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A STUDY ON ENGINE PERFORMANCE AND EMISSION ANALYSIS BY USING BIO-DIESEL & ITS BLENDS

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Abstract:

Biodiesel is an alternative fuel that is cleaner than Petro diesel and can be directly used as fuel for diesel engine without having to modify the engine system with major advantages like high biodegradability, excellent lubricity, and no sulfur content. Undi oil was found to be safe and efficient alternative fuel and has low impact on environment. Different blends with diesel fuel were used as fuel in a compression ignition engine and its performance and emission characteristics were analyzed. Low percent of blends (B5, B15) give a good improvement in the engine power and reduced BSEC. The fuel consumption increases as the biodiesel content in fuel rises due to lower heating power. Nevertheless, it should be noted that biodiesel maintains approximately same engine efficiency at that obtained with diesel fuel. The increase in engine speed caused an increase in fuel consumption rate, brake thermal efficiency, equivalence ratio, and exhaust gas temperature while at same time decreasing the bsfc, emission indices of CO2, CO. The research aimed to study emission of undi oil blends with diesel fuel and find optimum blend to be used in the diesel engine. The sample 2 has lower value of NO, Unburnt hydrocarbons than diesel. Hence use of undi biodiesel will increase the use of waste land and generate rural employment. The local production of alternative fuel will save huge amount of foreign exchange.

Keywords — **Undi (Calophyllum innophyllum L.), In-situ transesterification, Taguchi, DOE.**

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I. INTRODUCTION

A. BACKGROUND

The depletion of fossil fuels due to over-usage and many serious environmental threats associated with burning fossil fuels forced many researchers to find ways of using alternative sources of energy instead of conventional fuels such as gasoline and diesel. There are many alternative fuels available, and among them, biodiesel seems very promising due to various technical and non-technical advantages: It is highly biodegradable and very low toxic in nature. Blends of biodiesel can be used with existing diesel engines without major modifications and only minimal decrease in performances is reported, almost zero emissions of sulphates and aromatic compounds, a small increment in carbon dioxide (CO2) when the whole life cycle is considered (including cultivation, production of oil and conversion to biodiesel).

B. OBJECTIVES

- **i.** To study different types of experimentation methods related to engine performance and emission analysis by using biodiesel.
- **ii.** To get more efficient and accurate results by using biodiesel as fuel.
- **iii.** To study variety of biodiesels.
- **iv.** To compare the studied results with present fuels.

C. REVIEVED EXPERIMENTATION / METHODOLOGY

(1) Preparation of Biodiesel:

Oil Expelling:

Motorized oil expeller setup can be used to expelling oil from the vegetable seeds as shown in Fig. 1 It consists of a screw which rotated with the help of a motor. The

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screw crushes and chews the seeds which result in expelling of the oil from the seeds. [26]

Fig.1: Motorized operated oil expeller used for expelling oil from vegetable seeds [26]

Titration:

Titration process is used to find out the free fatty acid (FFA) content present in the oil. In stoichiometric transesterification process, oil does not contain any free fatty acids (FFAs). But in actual scenario, oil contains some FFA in it. Oils having FFA value less than 2% can be trans-esterified directly. However, if FFA content of oil is higher than 2%, oil must be neutralized first before undergoing transesterification process. In that case, acid pre-treatment is suggested before transesterification process. Direct transesterification of oils, having FFA content higher than 2%, will result in reduction of biodiesel yield. So, it is necessary to first check the FFA content present in oil by following titration process. [26]

Pre-Esterification Process:

When FFA content of oil is greater than 2%, it is always suggested to do pre-esterification process which helps to reduce it below 2%. By neutralizing oil with acid as a catalyst, FFA content can be reduced. In this process, oil is reacted with methanol in the presence of acid catalyst H2SO4, D5081, or A46. H2SO4 is used as acid catalyst in the **present** study. Methanol to oil ratio has been taken as 6:1and heated to 55 °C for 1 h in the presence of H2SO4 and is stirred continuously. [26]

Transesterification Process:

Transesterification process can be used to convert oil into biodiesel with the help of alcohol and catalyst. It is the process of exchanging the organic group R″ of an ester with the organic group R′ of an alcohol. It consists of many consecutive reversible reactions. In these reactions, the triglyceride is converted stepwise into diglycerides, then monoglyceride and finally into glycerol, being heavier, sinks to the bottom and biodiesel, being lighter, floats on the top of glycerol. Catalyst is usually used to improve the reaction rate and biodiesel yield. Since the transesterification reactions are reversible, excess amount of alcohol is used to shift the equilibrium to the products side. Methanol and ethanol are most commonly used alcohols for transesterification process, especially methanol because of its low cost and its physical and chemical advantages. Currently, homogeneous alkaline catalysts are usually favored over acid catalysts because of the higher reactivity and milder process conditions such as the lower temperature required. After transesterification of triglycerides, the products are a mixture of esters, glycerol, alcohol, catalyst, and tri-, di- and monoglycerides. Transesterification is one of the best methods among other approaches due to its low cost and simplicity. [26]

Washing & Heating:

Washing of biodiesel is necessary to separate extra methanol, catalyst, and soap suspended in the fuel. For washing, 2–3 times of water is required to wash the biodiesel and stirred. After washing and settling, the water along with the impurities has been drained from the bottom of the reactor. 3–4 wash cycles are recommended to make biodiesel clean. Heating is necessary after washing to remove remaining water from

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the biodiesel. Biodiesel is heated above 100 °C for the same. [26]

(2) Experimental Details:

Experimental Setup:

The schematic diagram of the experimental set up is show in Fig. 2. The engine is directly coupled to a hydraulic dynamometer of maximum load capacity. The load can be varied by adjusting load wheel on the top of the engine. Water pressure is constant. The torque and the fuel consumption rates can be measured for different loads and fuel blends. CO, HC and NOx emissions can be measured with a gas analyser. [6]

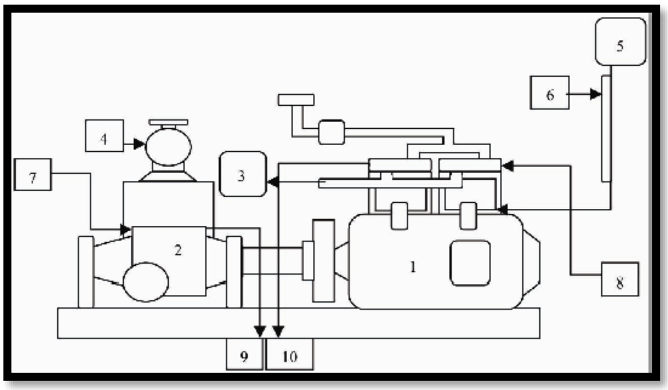

Fig. 2: Schematic diagram of the experimental setup. [6]

(**1.** Engine, **2.** Hydraulic dynamometer, **3.** Exhaust gas analyser, **4.** Loading unit, **5.** Fuel tank, **6.** Measuring burette, **7.** Inlet water for dynamometer, **8.** Inlet water for engine, **9.** Water outlet from dynamometer, **10.** Water outlet from engine)

Experimental Techniques:

Experimental test arrays are usually chosen based on a compromise between the cost of the experiments (cost includes the time required to run the experiments) and required accuracy of the results.

Below is a hierarchy of how you should choose a test array:

1) Full Factorial Array:

If cost is not a big issue (in other words, you have enough time, and the runs are inexpensive and don't take too long), or if the accuracy of the results is critical, use a full factorial array.

2) Taguchi Orthogonal Array:

If the cost (including time) of a full factorial array analysis is high, and the accuracy of the results is not so critical, use an orthogonal Taguchi array

3) Taguchi Non-Orthogonal Array:

If the cost is prohibitive (runs are extremely expensive or time consuming), and you can accept limited accuracy, use a non-orthogonal Taguchi array (but be sure to optimize it using the two rules given in the previous learning module for fractional factorial analysis).

Orthogonal arrays are the "best" and most common type of Taguchi array, and you are encouraged to use orthogonal arrays whenever time and cost permit. For selecting optimum number of experiments, **Taguchi Method** [26, 27] can be used to get more accurate results in a smaller number of experiments as well as time. Below Table No. 1 shows the iterations for three parameters (Speed, Load, Blends) to get optimum results by using Taguchi.

A series of experiments can be carried out over a considerable period to learn and compare the engine performance and exhaust emission characteristics using diesel and biodiesel blends. From the above test setup (shown in Fig. 2), brake thermal efficiency, brake specific fuel consumption, exhaust gas temperature, can be found under different operating conditions of load and injection pressures. From the experimental data thus generated conditions of optimum injection pressure can be obtained for all loads. Measurement of exhaust gas concentration NOx, CO, CO2, and HC measurements can be done with the help of AVL DITEST (AVL DiGas 4000 light) gas analyser. The detailed specifications of the exhaust gas analyser.

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B5 = 20% (Biodiesel)

EXPERIMENTS	SPEED	LOAD	BLENDS	RESULT
1	S1	L1	B1	X1
2	S1	L2	B2	X2
3	S1	L3	B3	X3
4	S1	L4	B4	X4
5	S1	L5	B5	X5
6	S2	L1	B2	X6
7	S2	L2	B3	X7
8	S2	L3	B4	X8
9	S2	L4	B5	X9
10	S2	L5	B1	X10
11	S3	L1	B3	X11
12	S3	L2	B4	X12
13	S3	L3	B5	X13
14	S3	L4	B1	X14
15	S3	L5	B2	X15
16	S4	L1	B4	X16
17	S4	L2	B5	X17
18	S4	L3	B1	X18
19	S4	L4	B2	X19
20	S4	L5	B3	X20
21	S5	L1	B5	X21
22	S5	L2	B1	X22
23	S5	L3	B2	X23
24	S5	L4	B3	X24
25	S5	L5	B4	X25

Table No. 1: Taguchi Orthogonal Array

Nomenclature: -

Speed: S1 = 1200rpm   Load: L1 = 2KG
S2 = 1500rpm   L2 = 4KG
S3 = 1800rpm   L3 = 6KG
S4 = 2000rpm   L4 = 8KG
S5 = 2500rpm   L5 = 10KG

Blends: (Biodiesel + Diesel):
B1 = 3% (Biodiesel)
B2 = 5% (Biodiesel)
B3 = 10% (Biodiesel)
B4 = 15% (Biodiesel)

D. BENEFITS & FUTURE SCOPE:

Benefits:

1. Biodiesel is safe in many ways. As compared to gasoline emissions, biodiesel emissions are much less
2. Biodiesel fuel does not need a new diesel engine, it can run any standard engine already used in a car.
3. Biodiesel fuel is renewable energy source, unlike petroleum-based diesel.
4. The lack of sulphur in 100% biodiesel extends the life of catalytic converters.
5. Biodiesel can be blended with other energy sources and oil.
6. Biodiesel fuel can be used in existing oil heating systems and diesel engines without any alterations to those systems or engines.
7. Biodiesel can be distributed through existing diesel fuel pumps, which is another advantage over other alternative fuels.
8. Sulphur, which acts as a lubricating agent, must be removed from conventional petroleum-based diesel fuel. The lubricating property of biodiesel fuel can lengthen the lifetime of engines

Drawbacks:

1. At present, Biodiesel fuel is more expensive than petroleum diesel fuel.
2. Biofuels are a solvent and therefore can harm rubber hoses in some engines.
3. As a solvent, biodiesel cleans dirt from engines. This dirt can then get collected in fuel filters, clogging them. As a result, filters must be changed after the first several hours of biodiesel use.
4. Biodiesel fuel distribution infrastructure needs improvement to make biodiesel more widely available.

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5. In cold weather, pure biodiesel can thicken or gel, making it hard to pump.

Future Scope:

Biodiesel produced from agricultural crops using current technology cannot sustainably replace fossil-based fuels in terms of its cost and environment impact. However, biodiesel from Undi seeds seems to have the potential as the alternative renewable biofuel, replacing fossil-based fuels.

E. CONCLUSION & REFERENCES:

Conclusion:

1. Biodiesel is an alternative fuel that is cleaner than Petro diesel and can be directly used as fuel for diesel engine without having to modify the engine system with major advantages like high biodegradability, excellent lubricity, and no sulphur content.
2. Undi oil was found to be safe and efficient alternative fuel and has low impact on environment. [2][3]
3. Different blends with diesel fuel were used as fuel in a compression ignition engine and its performance and emission characteristics were analysed. Low percent of blends (B5, B15) give a good improvement in the engine power and reduced BSEC.[11][12][14][20]
4. The fuel consumption increases as the biodiesel content in fuel rises due to lower heating power. Nevertheless, it should be noted that biodiesel maintains approximately same engine efficiency at that obtained with diesel fuel.[22][23]
5. The increase in engine speed caused an increase in fuel consumption rate, brake thermal efficiency, equivalence ratio, and exhaust gas temperature while at same time decreasing the bsfc, emission indices of CO2, CO [17][19][20]
6. The research aimed to study emission of undi oil blends with diesel fuel and find optimum blend to be used in the diesel engine. The sample 2 has lower value of NO, Un burnt hydrocarbons than diesel. [13][16]
7. Hence use of undi biodiesel will increase the use of waste land and generate rural employment. The local production of alternative fuel will save huge amount of foreign exchange. The capital when invested in our country will improve its financial structure.

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