Research Article

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Reduction of Emission and Fuel Consumptions based on Mingled Nano Additives in Biodiesel

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ABSTRACT

Using the lipids identified as well as extra residual cooking oil, vegetable, and animal fats, bio-diesel a substitute for fuels derived from petroleum can be produced. Since the 1970s oil crisis, there has been a resurgence of interest in using biodiesel as a fossil fuel substitute due to the fuel's rapidly rising prices, availability uncertainties, and growing environmental and greenhouse gas (GHG) concerns.To produce biodiesel, glycerin and fat or vegetable oil are separated chemically through a process termed transesterification. Glycerin, a valuable byproduct that is typically sold to be used in soaps and other products, and methyl esters, the chemical term for biodiesel, are the two products left over from the process. The industrial term for diesel derived from petroleum, petro diesel, and biodiesel have similar viscosities. Due to the nearly zero sulfur content,it is recommended to be used as an additive in diesel oil formulations to improve the lubricity of pure ultra-low sulfur diesel (ULSD).The current work focuses heavily on reducing emissions and fuel consumption in automobiles. In addition to lowering pollutants and fuel consumption, the transition metal oxide (Copper oxide) additions in nanocrystalline particle form aid in molecular combustion. To create a stable Nano fluid, soap nut biodiesel is combined with metal oxide additive and ultrasonicated. For our experimental investigation, single cylinder, air cooled, constant speed Kirloskar engine is used. The reduction of hydrocarbon (HC), carbon monoxide (CO) and nitrogen oxide (NOx) emissions is investigated. The highest break power of the biodiesel employed in the study is 3.82 KW, greater than the typical diesel's 3.23 KW. The result shows improved engine efficiency, reduced emissions, and better brake thermal efficiency.

Keywords: Brake thermal efficiency; Carbon monoxide; Hydrocarbon; Emission characteristics.

1. INTRODUCTION

Many studies have been conducted to examine how biodiesel affects engine performance and combustion characteristics. The effect of a nano addition in soap nut oil biodiesel in CI engines is the main topic of this investigation. A thorough evaluation of the literature has been done in light of this work.

Reducing emissions and fuel consumption are critical goals in today's world, where environmental concerns and energy efficiency are at the forefront of global discussions. One promising approach to achieving these goals involves the use of mingled nano additives in biodiesel. Biodiesel is a renewable fuel derived from organic sources such as vegetable oils, animal fats, or recycled cooking grease. It is considered a cleaner alternative to conventional diesel fuel because it produces fewer emissions of harmful pollutants such as carbon monoxide, particulate matter, and sulfur oxides (Elkelawy *et al*. 2022a). Nanoadditives are tiny particles typically ranging from 1 to 100 nanometers in size. When added to biodiesel, these nanoparticles can modify their properties in various ways, such as improving combustion efficiency, enhancing lubrication, and reducing engine wear. Mingled nano additives refer to a combination of different nanoparticles that are blended and added to biodiesel. By carefully selecting and mixing these nanoparticles, engineers can create synergistic effects that amplify the benefits of each additive (Elkelawy *et al*. 2021).

Mingled nano additives in biodiesel can lead to a significant reduction in harmful emissions during combustion. For example, nanoparticles such as cerium oxide or titanium dioxide can act as catalysts, promoting more complete combustion and reducing the formation of pollutants like nitrogen oxides (NOx) and particulate matter (Elkelawy *et al*. 2008a). By improving combustion efficiency and enhancing lubrication, mingled nano additives can also contribute to reducing fuel consumption. Better combustion means more energy extracted from each unit of biodiesel, while reduced friction between engine components leads to less energy loss due to frictional resistance (Elkelawy *et al*. 2008b). Overall, the use of mingled nanoadditives in biodiesel offers a promising pathway towards cleaner and more efficient transportation fuels. However, it's essential to conduct thorough research and testing to ensure that these additives are both effective and safe for use in engines.

Additionally, considerations such as cost, scalability, and environmental impact should be taken into account when evaluating the viability of this technology on a larger scale (Panwar *et al*. 2011).

The two most pressing issues facing the world today are environmental degradation and the depletion of fossil fuel reserves. The extraction and widespread use of fossil fuels depletes ground-based carbon sources. As a result, in the current situation, research into alternative fuels is justified because it holds the promise of a general advance in sustainable energy supplies, environmental improvement, and the establishment of a sustainable fuel life cycle. Biofuels, or fuels derived from plant and animal fats, are potential solutions to the world's petroleum problems (Yu *et al*. 2010). The main disadvantages of fossil fuels are that they are a non-renewable source of energy that will eventually run out; they harm the climate and the environment; and they increase the proportion of carbon oxides and nitrogen oxides in the atmosphere, contributing to the greenhouse effect, which causes an increase in temperature. As a result, scientists have looked into alternatives to fossil fuels, such as renewable energy sources. Wind power, biomass, and biofuels are typical forms of renewable energy. The contribution of all of these resources is critical for economic and environmental reasons, and biodiesel could be one of the answers. One of these sources is biodiesel, which is made from specific plant seeds and food waste. Furthermore, researchers have recently considered extracting it from flaxseeds, palm oil, sunflower, soybean, corn, and food waste. The advantages of using biodiesel. Include lower concentrations of unburned hydrocarbon emissions from exhaust, as well as the fact that it is a renewable fuel in comparison to fossil-based diesel fuels. Biodiesel also acts as a better lubricant than diesel fuel, extending engine life and reducing wear. It also significantly reduces engine waste due to the absence of sulfur and the presence of oxygen, which leads to more complete combustion. Furthermore, one of biodiesel's key features is its ability to run internal combustion engines without requiring engine modifications (Elkelawy *et al*. 2009).

However, long-term use of biodiesel can cause engine problems due to its high viscosity, low volatility, and cold flow properties. Biodiesel is mixed with a variety of alcoholic and nanometric additives to improve engine performance. These alcoholic additives include heptane, methanol, and nano-additives like iron oxide, copper oxide, graphene oxide, and titanium oxide. The yield of biodiesel produced using chemical methods is determined by the fuel source and production efficiency (Elkelawy *et al*. 2019). The efficiency of biodiesel engines is determined by differences in physical and chemical properties relative to diesel, such as viscosity, density, and temperature. This review investigates the practical and theoretical effects of biodiesel made from waste cooking oil and hydrodynamic cavitation on the performance metrics used to evaluate compression ignition engines. Biodiesel is gaining popularity around the world due to serious concerns about energy security and the inadequacy of fossil fuels (El-Din *et al*. 2010). Several countries have proposed various subsidies, incentives, and systems to encourage the use of biodiesel. Current research successfully improves the mixed properties of biodiesel, making it more suitable for compression ignition diesel engines. This study compares diesel and biodiesel mixtures with and without copper oxide, titanium oxide, and aluminum oxide nanoparticles (Elkelawy *et al*. 2022b).

One of the most pressing issues in the automotive industry is the reduction of fuel consumption and emissions from internal combustion engines. Previous work in this field has included changing engine design, improving fuel quality, applying techniques to exhaust gas, and, in particular, employing emulsification and additives/fuel supplements. Additives, even at the microscale, have limitations and issues with sedimentation, conglomeration, and non-uniform distribution (Elkelawy, 2014). The aforementioned issues were largely resolved with the introduction of nanotechnology in recent years, and significant conclusions were reached, which will be discussed further below. The use of nanoparticles in fuel, as well as the study of the combustion process while taking nanoparticles into account, were first reported in solid fuels and propulsion engines. According to Ivanov and Tepper's 1997 research, aluminum nanoparticles can increase the charge's burning rate when compared to micro particles.

Furthermore, nanoparticle application in fuel resulted in a shorter ignition delay in the combustion process when compared to microparticles. Furthermore, nanoparticles with a high surface area to volume ratio provide more contact between fuel and oxidizer. According to research conducted in 2004, adding aluminum nano powder to rocket fuel will improve combustion efficiency. Another study found that boron nanoparticles have a high potential for increasing the burning rate of solid propellants due to their high heat content and faster heat release rate. As a result, these nanoparticles can dynamically boost the combustion process by reducing ignition delay and burning time while increasing momentum density, which improves fuel injection velocity into the combustion chamber. In other studies, the interaction of metallic particles with nanotechnology in the combustion phase was investigated. In addition, the combustion behavior of some metals was investigated, with the combustion regimes of the metal particles being examined (Bastawissiand, 2014). To lessen the amount of pollution that is released into the environment, the research aims to lessen the amount of emission gas and to improve the efficiency of the engine.Injection timing and anti-oxidants were chosen as factors for the investigation and selection of levels of injection timing and anti-oxidants were elaborated in the author's earlier investigations (Saravanan *et al.* 2020; 2021).

2.EXPERIMENTAL DETAILS AND SETUP

2.1 Synthesis of Nanoparticles using Sol-Gel Method

In addition to its unique optical, electrical, and catalytic capabilities, nanostructured copper oxide with ultrafine crystallite sizes (< 30 nm) and high surface areas has garnered significant interest. One of the most popular materials for photocatalysis is copper oxide, which is employed in a wide range of redox processes under different pressure and temperature regimes. The phase composition and crystallite size of copper oxide determine its photocatalytic capabilities.

2.2 Engine Specifications

A vertical water-cooled,direct-injection, single-cylinder, four-stroke diesel engine at constant speed was used in the study. Experimental Engine Setup Line and Setup Line Diagram shown in fig. 1, 2.

Engine Type	Kirloskar
Bore& Stroke	87.5x 110(mm)
Number of cylinders	1
Maximum Power	5.9kW(8BHP)
Compression ratio	16:1
Speed	1600rpm
SFC	250g/kW-hr
Lubrication Oil	HD –3000 rpm
Power	5.2kWat15

Fig. 1: Experimental engine setup

Fig. 2: Experimental diesel engine setup

3. MATERIAL AND METHOD

3.1 Material

To lessen the amount of pollution that is released into the environment, the research aims to lessen the amount of emission gas and to improve the efficiency of the engine. Injection timing and anti-oxidants were chosen as factors for the investigation and selection of levels of injection timing and anti-oxidants were elaborated in the author's earlier investigations (Saravanan *et al.* 2020; 2021).

3.2 Method

The speed well's engine is fastened to the grou nd.A dynamometer with an eddy current was connected to the engine. A rheostat was used to electrically load the engine. An exhaust pipe mounted crypton gas analyzer for HC, CO, NOx, and CO_2 measurements is used. Calculating the time required to utilize 10 cc of fuel using the burette configuration. The engine was started, warmed up, and ran at low idle for the appropriate amount of time to achieve the recommended oil pressure in addition to being inspected for leaks of fuel, oil, and water. After the engine warmed up, the no load mode was engaged, and the fuel injection pump was adjusted to raise the engine's speed to 1600 rpm.

The load was added gradually as the engine wa s run at a constant speed. Six engine torque levels, namely 0, 3, 6, 9, 12, 15, and 18 Nm, were tested. Additionally, tests were done using mixes of coconut oil and rice bran oil at the same compression ratio and the aforementioned torque levels. The same compression ratio was used for both vegetable oil blends in the experiments.

The engine ran for at least five minutes under each load situation, with the last two minutes of operation being used to collect data. The NOX, CO, HC, and CO_2 emissions from engines were measured simultaneously. An apparatus for loading motors. The engine has been connected to an eddy current dynamometer in order to impart load and torque. Fuel consumption measurement instrument.

The fuel flow rate was ascertained by timing th e consumption of a known amount of fuel (10 cc) from a burette. A device for measuring emissions from exhaust gases. Exhaust gas emissions, such as CO_2 in terms of percentage by volume, CO in terms of percentage by volume, and HC in terms of percentage by volume, are directly measured using a device known as the Crypton Gas Analyzer.

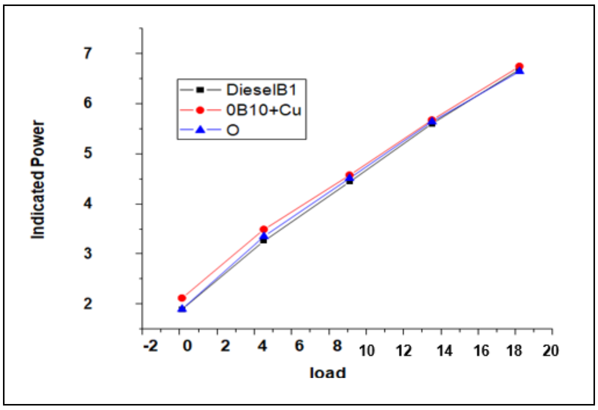

Fig. 3: Variation of indicated power

3.3 Brake Power (Bp)

The brake power is calculated by,

$$Brake\ Power = \frac{2\pi NT}{(60 * 1000)}\ kW$$

Where N represents the engine's speed in rpm
The torque in nm is T

3.4 The Overall Fuel Consumption (TFC)

The total fuel consumption is calculated by,

$$Total\ Fuel\ Consumption = \frac{r * x * 3600}{(t * 1000)}\ kg/hr$$

Where, r_{fuel} represents the specific gravity of fuel.
X is the fuel consumption in cc.
T isthe time taken to consume x cc of fuel.

3.5 Specific Fuel Consumption for Brakes (SFC)

The Specific Fuel Consumption for Brakes is calculated by,

$$Specific\ Fuel\ Consumption\ for\ Brakes = \frac{TFC}{BP}\ kg/kWhr$$

Where, TFC is the Total Fuel Consumption in kg/hr.
BP is the brake power in Kw.
Brake Thermal Efficiency(ηBT).
Brake thermal efficiency is given by,

$$Brake\ Thermal\ Efficiency\ \eta BT = \frac{(BP * 3600 * 100)}{(TFC * CV)}\ \%$$

Where, TFC is the overall Fuel Consumption in kg/hr.
Brake power is expressed in kW as BP.
Fuel's calorific value, expressed in KJ/kg, is called CV.

4. RESULTS AND DISCUSSION

4.1 Indicated Power

Fig. 3. illustrates how the stated power for the surfactant mixture changes as the load increases. The outcome demonstrates that, with a constant compression ratio of 16, the indicated power increases as the load increases. For mixtures, the maximum indicated power value is 3.82 kW, the minimum is 1.83 kW, and for pure diesel, the values are 3.23 kW and 3.15 kW, respectively. This suggests that the addition of nano-additives to biodiesel may increase the maximum power output of the engine. However, the minimum indicated power value of biodiesel with nano additives is 1.83 kW, which is lower than the minimum indicated power value for pure diesel (3.15 kW). This indicates that the performance of biodiesel with nano additives is highly variable compared to pure diesel. When compared to individual surfactants, the combination of span 80 and tween 80 shown significantly better performance in lowering friction power than did diesel by itself.

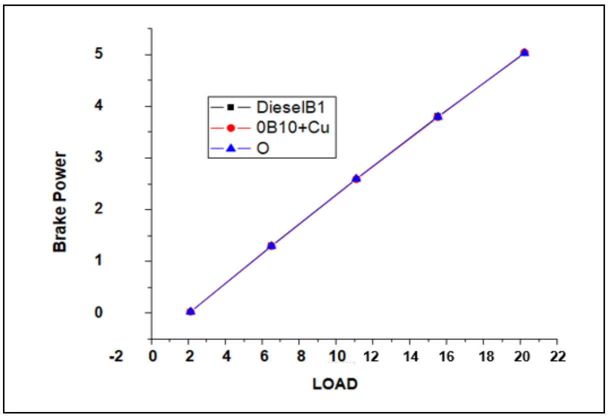

Fig. 4: Variation of brake power

4.2 Brake Power

Furthermore, it was found that for any given load, As the volume fraction of nanoparticles in the emulsion blend grows, fuel consumption decreases. Variation of Brake Power shown in fig. 4. Also, the B10 blend saw a greater rise in fuel consumption than other blends or diesel operations under higher load circumstances. This was because B10, in comparison to other blends and ordinary diesel fuel, had a higher viscosity and a lower calorific value.

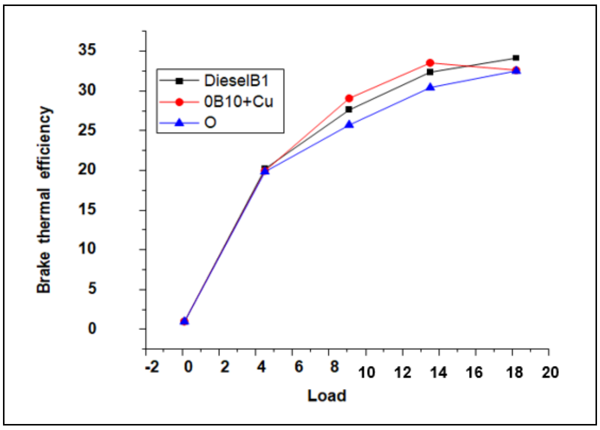

Fig. 5: Variation of brake thermal efficiency

4.3 Brake Thermal Efficiency

Brake thermal efficiency is the ratio of work production at the engine shaft to fuel energy. It serves as an indicator of how well the engine uses fuel. it was discovered that when the load was raised for every task requiring mixes and diesel, the brake thermal efficiency rose for both conventional diesel and different fuel blends at varied loads. When all fuel blends were compared, it was found that when the load increases. The blended diesel emulsion fuel containing copper oxide nanoparticles showed an increase in brake thermal efficiency. This is because biodiesel's encapsulation of copper oxide nanoparticles provides secondary atomization just after the blended fuel's initial micro explosion occurrence. Variation of Brake Thermal Efficiency shown in fig. 5.

4.4 Carbon Monoxide

The air to fuel ratio has a greater influence fuel ratio has a greater influence on carbon monoxide production than the stoichiometric ratio. The majority of the time, lean mixture operation in CI engines reduces CO emissions. Fig. 6 illustrates how CO emission changes in relation to braking power.

Because of the nanoparticles' quick evaporation and subsequent fast mixing of water molecules inside the diesel droplets, there is less need for air, which lowers the amount of unburned carbon that is converted to carbon monoxide. It was found that the secondary atomization caused by the emulsion fuel somewhat increased CO emission in the mixed biodiesel containing copper oxide nanoparticles.

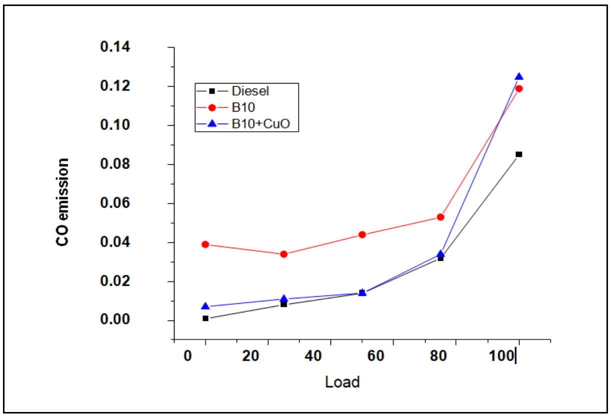

Fig. 6: Variation of carbon monoxide

4.5 Hydrocarbon

The variation in unburned hydrocarbon emissions with load for different blends of biodiesel and baseline pure diesel fuel is depicted in the fig. 7. It has been noted that partial combustion of B10 emulsion fuel results in significant amounts of unburned hydrocarbon.

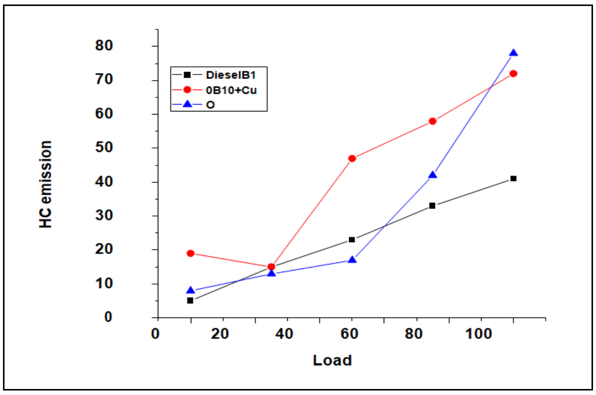

Fig. 7: Variation of hydro carbon

It was brought on by the fuel's higher density and longer igniting delay. However, in the case of the blended biodiesel emulsion with copper oxide nanoparticles, it was found to be less pronounced. It was caused by the presence of copper oxide nanoparticles, which support full combustion by acting as an oxygen buffer.

4.6 Oxides of Nitrogen

Fig. 8 shows how NOx emission changes in relation to braking load for different gasoline blends. It was noted that the B10 emulsion oil's NOx emission magnitude has fairly decreased. This occurred because the water in the biodiesel caused the heat inside the cylinder to evaporate, decreasing the flame temperature.

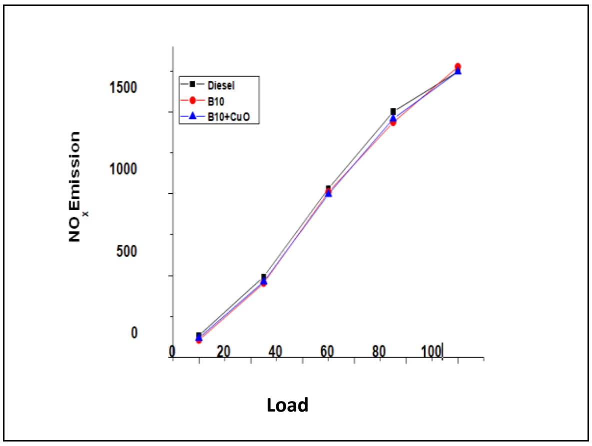

Fig. 8: Variation of oxides of nitrogen

Further reduction in the magnitude of NOx emissions was observed while using biodiesel fuel combined with nanoparticles. This resulted from the nanoparticles' capacity to provide a high surface area to volume ratio, which reduced igniting delay and heat transmission characteristic. This decreases the temperature inside the cylinder by accelerating the passage of heat from flame to biodiesel.

4. CONCLUSION

The current study is concentrated on reducing emissions and fuel consumption in automotive motives. After preparation, the nanocrystalline copper oxide is added as an additive. To create a stable Nano fluid, soap nut biodiesel is combined with metal oxide additive and ultrasonicated. For all diesel and mix operations, the brake thermal efficiency rises as the load is raised. It was discovered that the braking thermal efficiency of copper oxides nanoparticles was different across all fuel mixtures. As the load increases, the percentage of blended diesel emulsion fuel increases across different fuel blends. It was found that the secondary atomization created by the emulsion fuel somewhat increased the CO emission in the case of mixed biodiesel including copper oxide nanoparticles. This reduced the amount of air needed, which in turn reduced the amount of unburned carbon molecules that were converted to carbon monoxide. It was found that under ideal load circumstances, the biodiesel mix (B10) produces a greater value of HC emission. Additionally, because the ceramic nanoparticles have a higher melting point and thermal conductivity than other materials, the mixture bund the fuel as very good level. the mix containing them produces a lower value of hydrogen emission. Fig. 7 and Fig. 8 was shown the numerical evidence of reduce emission level.

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