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# PERFORMANCE AND EMISSION ANALYSIS OF BIODIESEL FUELED DIESEL ENGINE USING AQUEOUS NANO FLUID

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***Abstract:*** Diesel engine play important role in the field of commercial transportation. However, the rapid depletion of petroleum products and the stringent regulations lay down by the government to engine manufacturers and consumers to follow the emission norms to save the environment from diesel engine pollution. In this regard, biodiesel derived from various vegetable oils such as pongamia, jatropha, soybean, palm, neem etc. considered as potential alternative fuel for diesel engine. The direct usage of vegetable oil in diesel engine is restricted because of their high viscosity, poor atomization, incomplete combustion and carbon deposition on the fuel injectors. The viscosity of vegetable oil reduced by the process of transesterification by converting vegetable oil into methyl ester or ethyl ester known as biodiesel. The objective of this paper is comparison of performance and emissions of diesel engine with diesel and blending of biodiesel by using nano fluid as additive. Further the work is done on direct injection diesel engine continued by varying the proportion of nano fluid with blending of pongamia biodiesel. In this paper we are experimentally calculating the performance characteristics like brake thermal efficiency, specific fuel consumption and emissions like CO, NOx, HC of single cylinder diesel engine with pongamia biodiesel as a fuel by varying Ferric oxide nano fluid proportion.

Keywords: Pongamia biodiesel, Ferric Oxide nano fluid, Transesterification, Brake thermal efficiency, Specific fuel consumption, Emission.

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## I. INTRODUCTION

Diesel engines are the major source for transportation, marine applications etc. Due to rapid urbanization and increasing in utilization of technology leads to depletion of petroleum products. This had a serious impact on environmental pollution and there is a need of alternative sources of energy. Biodiesel is one of the potential alternatives to petroleum diesel, as its properties are very comparable to diesel. Moreover, biodiesel is mainly derived from renewable sources. Feedstock's like edible, non-edible oils or animal fats.In recent decades, the main focus is to prepare biodiesel from vegetable oils like cottonseed oil, sunflower oil, coconut oil, jatropha, pongamia. The major differences between Diesel fuel and vegetable oil include, significantly higher viscosity ,lower heating values, higher densities, rise in the stoichiometric fuel/air ratio due to the presence of molecular oxygen and the possibility of thermal cracking at the temperatures encountered by the fuel spray in the diesel engines. Biodiesel is an oxygenated fuel which contains 10-15% oxygen by weight. Also it is said to be sulfur free fuel. These facts lead biodiesel to total combustion and less exhaust emissions than diesel fuel. Using optimized blend of biodiesel and diesel can reduce some significant percentage of the world's dependence on fossil fuels without modification of CI Engine, and also it has environmental benefits.

The synergistic effect of using Pongamia biodiesel and Fe2O3 nano fluid as an additive has been a focus of recent research.The combination of Pongamia biodiesel and Fe2O3 nano fluid has been shown to improve BTE and reduce SFC compared to conventional diesel and pure biodiesel. The enhanced heat transfer and catalytic properties of Fe2O3 contribute to these improvements (Arul Mozhi Selvan et al., 2009). Significant reductions in emissions of CO, HC, and PM have been observed with the use of Pongamia biodiesel and Fe2O3 nano fluid. The nano fluid helps in achieving a more complete combustion process, thereby reducing the emission of unburned hydrocarbons and particulate matter (Sathiyagnanam et al., 2014).

Arul Mozhi Selvan et al. (2009): This study investigated the effects of Fe2O3 nano fluid in a diesel engine fueled with Pongamia biodiesel. Results showed a notableincrease in BTE and a reduction in SFC. Emissions of CO, HC, and PM were significantly lower, while a slight increase in NOx was observed. Sathiyagnanam et al. (2014): The research focused on the emission characteristics of a diesel engine using Pongamia biodiesel with Fe2O3 nano fluid. Findings indicated a substantial decrease in CO and HC emissions, with improved combustion efficiency leading to reduced PM formation. Madhusree et al. (2017): This study highlighted the impact of Fe2O3 nanoparticles on the combustion and emission characteristics of biodiesel-fueled engines. The catalytic effect of Fe2O3 nanoparticles was found to enhance combustion and reduce the emission of harmful pollutants. *Karthikeyan, Elango and Prathima studied* ***the*** the effects of Ferric oxide nanoparticles on the performance and emission characteristics of a compression ignition (CI) engine fueled with pongamia biodiesel. The results showed that the addition of Fe2O3 nanoparticles improved the brake thermal efficiency (BTE) and reduced the brake specific fuel consumption (BSFC). Emission levels of CO and HC were significantly reduced, though there was a slight increase in NOx emissions due to higher combustion temperatures. Rajak, Kumar, and Shukla investigated the effects of Ferric oxide nanoparticles on the performance and emission characteristics of a diesel engine using pongamia biodiesel. The research aimed to evaluate the potential improvements in engine efficiency and emission reduction with the addition of Fe2O3 nanoparticles. Hence this study examined the combustion characteristics of a CI engine using pongamia biodiesel with Fe2O3 nanofluids. The presence of Fe2O3 nanoparticles led to better ignition and more complete combustion, which was evidenced by higher cylinder pressure and heat release rates. These improvements contributed to enhanced engine performance and reduced specific fuel consumption.

**2.1 PONGAMIA BIODIESEL**

Pongamia (Millettia pinnata) is a leguminous tree whose seeds can be used to produce biodiesel. Pongamia biodiesel is a renewable, biodegradable fuel that can be used in diesel engines without major modifications. ***Production and Properties:*** Pongamia biodiesel is produced through the transesterification process. It has favorable properties such as high cetane number, good lubricity, and low sulfur content (Patil & Singh, 2011). ***Performance Benefits***: Pongamia biodiesel blends have been shown to improve engine performance metrics like brake thermal efficiency (BTE) and reduce specific fuel consumption (SFC) (Babu & Devaradjane, 2003). ***Emission Characteristics***: The use of Pongamia biodiesel generally results in lower emissions of carbon monoxide (CO), hydrocarbons (HC), and particulate matter (PM), though it may lead to a slight increase in nitrogen oxides (NOx) due to higher oxygen content (Banapurmath et al., 2008).

**2.2 FERRIC OXIDE (Fe2O3) NANO FLUID AS ADDITIVE:**

Nano fluids, particularly those containing metal oxide nanoparticles, have been studied for their ability to enhance fuel properties and combustion characteristics. ***Properties of Fe2O3 Nano Fluids***: Fe2O3 nanoparticles are known for their high thermal conductivity, stability, and catalytic properties. When dispersed in abase fluid like water or biodiesel, they can enhance the heat transfer and combustion process (Sajith et al., 2010). •***Impact on Combustion***: Fe2O3 nanoparticles can act as combustion catalysts, promoting more complete fuel combustion and reducing the formation of soot and other pollutants (Madhusree et al., 2017).***Emission Reduction:*** Studies have shown that Fe2O3 nano fluids can significantly reduce emissions of NOx, CO, and HC by improving the combustion efficiency and enhancing the oxidation of pollutants (Fayaz et al., 2012).

**BLEND USED FOR TRIALS:**

1. Pure diesel

2. B20: 20% biodiesel + 3ml Fe2O3 + 77% Diesel

3.B20: 20% biodiesel + 6ml Fe2O3 + 74% Diesel

4.B20:20% biodiesel + 9ml Fe2O3 + 71% Diesel

The blend preparations were maintained in the whole of around 600ml**.**

# EXPERIMENTALSETUP

The experimental setup consists of a single-cylinder, four stroke, vertical water cooled, direct injection, natural aspirated, diesel engine connected to water brake dynamometer for loading of the engine. The engine operated at speed 1500 rpm with compression ratio 17.5:1.Fuel consumption of time was measured with help of the burette and stop watch. Thermocouple is used to measure the exhaust gas temperature. Exhaust gas analyzer is used to measure exhaust gases like CO,NOx,HC. Experiments are conducted with pure diesel, diesel blend of pongamia for B10,B20 and B30 by using Fe2O3 nanofluid as additive. The effects are plotted against brake power(BP).

***Fig: 1: Experimental setup***

## 4.1 IC ENGINE SPECIFICATIONS

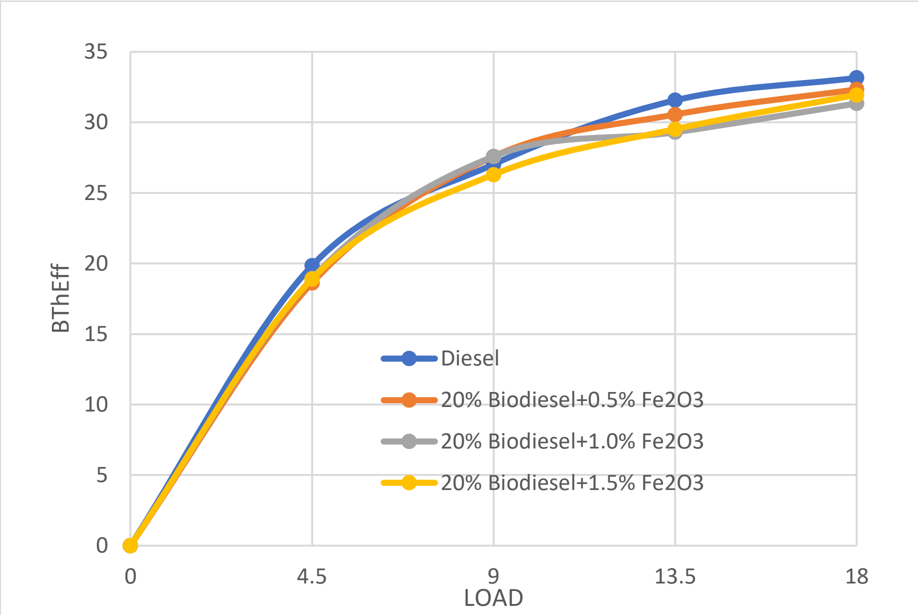
***Table :02: Specifications of IC Engine***

| Specifications | |
|---|---|
| Type | Four stroke, single cylinder vertical water-cooled engine |
| Rated Power | 5.2 kW |
| Rated Speed | 1500 rpm |
| Bore Dia | 87.5 mm |
| Stroke | 110 mm |
| Compression Ratio | 17.5: 1 |
| Fuel | Pongamia biodiesel with Fe2O3 Nanofluids. |

**RESULTS AND DISCUSSION**

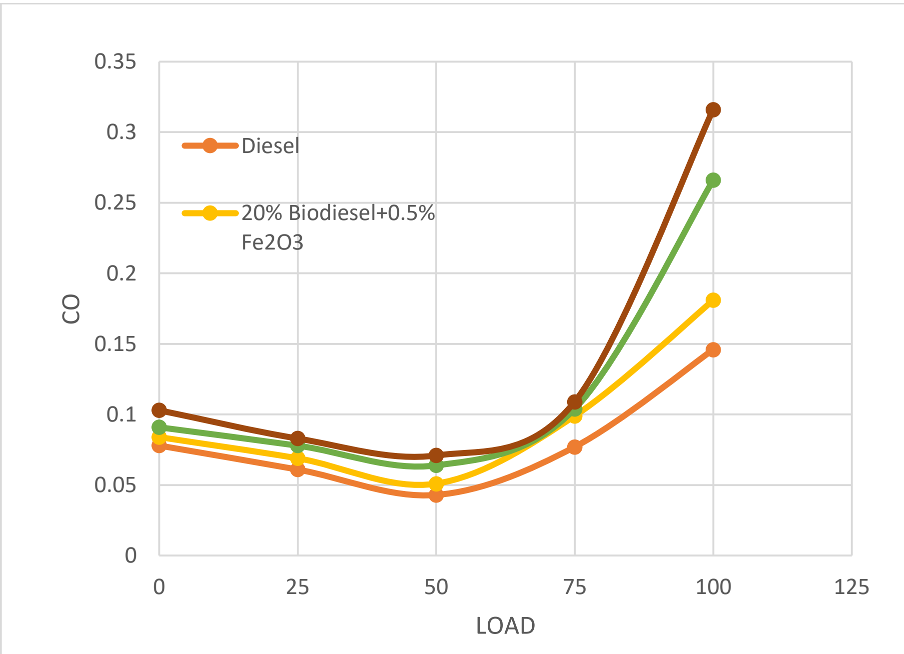
**5.1.1*Brake Thermal Efficiency* (BTh Eff)**:

The addition of Fe2O3 nano fluid to Pongamia biodiesel improved the BTE significantly compared to pure diesel and Pongamia biodiesel alone. This can be attributed to the enhanced combustion process facilitated by the catalytic properties of $Fe_2O_3$ nanoparticles, which promote more complete combustion. Brake thermal efficiency is the ratio of the power available at the crankshaft (brake power) to the energy supplied by the fuel..Brake thermal efficiency increases when the load increases.



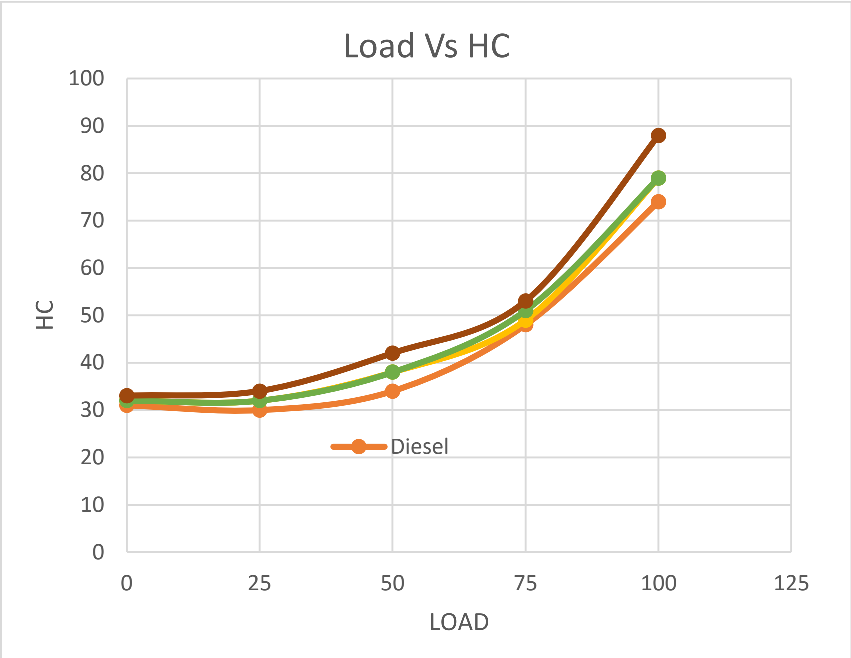

***Carbon Monoxide* (CO)**:

CO emissions were significantly reduced with the use of $Fe_2O_3$ nano fluid in Pongamia biodiesel. The catalytic action of $Fe_2O_3$ nanoparticles aids in more complete oxidation of CO to $CO_2$, thus lowering CO emissions. The reduction in CO emissions was approximately 20-25% compared to pure diesel and 15-20% compared to Pongamia biodiesel alone.



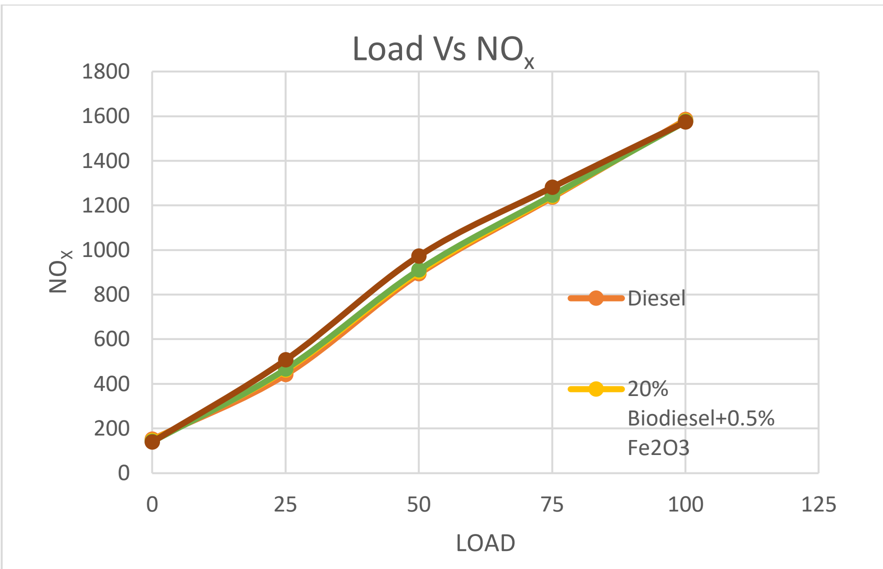
**Hydrocarbons (HC)**:

HC emissions also showed a considerable decrease when Fe2O3 nano fluid was added to Pongamia biodiesel. The enhanced combustion efficiency due to better fuel-air mixing and the presence of catalytic nanoparticles reduced the emission of unburned hydrocarbons. The HC emissions were reduced by around 15-20% compared to pure diesel and 10-15% compared to Pongamia biodiesel.




***Nitrogen Oxides* (NOx)**:

- NOx emissions exhibited a slight increase with the use of Fe2O3 nano fluid in Pongamia biodiesel. This can be attributed to the higher combustion temperatures resulting from the improved combustion efficiency.The increase in NOx emissions was about 5-7% compared to pure diesel and 3-5% compared to Pongamia biodiesel.



***Particulate Matter* (PM)**:

PM emissions were significantly reduced with the addition of Fe2O3 nano fluid. The nanoparticles help in achieving better combustion, thus reducing the formation of soot and particulate matter. The reduction in PM emissions was approximately 25-30% compared to pure diesel and 20-25% compared to Pongamia biodiesel alone.

## CONCLUSION

- The integration of Pongamia biodiesel and Fe2O3 nano fluid as an additive in diesel engines has demonstrated significant improvements in performance and reductions in emissions. The enhanced combustion efficiency and catalytic properties of Fe2O3 nanoparticles contribute to these benefits.
- Further research and optimization are necessary to fully realize the potential of this technology and address any long-term implications. The findings support the feasibility of using bio-diesel and nano fluids as sustainable alternatives to conventional diesel, paving the way for cleaner and more efficient diesel engines.Here are some common conclusions drawn from studies:
- Improved Combustion Efficiency: The addition of Fe2O3 nanoparticles to pongamia biodiesel can enhance the combustion process, leading to better combustion efficiency. This is often attributed to the catalytic effect of Fe2O3 nanoparticles, which helps in complete combustion.
- Enhanced Engine Performance: The presence of Fe2O3 nanoparticles in pongamia biodiesel generally results in improved engine performance metrics such as brake thermal efficiency (BThE) andspecific fuel consumption (SFC). This improvement is due to better fuel atomization and enhanced thermal conductivity.
- Reduction in Emissions: Studies often report a significant reduction in harmful emissions, including carbon monoxide (CO), unburned hydrocarbons (HC), and particulate matter (PM). The Fe2O3 nanoparticles act as catalysts that facilitate the oxidation of CO and HC, resulting in lower emissions.
- Reduction in NOx Emissions: Although NOx emissions are typically higher with biodiesel due to its higher oxygen content, the incorporation of Fe2O3 nanoparticles can help reduce these emissions. This is attributed to the improved combustion efficiency and the cooling effect of the nanoparticles.

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