PAGES: 223-233
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Ultrasonic Assisted Biodiesel Production From Waste Cooking Oil And Study Of Performance Characteristics In A Single Cylinder Diesel Engine

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ABSTRACT

The rapid expansion of both human settlements and the spaces they occupy is largely attributable to the widespread availability and widespread use of automobiles, industrial machinery, and other forms of cutting-edge technology. Which result from our use of the abundant fossil fuels found in the Earth's crust. As the price of crude oil continues to rise in response to rising global demand, several governments are exploring alternate fuel sources. Use of crude oil byproducts like motor spirit and high-speed diesel has a negative impact on the environment, which is only one of many reasons why governments are searching for cleaner energy sources. Many experts are now investigating the potential of biodiesel as a best alternative to high-speed diesel in order to conserve our planet for future generations, who must be free from earth exploitation for crude oil. For my project, I used ultrasonic methods to refine used cooking oil into biodiesel. Many eateries have leftover cooking oil that they discard after use. Oils like palm oil and coconut oil are the mainstays of the culinary world. In order to make biodiesel, we are utilizing palm oil in our project experiment. In addition to the photographic washing procedure, we are also considering the transesterification method.

Key words: Biodiesel, Ultrasonic technology, Transesterification, Photographic washing, Waste cooking oil

I. INTRODUCTION

The fast growth of the global human population, together with the corresponding rise in the consumption of goods and services, is a major contributor to the world's current energy issues. However, nations are increasingly concentrating on developing viable alternatives to fossil fuels. For the simple reason that our natural supplies of fossil fuels are dwindling. In order to provide the essential energy demands of humans in order to sustain their everyday lives. Many nations' experts have previously gone through many techniques and processes to identify alternatives to fossil fuels, therefore it is possible to go from using fossil fuels to using renewable energy sources. While high-speed diesel is a fossil fuel and a byproduct of crude oil, some people have found that biodiesel is the most dependable product. Which is mined from the soil and directly contributes to environmental degradation as a result of human usage. Biodiesel, when used in place of diesel, reduces environmental damage. Vehicles that run on diesel may release toxic gases such hydrocarbons, nitrogen oxides, and carbon monoxide. However, the use of biodiesel in cars reduces the emission of these pollutants. It is possible to produce biodiesel without harming the environment or any living organisms, and unlike conventional diesel, it does not need the extraction of any natural resources. Crude oil extraction may have little immediate environmental impacts on marine life, but it will have long-term repercussions for our children and grandchildren. But the hopes of modern scientists rest on the idea that even a modest improvement may have far-reaching consequences. Our goal is the same, and we're starting to get there by finishing this project. In this experiment, we used palm oil, which is a kind of waste cooking oil that comprises a complicated triglyceride structure.

We use transesterification to create the biodiesel. Transesterification generates glycerol as a byproduct from the reaction of a lipid and alcohol to make ester. Biodiesel is produced from harmless biological resources like vegetable oil, animal fats, or even waste cooking oil and is chemically a blend of methyl esters with long chain fatty acids. To make ester and glycerine, transesterification typically uses methanol or ethanol. The method typically has three distinct phases, the third of which involves the addition of a catalyst to the reaction. Diglycerides are the byproduct of the first triglyceride step. The second step involves converting diglyceride into monoglyceride. The conversion of monoglyceride to glycerine occurs in the third step.Esters are the end product of all reactions. Alcohol and oil have a stoichiometric ratio of 3:1. In most cases, however, adding additional alcohol will enhance the reaction and provide the desired result. We employ a photographic washing process and an ultrasonic technology to create biodiesel, and we've already used the latter to power a one-cylinder diesel engine. Using the engine's emission profile, researchers analyzed the efficiency of a single-cylinder engine. At the outset of the project, we looked into the relevant references.

II. LITERATURE REVIEW

Dr. Tapaswy Muppaneni at 2015

Using ethanolysis with hexane as a co-solvent, he was able to effectively generate biodiesel, demonstrating that biofuel has become a very promising, substitutable alternative fuel. Minimizing the taut process parameter and maintaining a high quality biodiesel production is the goal of this ethanolysis process. And he ran experiments to determine the impact of factors like reaction temperature, molar ratio (ethanol to oil ratio), and reaction time on biodiesel yield, ultimately concluding that these factors are best controlled for at a temperature of 3000C, for a reaction time of 20 minutes. And he compared the biodiesel he created from recycled cooking oil to the ASTM standard, finding that it really achieves the required characteristics.

Mihir J. Pate, Tushar M. Pate, Gaurav R. Rathod at 2015

He made biofuel from used cooking oil by blending it with other oils, and then tested it in a single-cylinder diesel engine. The B20 mix produced the lowest BSFC and the best Mechanical Efficiency of the three.

B. K. Abdalla at 2013

This study elucidates the fundamentals of turning burned cooking oil into biodiesel. The oil is gathered mostly from local hotels, catering services, cafeterias, etc., and is used to lower the price of biodiesel manufacturing. The production of biodiesel, which he says ranges between 92 and 94 percent depending on the quality of the raw oil he collects, has a kinematic viscosity of 5.5091 mm2 s-1 at 400 degrees Celsius, a flash point of 1740 degrees Fahrenheit, and a cetane number of 4820.

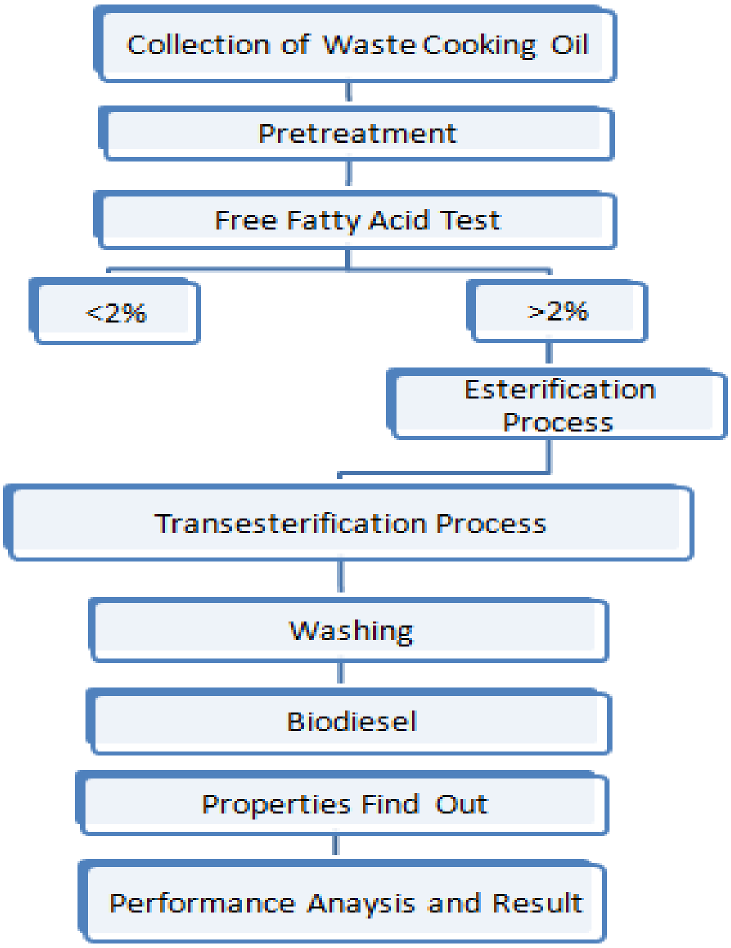
Suresh Kumar P at 2012

This paper demonstrates that used cooking oil may be successfully used as a feed stock for biodiesel synthesis, and he tests the fuel in a diesel engine to back up his claims. He finds that, for a biodiesel engine running at full load, increasing the fuel injection pressure improves brake thermal efficiency while doing so for a diesel engine running at full load has the opposite effect, decreasing brake thermal efficiency and steadily increasing carbon monoxide emission.

CONCLUSION FROM LITERATURE

The literature review we conducted led us to the conclusion that used cooking oil has great potential as a feed stock for biodiesel production from both an economic and environmental perspective. Since sunflower oil is an edible oil, the cost of edible oil, the formation of edible oil seeds, and the requirement of land to form all contribute to the high cost of producing biodiesel.

III. METHODOLOGY



PRODUCTION OF BIODIESEL FROM WASTE COOKING OIL

To create biodiesel from vegetable oils, animal fats, or discarded cooking oil, a number of different processes are possible, including transesterification, alcoholises, and supercritical methanol. Transesterification is the most common catalyst-based process for converting waste oil into industrial biodiesel. Transesterification in biodiesel synthesis often uses a strong alkali catalyst since it uses less catalyst and responds more quickly than a strong acid catalyst.

THE PROJECT WAS CARRIED OUT IN THREE PHASES AS SHOWN BELOW.

1. As a first step, we amassed pretreated waste cooking oil from area eateries and cafeterias, as well as catering companies and the like.
2. Second, we created the blends B20, B30, and B40 by converting waste cooking oil (WCO) into biodiesel by transesterification utilizing ultrasonic aided technology (UT).
3. Third, we tested the mixes' performance and compared the results to those of normal diesel at various compression ratios.

PAGES: 223-233
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(A) CONVERSION OF WASTE COOKING OIL (WCO) INTO BIODIESEL BY TRANSESTERIFICATION USING MECHANICALSTIRRER (MS) METHOD

The process of transesterification may convert many different types of oil, including vegetable oils, animal fats, and used cooking oils, into biodiesel. Conversion to fatty acid alkyl esters occurs when glycerides and alcohols react (usually in the presence of a catalyst). As seen in Figure, transesterification occurs.

Fig 1: Transesterification process

Fig 2: Photograph of washing process of biodiesel

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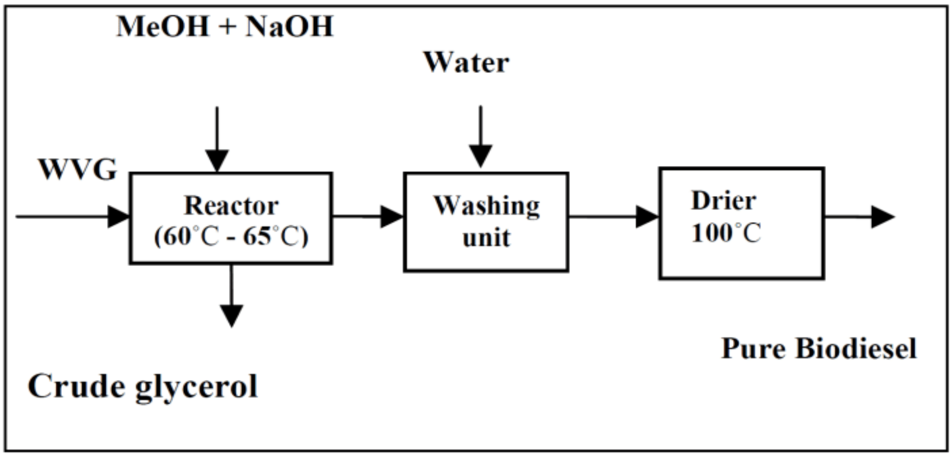

We need to transfer the liquid to a 500 ml or larger beaker and give it a good swirl. In only a few minutes, magnetic stirrer heated 400 mL of oil.

Below 500 revolutions per minute, we put the magnetic pellet to action. We keep a close eye on the oil temperature using a thermometer.

After the oil reaches 40 degrees Celsius, we add the methanol. We recommend heating the solution.

To dissolve 3.5 grams of sodium hydroxide, or 12 pellets of NaOH, we require 125 milliliters of methanol. We turn down the heat when the oil reaches 56 to 58 degrees Celsius.

We give it an hour for everything to calm down. Separating the glycerol and methyl ester layers is evident.

We have been putting the oil into the separator's funnel. To evaporate glycerine, pour it into a separator and let it sit there. The oil and glycerin are now in separate containers.

We then refilled the funnel with oil and reinstalled it. In a separate funnel, we combine oil and hot water to neutralize soap odors. We recommend doing this twice or thrice for optimal results. We drain the oil out of the beaker and throw it away afterwards. Possible elimination of any remaining water by heating the oil to 90 degrees Celsius. Producing biodiesel from the spent oil.

The amount of free fatty acids (FFA) in the used cooking oil was determined by titrating the oil with a chemical indicator called phenolphthalein. The titration determined the needed quantity of NaOH to complete the reaction. Using the titration reading in milliliters (ml), we calculated that (3.5+X) gram of NaOH per liter of oil was required for the reaction. After dissolving NaOH pellets as catalyst in analytical grade methanol in a 1:3 ratio (for 1000ml of oil 300ml of methanol), the solution was added to the waste cooking oil in a conical flask and stirred vigorously to initiate the transesterification process. Adding the methoxide mixture to the oil in the round bottom flask, we kept the temperature at 70 degrees Celsius, stirred constantly with a magnetic stirrer for an hour. A water-cooled condenser was attached to the round bottom flask's mouth to reduce the rate at which methanol evaporated. After the reaction period, the condenser was taken off the round bottom flask, and the reagent was heated openly while being stirred for an additional 15 minutes to evaporate any surplus methanol that hadn't been consumed during the reaction. The solution was allowed to rest overnight in a conical separating funnel once the reaction was complete, and the two layers were then separated. Soon after the reaction began, the phases began to separate, and by the next day, they should have completely separated. After collecting the crude biodiesel and removing the glycerol layer at the bottom, it was washed with water. By using a mechanical stirrer, we were able to determine the characteristics of the methyl ester we had produced.

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B) Conversion of waste cooking oil (WCO) into biodiesel by transesterification using ultrasonic assisted technique (UT).

Fig 3: Ultrasonic bath sonicator

As mentioned above, titration was used to determine how much more NaOH would be needed to complete the reaction. Using an ultrasonic bath sonicator and an ultrasonic probe sonicator, we were able to create biodiesel through a transesterification process. We used a mechanical stirrer to do the same thing that the mechanical stirrer technique does while performing the transesterification process. However, because the probe of an ultrasonic sonicator makes direct contact with the sample, a water-cooled condenser is unnecessary and impractical. The biodiesel preparation process included three sets of amplitude temperature testing at intervals of five minutes. After using an Ultrasonic bath and a probe sonicator, we were able to determine the characteristics of the methyl ester we had produced.

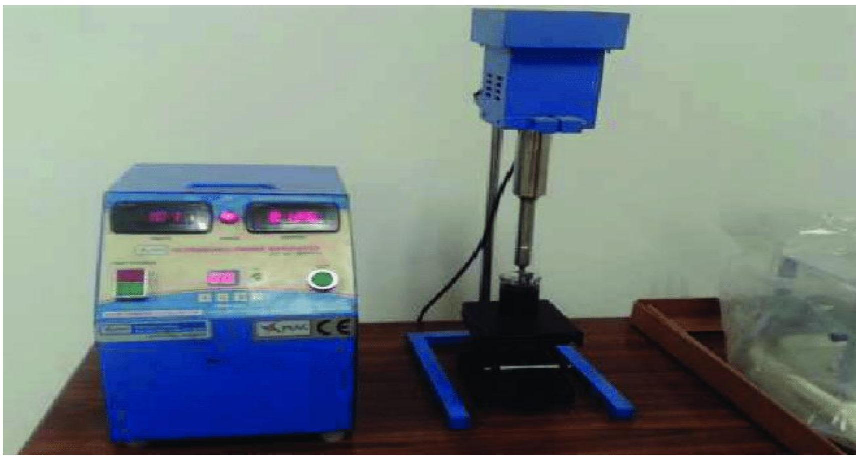

Fig 4: Ultrasonic probe sonicator

JOURNAL OF SCIENTIFIC RESEARCH AND TECHNOLOGY(JSRT) VOLUME-1 ISSUE-6 SEPTEMBER
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IV. USE OF BIODIESEL IN A SINGLE CYLINDER DIESEL ENGINE

Fig 5 Front view of VCR 4-stroke diesel engine

Fig 6 Side view of VCR 4-stroke diesel engine

The trials used a single-cylinder, water-cooled, compression-ignition engine. Full throttle produced 5.2 kW at 1500 rpm from the engine. The engine is a Kirloskar TV1, and it uses pushrods to operate its overhead valves. We kept the fuel injection time and pressure at 23 degrees before TDC and 200 bar, respectively. The engine coolant was circulating in water jackets around the cylinders, keeping the temperature steady at about 80 degrees Celsius. It was feasible to gauge cylinder pressure by attaching a transducer to the top of the cylinder. An eddy current dynamometer was used to test the engine's performance. There were four loads tried out: 25%, 50%, 75%, and 100%. The engine's efficiency and emissions were measured over a range of load and speed circumstances.

Modifying an IC engine's compression ratio during operation is possible using VCR (Varying compression ratio) technology. Changing the cylinder head will result in a different compression ratio for the engine. It is possible to adjust the cylinder head depending on the load and acceleration by employing a hydraulic system or mechanical arrangement connected to the crank shaft.

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V. 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. After compiling the necessary data for the performance test in Excel, we began running the tests on the B20, B30, and B40 blends. 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.

1)Mechanical Efficiency

The y-axis shows how efficient the brakes are while the x-axis shows how much power is being applied to them. Moreover, we used the chart to evaluate the efficacy of various diesel blends. It has been determined that diesel and all biodiesel mixes are mechanically equivalent. This means that all biodiesel mixes effectively convert fuel energy into mechanical work.

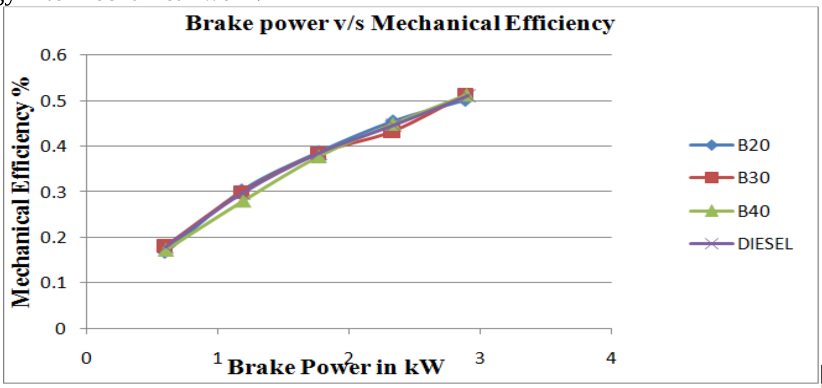

Fig 7 Mechanical Efficiency v/s Brake power

2)Brake Specific Fuel consumption (BSFC)

The y-axis in the figure below represents BSFC, while the x-axis represents brake power. Based on the data shown, blend B40 has the lowest fuel economy. When compared to other blends, the B40 has the highest braking thermal efficiency of the engine due to its lower fuel usage. Increased fuel consumption is a result of a low compression ratio..

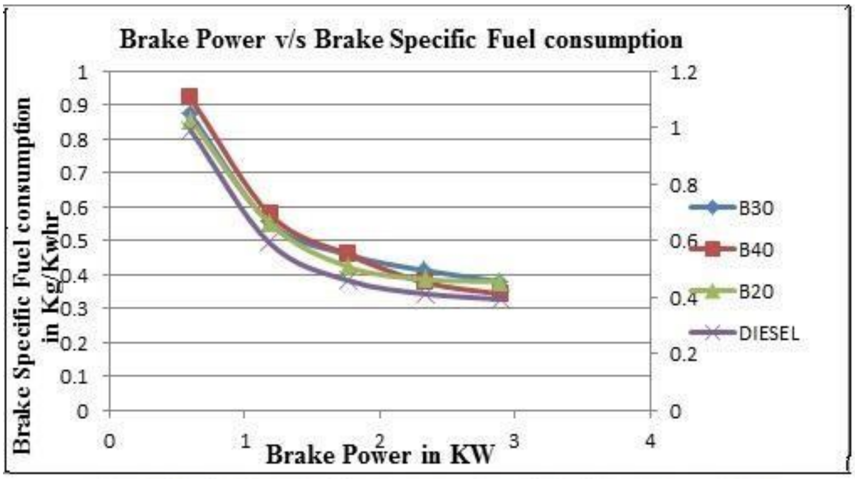

Fig 8 BSFC Vs BP

3)Brake Thermal Efficiency

The image below shows the relationship between brake power (x-axis) and brake thermal efficiency (y-axis). As you can see from the graph, where we compared various diesel blends, a rise in braking power results in a rise in the engine's thermal efficiency. Compared to Diesel, Blend B40 contains the most BTE. This shows that Blend B40 has the highest efficiency of all the mixes.

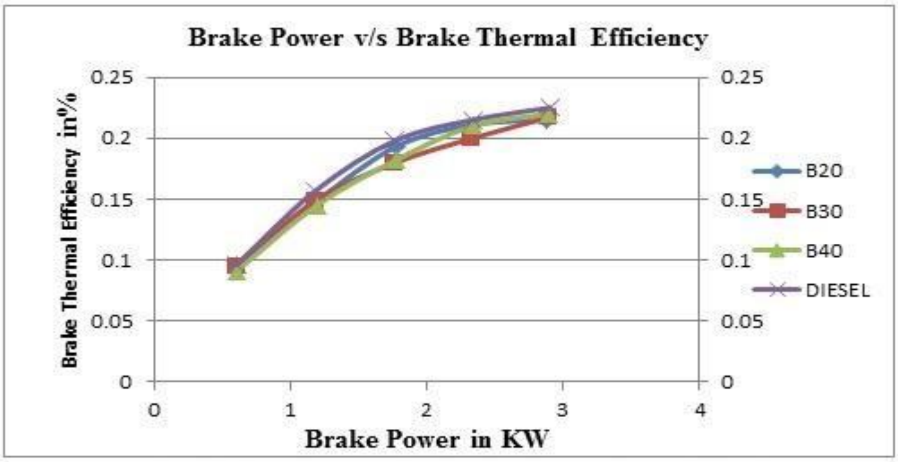

Fig 9 BTE Vs BP

4)Indicated Thermal Efficiency

Below is a graph showing the relationship between brake power (x-axis) and suggested thermal efficiency (y-axis). We also compared various diesel blends. The graph shows that when braking power increases, thermal efficiency of the engine falls. Compared to Diesel, B30 Blend ITE is most like it. This shows that blend B30 has the highest efficiency of all the mixes.

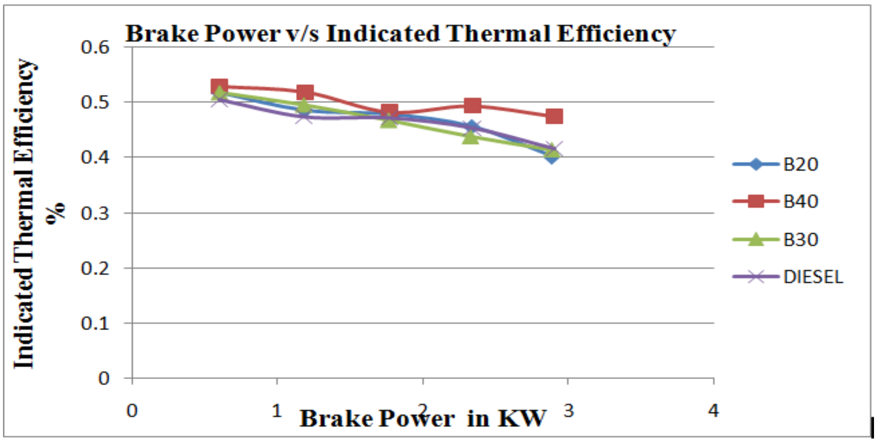

Fig 10 ITE Vs BP

5)Indicated Power

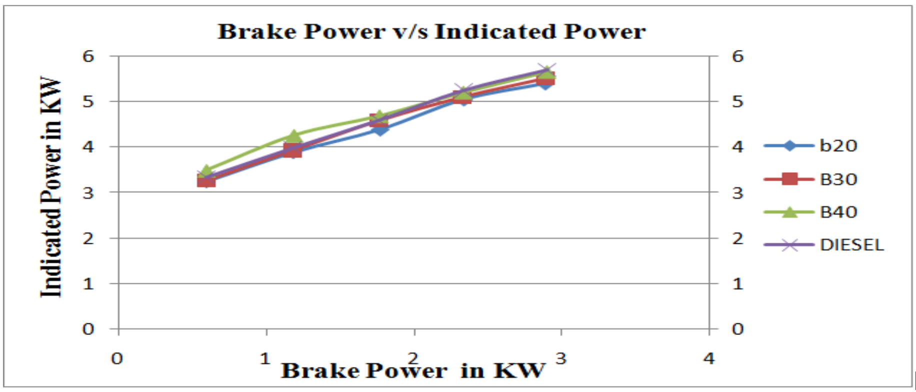

Fig 11 IP Vs BP

The x-axis in the above graph shows brake power, whereas the y-axis shows suggested power. We also compared various diesel blends. The graph clearly demonstrates the rising trend of indicated power as the braking power rises. IP is most similar to Diesel in Blend B40. This shows that Blend B40 has the highest efficiency of all the mixes.

VI. CONCLUSION

WCO is a possible alternative feedstock for biodiesel production because of its low cost compared to refined vegetable oils. It's true that every country produces a lot of used cooking oil, and if there isn't a good system in place for getting rid of it, it might contaminate the environment.
This section summarizes the outcomes of the many experiments and evaluations carried out in the lab and in the field.

- Ultrasonic probe type sonicator shortens the transesterification reaction time and improves the percentage yield compared to the other two kinds. Esterification significantly lowers the kinematic viscosity and specific gravity of WCO, two fuel characteristics.
- No temperature control is required to complete the transesterification process in as little as 30 minutes.
- While the influence of applying different amplitudes on the end of a response is not huge, it is clear that it does exist.
- Compared to blend B20 MS (mechanical stirring) and diesel, thermal efficiency is best for blend B20 UT (Ultrasonic aided method). The thermal efficiency of all three fuels is greatest at full load and gradually decreases below that point.
- When compared to blends B20 MS (mechanical stirring) and diesel, blend B20 UT (Ultrasonic aided method) has the lowest BSFC. The lower BSFC for B20 mix UT is indicative of improved combustion with biodiesel blends, leading to lower emissions of carbon monoxide and unburned hydrocarbons.
- Exhaust gas temperature for B20 UT mix has risen as compared to other two fuels with increase in load and quantity of biodiesel, which has led to higher NOx emissions in the engine for waste cooking oil biodiesel and its blends..

Therefore, it is reasonable to infer that there is a financial upside to converting used cooking oil into biodiesel. Additionally, unlike B20 blends of MS and diesel, biodiesel made using the UT technique may be blended with diesel and utilized in stationary diesel engines without requiring any modifications to the engines. Biodiesel is a renewable fuel with physical qualities similar to diesel. Using biodiesel also means less reliance on foreign crude oil and less negative effects on the environment from transportation.

SCOPE OF THE PROJECT

During the course of this study, we have come a long way toward our goals for this experimental inquiry. Improved performance with biodiesel blends is possible with further research that takes into account the following recommendations.

1. In order to make WCO biodiesel, one must first determine the optimal methanol-to-oil ratio and catalyst concentration.
2. To make WCO biodiesel, ethanol and several catalysts are required.
3. Biodiesel and its many mixes are amenable to performance and emission testing under varying conditions and loads.
4. By altering the injection pressure and injection time, researchers may examine the engine's performance and emissions while using WCO biodiesel and mixes.
5. To compare the performance and emission results of a multi-cylinder diesel engine to those of a single-cylinder diesel engine, we may conduct engine performance and emission tests.

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