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Commercialization of biodiesel production from non-edible oil seeds using mixed base catalyst and performance study on CI Engine

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ABSTRACT

More and more industries are turning to diesel engines, driving up the need for mineral diesel. Diesel engines' exhaust is a significant contributor to air pollution. If we keep using it at our present pace, we'll run out of mineral diesel in a few years, too. Trans-esterification of renewable sources like vegetable oil, animal fat, etc., produces biodiesel, which is one of the current alternatives to mineral diesel. As of right now, the food crisis has made non-edible vegetable oils the oil of choice for biodiesel manufacturing. Several naturally occurring, non-edible oil plants provide a sufficient quantity of oil for use as biodiesel feedstock. This document presents an overview of the numerous varieties of biodiesel, including their possible sources of non-edible vegetable oils, techniques of viscosity reduction, engine performance, combustion characteristics, and emission characteristics. Researchers also look at the benefits and drawbacks of biodiesel blends and their effects on fuel efficiency.

Keywords: Biodiesel, oil seeds, CI engine, viscosity

I. INTRODUCTION

Diesel engines are becoming more popular because of their many useful qualities (high efficiency, high durability, low cost, high energy density, etc.). Diesel engines, which are ubiquitous in trucks and buses, are a major contributor to air pollution. At the same time, the present consumption rate will deplete the mineral diesel supply in a few years. There is a pressing need for a sustainable liquid fuel that can replace mineral diesel as a solution to global problems including energy security and vehicle pollution. The transesterification process may convert renewable resources like vegetable oil, animal fat, or algae into biodiesel, which is one of the current options. At the moment, most nations manufacture biodiesel from first generation feed stocks such soy, rapeseed, sunflower, palm, peanut, and coconut oils. Possible future food shortages due to biodiesel manufacturing using edible oil. To ensure we always have access to both food and energy, we can also make biodiesel from oils that aren't fit for human consumption. Most of the plants used to make non-edible vegetable oils are found in forests, while some of them may also be found in less productive, degraded, or barren areas of land and have no negative impact on crop yields. People will be able to supplement their incomes by collecting seeds, which might have a positive effect on the rural economy.

II. LITERATURE REVIEW

BIODIESEL PRODUCTION PROCESS REVIEW:

Chatpalliwarl, Deshpande, Modak and Thakur (2011) provided a high-level summary of the Biodiesel manufacturing facility. This article discusses a wide range of topics associated with the manufacture of biodiesel, including potential sources, potential problems, plant design, plant assessment, and evaluation. The presented work contributes significantly because it: (1) discusses key issues related to Biodiesel production plant design; (2) provides background information necessary for the formulation of the Biodiesel plant design problem; and (3) suggests a mathematical model with which to evaluate the design of such a facility. [3]

Gulab N. Jham et al.(2009) Evaluation of wild mustard (Brassica juncea L.) oil as a feedstock for biodiesel synthesis has been the subject of recent scientific study. The conventional transesterification method using methanol and sodium methoxide catalyst produced biodiesel with a yield of 94% wt. The linoleic acid (9(Z), 12(Z)-octadecadienoic; 14.2 wt.%) and the linolenic acid (9(Z), 12(Z),15(Z)-octadecatrienoic; 13.0 wt.%) accounted for the majority of the remaining fatty acids in the wild mustard oil. Methyl esters had a cetane number of 61.1, a kinematic viscosity of 5.33 mm2 s1, and an oxidative stability of 4.8 h at 110 °C (Rancimat technique). The cloud filter had a plugging point of -4 °C, the pour filter was -21 °C, and the cold filter was -3 °C. We also measured and spoke about the biodiesel's lubricity, acid value, free and total glycerol content, iodine value, Gardner color, specific gravity, and sulfur and phosphorus concentrations, to name a few. In conclusion, it seems that wild mustard oil is a viable feedstock for biodiesel production. [9].

Hanifa Taher, et al.(2011) Extracting oil from microalgae and evaluating its quality is a significant part of making biodiesel. Supercritical carbon dioxide (SC-CO2) has recently been suggested to replace traditional solvent extraction methods due to its many advantages over these methods, including being nontoxic, nonhazardous, chemically stable, and cheap. The solvent is safe for the environment and easy to distill from the final goods. Biodiesel generation reactions using immobilized enzymes as catalysts have inhibition issues, however employing SC-CO2 as a reaction medium might solve such problems. In addition, SC-CO2 facilitates straightforward product isolation. Here, we examine the differences between traditional biodiesel synthesis using first-generation feedstock, which relies on chemical catalysts and solvent-extraction, and cutting-edge methods, which prioritize the use of microalgae, immobilized lipase, and supercritical carbon dioxide (SC-CO2) as the extraction solvent and reaction medium. [11].

III. WORKING PRINCIPLE

Experimental work

Raw materials for making biodiesel included castor bean, hemp, neem, and pongame seeds. We used a German-made electric oil expeller (KEK P0015-10127) to press the oil out of the seeds of these plants. Merck (Germany) supplied laboratory grade methanol (99.9% pure), sodium hydroxide (NaOH), and anhydrous sodium sulfate (Na2SO4).

Soxhlet Extraction

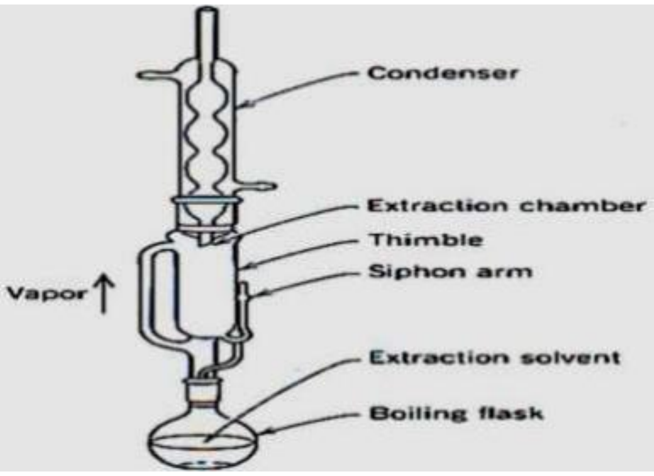
It is a continuous process of liquid extraction from solids. A thimble, acting as a kind of filter paper, is used to collect solids by placing them inside of it while allowing only liquids to flow through.Next, you'll insert the thimble into the extractor. A condenser collects the boiling vapors produced by heating the organic solvent in reflux, and the thimble is filled to capacity when the vapors fall back to earth. You need to keep doing this until you've removed all you can from the solids [37]. The components of a Soxhlet extractor are as follows. [54],

1) Soxhlet Extractor

2) Mantle Heater (Electric)

3) Water Condenser

4) Flash Evaporator



3.1 Transesterification

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Transesterification of seed oils into fatty acid methyl esters (FAME) needs, on a mass basis, raw oil, 15% methanol, and 5% sodium hydroxide. However, as transesterification is an equilibrium reaction, a large amount of alcohol is necessary to push the process to its final end.To make FAMEs, the vegetable oil underwent a chemical reaction with an alcohol in the presence of a catalyst. The transesterification procedure yielded glycerol as a byproduct (Rao et al., 2008). A two-liter round bottom flask fitted with a reflux condenser, magnetic stirrer, thermometer, and sample outlet was used for the transesterification procedure. Drying out the moisture in one liter of crude oil requires heating it to 120 degrees Celsius. We used 0.34%, 0.67%, and 1.35% (w/w) NaOH as catalyst for the transesterification process between methanol and oil at a 6:1 molar ratio. We kept the temperature at 60 degrees Celsius and the stirring speed at 600 revolutions per minute for two hours to ensure a complete reaction. The resulting mixture was brought down to room temperature, at which point the two phases could be separated (Plates 1-4). Biodiesel was located in the top phase, whereas glycerin (a byproduct) was located in the lower. Some entrained methyl esters and partial glycerides are present, as well as the soap generated during the synthesis and any leftover catalyst in crude biodiesel.

Table 1: List of non-edible oil plants and oil content percentage (Atabani et al. 2013).

Sl No.	Plant	Botanical Name	Oil Content (Seed), %	Oil Content (Kernel), %
1	Jatropha	*Jatropha curas*	20- 60	40- 60
2	Karanja	*Pongamia pinnata*	25- 50	30- 50
3	Mahua	*Madhuca indica*	35- 40	5 0
4	Polanga	*Calophyilum inophyllum*	65- 75	2 2
5	Neem	*Azadirachta indica*	20- 30	40- 50
6	Castor	*Ricinus communis*	46- 55	-
7	Soapnut	Sapindus mukorossi	2 3	-
8	Moringa	*Moringa oleifera*	4 0	-
9	Jojoba	*Simmondsia chinensis*	45- 55	-
10	Karabi	*Thevettia peruviana*	-	6 7
11	Kusum	*Schleichera oleosa*	60- 70	-
12	Seamango	*Cerbera odollam*	5 4	6.4
13	Rubber	*Hevea brasiliensis*	50- 60	40- 50
14	Tobacco	*Nicotiana tabacum*	36- 41	1 7
15	Putranjiva	*Putranjiva roxburghii*	41- 42	-
16	Croton	*Croton megalocarpus*	40- 45	-
17	Kapok	*Ceiba pentandra*	24- 40	-
18	Poon	*Sterculia feotida*	50- 60	-

Fig 1:Trasesterification process

IV. ENGINE PERFORMANCE

The effectiveness of both unadulterated biodiesel and biodiesel blends in various diesel engines is the subject of several studies. This section provides a concise overview of many various metrics, including brake thermal efficiency (BTE), brake specific fuel consumption (BSFC), peak pressure, heat release rate, and exhaust gas analysis.

Engine performance and Emission Tests

Water dynamometer and a water-cooled, direct-injection, four-stroke diesel engine producing 5 horsepower. We've made some adjustments to the gasoline distribution system. It was necessary to employ a two-way control value in the test rig to quickly switch between the conventional petro diesel oil and the test fuels. Using a portable tachometer, we determined the shaft speed at each loading. To determine the volumetric flow rate, we observed how long it took for 50 ml of gasoline to pass through a graded measuring device and into the injector pump while operating at atmospheric pressure. In this configuration, we successfully tested blends of petro diesel with pongamia pinnata SVO, jatropha curcus SVO, pongamia pinnata methylester, and petro diesel with jatropha curcus methylester. For the sake of comparison, we also ran tests using approved petro diesel fuel. Power output was varied in all instances by applying different loads to a hydraulic dynamometer, but engine speed remained rather stable at about 1500 RPM. Exhaust emissions from vehicles running on Petro diesel, B15, and B20 fuel made from Pongamia Pinnata and Jatropha curcus methylesters were analyzed for carbon monoxide and hydrocarbons using an infrared exhaust gas analyzer.

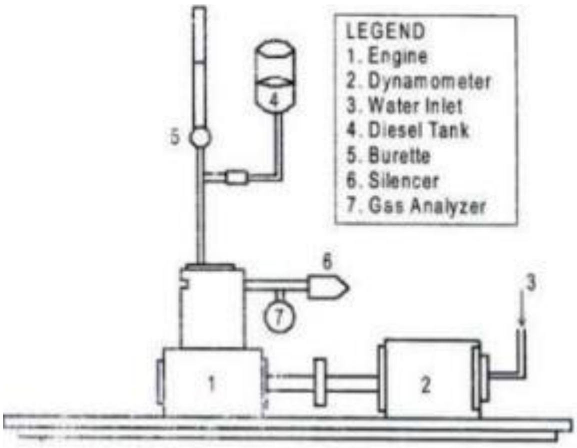

Fig 2: Engine Setup

Table 2: Specifications of engine

Manufacturer	Kirloskar
Number of cylinder	1
Power 5 HP	5HP
Stroke	110 mm
Volume displaced	553 cc
Compression Ratio	16:1
Loading device	Hydraulic Dynamometer
Cooling system	Water cooled

Fig.3 Front view of VCR 4-stroke diesel engine

Fig.4 Side view of VCR 4-stroke diesel engine

Study of performance characteristics of the engine

We started with pure diesel and ran our performance tests at 2, 4, 6, 8, and 10 kg to provide a baseline. We began doing performance tests on blends B20, B30, and B40 after receiving the necessary results on the computer in the form of Excel. For the efficiency evaluation, we tried out 16, 17, and 18-to-1 compression ratios. The computer performance test revealed the following outcomes for the various fuels tested.

Mechanical Efficiency

Figured below: Mechanical efficiency is shown along the y-axis, and braking power along the x-axis. Furthermore, we used the chart to evaluate the efficacy of various diesel blends. Diesel and all biodiesel mixes are shown to have similar mechanical efficiency. It's clear that all biodiesel mixes effectively convert fuel energy into useful mechanical motion..

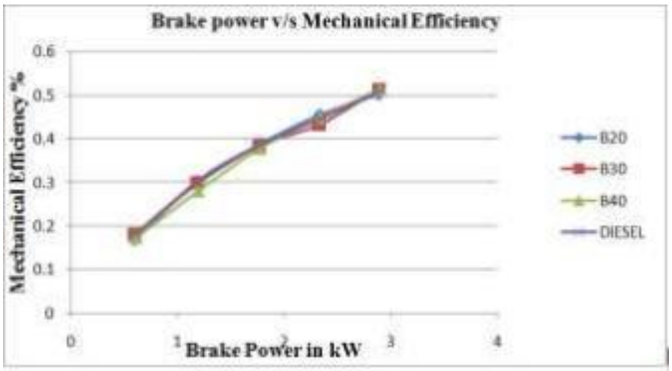

Fig 5 ME Vs BP

See below for some numbers: The y-axis shows BSFC, while the x-axis shows brake power. Based on the data shown, blend B40 has the lowest fuel economy. The B40 blend has the highest brake thermal efficiency of any blend since it uses the least amount of gasoline. Greater fuel consumption is a result of the low compression ratio.

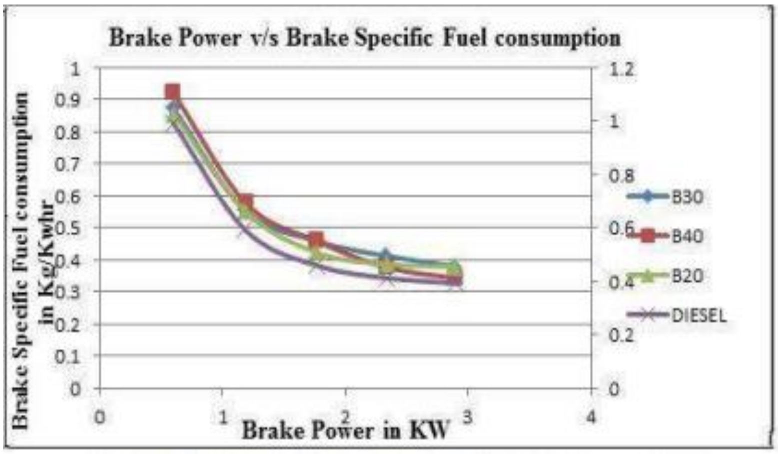

Fig 6 BSFC Vs BP

Brake Thermal Efficiency

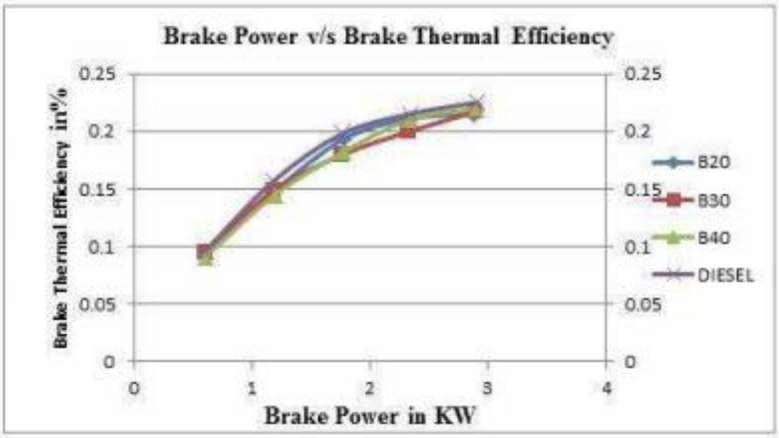

Fig 7 BTE Vs BP

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The y-axis shows the thermal efficiency of the brakes while the x-axis shows the brake power. An increase in braking power results in a rise in brake thermal efficiency of the engine, and we compared this trend to the graphs of several diesel blends. Compared to Diesel, Blend B40 contains the most BTE. Blend B40 seems to have the highest efficiency of all the mixes tested.

Indicated Thermal Efficiency

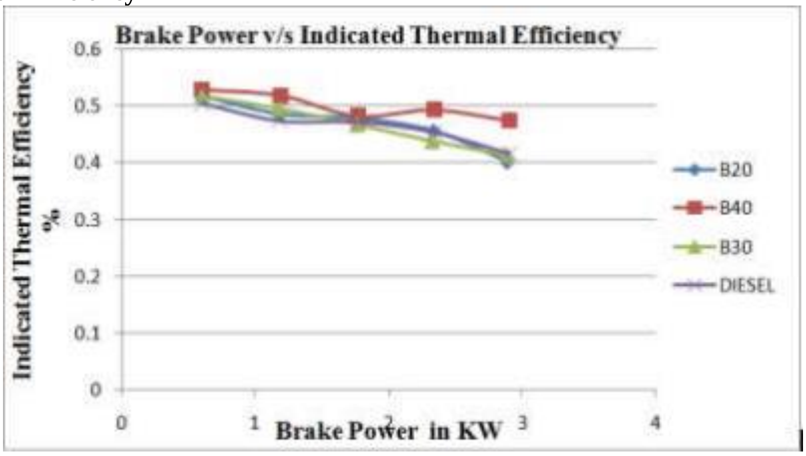

Fig 8 ITE Vs BP

The y-axis shows the suggested thermal efficiency, while the x-axis shows the brake power. We also compared various diesel blends. The graph shows that when braking power increases, thermal efficiency of the engine falls. Diesel's closest equivalent is Blend B30's ITE. This shows that blend B30 has the highest efficiency of all the mixes.

Indicated Power

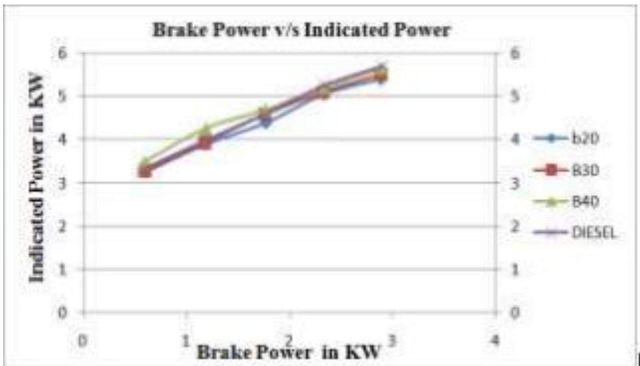

Fig 9 IP Vs BP

Figure 10 shows a comparison between brake power (x-axis) and indicated power (y-axis). We also compared various diesel blends. The graph clearly displays the trend of indicated power, which indicates that as brake power rises, so does indicated power.
IP's Blend B40 is the closest it gets to Diesel. This data demonstrates that Blend B40 is the most effective of all the blends tested.

V. CONCLUSIONS

This research investigates the many uses of biodiesel made from oils that aren't suitable for human consumption, and draws the following conclusions:

1. Biodiesel made from non-edible oils is preferable since it does not pose a threat to global food supplies.

2. As a cleaner alternative to mineral diesel, it has the potential to reduce air pollution and become an important energy source in the years to come.
3. In theory, they may work, and they wouldn't need any adjustments to the diesel engine's fuel system.
4. Using biodiesel allows for enhanced air pollution management since it significantly reduces CO, HC, and smoke emissions.
5. Blends of biodiesel with a lower proportion of biodiesel have almost the same physicochemical qualities as mineral diesel and may be used as a replacement for mineral diesel in engines without any adjustments being made to the systems that run on either fuel type.
6. Because feed supplies are often found in rural or forested regions, the usage of biodiesel would enhance the economic situations of rural or tribal people.
7. The decrease in crude oil imports will also benefit the country's economy.

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