ScienceDirect

Materials Today: Proceedings

Available online 28 February 2023

In Press, Corrected Proof What's this?

Enhancement of engine performance by nano-coated pistons fuelled with nano-additive biodiesel blends

S. Padmanabhan [a], M. Selvamuthukumar [b], B. Gopi Krishna [a], Manoj Kumar [c], K. Sudheer [a], S. Baskar [d], Rahul Mishra [e], Y. Anupam Rao [f]

Show more

Share Cite

https://doi.org/10.1016/j.matpr.2023.02.231

Get rights and content

Abstract

Researchers have been interested in making a more energy-efficient engine for a long time. This is because the use of fossil fuels like diesel has grown along with the need for more electricity, industry, and transportation. Thermal barrier coating (TBC) on engine parts has become more popular in recent years because it improves thermal and mechanical efficiency, reduces emissions, and saves fuel. In a similar way, biodiesel, which is safe and made from renewable sources of bioenergy, has been suggested as a good alternative to diesel. The present study aims to increase the efficiency of the diesel engine while simultaneously lowering emissions using a piston with a thermal barrier coating, engine operates on biodiesel blends, and a dosage of nano-additives to minimize emissions,. The engine efficiency of nano additives was found to be about 5.4% higher than that of base diesel, and with 6.5% better fuel consumption. Additionally, nano additives reduced carbon monoxide emissions in the range of 6.1–11% and hydrocarbon emissions in the range of 5.2–

9.5%. The results were further analysed using the design of experiment tool to determine the influential parameters.

Introduction

Energy is a significant part of manufacturing expenses, thus conserving and managing it has become a critical industrial activity. As a result of this positive approach, worldwide patterns of energy usage have been altered. This has led to an increase in productivity, but a decrease in energy use, in wealthy countries. Finally, in today's rapidly expanding world, local and low-emission sources of renewable energy are just as important. Reducing pollution by fully using these resources might be very beneficial [1]. Research on internal combustion engines is being done with the goal of lowering fuel and operating costs and consumption. By decreasing heat rejection, upgraded ceramic coatings might boost engine performance and cut emissions. In addition, it's important to convert as much fuel energy as possible into usable mechanical energy. The combustion chamber of the engine has to be coated with high-tech ceramics that have a low heat transmission rate if these goals are to be realized [2].

Thermal barrier coating (TBC) on engine components has gained popularity recently due to improved thermal and mechanical efficiency, lower harmful pollution, and lower energy consumption. The waste heat from the engine's insulation may be used to oxidise soot precursors in hydrocarbon combustion, lowering emissions [3]. Ceramic materials excel in high temperature applications because of their high melting point, adhesion, and wear resistance. Ceramics may cover combustion chamber components due to their properties. A covered engine maintains heat better in the combustion chamber. So fewer emissions and fuel are created [4].

An uncoated piston was tested against two coated pistons of varying thicknesses. The influence of biofuel was revealed by comparing results from studies utilising diesel for coated and non-coated pistons. A thicker layer reduces thermal efficiency, fuel use, and pollution [5]. Grey relational analysis improved the efficiency and pollution levels of a diesel engine covered with copper alloy. The copper-chromium-zirconium-coated piston is more efficient and produces less emissions [6]. Coatings made of zirconia are effective in reducing heat conduction. Glow plugs used with ethanol as a fuel reduce pollution while improving fuel efficiency. The thermal efficiency of the engine improves when the injection time is prolonged [7]. With a higher combustion temperature, pollutants like carbon monoxide (CO) and unburned hydrocarbons (UHC) are less likely to be decreases, whereas nitrogen oxide (NO) emissions increases [8]. A thermal barrier coating of aluminum silicate and zirconia with a nickel layer was tested in experiments with diesel and palm oil biodiesel to see how it would affect engine performance and emission levels. Their low emissions from fuel and biodiesel made them the greenest option [9].

Recent advancements in nanotechnology have opened the door for the development of nanoscale energetic materials, which provide significant benefits over materials that are just a few microns in size or larger. For a diesel engine to function well and emit low emissions, ignition temperatures and ignition delay are crucial characteristics to measure [10], [11]. Using the hot experiment, researchers aimed to enhance the igniting qualities of diesel fuel by incorporating aluminium oxide nano-particles (AONP) into the fuel. It was discovered that the ignition possibility for the nanoparticle combination was greater than the ignition probability for pure diesel in all of the scenarios investigated [12].

A novel low-cost feedstock for biodiesel manufacturing is being investigated in this study i.e.pumpkin seed oil. Pumpkin seeds have an astonishingly high oil content, according to the research. Pumpkin oil has been shown to be a suitable feedstock for biodiesel manufacturing, notwithstanding the study's findings [13]. Except for NO_x emissions, significant reductions in exhaust emissions such as CO, HC, and smoke were seen under high engine running conditions. Pumpkin seed biodiesel was shown to have excellent performance, combustion, and emission properties, making it a viable alternative to regular fuel provided the operating parameters of the engine are modified [14]. The alkali-catalyzed conversion of pumpkin seed oil into biodiesel resulted in a boron coated engine with enhanced performance characteristics, including a greater brake thermal efficiency and a lower brake specific energy consumption [15]. The study was carriedout to analysis the impact of alumina nanoparticle added biodiesel blend on engine behaviour, stability enhancement, and characterisation techniques to determine chemical bonding, nanoparticle form, and size, nano-additives in liquid fuel, health implications, and automotive applications [16]. Nanoparticle helps to boost the combustion and enhance the performance and minimize emissions [17].

The purpose of this research is to measure the performance and emissions of a single-cylinder diesel engine under varying loads. The purpose of this study is to investigate what happens when regular diesel is blended with pumpkin seed biodiesel at concentrations of 15% and 30% using AONP as a nano-additive. Based on the results of a “Full Factorial Design” experiment, the optimal ratios of biodiesel to AONP nano-additive dosage were determined, resulting in reduced fuel use, less UHC, and fewer carbon monoxide (CO_2) emissions.

Section snippets

Material and methods

Compared to other alternative fuels, biodiesel's many advantages stem from its chemical similarity to diesel fuel made from petroleum. Since biodiesel is competitive with conventional petroleum fuels in terms of engine efficiency, power production, climbing, and hauling, it is being increasingly adopted by the oil industry as a diesel replacement. Biodiesel behaves similarly to regular diesel in freezing temperatures, fogging up and gelling. In developing nations like India, diesel engines are

Experimental details

The performance of a combination of pumpkin seed biodiesel and AONP was tested using a single-cylinder, constant-speed, direct-injection engine. Fig. 1 shows the test engine photograph.

The eddy current dynamometer applied varying loads to the engine, starting at zero and going all the way up to one hundred. At 1500 rpm, the engine produces 4.2 kW of power, which is used to raise the load on each testing mixture by 25%. An eddy current dynamometer is used to manually vary engine loads. The fuel

Brake thermal efficiency

Low thermal conductivity coating on the combustion chamber surface prevents heat from escaping into the coolant and environment, as well as controlling temperature distributions and heat flow. When tested under maximum load, BD15AONP100′s brake thermal efficiency (BTE) was found to be roughly 5.4% greater than that of pure diesel. Increased thermal performance may be achieved by increasing AONP's content of oxygen [24]. Fig. 2 shows that the 10% of BTE is lower than that of BD30AONP100 due to

Conclusion

Energy management and conservation have become more important in the industrial sector in recent years, as the cost of energy constitutes a significant portion of the overall cost of production. Through the utilization of a thermal barrier coated piston that runs on biodiesel blends and the addition of a dosage of AONP nano-additives, the current investigation intends to improve the performance of a diesel engine. This will be accomplished by reducing emissions. It was discovered that 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.

Recommended articles

References (32)

S. Sparsh *et al.*
Future prospects of biodiesel production from jatropha in India
Mater. Today Proc. (2022)

V. Dananjayakumar *et al.*
Experimental analysis of CI engine using zirconia ceramic powder coated piston fuelled with Karanja biodiesel
Mater. Today Proc. (2021)

A.M. Narad *et al.*
Experimental analysis of CI engine using titanium oxide and aluminum oxide alloy coated piston fuelled with biofuel made up of agricultural waste
Results Mater. (2020)

A. Sharma *et al.*
Investigation on the behaviour of a DI diesel engine fueled with Jatropha Methyl Ester (JME) and Tyre Pyrolysis Oil (TPO) blends
Fuel. (2013)

P. Schinas *et al.*

Pumpkin (Cucurbita pepo L.) seed oil as an alternative feedstock for the production of biodiesel in Greece

Biomass and Bioenergy. (2009)

S. Wang *et al.*

Experimental investigation on pumpkin seed oil methyl ester blend in diesel engine with various injection pressure, injection timing and compression ratio

Fuel. (2020)

U. Öztürk *et al.*

Investigation of using pumpkin seed oil methyl ester as a fuel in a boron coated diesel engine

Energy. (2019)

M. Ghanbari *et al.*

Effect of alumina nanoparticles as additive with diesel–biodiesel blends on performance and emission characteristic of a six-cylinder diesel engine using response surface methodology (RSM)

Energy Convers. Manag. X. (2021)

M.S. Gad *et al.*

A comparative study on the effect of nano-additives on the performance and emissions of a diesel engine run on Jatropha biodiesel

Fuel. (2020)

A. Sharma *et al.*

Effect of nozzle opening pressure on the behaviour of a diesel engine running with non-petroleum fuel

Energy. (2017)

View more references

Cited by (5)

Effect of variable geometry turbocharger on the performance of the opposed piston engine – An experimental approach

2024, Applied Thermal Engineering

Show abstract

Effect of ZnO nanoparticle on combustion and emission characteristics of a diesel engine powered by lemongrass biodiesel: an experimental approach ↗

2024, Discover Applied Sciences

PERFORMANCE AUGMENTATION AND EMISSION REDUCTION IN DIESEL ENGINES USING HFC-COATED PISTONS WITH BIODIESEL BLENDS ↗

2024, Thermal Science

Sustainable Energy Solutions from Water Hyacinth Bioethanol Blends in Diesel Engines with Nano-Coated Pistons ↗

2024, International Research Journal of Multidisciplinary Scope

Application of response surface methodology to the operating parameters of diesel engines fueled with SiO<inf>2</inf> nanoparticles in Abrus precatorius biodiesel ↗

2023, Emergent Materials

View full text