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Optimization of Biodiesel Blends using Multi-Functional Criteria Technique (MFCT)

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Abstract— Abstract-The depletion of conventional fossil fuel source, increased emissions of combustion-generated pollutants and their increasing costs has given rise to development of alternate sources of energy as substitute for traditional fossil fuels. In this view biodiesel has gained lots of importance as an alternative fuel for the diesel engines. In this work waste cooking oil(WCO) is selected as a feedstock for the production of biodiesel. The WCO is tested for its Physio-Chemical properties and after pretreatment of the WCO it is converted into biodiesel by the process called transesterification. The produced bio-diesel is mixed with diesel in various proportion and blends are prepared namely B20 (20% biodiesel, 80% diesel), B40, B60, B80 and B100. MFCT method is used to find the best blend and out of various blends B20 was found to be optimum.

Index Terms— Transesterification, triglycerides, diglyceride, waste cooking oil (WCO), FC, BSFC, BP,

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1 INTRODUCTION

The depletion of conventional fossil fuel source, increased emissions of combustion-generated pollutants and their increasing costs has given rise to development of alternate sources of energy as substitute for traditional fossil fuels. The current methods to produce, convert and consume energy derived from fossil fuels throughout the world are not sustainable [1]. Due to limited amount of fossil fuels and increasing concerns of global warming, there is ever-growing urge to develop fuel derived from renewable resources. Thus, looking for alternative sources of new and renewable energy, biodiesel is one of such renewable alternative fuel derived from vegetable oils and animal fats. Biodiesel is produced by the process known as transesterification in which a reaction of a vegetable oil or animal fat is carried out with an alcohol such as methanol or ethanol in the presence of a catalyst to yield mono-alkyl esters and glycerin, this mono-alkyl esters are eventually known as boidiesel.

1.1 Potential of waste cooking oil as a feedstock for biodiesel source:

Huge quantities of waste cooking oils and animal fats are available throughout the world, especially in the developed countries. Management of such oils and fats pose a significant challenge because of their disposal problems and possible contamination of the water and land resources. Even though some of this waste cooking oil is used for soap production, a major part of it is discharged into the environment. As large amounts of waste cooking oils are illegally dumped into rivers and landfills, causing environmental pollution, the use of waste cooking oil to produce biodiesel as petro diesel substitute offers significant advantages because of the reduction in environmental pollution.

1.2 Biodiesel

Biodiesel is defined as mono-alkyl esters of long chain fatty acid derived from vegetable oils or animal fats. It can also be defined as a naturally oxygenated fuel produced from organic feed sources such as vegetable oils, and animal fats. Since biodiesel has physical properties similar to petroleum diesel, biodiesel can be blended in any ratio with petroleum diesel or it can be used in its pure form (B100 or "neat") to achieve cost efficiency and improve cold weather performance.

2 BIODIESEL PRODUCTION:

Biodiesel is derived from vegetable oils or animal fats which are basically long chain triglyceride esters with free fatty acids. The long chain triglyceride ester is converted into mono ester by the process called transesterification.

Transesterification is a series of reversible reactions in which the triglycerides are converted into diglycerides and diglycerides are converted into monoglycerides as shown below.

Triglyceride + Alcohol Diglyceride + R'COOR
Diglyceride + Alcohol Monoglyceride + R"COOR

In this,alcohol usually methanol is added to the vegetable oil, esterified oil is taken into reactor and using sodium or potassium hydroxide as a catalyst, the glycerin and methyl esters are separated. The glycerin is then seperated from biodiesel. This process is economical and straightforward because it occurs at low temperature (65°C).

Once the transesterification process is complete, glycerol must be separated from the ester product and methanol must be evaporated for reuse. The biodiesel ester is then washed with acidified water in order to remove the glycerol and methanol. After vegetable oil has undergone transesterification, it has become biodiesel and can then be readily utilized in existing diesel engines without any modifications.

2.1 Experimental setup

The CAD drafting of lab scale reactor for transesterification process is shown in Figure. 2.1 below.

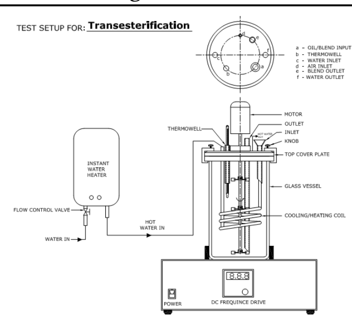

Fig. 1. Lab Scale Reactor for Transesterification

2.2 Experimental Procedure.
The Transesterification process is conducted in single stages for the production of biodiesel from the waste cooking oil. In the figure 2.2 a detailed step by step procedure to carry out process is explained

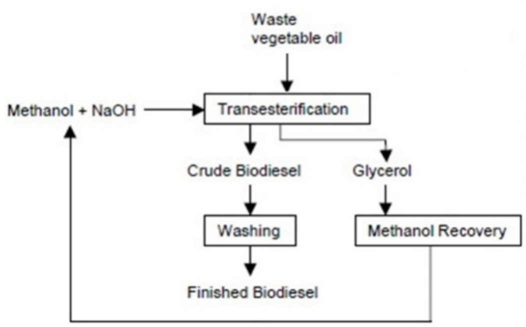

Fig. 1. Biodiesel Production

2.3 Blending Bio-diesel with Diesel
The pure biodiesel are blended with the diesel in the ratio of B20, B40, B60, B80 and B100. And is kept for minimum of 24 hours to get a homogenous mixture

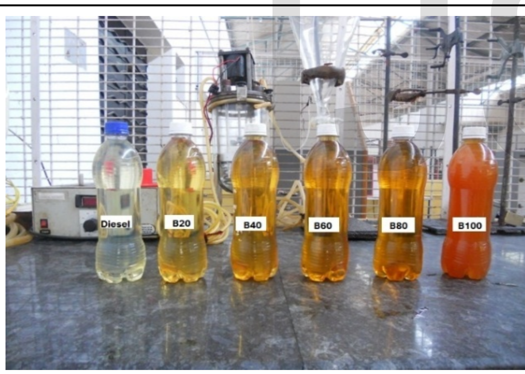

Fig. 1. Various Blends of Biodiesel

3 Fuel Properties Measurement:
The physical and chemical properties of Waste cooking oil were measured. The calorific value was measured by Bomb Calorimeter, The viscosity was measured by Redwood Viscometer, The flash point and fire point were determined by Pensky-Martens apparatus by closed-cup method.

4 Exprimental
4.1 Biodiesel
The Test-Rig for the testing of biodiesel consists of four strokes Diesel Engine, which is connected to the electrical swinging field dynamometer with the resistive loading. The DC machine is used as motor for starting the engine. Once the engine is started with the change over of the switch to the generator mode; it will act as a DC generator which is connected to the resistive load Air heaters. The engine and the dynamometers are coupled by a coupling. The exhaust of the engine is connected to the exhaust gas calorimeter. The complete set up is mounted on Anti Vibration Mounts.

4.2 Output Parameter
Output Parameters are displayed in the engine analyzer soft-

TABLE 1
Properties of Biodiesel

PROPERTIES	VALUE
FLASH POINT	50 °C
FIRE POINT	70 °C
POUR POINT	4 °C
CLOUD POINT	12 °C
VISCOSITY	3.46 cSt
CALLORIFIC VALUE	39.7 MJ/kg

ware are as follows:
- Brake power
- Specific fuel consumptionVo
- lumetric efficiency
- Brake thermal efficiency
- Air fuel ratio

5 Multifunctional Criteria Technique
Multifunctional Criteria Technique (MFCT) is a sub-discipline of operations research that explicitly considers multiple criteria in decision-making environments whether in our daily lives or in professional settings, there are typically multiple conflicting criteria that need to be evaluated in making decisions. Cost or price is usually one of the main criteria. Some measure of quality is typically another criterion that is in conflict with the cost.

Multi criteria decision making (MCDM) is concerned with structuring and solving decision and planning problems involving multiple criteria. The purpose is to support decision makers facing such problems.. It could correspond to choosing the "best" alternative from a set of available alternatives (where "best" can be interpreted as "the most preferred alternative" of a decision maker.

There are different classifications of MFCT problems and methods. A major distinction between MFCT problems is based on whether the solutions are explicitly or implicitly de

Formula used for performance and emission parameters,

5 Determination of the Optimum Blends

In the performance parameter for FC and SFC we are assigning 0 to the higher value 9 to the lesser value and for BP and BTE its vice versa 9 for higher value 0 for lesser value.

Then for the remaining values we calculate the preference number (PN) and it can be calculated by following steps.

Using this A in the equation for preference number (PN)

After assigning the 0 and 9 and the corresponding valves to the above table.

By multiplying the corresponding multiple factors to the above table as shown

For pressure of 200 bar using MFCT, B20 was found to be optimised because from the above table we got maximum value for B20.

6 Conclusion

The results of this work clearly indicate that biodiesel derived from waste cooking oil [WCO] is a compatible fuel for CI engines as an alternative to the conventional diesel. The properties of bio-diesel like flash point, fire point, viscosity, calorific value, and density and Ph value are found to be in the range of Indian standard IS 15607: 2005. From the Exhaustive Study and by using MFCT it is concluded that the optimum mix and blend is B20 hat is 20% bio-diesel mixed with 80% petroleum Diesel.

TABLE 2
Performance observations for 200 bar pressure

BLENDS	FC	BSFC	BP	BTE
Diesel	0.66	0.19	3.11	42.62
B20	0.60	0.18	3.24	48.87
B40	0.72	0.29	3.1	38.92
B60	0.74	0.18	3.07	37.52
B80	0.69	0.18	3.06	40.11
B100	0.66	0.22	3.03	41.52

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$$A = \frac{9}{\log \frac{\text{Value of the corresponding parameter}}{\text{Value of the parameter to which 0 is assigned}}}$$

Using this A in the equation for preference number (PN)

$$PN = A \log \frac{\text{Value of the corresponding parameter}}{\text{Value of the parameter to which 0 is assigned}}$$

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TABLE 3
Assigning Preference Numbers.

BLENDS	FC	BSFC	BP	BTE
Diesel	4.90	7.97	3.50	4.46
B20	9	9	9	9
B40	1.18	0	3.06	3.28
B60	0	9	1.76	0
B80	3.01	9	1.33	2.3
B100	4.91	5.21	0	3.58

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TABLE 4
Optimising Performance parameters using MFCT..

BLENDS	FC(0.1)	BSFC(0.2)	BP(0.3)	BTE(0.4)	TOTAL
Diesel	0.49	1.59	1.05	1.78	4.91
B20	0.9	1.8	2.7	3.6	9
B40	0.12	0	0.92	1.31	2.35
B60	0	1.8	0.53	0	2.33
B80	0.31	1.8	0.39	0.92	3.42
B100	0.49	1.04	0	1.43	2.96

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