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# Production of Biodiesel from Jatropha Seeds and its Performance

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**ABSTRACT**

The increasing demand for renewable sources has led to the increasing of biodiesel as an alternative to fossil fuels. This report aims to investigate biodiesel which is produced by Jatropha seeds and the incorporation of nanoparticles that are titanium dioxide ($TiO_2$), zinc oxide (ZnO), aluminium oxide ($Al_2O_3$), and iron oxide ($Fe_2O_3$), etc.... in biodiesel production processes to increase its efficiency and performance. Nano particles are increased surface area and catalytic activity. In this study, various types of nanoparticles that will be synthesized and added to jatropha oils during the trans-esterification process to improve the biodiesel yield and quality. The effects of nanoparticle concentration size, and type on the reaction kinetics, yield, and fuel properties will be systematically analysed. Additionally, engine performance and emissions of the nanoparticle-enhanced biodiesel will be evaluated through engine testing. The results of these papers are the optimization of biodiesel production methods with nanoparticles and contribute to the development of more efficient and sustainable energy solutions.

**Keywords:** jatropha oil, biodiesel, nanoparticles, transesterification

## 1. Introduction

Due to the increase in the price of petroleum crude oil and environmental concerns about air pollution caused by the combustion of fossil fuels. They have One option is biodiesel made from vegetable oils or animal fats by trans-esterification process. Biodiesel is better for the environment and can replace regular diesel In India, we buy a lot of petroleum from other countries, which costs a lot of money. If even a small part of regular fuel is replaced with biodiesel, India can save a lot of money. The present work studied the trans-esterification of Jatropha oil with methanol and Effects of various parameters were also studied.

Jatropha, a fast growing, drought resistant native tree of Latin America attracted attention in the field of Research because of its unique ability to grow in any wasteland and almost in any territory, even on soils having gravels, sand and salinity [1]. At present, biodiesel is usually produced by reacting methanol and vegetable oil in a batch stirred tank reactor using a liquid Alka-line catalyst. The catalyst cannot be recovered from the reactor and it is instead neutralized and disposed of as a waste stream [2].

biodiesels are fatty acid esters produced from vegetable oils or animal fats through a chemical process known as transesterification. The differences in the composition and properties of biodiesels produced from soyabean oil, rapeseed oil, karanja oil, jatropha oil or animal fats, from pure diesel will influence the engine performance, combustion and also the emission characteristics. experimentally observed that the increase in the content of biodiesel in diesel-biodiesel blend decreases engine power. this loss in engine power with the use of biodiesel is mainly due to the reduction in heating value of biodiesel compared to diesel [3].

This high demand of energy is presently served by fossil fuels in the form of petroleum or coal Diesel, being one of the fossil fuels, is highly used in heavy-duty engines to meet the high demand of power. But in turn, their combustion in IC engines produce harmful oxides and pollutants. Controlling these pollutants with stricter emission norms is a matter of concern all over the world [4].

## 2. Methodology

### *2.1 Extraction Of Oil*

In this method, the process begins with the preparation of a slurry by grinding Jatropha seed kernels (100 g) in distilled water (600 ml) until a homogeneous mixture is obtained. The pH of the slurry is adjusted to 6.5. Subsequently, 50 ml of ammonium sulphate is added, and the mixture is gently vortexed. To this, 600 ml of tert-butanol is added, initiating the three-phase formation. The slurry is then allowed to incubate at 25°C for 1 hour. Following incubation, the upper organic layer, containing the extracted oil, is carefully collected. Tert-butanol is then distilled at 85°C to isolate the oil. The amounts of recovered oil are quantified as percentages relative to the total oil content in Jatropha seed kernels, which is reported to be 34.33%.

It is noteworthy that 27 grams (80%) of oil are obtained from 100 grams of seed kernels using the standard procedure. The efficiency of oil extraction is observed to increase with smaller particle sizes. Utilizing sonication for 5 minutes yields 29 grams (85%) of oil from the same quantity of seed kernels. This suggests that sonication is an effective method for breaking down larger particles into smaller ones, leading to higher oil yields. The innovation in this method lies in the combination of a recently developed technique known as TPP (presumably a typo, possibly referring to a three-phase partitioning method) with sonication. This hybrid approach proves to be an efficient procedure for extracting oil from Jatropha seed kernels. Importantly, unlike the traditional Soxhlet extraction, which requires a 24-hour duration, the method outlined here completes the extraction process in approximately 2 hours, emphasizing its time efficiency and practical applicability.


*Figure 1 Extraction Of Oil*

### *2.2 Synthesis of Biodiesel*

Various methods and techniques were adopted to optimize conditions for production of biodiesel, which could give the maximum yield. The method that was considered best after various series of experiments was transesterification.

**Catalyst Preparation:**

from Akar Enterprise, also located in Ahmedabad. The catalyst was meticulously prepared through the impregnation of alumina with a potassium nitrate aqueous solution. In the impregnation process, 30 ml of a 35% potassium nitrate solution was loaded onto 10 grams of alumina. This mixture was then subjected to the impregnation method and subsequently dried in an atmospheric dryer. Before each reaction, the catalysts underwent a crucial calcination step in a muffle furnace, typically at 773 K, in the presence of air for a duration of 4 hours. The alumina, serving as the support material, boasted a surface area of 126 $m^3/g$ as documented in previous research [2]. This choice of alumina support is indicative of its favourable characteristics for catalytic purposes. The detailed procurement information and preparation steps provide clarity and context to the experimental setup, contributing to the reproducibility and transparency of the research.

**Trans-Esterification process:**

trans-esterification reaction of oil extracted from Jatropha seeds At 40 C, immobilization of lipase on Celite-545 increased biofuel production from 62% to 71% in the time span of 8hours. It was observed that adding water enhanced the yields to 73 and 92%, when added to the free and immobilized enzyme preparations. Immobilized Chromobacterium viscosum enzyme lipase thus can be used for transformation of oil. Therefore, it was concluded that adequate amount of bio diesel can be produced by immobilization of lipases in optimized trans-esterification process. [1].


*Figure 2 Trans-Esterification Process*

### *2.3 Experimental Setup*

double-cylinder, constant-speed, direct injection diesel engine with compression ignition. The engine was directly linked to a hydraulic dynamometer with a maximum load capacity of 20 kgf. Operating at a rated speed of 1500 rpm, the load was adjusted by manipulating the load wheel located on top of the engine. Throughout the experiments, water pressure was maintained at a constant level of 1.5 kg/cm².To capture a comprehensive set of data, torque and fuel consumption rates were systematically measured under varying loads and with different fuel compositions. Exhaust gas temperatures were monitored using thermocouples [3]. The exhaust gas composition, including CO, HC, and NO, was analysed using the AVL 444 Digas analyzer. Smoke opacity was quantified using the AVL 437 smoke meter [5][6]. The engine underwent loading conditions spanning from no load to 20%, 40%, 60%, 80%, and 100% loads. The fuels under investigation included neat biodiesel and various blends of biodiesel and diesel (5%, 10%, 20%, 30%). These were comprehensively compared against the performance, combustion characteristics, and emission profiles of conventional diesel fuel [7]. This systematic evaluation allows for a thorough understanding of how different fuel compositions, especially biodiesel blends, impact the engine's performance, combustion efficiency, and emission characteristics under diverse load conditions. The utilization of advanced measuring instruments, such as the AVL 444 Digas analyzer and AVL 437 smoke meter, ensures precise and reliable data collection for a comprehensive analysis of the engine's behaviour.

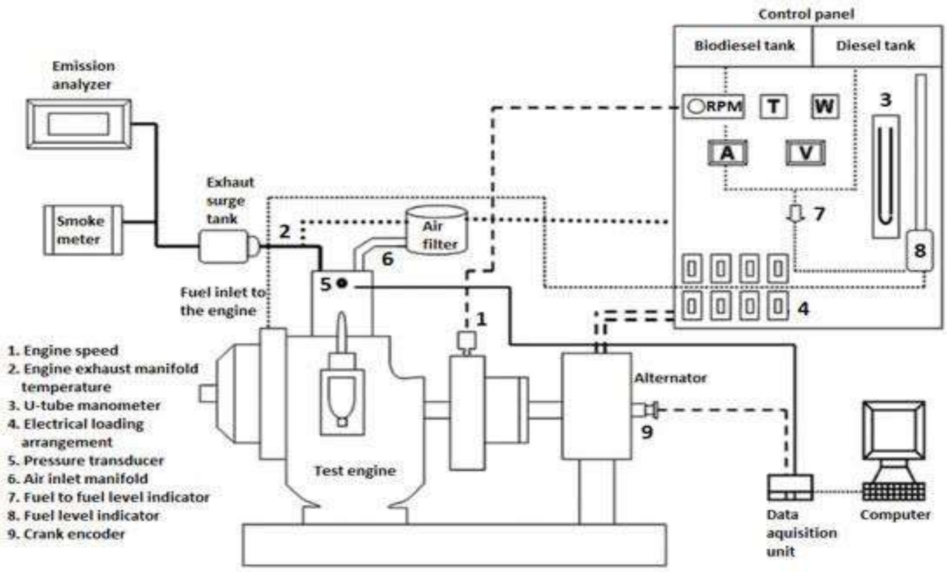


*Figure 3 Diesel engine*

## 3. Literature Review

I. *Anjana Agarwal (2016),* Biodiesel is an alternative fuel that reduces emissions of CO, HC, and particulate matter. Specific fuel consumption of biodiesel is slightly greater than petrol. Standard quality biodiesel is available, with various blends being used in different countries. Incentives and support are provided to farmers for enhancing oil seed productivity. Biodiesel is an inexhaustible and biodegradable fuel suitable for engines. Incentives and finance support are provided to farmers for oil seed production.

II. *Amish p. Vyas, N. Subrahmanyam (2018),* Conversion of Jatropha oil reached over 84% under specific conditions. Efficient mixing of reagents is essential for high conversion of oil. Increase in reaction temperature leads to increased conversion. Catalyst can be reused at least three times. Conversion initially increases with catalyst amount, then decreases. Alumina loaded with potassium nitrate is a strong solid base catalyst for transesterification.

III. *Gaurav paul, Ambarish Datta (2013),* Performance and emission characteristics of a diesel engine fueled with jatropha biodiesel were investigated. Brake specific fuel consumption (BSFC) increased and brake thermal efficiency decreased with jatropha biodiesel. NOx emissions increased with load and use of biodiesel. Combustion characteristics showed an increase in peak cylinder pressure and a decrease in ignition delay period with biodiesel blend. Smoke and PM emissions decreased with biodiesel blend. jatropha biodiesel decreases torque and brake thermal efficiency in a diesel engine and Jatropha biodiesel causes higher carbon dioxide emissions at the tailpipe.

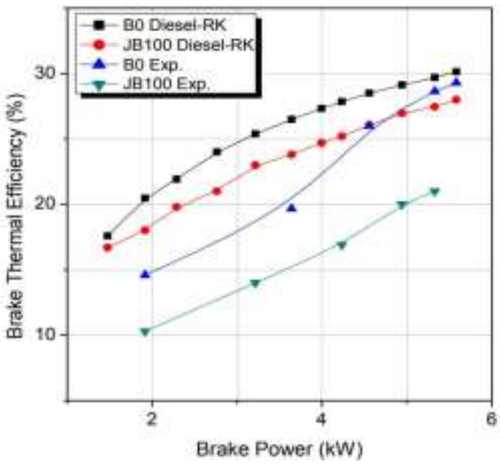


*Figure 4 Brake Power Vs Thermal Efficiency*

IV. *Nitin Shrivastava, Devanshu Shrivastava (2018),* Biodiesel can be a good replacement for conventional diesel fuel. Alumina nanoparticles improve the performance of biodiesel and diesel engines. Performance parameters (thermal efficiency, fuel consumption) compared for different fuels. Emission parameters (HC, CO, NOx, smoke) compared for different fuels. Emission characteristics of biodiesel are better than diesel, except for NOx. Nanoparticles reduce CO, HC, and smoke emissions in biodiesel engines. Nanoparticles can be a solution for issues in diesel and biodiesel operations [4].

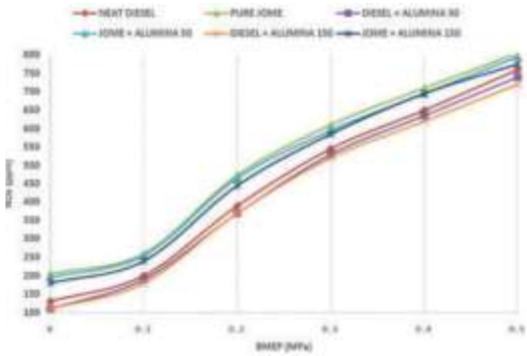

*Figure 5 BMEP Vs $NO_x$*

V. *Prabu Arockiasamy, Ramachandran Bhagavathiammal Anand (2015),* Percentage reduction of NO by 9% for JBD30A test fuel Percentage reduction of unburned HC by 33% for JBD30A test fuel - Percentage reduction of CO by 20% for JBD30A test fuel and Percentage reduction of smoke opacity by 17% for JBD30A test fuel, Percentage reduction of NO by 7% for JBD30C test fuel. Percentage reduction of unburned HC by 28% for JBD30C test fuel - Percentage reduction of CO by 20% for JBD30C test fuel Percentage reduction of smoke opacity by 20% for JBD30C test fuel. Both test fuels showed a 5% increase in brake thermal efficiency compared to neat biodiesel.

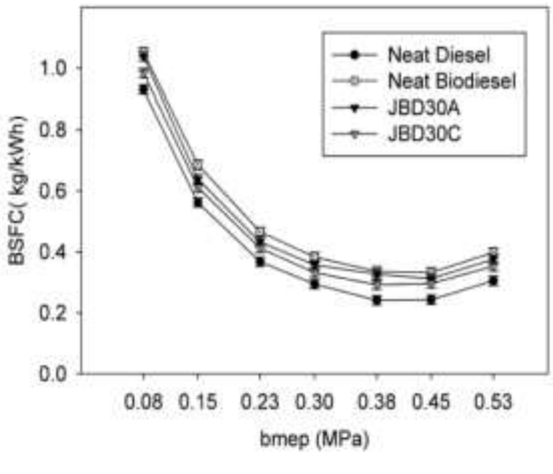


*Figure 6 BMEP Vs BSFC*

VI. *A. Anderson, M. V. Ramanana, A. Prabhu, J. Jaya Prabakara (2019),* NOx emissions slightly increase due to high peak pressure and heat liberation. Thermal efficiency significantly enhances with lower fuel consumption. Modified fuels reduce harmful emissions from unmodified diesel engine. JME biodiesel can be used in a diesel engine without modifications. CO, HC, and smoke emissions decrease significantly with $TiO_2$ nanoparticle addition. Catalytic activity and increased surface area to volume ratio contribute to emission reduction.

VII. *Bhupendra Singh Chauhan, Naveen Kumar (2011),* Ignition of Jatropha biodiesel starts earlier than diesel fuel. Maximum cylinder gas pressure is lower for biodiesel-based fuels. Biodiesel has higher cetane index than conventional diesel fuel. Brake thermal efficiency of Jatropha biodiesel and its blends is lower than diesel fuel. Brake specific fuel consumption of Jatropha biodiesel and its blends is higher than diesel fuel. Unburned hydrocarbon emissions are lower for Jatropha biodiesel and its blends.

VIII. *Jincheng Huang, Yao dong Wang (2010),* $CO_2$ emissions are lower for diesel fuel compared to Jatropha biodiesel and its blends. Biodiesel derived from Jatropha and its blends can be used in a conventional diesel engine without modification. Emissions such as CO, smoke density, and HC are reduced with Jatropha biodiesel, Oxides of nitrogen emissions are higher with Jatropha biodiesel compared to diesel.

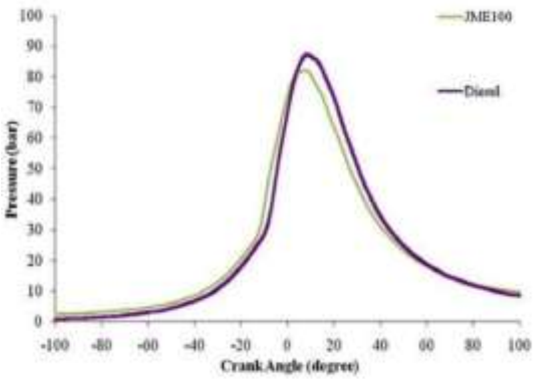


*Figure 7 Crank angle Vs Pressure*

IX. *Ambarish Datta, Samiddha Palit and Bijan Kumar Manda (2013),* Ternary blends with heptanol can be used as sustainable fuel for diesel engines, Addition of 40% heptanol improves engine performance and lowers fuel consumption. Ternary blends reduce CO and UHC emissions compared to diesel. Higher blend percentage of heptanol increases smoke opacity. Ternary blends result in higher NOx emissions compared to diesel. Higher blend proportion of heptanol resulted in higher BTE.

X. *Chandrapal Singh Indah, Sumit Sharma, Pushpendra Kumar Sharma (2020),* Fuel consumption slightly higher with biodiesel compared to pure diesel. Carbon monoxide and hydrocarbon emissions lower with biodiesel. Nitrogen oxides emissions mostly lower with biodiesel. Smoke emissions significantly lower with biodiesel. Chinese Pistache and jatropha biodiesel have similar engine performance and emissions. Brake thermal efficiencies of engine fueled by biodiesels are comparable to diesel.

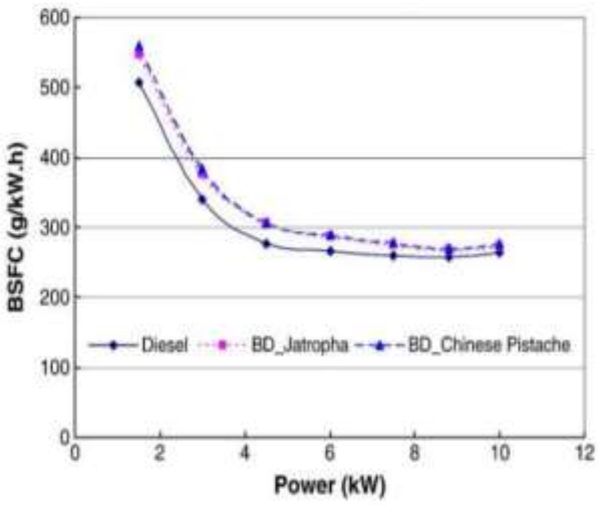


*Figure 8 Power Vs BSFC*

## Conclusion

The production of Jatropha biodiesel has gained attention as a potential sustainable alternative to conventional fossil fuels. This biodiesel is derived from the seeds of the Jatropha plant, which is known for its high oil content and ability to grow in diverse climates, including marginal lands unsuitable for food crops. However, while the cultivation of Jatropha offers promising advantages for biodiesel production, its performance on various parameters is contingent upon several intricate factors throughout the production and utilization stages [4].

In terms of production, the quality of the Jatropha seeds, extraction methods, and refining processes significantly impact the biodiesel's quality and performance. Factors like seed variety, soil quality, climate conditions, and agricultural practices influence the oil yield and chemical composition of the extracted oil. Efficient extraction methods such as mechanical pressing or solvent extraction, followed by refining processes like transesterification, are utilized to convert the oil into biodiesel. These methods directly affect the biodiesel's purity, viscosity, cetane number, and oxidative stability [6].

When considering its performance, Jatropha biodiesel exhibits both positive and challenging characteristics. It generally possesses good energy efficiency, emits lower greenhouse gases during combustion compared to traditional fossil fuels, and can be blended with diesel in varying ratios to reduce overall emissions. However, challenges arise in its performance, such as higher viscosity at lower temperatures, which may require modifications in engine design or the use of additives to improve flow properties.

To optimize Jatropha biodiesel's performance on various parameters, ongoing research and development are essential. This involves exploring advanced cultivation techniques, genetic modification for higher oil content, improved extraction and refining processes, and additive formulations to enhance cold flow properties and ensure better compatibility with existing engine systems. Addressing these challenges will be crucial to maximizing the potential of Jatropha biodiesel as a viable and sustainable alternative fuel source while mitigating its drawbacks on performance parameters.

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