IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

EXPERIMENTAL INVESTIGATION ON PERFORMANCE AND EMISSION CHARACTERISTICS OF DIESEL ENIGINE FUELED WITH PALLMYRA BIODIESEL

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Abstract-

The constant increase in the consumption of fossil fuels is consequent upon the ever-increasing population in the present days. The Greenhouse Gas emissions from these fossil fuels are constantly degrading the planet and causing global warming and other pollutant emission-related problems. As such, the situation demands an alternate source of energy that can be used to overcome the forecasted future energy crisis. In addition, if the energy source is clean and renewable, it will also reduce environmental issues. In this quest for an alternate and renewable energy resource, scientists have come up with a variety of options among which biodiesel-diesel blends as alternative fuels have become a popular option and have the attention of many researchers.

In this work biodiesel production from palmyra seeds oil has been synthesized by a transesterification process with the influence of catalyst concentration, methanol is used to produce the palmyra oil methyl ester from the palmyra crude oil which is extracted from the palmyra seeds by the application of mechanical pressing operation. Preliminary tests will be conducted with Palmyra Oil Methyl Ester blends (POME10, POME20, POME30, POME40) of palmyra biodiesel on a diesel engine at a fixed engine speed of 1500 rpm, no load to full load, and at a compression ratio of 16.5:1. The impact of various load on fuel consumption and exhaust gas emissions will be examined. The current work is to explore the impact of biodiesel blends on the efficiency and emissions of diesel engines.

KEYWORDS: Palmyra oil, Transesterification, Palmyra oil methyl ester (POME), Biodiesel, Performance, Emission.

1. INTRODUCTION

The exponential increase in energy demand in the past few decades are be due to rapid urbanization and industrialization. Urbanization of developing countries practically relies on energy (i.e. renewable and non-renewable) sources. Fossil fuels are the primary source of fulfilling such energy requirements. Industries and transport sectors are dependent primarily on fossil fuels. The exhaustion of fossil fuels in the next few decades could increase costs and the associated impact on global warming and greenhouse gas emissions are the primary reasons that require extensive research on alternate fuels for the future. Biodiesel seen be the potential alternative to diesel fuel that compensates for high energy demand. In addition, the use of biodiesel does not seek a major modification to the existing diesel engine. Biodiesel production from renewable energy sources (oils derived from plant and animal fat) possesses excellent features such as biodegradability, nontoxic, carbon neutral, and eco-friendly.

In recent years, edible (soybean, sunflower, coconut, palm, pine, and so on) and non-edible (mahua, Karanja, jatropha, cotton seeds, algae, etc.) oils are used as a potential source for the production of biodiesel. India has the world's second-largest population and the fulfillment of huge energy demand with edible and non-edible oils has been criticized due to its low sustainability, shortfall of agricultural land, and conflict with food and fiber production. The feedstock (raw material) price is a key factor that accounts for approximately 70- 95% of total biodiesel production cost. Edible and non-edible oils grown particularly for biodiesel production are treated as uneconomical due to their high raw material cost. Fish oil (i.e. residue after extraction of omega-3 fatty acids) is used as a source for biodiesel production and is treated sustainably due to its minimal processing steps.

In comparison with conventional diesel fuels, biodiesels promote more complete combustion and thus effectively reduce emissions of particulate matter (PM), carbon monoxide (CO), and smoke. However, the use of biodiesel increases the content of Nitrogen oxides (NOx) in combustion products. This higher NOx emission is due to the comparatively high temperature inside the cylinder owing to the combustion of biodiesel and the higher oxygen content of the fuel. Biodiesel is considered one of the promising alternative resources for diesel engines, especially from non-edible oil feedstock as well as its potential to be a part of a sustainable energy mix in the future. The advantages of non-edible oils as diesel fuel are liquid nature portability, ready availability, renewability, higher heat content, higher flash point, higher cetane number, lower sulfur, and aromatic content as well as biodegradability. The biodiesel produced from non-edible feedstock as well as biomass can overcome the socio-economic disadvantages of current biodiesel technology and be able to address many of the challenges of climate change and the energy crisis. So, we perform an Experimental Investigation on the Performance and Emission Characteristics of a Diesel Engine Fueled with Palmyra Biodiesel. To get a bio-diesel with good performance and less emission. In the experiment, we test the performance and emission characteristics of Palmyra Bio-Diesel with different blends of POME10, POME20, POME30, and POME40. The tests are conducted on a 4-Stroke Single Cylinder Diesel Engine at constant speed by varying loads from no load to full load conditions and the readings are analyzed to find which blend gives the best performance and low emissions.

Palmyra Oil

The palmyra palm’s name derives from the Greek words “Borassus” which means “fruit with a leather covering” and “Flabellifer” which means “fan-bearer”. Female inflorescences produce spherical fruits ranging in diameter from 15 to 20 cm and averaging 1.5 kilograms. Each fruit has one to three hard-coated seeds, rarely four, surrounded by yellowish edible mesocarp pulp. The sequence of palmyra oil preparation from the palmyra fruits is shown in figure 1.1. When a seed is young, its gelatinous endosperm is delicious and, it becomes hard, ivory-like, and hollow as it matures. Eventually, the immature seed hardens and generates a fibrous kernel that aids in the extraction of oil. Palmyra palm nuts include 0.08 percent ash, 0.18 percent protein, 0.26 percent fiber, 0.09 percent lipids, and 26.18 percent amylase. Annually, 100 million Palmyra fruits are harvested worldwide; however, only around 5 to 10 million are consumed; the remaining is dried. Palmyra oil is derived from dried Palmyra seed kernels manually or mechanically. Oil extraction methods include mechanical extraction, solvent extraction, and enzymatic extraction. The various physicochemical properties are determined as per the ASTM standards and found higher viscosity for the palmyra oil. Then the extracted oil from palmyra seeds is trans esterified to produce palmyra oil methyl ester.

Ester

In chemistry, an ester is a compound derived from an oxoacid (organic or inorganic) in which at least one hydroxyl group (−OH) is replaced by an alkoxy group (−O−R),[1] as in the substitution reaction of a carboxylic acid and an alcohol. Glycerides are fatty acid esters of glycerol; they are important in biology, being one of the main classes of lipids and comprising the bulk of animal fats and vegetable oils. Esters typically have a pleasant smell; those of low molecular weight are commonly used as fragrances and are found in essential oils and pheromones. They perform as high-grade solvents for a broad array of plastics, plasticizers, resins, and lacquers, and are one of the largest classes of synthetic lubricants on the commercial market. Polyesters are important plastics, with monomers linked by ester moieties. Phosphoresces form the backbone of DNA molecules Nitrate esters, such as nitro-glycerine, are known for their explosive properties. A carboxylate ester. R′ denotes any alkyl or aryl group.

2.LITERATURE SURVEY

2.1 PALMYRA BIO-FUELS

Gaura Pual et al [1] In this work we observe that the effect of the addition of jatropha biodiesel to mineral diesel on the performance and emission characteristics of a conventional engine has been experimentally investigated and compared with simulated data using Diesel- RK software. In respect of emission characteristics, NOx emission is found to increase with the load as well as the use of biodiesel in both experimental and simulation studies. Combustion characteristics show an increase in peak cylinder pressure and a decrease in ignition delay period with the increase in fuel share in the blends, whereas the emission of NOx and CO2 increases. Smoke and PM emission decreases for the same.

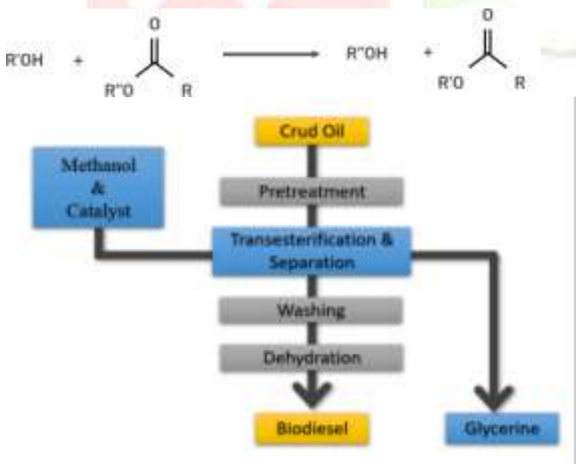
L. Narsinga Rao et al [2] From this work we know that biodiesel obtained from various renewable sources has been recognized as one of the alternative fuels due to its biodegradability, high cetane number, no sulfur emissions, and low volatility. Biodiesel derived from non-edible feedstocks such as linseed oil is reported to be a feasible choice for developing countries including India where the consumption and cost of edible oil are very high. The present work aims to optimize biodiesel production from linseed oil through the transesterification process. The various performance and emission parameters like brake power (BP), brake specific fuel consumption (BSFC), Brake thermal efficiency (BTE), CO emissions, CO2 emissions, HC emissions, NOx emissions, and smoke were evaluated at different loads in a 4 stroke, single cylinder Diesel engine. These performance and emission parameters of diesel fuel were compared with that of B25, B50, B75, and B100.

Dr. K. Prasada Rao et al [3] In this work we know that the rapid depletion of petroleum fuels and their ever-increasing costs and concern for vehicular emissions have led to an intensive search for alternative fuels. Bio-diesel is an attractive alternative fuel that is renewable, non-toxic, and reduces carbon monoxide and hydrocarbon emissions due to its higher content of oxygen. At present, biodiesel is commercially produced from refined edible vegetable oils such as rice bran oil (RBO), sunflower oil, palm oil, oil, etc. by the trans- esterification process. The various parameters that have been considered for the research in this direction with edible oil have yielded encouraging results with rice bran oil which is edible and has been considered as an alternative fuel. Along with this, biodiesel has a high cetane number which is a measure of fuel's ignition quality. It replaces the exhaust odour of petroleum diesel with a more pleasant smell of popcorn or French fries. RBO is the best biodiesel to use in the internal combustion engine and g a better result when compared with the others. The lower blends of biodiesel increase the brake thermal efficiency and reduce fuel consumption. The exhaust gas emissions are reduced with an increase in biodiesel concentration. The experimental results proved that rice bran oil can be substituted for diesel without any engine modification as a fuel.

3. METHODOLOGY

Transesterification

Transesterification is a chemical reaction used for the conversion of fats contained in oils, into usable biodiesel. Biodiesel produced by the process of transesterification has a much lower viscosity, making it capable of replacing diesel fuel used in diesel engines. Transesterification is an organic reaction in which an alcohol's R group is substituted for an ester's R' group. In most cases, this is achieved by applying an acid or base catalyst to the reaction mixture. It can also be achieved with the aid of enzyme catalysts (such as lipases). The exchange of an R' group from alcohol with an R'' group from an ester in a transesterification reaction is illustrated in the figure below

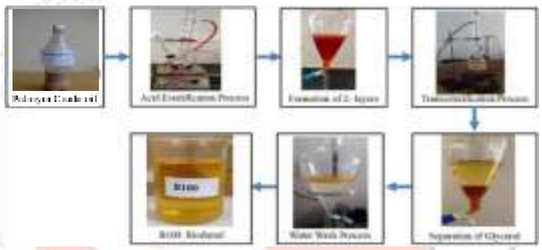


Transesterification Reaction

When this reaction is catalysed by an acid catalyst, the carbonyl group is converted by the donation of a proton to it. On the other hand, base catalysts take a proton away from the alcohol group, creating a strongly nucleophilic alkoxide ion. It should be noted that transesterification can be used to produce esters with relatively large alkoxy groups from methyl and ethyl esters. This is normally achieved by heating the ester (methyl or ethyl) with the acid/base catalyst and large alkoxy alcohol, then evaporating the smaller alcohol to push the equilibrium reaction in the desired direction.

Palmyra Bio Diesel Preparation

The palmyra crude oil is extracted from the palmyra seeds by the application of mechanical pressing operation. Crude oils derived from palmyra seeds have high viscosity, hence transesterification process is used to reduce the viscosity and palmyra biodiesel is obtained by the technique. Then the palmyra crude oil is heated to a temperature of 60°C to prepare the crude oil for the transesterification process. After the pre-treatment of crude oil, the catalyst concentration and methanol are used to produce the palmyra oil methyl ester. The mixture is stirred on a magnetic stirrer until the crude oil perfectly mixes with the catalyst concentration and methanol. The mixture is allowed to settle for 24 hours to form layers of glycerines and biodiesel to develop. During gravity separation, the glycerine forms a lower layer is settle down at the bottom of the beaker and the biodiesel stays at the top of the beaker. The biodiesel above the glycerine is separated from the glycerines and washed with distilled water to clean any impurities in the oil or glycerine left over. Now the oil is heated to a temperature of 1000C to dehydrate the oil the distilled water gets evaporated and pure biodiesel is available.



Framework for biodiesel conversion from palmyra crude oil

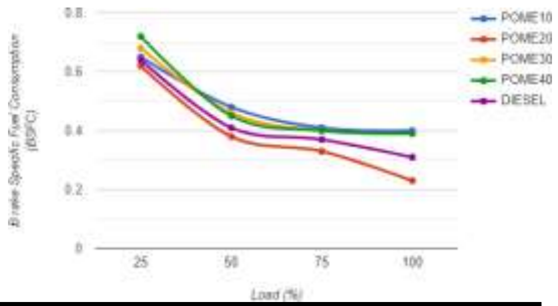
After the preparation of biodiesel, the biodiesel is blended with diesel at different percentages to get different blends of POME10, POME20, POME30, and POME40. These blends are used for performance and emission tests on the diesel engine. The Framework for biodiesel conversion from palmyra crude oil is shown in above figure

4. RESULTS AND DISCUSSIONS

4.1 Performance Analysis

4.1.1 Brake-Specific Fuel Consumption (BSFC)

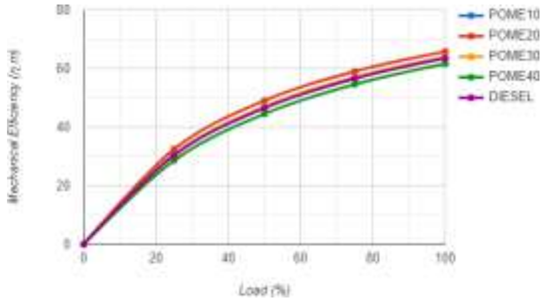
The variation of brake-specific fuel consumption with load is shown in the figure below. The plot it is revealed that as the load increases brake specific fuel consumption decreases. At no load to full load conditions, the brake-specific fuel consumption obtains from POME10, POME20, POME30, POME40, and pure diesel are



represented. The brake-specific fuel consumption of palmyra oil blend POME20 slightly decreased when compared to the diesel at full load condition.

4.1.2 Indicated Specific Fuel Consumption (ISFC)

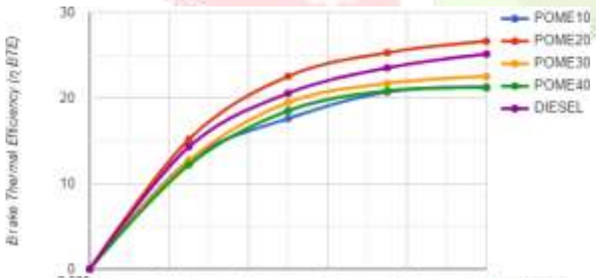
The variation of indicated specific fuel consumption with load is shown in the figure below. The plot it is revealed that as the load increases indicated

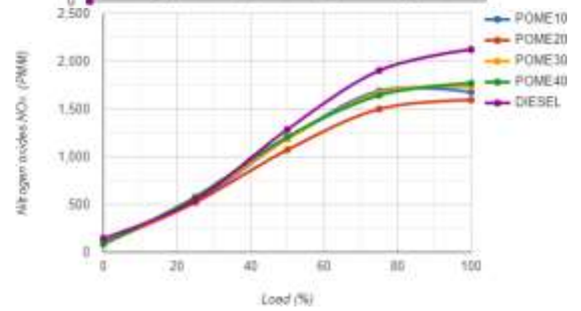


specific fuel consumption decreases. At no load to full load conditions, the indicated specific fuel consumption obtained from POME10, POME 20, POME30, POME40, and pure diesel are represented. The indicated specific fuel consumption of palmyra oil blend POME20 slightly decreased when compared to the diesel at full load condition.

4.1.3 Brake Thermal Efficiency (η_{bte})

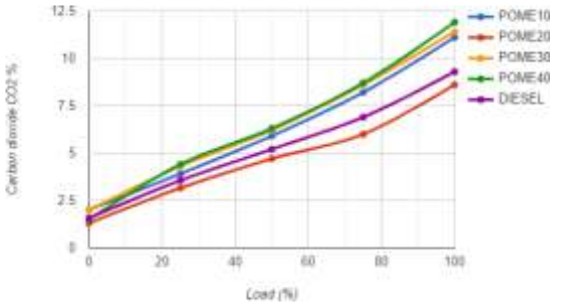
The variation of brake thermal efficiency with load is shown in the figure below. The plot it is revealed that as the load increases brake thermal efficiency increases. At no load to full load conditions, the brake thermal efficiency obtains from POME10, POME20, POME30, POME40, and pure diesel are represented. The brake thermal efficiency of palmyra oil blend POME20 increased when compared to the diesel at full load condition.





4.1.4 Indicated Thermal Efficiency (η_{ITE})

The variation of indicated thermal efficiency with

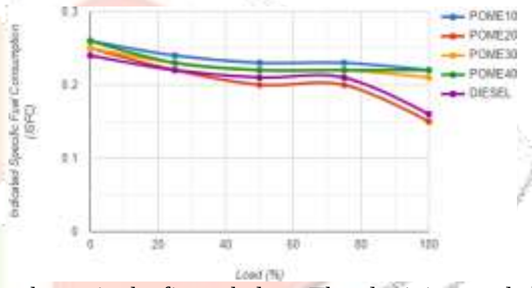


load is shown in the figure below. The plot it is revealed that as the load increases indicated thermal efficiency increases. At no load to full load conditions, the indicated thermal efficiency obtains

from POME10, POME20, POME30, POME40, and pure diesel are represented. The indicated thermal efficiency of Palmyra oil blend POME20 increased when compared to the diesel at full load condition.

4.1.5 Mechanical Efficiency (η_m)

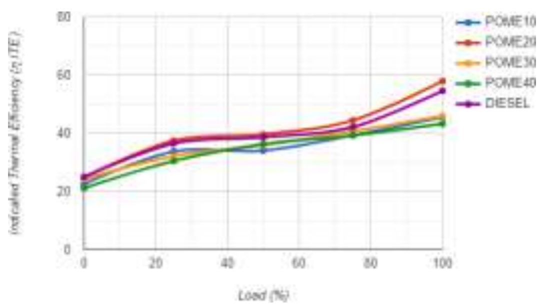
The variation in mechanical efficiency with load is



shown in the figure below. The plot it is revealed that as the load increases mechanical efficiency increases. At no load to full load conditions, the mechanical efficiency obtains from POME10, POME20, POME30, POME40, and pure diesel are represented. The mechanical efficiency of Palmyra oil blend POME20 increased when compared to the diesel at full load condition.

4.2 Emission Analysis

4.2.1 Nitrogen Oxide (NOx)



The variation of NOx with load is shown in figure below the plot it is revealed that as the load increases NOx decreases. At no load to full load conditions, the NOx was obtained for POME10, POME20, POME30, POME40, and pure diesel are represented. The NOx of palmyra oil blend POME20 slightly decreased when compared to the diesel at full load condition.

4.2.2 Carbon dioxide (CO2)

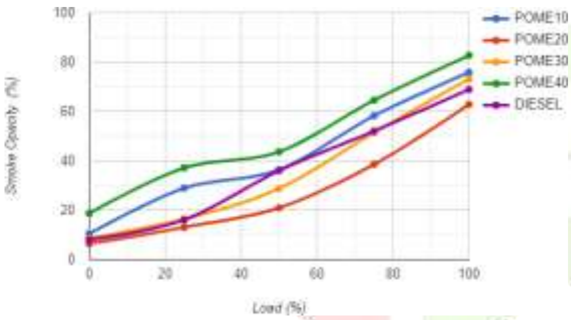
The variation of CO2 with load is shown in figure below. The plot it is revealed that as the load increases CO2 decreases. At no load to full load conditions, the CO2 are obtained for POME10, POME20, POME30, POME40, and pure diesel are represented. The CO2 of palmyra oil blend POME20 slightly decreased when compared to the diesel at full load condition.

4.2.3 Hydrocarbon (HC)

The variation of HC with load is shown in figure below. The plot it is revealed that as the load increases HC decreases. At no load to full load conditions, the HC was obtained for POME10, POME20, POME30, POME40, and pure diesel are represented. The HC of palmyra oil blend POME20 slightly decreased when compared to the diesel at full load condition.

4.2.4 Smoke Opacity

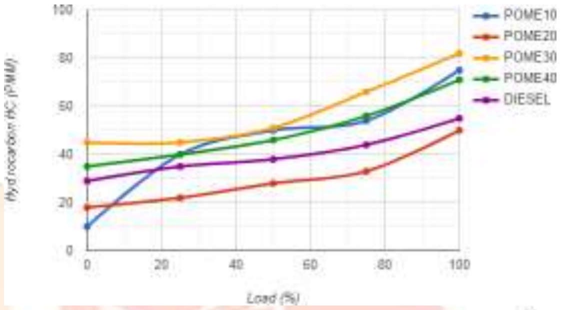
The variation of smoke opacity with load is shown in figure below. The plot is revealed that as the load increases smoke density decreases. At no load to full load conditions, the smoke obtains from POME10, POME20, POME30, POME40, and pure diesel are represented. The smoke density of palmyra oil blend POME20 slightly decreased when compared to the diesel at full load condition.



CONCLUSION

The comprehensive experimental investigation has discussed the influence on the performance, combustion, and emission characteristics of a diesel engine fueled with the POME10, POME20, POME30, and POME40 blends. The key experimental findings from the current work as presented below.

- It is found higher brake thermal efficiency for the POME 20 blend operated at full load and is 26.63%. Compared to other blends and diesel i.e., POME10, POME30, POME40, and diesel with 21.28%, 22.50%, 21.19%, and 25.13% respectively. However, the BTE of POME 20 operated at different load conditions shows a slightly higher value than diesel at all load conditions.
- It is observed that BSFC is reduced by 0.23Kg/Kw-hr for POME20 operated full load condition. Whereas POME10, POME30, POME40, and diesel by 0.4Kg/Kw-hr, 0.39Kg/Kw-hr, 0.39Kg/Kw-hr, and 0.31Kg/Kw-hr.
- It is also found that the higher indicated thermal efficiency for the POME 20 blend operated at full load is 57.92%. Compared to other blends and diesel i.e., POME10, POME30, POME40, and diesel with 45.52%, 45.92%, 43.24%, and 54.59% respectively and it also observed that ISFC reduced by 0.15 Kg/Kw-hr of POME20 operated at full load condition compared to other blends and diesel is 0.22Kg/Kw-hr, 0.21Kg/Kw-hr, 0.22Kg/Kw-hr, 0.16Kg/Kw-hr.
- It is noticed that the higher mechanical efficiency of the POME20 blend operated at full load condition and is 65.75%. Compared with other blends and diesel i.e., POME10, POME30, POME40, and diesel is 63.57%, 63.89%, 61.58%, and 63.47% respectively.
- The current experimental investigation reveals significant reductions of NOx, CO2, HC, and smoke emissions of the POME20 biodiesel blend operated at full load condition. The NOx, CO2, HC, and smoke emissions decreased by 1593PMM, 8.6%, 50%, and 62.8% respectively in contrast with other blends (POME10, POME30, POME40) and diesel at peak load.



From the analysis above, the blend POME20 performs better than other blends (POME10, POME30, POME40) in terms of performance metrics like brake thermal efficiency, mechanical efficiency, indicated thermal efficiency, brake-specific fuel consumption, indicated specific fuel consumption, and emission metrics like nitrogen oxide, carbon dioxide, hydrocarbon, smoke opacity. POME20 is therefore considered to be the ideal blend due to its improved performance. Overall, biodiesel showed increased engine performance with reduced emissions, and this has the potential to use as an alternative fuel for diesel.

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