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Diesel Engine Performance: A Study on Biodiesel Blends and Nano-Enhanced Fuel Additives

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A B S T R A C T

This study comprehensively analyzes the performance and emissions of a Diesel engine using various blends: pure Diesel, B20 (80% Diesel + 20% Jatropha-based biodiesel), and a novel nano-enhanced B20 50S 25 Fe blend (B20 + nano-sized SiO_2 in 50 ppm + nano-sized Fe_2O_3 in 25 ppm). Assessing engine efficiency and emissions, the study explores the impact of biodiesel blending and introduces nano-sized additives to enhance combustion efficiency and reduce emissions. Preliminary results suggest that the B20 blend and the nano-enhanced variant show potential in improving combustion efficiency and reducing emissions, offering valuable insights into the feasibility of biodiesel blends and nanomaterial additives for optimizing Diesel engine performance. These findings contribute to future developments in sustainable fuel technologies, promoting environmentally friendly and efficient combustion systems.

Keywords: B20 (80% Diesel + 20% Jatropha-based biodiesel), B20 50S 25 Fe blend (B20 + nano-sized SiO_2 in 50 ppm + nano-sized Fe_2O_3 in 25 ppm)

INTRODUCTION

Biodiesel, sourced from renewable materials, is a promising alternative fuel for internal combustion engines, aiming to cut greenhouse gas emissions [1-4]. Researchers are addressing challenges by exploring methods like hybrid nano additives, combining two or more nano additives, to enhance biodiesel-diesel blend performance. While biodiesel has benefits, it also has limitations like higher viscosity. Recent focus involves incorporating hybrid nano additives—metal, metal oxide, and carbon-based nanoparticles—to overcome biodiesel drawbacks. This avenue shows promise in optimizing engine performance and emissions of biodiesel-diesel blends.

In recent years, Jatropha biodiesel blends have gained prominence as a sustainable alternative to traditional fossil fuels. Derived from the seeds of the drought-resistant Jatropha curcas plant, these blends are extensively studied for their potential to enhance combustion properties and reduce environmental impact when integrated into conventional diesel fuels [6-8]. Research indicates that blending Jatropha biodiesel with Petro diesel improves fuel properties, enhancing cetane number, lubricity, and oxygen content. This results in heightened combustion efficiency, reduced pollutant emissions, and decreased reliance on fossil fuels. However, challenges like high viscosity, low volatility, and poor oxidative stability associated with Jatropha biodiesel require optimization of blend ratios and the incorporation of additives to meet international fuel standards. Studies highlight the economic and environmental benefits of Jatropha biodiesel blends, emphasizing reduced greenhouse gas emissions and enhanced energy security. The cultivation of Jatropha as a biofuel feedstock is explored in the context of sustainable agriculture, considering its adaptability to marginal lands and potential to boost income for rural communities.

Simultaneously, biodiesel blends with nano additives have emerged as a focus in scientific research, offering enhancements to biodiesel performance [9-13]. Nanoparticles, such as metal oxides or carbon-based materials, act as catalysts, improving oxidation stability, thermal stability, and combustion efficiency [14-18]. The literature underscores the role of nano additives in addressing fuel stability during storage, preventing oxidation, and degradation over time [19-21]. Additionally, these additives modify physicochemical properties, enhancing lubricity and reducing engine wear.

Advancing this field, biodiesel blends with hybrid nano additives combine various nanoparticles to synergistically enhance properties, providing a holistic solution to challenges in biodiesel combustion [22-25]. Ongoing research explores optimal dosage, potential environmental impacts, and novel nanomaterial synthesis tailored for biodiesel applications. The convergence of Jatropha biodiesel blends and advanced nano additives reflects a dynamic pursuit of sustainable and efficient biofuel solutions.

EXPERIMENTAL SETUP AND EXPERIMENTATION:

Figure 1: Engine Setup

The power supplied by the water-cooled single-cylinder diesel engine (*Figure 1*) is absorbed by a rope pulley break system that is attached to it. Weights and spring balances that are required are incorporated to apply load to the break drum. There is an appropriate cooling water setup for the break drum. For cooling the engine, separate cooling water lines equipped with thermos couplings are offered. A system for measuring fuel is offered, including a fuel tank set on a platform, a burette, a three-way cock, and a stopwatch. An air tank with an aperture and a water manometer are used to measure air intake. A load test is run to analyse the engine's performance.

RESULTS AND DISCUSSION

The obtained results in terms of performance and emissions were analyzed as follows

a. Break Thermal Efficiency:

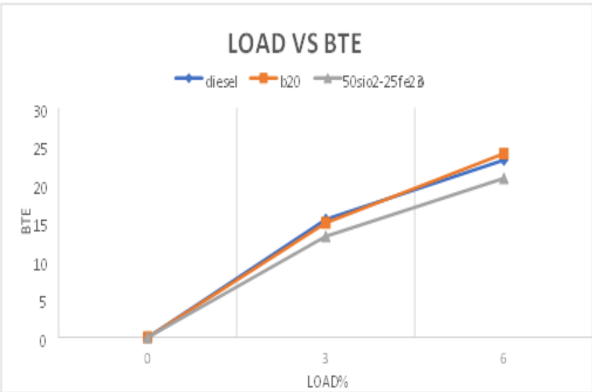

Figure 2: Load Vs BTE

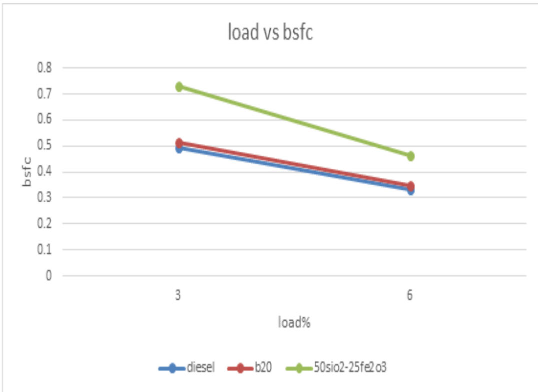

Figure 3: Load Vs bsfc

From *Figure 2*. the break thermal efficiency of diesel and b20 show similar values from lower to medium loads and slight lower break thermal efficiency was resulted with B20(50sio$_2$-25fe$_2$O$_3$) than the other two at medium load.

b. Specific Fuel Consumption:

In *Figure 3*. the specific fuel consumption of both diesel and B20 are similar at lower to medium loads. B20(50Sio$_2$-25Fe$_2$O$_3$) shows higher specific fuel consumption at low load and lower at medium load.

c. Hydro carbons (HC):

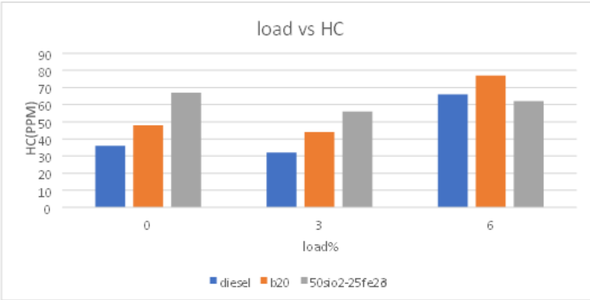

Figure 4.: **Load Vs HC**

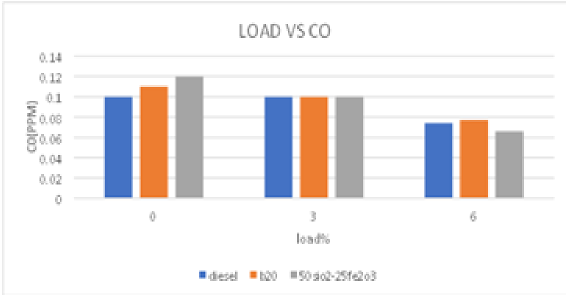

Figure 5. : **Load Vs CO**

The above graph, *Figure 4* shows the HC emissions of diesel,b20 and 50sio2-25fe2o3 and the biodiesel blend of B20(50Sio_2-25Fe_2O_3) shows higher emission values at lower conditions and diesel shows lesser emission value. B20(50Sio_2-25Fe_2O_3) shows higher emission values shows lower emission values among them at higher value because of the inbuilt oxygen.

d. Carbon monoxide (CO):

The above *Figure 5*the CO emissions are higher at lower load conditions and lower at heavy load conditions**.** At medium conditions all the three fuels shows equal emission values of carbon monoxide. B20(50Sio_2-25Fe_2O_3) shows higher emission values shows lower emission values among them at higher value because of the inbuilt oxygen.

e. CARBON DIOXIDE (CO_2):

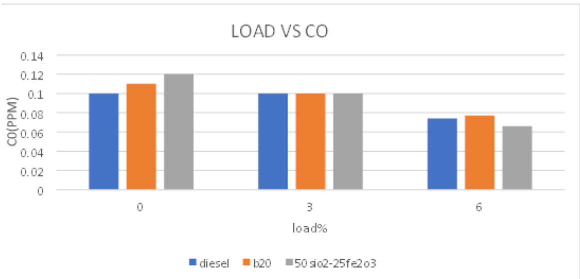

Figure 6.: **Load Vs CO_2**

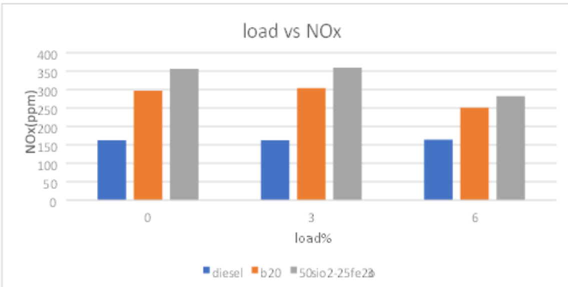

Figure 7. : **Load Vs NOx**

The above *Figure 6* shows the CO_2 emissions of diesel,b20 and 50sio2-25fe2o3 and the biodiesel blend of B20(50sio_2-25fe_2O_3) shows higher emission values at lower conditions and diesel shows lesser emission value. B20(50Sio_2-25Fe_2O_3) shows higher emission values shows lower emission values among them at higher value because of the inbuilt oxygen.

NOx emissions:

The above *Figure 7* shows the NOx emissions of diesel,b20 and 50sio2-25fe2o3 and the biodiesel blend of B20(50Sio_2-25Fe_2O_3) shows higher emission values at lower load to medium load and diesel shows lesser emission value.

CONCLUSION

The following conclusions were drawn from the above discussion**.**

1. At lower to medium loads, both diesel and B20 exhibit comparable break thermal efficiency. B20(50Sio_2-25Fe_2O_3) shows only a slight decrease at medium loads, maintaining compatibility.
2. Diesel and B20 demonstrate similar specific fuel consumption at lower to medium loads. B20(50Sio_2-25Fe_2O_3) has higher SFC at low load and lower at medium load, suggesting acceptable combustion efficiency.
3. B20(50Sio_2-25Fe_2O_3) displays higher HC emissions at lower conditions, attributed to inbuilt oxygen. For CO_2 emissions, B20(50Sio_2-25Fe_2O_3) shows higher values at lower conditions but lower at higher loads, maintaining compatibility. In NOx emissions, B20(50Sio_2-25Fe_2O_3) exhibits higher values at lower to medium loads compared to diesel, yet overall emissions remain lower.

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