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COMBUSTION ANALYSIS OF SINGLE CYLINDER 4-STROKE DIESEL ENGINE USING WASTE COOKING OIL WITH CERIUMOXIDE(CeO2) NANOPARTICLE

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Abstract :
In this investigation, the significance of biodiesel as a renewable and eco-conscious fuel derived from organic sources such as waste cooking oil. This alternative fuel addresses crucial challenges in both energy production and waste management, offering a sustainable solution that aligns with environmental principles. By repurposing waste cooking oil, promote sustainable practices and enhance resource efficiency.The present work centers on the production of biodiesel through the transesterification process, showcasing its potential as a feasible replacement for traditional diesel on a broader scale. The investigation primarily focuses on assessing biodiesel's. Additionally,The meticulously analyze Combustion of cylinder pressure,rate of pressure rise, mean gas temperature,net heat rate of B20, B20+10% methanol,B20+NPs 50 ppm +TWEEN 80 50 ppm,B20+NPs 50 ppm+ TWEEN 80 50 ppm+10% methanol.substantiate the environmental advantages of biodiesel over conventional diesel. Through this examination,The aim is to provide valuable insights into the viability and sustainability of biodiesel sourced from waste cooking oil.

Keywords: *Diesel, Biodiesel, waste cooking oil bio-diesel, Transesterification process*

TEST FUELS NOMENCLATURE:

- Name of the biodiesel: Used cooking oil biodiesel
- Nanoparticles (NPs): CeO_2 (Ceriumoxide)
- Dispersant Name: TWEEN 80
- Alcohol: Methanol
- D100- Pure Diesel
- B20- Diesel and WVO Biodiesel
- C1: B20+10% methanol
- C2: B20+NPs 50 ppm +TWEEN 80 50 ppm
- C3: B20+NPs50 ppm+ TWEEN 80 50 ppm+10% methanol

INTRODUCTION

In an agricultural country like India, the use of vegetable oils in diesel engines has to be thoroughly investigated because of the large production capacity and possibility of producing it near the consumption points. Vegetable oils can be used in existing compression ignition engines with little or no modification because their cetane numbers are similar to diesel fuels. Many vegetable oils can be used in diesel engines, including peanut oil, linseed oil, rapeseed oil, and sunflower oil. Vegetable oil has numerous advantages, including sustainability, reduced greenhouse gas emissions, regional development, and agricultural improvement. A greener substitute that could lead to sustainable energy production and be a solution to the environmental complications associated to waste dumping would be attractive. A key obstacle in the extensive utilization of biodiesel is its higher price compared to petroleum-based fuels. This cost could be reduced by decreasing the price of feedstock utilized for biodiesel production. Waste vegetable oils (WVO) present themselves as such an alternative. WVO could be converted into biodiesel (WVOB) to be used as a liquid fuel. The conversion of WVO to liquid fuel also rectifies the dumping snags of cooking oil which is otherwise dumped into water sources and therefore pollutes drinking water and clog drainage. Biodiesel can be used in unmodified diesel engines, either alone or blended with conventional petro diesels. The use of edible vegetable oils such as like sunflower oil, rapeseed oil and soybean oil for fuel purposes may directly affect the economy, i.e., it may cause an increase in the prices of cooking oils. In order to avoid that consequence, it is essential to use non-edible oils for biodiesel production. Rubber seed oil, cooking oil and linseed oil are examples of non-edible oils. As diesel engine fuel is a great subject for research and development, many researchers have been working on many vegetable oils to produce diesel like engine fuel. When vegetable oils are burned, their chemical composition helps to reduce the emission of unwanted components. According to Murayama et al., vegetable oil fuels produced acceptable engine performance and exhaust gas emission levels for short-term operation only but caused carbon deposit build-up and piston ring sticking after extended operation. Nowadays, in CI (compression ignition) engines, biodiesel is the popular alternative fuel used. It can be used without further variations in the engine's present design due to its sulfur-free, biodegradable and nontoxic nature. In the current era, diesel engines are more commonly used in the transportation field when compared to gasoline engines due to their advantages like wider torque range, low maintenance cost, and high power. The concerns over global warming are closely tied to the rising need for energy.

BIOFUELS

Waste cooking oil, often referred to as "waste cooking oil" or "recycled cooking oil," is a type of biodiesel produced from used cooking oils that have been discarded from households, restaurants, and food processing industries. Instead of being disposed of as waste, these cooking oils are collected and processed to remove impurities and converted into biofuels.

Waste cooking biofuels oil offers several environmental benefits, including reducing the dependence on fossil fuels, lowering greenhouse gas emissions, and providing a sustainable solution for managing used cooking oil waste. Additionally, it can help reduce the environmental impact associated with the disposal of used cooking oil, such as clogging sewage systems and contaminating water bodies.

Figure 1 Renewable resources and non-renewable sources

MAKING OF BIODIESEL

Making Biodiesel is not as difficult as it sounds and anyone that wants to can make quality biodiesel right at their own homes. The biodiesel making process can be broken down as follows.

- Preparation
- Reaction (Biodiesel Transesterification)
- Settling and Separation
- Biodiesel Washing
- Biodiesel Storing &Using

IMPORTANCE OF BIODIESEL

Bio-diesel is the most valuable form of renewable energy that can be used directly in any existing, unmodified diesel engine.

- Smaller trade deficit
- Energy independence
- Economic growth
- Cleaner air

LITERATURE SURVEY

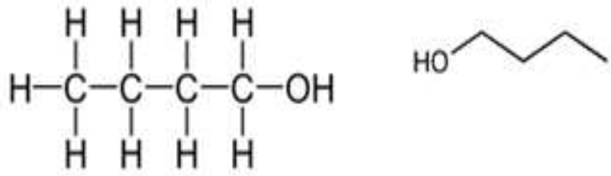
1. Influence of metal-based cerium oxide nanoparticle additive on performance, combustion, with biodiesel in diesel engine.
2. Role of cerium oxide nanoparticles as diesel additives in combustion efficiency improvements and emission reduction.
3. Effect of injection pressure on the combustion, characteristics of a biodiesel engine with cerium oxide nanoparticle additive.
4. Experimental investigations on the performance characteristics of CI engine fuelled with cerium oxide nanoparticle added biodiesel-diesel blends.
5. of cerium oxide nanoparticles and carbon nanotubes as fuel-borne additives in diesterol blends on the combustion characteristics of a variable compression ratio engine.
6. Effects of particle size of cerium oxide nanoparticles on the combustion behavior of a diesel engine powered by biodiesel/diesel blend.
7. Effects of Cerium Oxide Nano Particles Addition in Diesel and Bio Diesel on the Performance and Emission Analysis of CI Engine.
8. Multivariate analysis of nano additives on biodiesel fuelled engine characteristics.
9. Environment Effect of CeO2 nano additive on performance and in a COME operated CI marine engine.
10. Effect of cerium oxide nano additive on the working characteristics of water emulsified biodiesel fueled diesel engine.

METHANOL

Methanol and ethanol are the most often used alcohols in biodiesel production. Methanol is particularly preferred because of its physical and chemical advantages. Beside its reaction with triglycerides is quick and it can be easily dissolved in NaOH,KOH is usually simpler to find compared to ethanol. For biodiesel production via transesterification reaction, methanol is the most common alcohol used. However, the level of water in an alcohol is crucial for its successful application in the production of biodiesel. This is because the presence of water during transesterification reaction causes hydrolysis of triglycerides to free fatty acids which leads to soap formation, and poor yield.

Properties of methanol:

- Chemical formula: $C_4H_{10}O$
- Boiling temperature: 118˚C
- Density:810 kg/m^3
- Molar mass:74.121 g/mol
- Melting point:-89.8^{o}c



CATALYSTS

The catalysts employed in triglyceride transesterification can be classed as basic. Sodium hydroxide (NaOH), potassium hydroxide (KOH), carbonates, and their equivalent alcoxides are all basic catalysts (for instance, sodium methoxide or ethoxide).Enzymes, titanium silicates, alkaline earth metal compounds, anion exchange resins, and guanidines in organic polymers have all been investigated as heterogeneous catalysts for biodiesel generation. Lipases are the most often utilised enzymes in the synthesis of biodiesel.The catalysts contain lipase enzymes.

- *Potassium hydroxide:*

  Potassium hydroxide, also known as lye is an inorganic compound with the chemical formula KOH Also commonly referred to as caustic potash. Sodium hydroxide is a caustic base and alkali that decomposes proteins at room temperature and can cause chemical burns.

Figure 1 sodium hydroxide

- *Glycerin:*

  Glycerin, often known as glycerol, glycerin, or glycol alcohol, is the common term for 1, 2, 3-propanetriol. It is a viscous liquid with high viscosity at room temperature, is odorless, clear, and colorless, has low toxicity, and has a pleasant flavor. Glycerin has a high boiling point of 290°C (563°K), and its viscosity increases significantly at low temperatures, down to its freezing point of 18°C (291 K). It's a polar chemical that mixes well with water and alcohol and also works well as a solvent. Glycerin is a humectants and hygroscopic substance. Glycerin was a result of candle making (from animal fat) until the later years of the nineteenth century, and it was primarily employed in the creation of nitroglycerin for explosives.

Figure 2 Glycerin

- *Alcohol-catalyst mixing*

  Before adding the oil, the alcohol used in biodiesel manufacturing must be combined with the catalyst. The catalyst is entirely dissolved in the alcohol after stirring the mixture. It is important to note that the alcohol must be free of water (anhydrous) for the reasons stated in the preceding paragraph.

Figure 4 mixture of WVO and Glycerin

The most commonly used basic catalysts are sodium and potassium hydroxides. Sodium or potassium methoxides or methylates are commercially available for industrial manufacture. When working with methanol, hydroxides, and methoxides, regardless of the size of production, extreme caution must be maintained and all applicable safety requirements must be observed.

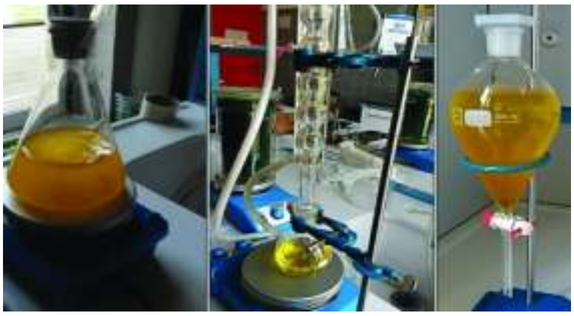
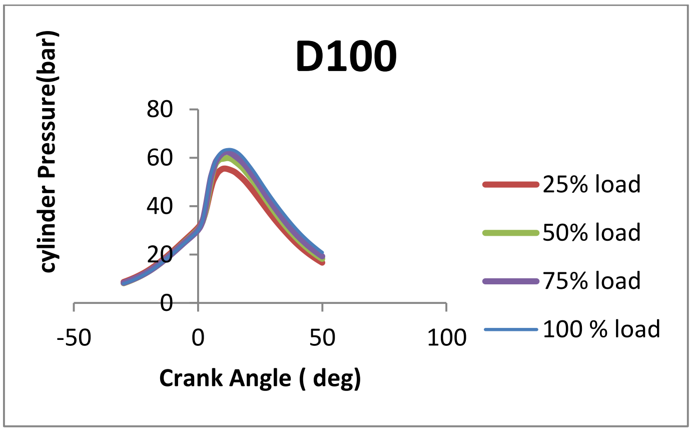


Figure 5 Alcohol-catalyst mixing

RESULTS AND CONCLUSION

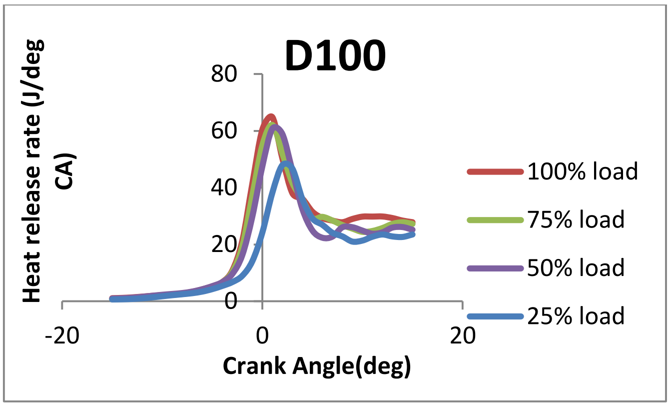
Mean gas temperature (D100)



Graph 1 Mean gas temperature vs load

The temperature against crank angle like in Graph 1. shows a variation in mean gas temperature compared to diesel (D100). The values for B20, B20+10% methanol,B20+ NPs 50 ppm +TWEEN 80 50 ppm,B20+NPs 50 ppm+ TWEEN 80 50 ppm+10% methanol are 54.39 deg, 59.45 deg, 61.34 deg, and 63.07 deg respectively, at 100% load. The adding of nanoparticles the temperature improved by 2.67%, 4.78%, 8.50%, and 9.86% respectively. Considering the B20+NPs 50 ppm+ TWEEN 80 50 ppm+10% methanol blend had better combustion characteristics than the other fuel blends like i.e., B20, B20+10% methanol, and B20+ NPs 50 ppm +TWEEN 80 50 ppm.

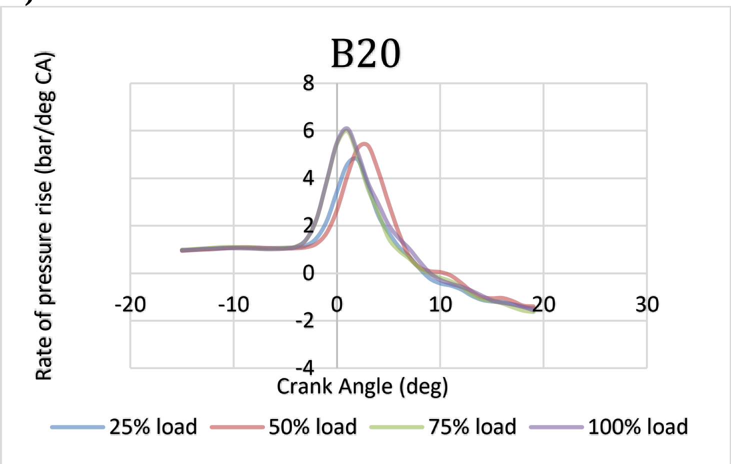
Net heat release rate (D100)



Graph 2 Net heat release rate

The fuels B20, B20+10% methanol,B20+ NPs 50 ppm +TWEEN 80 50 ppm,B20+NPs 50 ppm+ TWEEN 80 50 ppm+10% methanol relative to the crank angle at the maximum 100% load. The results demonstrate that the B20+NPs 50 ppm+ TWEEN 80 50 ppm+10% methanol blend produces the most heat when compared to the other test fuels. The inclusion of nanoparticles utilizing B20,B20+10% methanol,B20+ NPs 50 ppm +TWEEN 80 50 ppm,B20+NPs 50 ppm+ TWEEN 80 50 ppm+10% methanol at 100% load, respectively.B20+NPs 50 ppm+ TWEEN 80 50 ppm+10% methanol has the highest Net heat release rate compared to all engine loads**.**

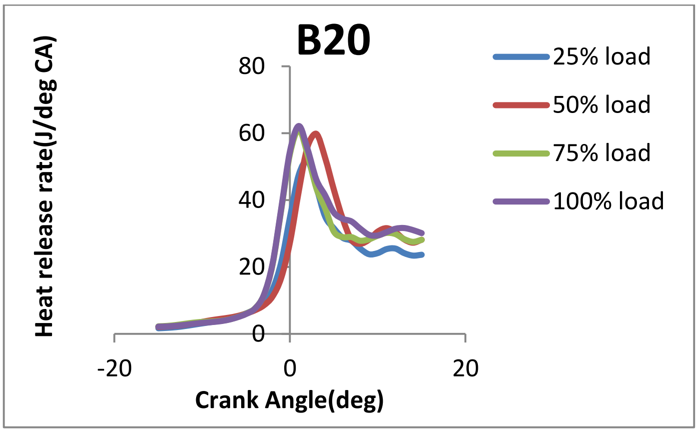
Rate of pressure rise (B20)



Graph 3 Rate of pressure rise

The higher pressure increase and decrease within the cylinder for the B20,B20+10% methanol,B20+ NPs 50 ppm +TWEEN 80 50 ppm,B20+NPs 50 ppm+ TWEEN 80 50 ppm+10% methanol at a maximum load of 100%. The highest-pressure readings for 100% load are 5.22bar, 5.57bar, 5.98bar, and 6.12bar. The including of nanoparticles increases the cylinder pressure B20, B20+10% methanol,B20+ NPs 50 ppm +TWEEN 80 50 ppm,B20+NPs 50 ppm+ TWEEN 80 50 ppm+10% methanol at 100% load. Comparing with the diesel (D100) the test fuel B20+NPs 50 ppm+ TWEEN 80 50 ppm+10% methanol had better combustion characteristics than the other samples, a high cylindrical pressure was observed.

Net heat release rate (B20)



Graph 4 Net heat release rate (B20)

The fuels B20, B20+10% methanol,B20+ NPs 50 ppm +TWEEN 80 50 ppm,B20+NPs 50 ppm+ TWEEN 80 50 ppm+10% methanol relative to the crank angle at the maximum 100% load. The results demonstrate that the B20+NPs 50 ppm+ TWEEN 80 50 ppm+10% methanol blend produces the most heat when compared to the other test fuels. The inclusion of nanoparticles and B20, B20+10% methanol,B20+ NPs 50 ppm +TWEEN 80 50 ppm,B20+NPs 50 ppm+ TWEEN 80 50 ppm+10% methanol at 100% load, respectively. B20+NPs 50 ppm+ TWEEN 80 50 ppm+10% methanol has the highest Net heat release rate compared to all engine loads**.**

CONCLUSIONS

The combustion characteristics of a single cylinder four stroke diesel engine fuelled with diesel and blends of waste cooking oil biodiesel at injection pressures at constant injection timing of bTDC at engine rated speed of 15000rpm

1. The rate of pressure rise is found to be higher for diesel D100 and lower for waste cooking oil oil biodiesel B20.
2. The rate of pressure rise decreases with an increase in the percentage of volume of waste cooking oil biodiesel in the fuel.
4. The brake thermal efficiency of the Waste vegetable oil biodiesel(WVOB) B20 are slightly lower than that of diesel D100 and other blends B20+10% methanol, B20+ NPs 50 ppm +TWEEN 80 50 ppm,B20+NPs 50 ppm+ TWEEN 80 50 ppm+10% methanol due to the early start of combustion of waste cooking oil biodiesel and its blends, which increases the compression work.
7. From the results, it is concluded that B20+NPs 50 ppm+ TWEEN 80 50 ppm+10% methanol and B20 blend shows higher mechanical efficiency by load variations than that of conventional diesel D100.
8. After 75% load condition there is sudden rise in in cylinder gas pressure is observed.
9. Finally, it is concluded that blend B20+NPs 50 ppm+ TWEEN 80 50 ppm+10% methanol is having better combustion characteristics at constant pressure.

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