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A THOROUGH ANALYSIS OF THE TWO DISTINCT BIOFUELS COMBINED TO POWER THE SINGLE-CYLINDER DIESEL ENGINE.

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Abstract

Fossil fuel reserves are being significantly depleted as a consequence of growing fossil fuel use to fulfil rising globalization-related demand. Environmental regulations that are too strict and a rise in greenhouse gas emissions have compelled scientists to look for fossil fuel alternatives. One of the substitutes that may be utilized as fuel in ordinary diesel engines without requiring any design changes is biodiesel (Methyl Ester). The goal of this study is to create high-quality hybrid methyl ester from Nahar and Karanja seeds, Undi and Waste cooking oil which are inexpensive in rural regions and cultivated on marginal soil.

Keywords:
Hybride methyl ester, Diesel engine, nano particles

Graphical Abstract:

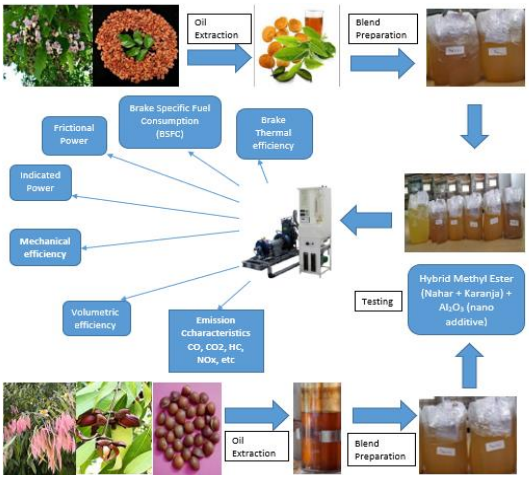

Figure 1: Sample of Nahar + Karanja Hybrid Blend

I. Introduction

1.1 Preamble

Fossil fuel reserves are being significantly depleted as a consequence of growing fossil fuel use to fulfil rising globalization-related demand. Environmental regulations that are too strict and a rise in greenhouse gas emissions have compelled scientists to look for fossil fuel alternatives. One of the substitutes that may be utilized as fuel in ordinary diesel engines without requiring any design changes is biodiesel (Methyl Ester). The goal of this study is to create high-quality hybrid methyl ester from Nahar and Karanja seeds, Undi and Waste cooking oil, which are inexpensive in rural regions and cultivated on marginal soil. To examine the qualities of blends, various proportions of N+K and U+WCO biodiesels are prepared. Moreover, it deals with the ASTM 6751-9b standards-compliant validation of the synthesized Nahar and Karanja and Undi and Waste cooking oil Methyl ester's characteristics.

1.2 Karanja and Nahar Biofuel

The last 10 years have seen a lot of interest in biodiesel, an alternative fuel that is renewable, biodegradable, and non-toxic. Although there is growing uncertainty over the production and supply of energy on a worldwide scale, environmental concerns over the usage of fossil fuels like petroleum products, particularly diesel fuel, have increased dramatically. Producing biodiesel from used fats and oils has lower costs than using fossil fuel, and another way to save costs is to optimize the process factors that influence the production and purity of biodiesel.[1] Many trees, including the jatropha (jatropha curcus), mahua (madhuca indica),Karanja (pongamia pinnata) pilu (salvodara oleoids), nahar (mesua ferralina), kokam (garcinia indica), rubber seed (heave brasilensis), undi (Calophyllum inophyllum) among others, bear oil in India.[2] Pongamia pinnata has been identified as one of the most appropriate species among those that can produce oil as an energy source that takes the form of biofuel thanks to a number of positive traits including its hardiness and high oil recovery. Using Nahar oil (Mesua ferrea Linn) as a possible source of biodiesel is another option. Throughout the Himalayas from Nepal eastward, in North-Eastern India, the Deccan Peninsula, and the Andaman Islands, you may find Nahar oil trees, which range in size from medium to huge and have short rhizomes.[3] The main purpose of making the hybrid blend of karanja and Nahar is that the properties and result it have regarding the performance and emission characteristics. The experimentation results of Pongamia pinnatta shows that it lowered CO, smoke density, and HC emissions compared to diesel. Complete fuel combustion may reduce emissions. The findings imply that biodiesel from non-edible oils like Karanja may be an effective diesel engine alternative and may be important in the future, notably for addressing energy needs in agriculture, industry, and transportation.[3] In case of nahar fuel the results are at full load, B30 and B40 blends' BTE declined by 1.64% and 1.83% compared to diesel fuel, but their BSFC rose by 5.07% and 6.76%. B30 and B40 reduced CO, HC, NOx, and smoke by 12.66%, 17.99%, 8.31%, and 10.61%, namely in contrast to diesel fuel. [4] As the properties of Karanja and nahar oil seed possess the characteristics of non-edible seeds and have a good content of oil so it can be utilised in the blend form with diesel to check its performance and emission characteristics on single cylinder diesel engine or also on the small size agriculture engine.[5][6] The images of Millettia pinnata (Karanja) and Mesua ferrea (Nahar) and are shown indicating the fully developed tree, Fruit stage and dried seed of it respectively.

- Millettia pinnata (Karanja)

Figure1.1 Millettia pinnata fruit Figure **1.2.** Millettia pinnata dried seeds

Mesua ferrea (Nahar)

Figure 1.3 Mesua ferrea fruit **Figure 1.4** Mesua ferrea dried seeds

2. Literature Survey

2.1 Introduction To make biodiesel from raw Jatropha curcas L. oil, a two-step method comprising pre-esterification and transesterification was established. In the pre-esterification stage, the free fatty acids (FFAs) in the oil were converted to methyl esters using sulfuric acid or solid acid produced by calcining metatitanic acid as catalysts. The acid value of oil was lowered from 14 mgKOH/g-oil to less than 1.0 mg-KOH/g-oil in 2 hours under circumstances of 12 wt% methanol and 1 wt% H_2SO_4 in oil at 70C. FFA conversion was greater than 97% at 90 C in 2 hours using 4 wt% solid acid and a molar ratio of methanol to FFAs of 20:1. Phospholipid molecules were removed during preesterification; hence a separate degumming procedure was not required. The output of biodiesel via transesterification was greater than 98% in 20 minutes using 1.3% KOH as a catalyst and a molar ratio of methanol to oil of 6:1 at 64 C. The process design and operating parameters vary depending on the characteristics of the feedstock oils and the target biodiesel grade. Commercial biodiesel methods based on rapeseed oil (in Europe) and soybean oil (in the United States) have been thoroughly examined, as have the qualities of their biodiesel products. To make J. curcas L. oil biodiesel, a two-step procedure was devised. Before transesterification, FFAs in raw oil were transformed to methyl esters by pre-esterification catalysed by sulfuric acid or solid acid. Under the conditions of 12 wt% methanol in oil and 1 wt% H_2SO_4 in oil, the acid value of the oil decreased from 14.0 mg-KOH/g-oil to less than 1.0 mgKOH/g-oil in 2 hours at 70 C. Water in oil might slow down the reaction rate, and phospholipid molecules could be removed during the pre-esterifiction process. The solid acid catalyst SO_4 2/TiO_2 (ST) for pre-esterification was made by calcining metatitanic acid. It was discovered that the conversion of FFAs was greater than 97% at 90 C for 2 hours using 4 wt% ST-serial catalysts with a molar ratio of methanol to FFAs of 20:1. The output of biodiesel via transesterification was greater than 98% in 20 minutes using 1.3% KOH as a catalyst and a molar ratio of methanol to oil of 6:1 at 64 C. The transesterification process is pseudo-second-order, with a low activation Ea of 15.46 kJ/mol. [7]

Seventy-five plant species were analysed for their fatty acid profiles of their seed oils, and all of them had 30% fixed oil or greater in their seed or kernel. Fatty acid methyl esters of oils were empirically determined to have a saponification number (SN) between 169.2 and 312.5, an iodine value (IV) between 4.8 and 212, and a cetane number (CN) between 20.56 and 67.47. Oil's fatty acid methyl esters' quality as biodiesel was predicted using the oil's fatty acid composition, as well as IV and CN. Oils from 26 different plants were tested, and those with the highest fatty acid methyl ester content were determined to be the best candidates for use as biodiesel. These plants included Azadirachta indica, Calophyllum inophyllum, Jatropha curcas, and Pongamia pinnata. Eleven other species' fatty acid methyl esters also conform to the United States' strict standards for biodiesel. The potential for using these plants to produce biodiesel is high. It is generally accepted that the decreasing stocks of fossil fuel, the rising demand for diesels, and the unpredictability of the availability of these fuels have prompted several attempts to investigate plantbased fuels and plant oils and fats as fuels with promising future availability. [8] In this study, bifunctional heterogeneous catalysts were examined to generate an active and stable biodiesel catalyst from waste cooking oil. The catalysts' physicochemical characteristics were analysed using different approaches. Transesterification of waste cooking oil for low-cost biodiesel generation was examined. Increasing energy consumption, depletion of fossil resources, and environmental difficulties face researchers and scientists worldwide. The current energy situation has boosted biofuel research. Due of its intriguing properties, biodiesel may replace petroleum-derived diesel in the future. Biodiesel is made of monoalkyl esters of long chain fatty acids from vegetable oils or animal fats.[9]

Concerns about depleting oil sources and pollution have boosted the desire for a sustainable fuel. Biodiesel, made from Fatty Acid Methyl Esters (FAME), is a good diesel alternative. Biodiesel is made from edible and non-edible vegetable oils. This study examines edible and non-edible biodiesel, their composition, and standards. FA profiles of 28 edible and 40 non-edible vegetable oils were obtained. Vegetable oil and biodiesel were evaluated for sulphur content, density, viscous, flash point, cloud point, pour point, cold filter plugging point, cetane number, iodine number, heating value, acid value, and carbon residual before and after transesterification. Many academics have built predictive model to quantify biodiesel parameters to enhance manufacture. Influential variables include fatty acid profiles, FA unsaturation, and molecular weight. These qualities have inspired several models. Models quantify the link between biodiesel specs and thermodynamic or other specs. Second, we examined existing prediction models. All models' predicted errors were addressed. [10]

This study focuses on using biodiesel from three distinct catalysts (NaOH, KOH, CaO). The biodiesel fulfilled ASTM D6751 and EN standards (EN 14214). 20%, 40%, 60%, and 80% biodiesel was combined with diesel as diesel engine fuel. To comparison, the engine ran on neat biodiesel. Different loads and fuels were utilised to study diesel engine performance and emissions. In compared to diesel, B20%, B40%, B60%, B80%, and B100% biodiesel enhanced break thermal efficiency. Blends reduced emissions and fuel use. More biodiesel in the mix reduces smoke density. In this study, kusum oil-based Biodiesel was made using three different catalysts (NaOH, KOH, CaO). High-quality biodiesel is produced by examining volumetric ratio, catalytic agent kinds, and concentration. The American Standard for Biodiesel Testing Materials (ASTM D6751) and European Norm are followed (EN 14214). Different oil-methanol ratios and NaOH amounts were tested for yield. Different molar ratios, catalytic agent kinds, and concentrations affect biodiesel generation. One of the samples made with

NaOH, which yields the most biodiesel, was tested in a single-cylinder DI engine under varied load conditions to analyse its combustion characteristics and engine performance. [11]

With urbanisation and increasing living conditions, the world's energy consumption is likely to rise in the future. At this pace of gasoline usage, biodiesel will contribute significantly to the future energy needs of humans. Biodiesel may be made from edible and non-edible oil sources, however given population growth and future food and resource needs, biodiesel from nonedible oil sources is a safer and better answer. Feed for non-edible oil sources is cheaper than for edible oil sources, helping to minimise costs. Also, today's energy sources produce significant pollution, thus alternative fuel sources should emit fewer hazardous gases and cause less environmental damage if they can't eliminate pollution entirely. Future fuel demands, toxicity, and dangerous gas emissions must be considered. In this research, the emission properties of non-edible biodiesels are investigated. [12]

Tanmay Jain published a paper to study the emission parameters of biofuel produced from non-edible oil. Author specially focused on biodiesel from nonedible oil sources. In which, author studied about Jatrophacurcas, Ricinuscommunis (Castor oil), Madhucaindica –Mahua, Pongamia oil, Oleander, Kusum, Neem tree oil, Rapeseed oil, Rubber seed oil, etc. Competative emission values among considered non edible biodiesel samples are studied. In which, unburned hydrocarbons, nitrogen oxides, carbon monoxides, etc. are studied. Author concluded with following conclusions as: Neem oil is showing least NOx emissions and bitter guard seeds are showing maximum NOx emissions, whereas rapeseed oil have results close to that of diesel results. Least HC emissions are observed again with neem oil performance and which are far less than that of diesel emission performance. But HC emissions are increased in rapeseed oil as biodiesel. The important CO emissions are observed for all the sources among which, mahua oil biodiesel is showing least emissions and oleander oil is having maximum CO emissions. Similarly smoke density is also found minimum in mahua oil and maximum in oleander ground nut oil. [12]

At low loads and medium engine speeds, biodiesel emits less NOx than diesel. An experimental study on NOx emission based on biodiesel combustion was conducted. At low loads and medium speeds, high viscosity and distillation temperature negatively affect spray quality and mixture uniformity. Biodiesel's BTE and combustion temperature are lower than diesel's, reducing NOx emissions. Load increases cylinder temperature and injection pressure, while speed increases air swirl. Oxygenated biodiesel creates more reactive radicals than diesel, which accelerates combustion, enhances diffusion combustion, shortens combustion duration, and increases BTE. Biodiesel's diffusion and peak combustion temperatures are greater than diesel. Biodiesel's NOx emissions are generally greater than diesel's, unless under low loads and slow speeds. [13] Thailand promotes biofuels the most in Southeast Asia. Thailand encourages biofuels but hasn't met policy goals. This report investigates seven stakeholder groups' opinions of first-generation biofuel production in Thailand to assist policy development. Feedstock producers, biofuel producers, government agencies, automakers, oil firms, nonprofits, and end consumers were involved. It combines SWOT, AHP, and TOWS to analyse stakeholder views and offer policy development goals. Biofuel development required five policies. Promoting biofuel production and use through government policies, revising regulations to permit selling of biofuel products to other domestic companies while keeping pricing of blended biofuels below those of regular ethanol and biodiesel, working to improve farm management and advancing contract farming, continuing to expand cultivation area and yield without impacting food production and environmental sustainability, and balancing biofuel feedstocks. [14] Environmental concerns and rising fossil fuel costs have prompted the globe to seek alternatives. Straight vegetable oils in compression ignition engines are a ready option with certain restrictions and benefits, according to researchers. A critical assessment of straight vegetable oils in diesel engines is offered. A thorough historical account. We evaluate Indian and worldwide studies on using straight vegetable oils in diesel engines. Straight vegetable oils in tiny percentage mixes with diesel have showed significant potential in thermal performance and exhaust emissions, according to several studies. This is clear. Finally, a SWOT analysis is conducted based on foreign and Indian research. The review finds further research is needed. [15]

Due to the limited supply of fossil fuels and their harmful effect on the environment, many nations are turning to renewable forms of energy including solar, wind, biofuel, hydropower, geothermal, and ocean energy to assure development security. Biodiesel is a renewable, biodegradable biofuel with diesel-like characteristics. This article provides academics, engineers, and policymakers with biodiesel information. This document outlines biofuel development, feedstocks across the globe, oil extraction techniques, and biodiesel manufacturing procedures. This study compares biodiesel to fossil fuel. Finally, the combustion behaviour of biodiesel in an internal-combustion engine is addressed. Feedstock choice for biodiesel production is particularly significant since it accounts for 75% of production costs, according to research. The kind of feedstocks, origin nation, and manufacturing procedure affect the fuel's qualities before use in the engine. Most researches claim that biodiesel decreases diesel engine power but reduces hazardous emissions. The research finds that biodiesel might replace diesel fuel in diesel engines to alleviate the energy and ecological issues. [16]

Thermal efficiency, fuel consumption, and pollutant emissions from biodieselfueled diesel engines are research priorities. Rapid and accurate air-fuel mixing is key. Better injection settings and combustion chamber design may enhance biodiesel spray mixing with air. Experiments were done on a DI diesel engine with a standard jerk-type injection system and HCC and TRCC pistons. The effects of injection pressure and combustion chamber geometries on combustion, performance, and exhaust emissions were examined using a 20% POME (pongamia oil methyl ester) mix in diesel. Test findings revealed that greater injection pressure improved brake thermal efficiency and fuel economy for TRCC. Higher injection pressure improved TRCC's emission reductions. Improved combustion from enhanced cylinder airflow and high-pressure injection increased NOx (NOx). Increasing injection pressure reduced ignition delay and increased cylinder pressure and heat release rate. [17] Many researchers emphasised the necessity for operating parameter research to fit a larger percentage of biodiesel diesel mix in diesel engines without reducing performance. Compression ratio (CR), injection time (IT), and injection pressure (IP) are utilised to improve diesel engine performance and reduce emissions. In the current study, the effects of CR, IT, and IP on diesel engine performance, combustion, and emission characteristics utilising 20% biodiesel diesel mix were investigated (A20). This article also seeks optimal operating settings. At high CR (19.5), IP (250 bar), and IT (33° CA), BTE improved by 7.14 percent above initial operating settings. HC, CO, and smoke emissions were decreased 4.78, 5.54, and 2.3% from original operating settings, excluding NOx. [18]

Corn and soybean fuel blends at the required blending ratio of 20% biodiesel (C20 and S20) with conventional diesel fuel have been tested. The influence of fuel injection pressure (IP) on C20 and S20 diesel engine performance is explored. Preliminary investigations on fuel qualities show that biodiesel fuel mixes must be warmed to 60–80 C to compensate for their greater viscosity relative to clean diesel fuel. Four-stroke single cylinder air-cooled direct injection (DI) diesel engine speeds, loads, and IP of 180, 190, and 200 bar are tested. The features of maize and soybean mixed fuels alter the fuel injection system and prolong the length of fuel injection to offset biodiesel's low energy content. The main finding is that increasing the injection pressure improves engine performance (BSFC) for all tested fuels, therefore the best results are achieved at 200 bar. At these settings the fall of BSFC approach 15% (from the initial pressure of 180 bar), whereas diesel fuel Pmax values are somewhat greater than those for mixed fuels regardless of engine operating conditions. [19]

Performance, pollution, and combustion and emission characteristics of a single cylinder four stroke variable compression ratio multi fuel engine is explored and compared with normal diesel. This research established waste frying oil methyl ester as a biofuel. This research employed biodiesel made from waste sunflower oil through transesterification. Experiments were run at 1500 rpm, 50% load, and 18:1, 19:1, 20:1, 21:1, and 22:1 compression ratio. Compression ratio's influence on fuel consumption, combustion pressures, and exhaust gas pollutants was studied. Best compression ratio discovered. Compared to diesel, waste cooking oil methyl ester has a longer ignition delay, maximum pressure increase, lower heat release rate, and greater mass fraction burned at higher compression ratio. Blend B40 has the highest braking thermal efficiency at 50% load for waste cooking oil methyl ester blends and diesel. Blended fuels reduce CO, hydrocarbon, and NOx emissions. [20]

2.2 Critical Literature review:

- The study of this research presented here investigated different aspects of using biodiesel blends as an alternative to conventional diesel fuel in compression ignition (CI) engines. While biodiesel blends offer potential benefits in terms of reduced emissions. (1,2,3,4,5,6,7,8,9,10,11,12)
- This study investigates the performance characteristics of bio-diesel blends and biodiesel fuelled engines. The author focuses on the impact of mixing biodiesel petroleum diesel on smoke emissions, fuel economy, and power output (13,14,15,16,17,18,19,20,21,22)

3. Conclusion

Many researchers have done testing on non-edible oil seeds. But very few have started to do work on the combination of fuels by mixing them in volume basis proportions. The idea of mixing the blends is a good opportunity for researchers to do experimentation and get the alternate way of finding the different alternative for fossil fuels. Additionally the researchers can add the Nano particles in the blend to improve its properties which lead to the better combustion of fuel inside the combustion chamber of single cylinder diesel engine.

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