process. The chemical properties of waste plastic fuel vary significantly depending on the plastic grade and pyrolysis method used. In this research, Low-Density Polyethylene (LDPE) was utilized as a kind of waste plastic. LDPE has lower intermolecular resistance, a lower tensile strength, and a stiffer structure than High-Density Polyethylene due to the diversity of forms it may adopt.…

Experimental result analysis

The engine research used a constant speed single-cylinder water-cooled direct injection diesel engine with a power output of 4.4kW. The test engine was started manually to assess its performance, then measured using an eddy current dynamometer Fig. 2. Manually load the engine in increments of 25% to 100%, depending on the engine's power output. The test engine was permitted to run under standard test conditions throughout the experiment, including 210bar injection pressure and 21° bTDC…

Optimization of SFC, CO, and HC by full factorial design

Experimentation is often done in process development to verify that the problem is handled completely. In contrast to the traditional approach, this method utilizes specific statistical data from particular trials to forecast the knowledge and effects of an ongoing complicated and multi-variable process. In contrast to other types of research, the design of experiments (DOE) is the most often used statistical method for optimizing findings. A full factorial design (FFD) is a straightforward,…

Conclusion

Plastics have the potential to be utilized as an alternative fuel. It is possible that using waste plastic oil to substitute diesel would benefit the energy sector. Similarly, ethanol contains more oxygen than gasoline, and it guarantees that the fuel and air are mixed in an equal amount while burning. We experimented with blending plastic fuel with diesel to create a tertiary fuel and including ethanol as an oxygenated component. The addition of ethanol to waste plastic fuel improved the…

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.…

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References (16)

Y. Çelebi *et al.*
An overview on the light alcohol fuels in diesel engines
Fuel (2019)

V.L. Mangesh *et al.*
Experimental investigation to identify the type of waste plastic pyrolysis oil suitable for conversion to diesel engine fuel
J. Clean. Prod. (2020)

R.K. Singh *et al.*
Waste plastic to pyrolytic oil and its utilization in CI engine: performance analysis and combustion characteristics
Fuel (2020)

M. Mani *et al.*
Characterisation and effect of using waste plastic oil and diesel fuel blends in compression ignition engine
Energy (2011)

J.E. Tibaquira *et al.*
The effect of using ethanol-gasoline blends on the mechanical, energy and environmental performance of in-use vehicles
Energies. (2018)

S. Ganesan *et al.*
Effect of C3, C4, and C5 alcohols addition to diesel in conjunction with injection timing and intake dilution on the characteristics of a DI diesel engine
Energy Fuels (2020)

H.Y. Kim, C.G. Jun, N.J. Choi, 2020, Effects of ethanol–diesel on the combustion and emissions from a diesel engine at...

R. Geyer *et al.*
Production, use, and fate of all plastics ever made
Sci. Adv. (2017)

There are more references available in the full text version of this article.

Cited by (15)

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> …They then added 100 ppm graphene nanoparticle in the blend and found that exergetic efficiency of 80D20WPPO100G fuel mixture was increased by 22.2 % at low load and 18.98 % at full load. Addition of ethanol to WPPO increased the combustion efficiency of the engine [119]. The blend D70%+WPPO20%E10% consumed 3.5 to 7.5 % less fuel than diesel.…

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