COMPARISON OF ALUMINA, FLYASH, REDMUD AND ZEOLITE CATALYTIC PYROLYSIS IN DIESEL ENGINE

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ABSTRACT: The utilisation of vegetable oils as a source of bioenergy presents a compelling alternative to fossil fuels, as it offers the potential to mitigate carbon emissions and foster the establishment of a circular economy. The catalytic cracking process exhibits significant potential as it possesses the capacity to effectively handle diverse feedstocks and generate a broad spectrum of fuels. The process of catalytic pyrolysis is employed for the conversion of waste cooking oil. The acidity of the catalyst was evaluated, and the analysis revealed a significantly higher level of activity in comparison to the recently reported findings. The physical characteristics of the biofuel developed, such as viscosity, density, acid value, cloud point, pour point, flash point, and cetane number, align with the corresponding standards set by ASTM. Moreover, the aforementioned values exhibited superior performance in comparison to the recently released data. The primary process constraint of concern is the generation of greenhouse gases during the operation, which is minimised when the catalyst ratio is optimised. The present study involved conducting engine tests to examine the features of the biofuel obtained, as well as evaluating the engine performance of different blends of biofuel and diesel. The results indicated that the utilisation of various blends of biofuel-diesel demonstrated their compatibility and acceptability for use.

Key words: Waste cooking oil, Alumina, Flyash, Redmud and Zeolite 5A, Catalyst, Fuel Reformer;

1.INTRODUCTION

Biodiesel production began and grew due to efforts to lower diesel engine emissions without modification. The urgent need to drastically reduce diesel engine emissions to mitigate global warming has also contributed to this trend. Biodiesel can be produced immediately using catalysts like methanol or ethanol in the transesterification reaction and waste cooking oils. Biodiesel's biodegradability, reduced exhaust gas emissions, and renewable nature are major benefits [1]. The federal government has implemented a credit tax structure to encourage biodiesel production and use in many US states [2]. Multiple studies have demonstrated that biodiesel reduces polycyclic aromatic hydrocarbons, polychlorinated dibenzofuran, carbon monoxide, and sulphur dioxide emissions from diesel engines. Biodiesel has quickly supplanted petroleum-based diesel as the preferred alternative fuel due to its biodegradability, energy efficiency, non-toxicity, and environmental friendly. The high price of vegetable oil has been mentioned as a major biodiesel business barrier. Biodiesel costs 1.5 times more than petroleum-based diesel [16-19]. High biodiesel catalyst and feedstock costs add to the high cost of raw materials and labour in commercialization. Thus, biodiesel production might employ used cooking oil. This may also clarify used cooking oil garbage disposal issues [19-25]. Waste-based catalysts can reduce biodiesel production costs. Chicken and quail eggshells contain 90% calcium carbonate, so Asikin et al. [26] considered them reliable CaO sources [27]. An eggshell sample crystallised above 80^{oC} improved soybean biodiesel production to 97–99%. Increasing calcination temperature from 600^{oC} to 700^{oC} yielded 90% [27,28]. Eggshells also behaved well during transesterification, according to Asikin et al. [26]. The calcium in the shells was calcined in air at 800^{oC} for 2–4 hours to make active CaO catalysts. The catalytic agent produced biodiesel with over 90% FAME production in 2 hours [28].

However, the synthesis of biodiesel utilising a pyrolysis technique and various catalytic materials such alumina, flyash, redmud, and zeolite 5A has been examined [29]. Several research have evaluated the potential of waste cooking oil (WCO) for biodiesel production. In order to reduce the reaction or response time to biodiesel production, our study investigates the production of biodiesel from WCO by employing a base catalyst composed of inexpensive and recycled waste materials such as alumina, flyash, redmud, and zeolite 5A.

2.Engine Test Rig Setup

The Kirloskar single-cylinder, four-stroke, direct injection (DI), naturally-aspirated diesel engine that is tested in the laboratory with varied loads while keeping its rotational speed at a constant of 1500 revolutions per minute (rpm). A schematic of the apparatus used in the experiment may be found in Figure.1. Dynamometers that use eddy currents to measure power output by making a direct connection to the engine being tested. Both diesel and used cooking oil are delivered to the test engine in their respective fuel tanks that are designed specifically for that purpose. Provide further information regarding the engine configurations shown in Table 1.

Table.1: Technical Specifications of the Engine

Details	Specifications
Engine	Kirloskar, four stroke water cooled, Single Cylinder, VCR
Stroke	110 mm
Bore	87.5 mm
Capacity	661 cc
Power	5.2 kW
Speed	1500 RPM
Compression Ratio	12-18 or 17.5:1
Injection system	Common rail direct injection with open ECU
Injection timing	23° before TDC
Injection pressure	300 bar
Dynamometer	Eddy current dynamometer
Dynamometer Arm	185 mm
Method of Cooling	Water
Combustion Chamber	Hemispherical Open Type
ECU	Model Nira i7r

The K-type thermocouple and a digital temperature meter are utilized in order to get an accurate reading of the temperature of the exhaust gas. AVL 444 DI-gas analyzer can be utilised for the purpose of measuring emissions of NOx, HC, and CO. The accuracy of the instrument is within +1 ppm. For this particular purpose, AVL smoke meter is used. When taking a sample of the exhaust gas produced by the motor, a piece of apparatus known as a probe is utilised.

Figure.1: Photographic View of the Experimental Setup

In the initial series of tests, diesel fuel is used. All the tests are run with the engine running at the maximum recommended speed, which is 1500rpm. During the testing, diesel fuel is solely used to start the engine as a kick starter. Following that, power is transferred to the CFR. The temperature of the reformer is currently set to 200ºC, and it tooks 15 to 20 minutes to reach 80ºC. Around 80ºC the temperature at which the reformer started producing gas. In order to get into the combustion chamber, the by-product gas must first go via the intake air manifold. The tests are carried out at total of three times, once at each level of load, During each test, the engine is operated for a full twenty minutes to guarantee that it reaches a stable state. Repeat steps 1-3, this time bringing the temperature of the CFR up to 300ºC.

This section discusses the different catalyst temperatures that are used to evaluate the engine characteristics by using various catalysts such as alumina 300, flyash 200, redmud 300, and zeolite 300 in a diesel engine at the optimal engine operating state. These temperatures are employed in the evaluation of the engine characteristics.

3. RESULT AND DISCUSSION

3.1 IMPACT ON BRAKETHERMALEFFICIENCY

The variation in thermal efficiency of the brakes with brake power is depicted in Figure.2 for alumina 300, fly ash 200, red mud 300, and zeolite 300. This graph compares the results that are optimal for each phase of the process. When compared the performance of diesel fuel with the other catalysts, the graph clearly demonstrates that the alumina 300 exhibits superior results.

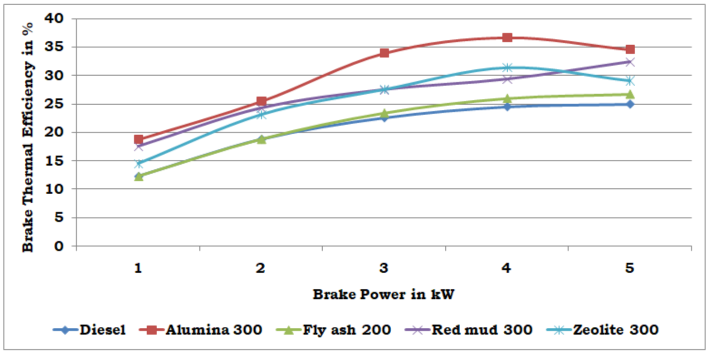

Figure.2 Variation of BTE with BP

3.2 IMPACT ON SMOKEDENSITY

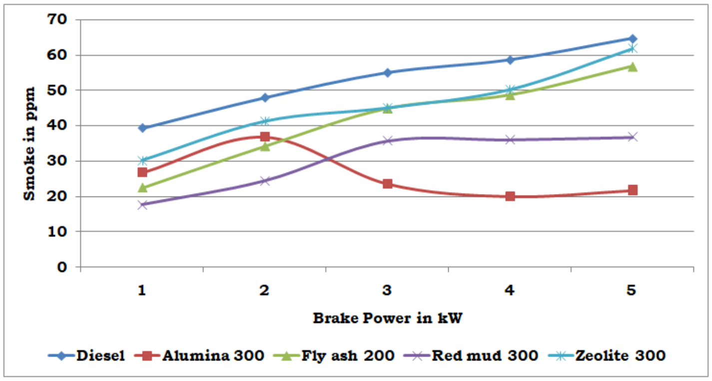

Figure.3 Variation of smoke density with BP

The graphic illustrates the density of smoke varies with the amount of braking power for alumina 300, fly ash 200, red mud 300, and zeolite 300representated in the fig.3. This graph compares the optimal result of each phase of smoke density. The conclusion drawn from the graph shows that the results obtained with alumina 300 were better to those obtained with diesel fuel and other catalysts.

3.3 IMPACT ON OXIDES OF NITROGEN

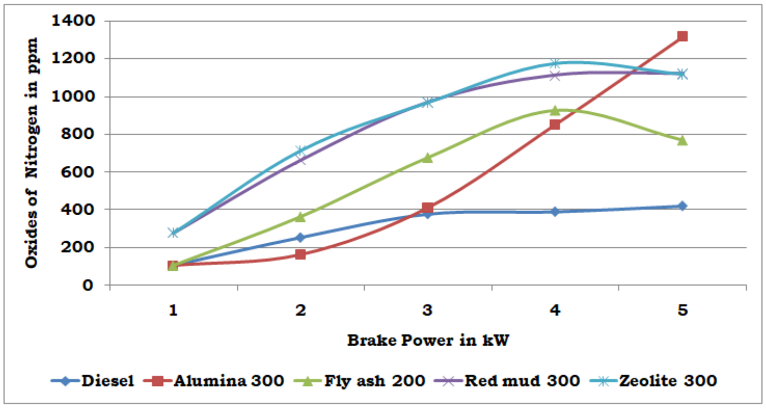

Figure.4 Variation of NOx with BP

The variation in oxides of nitrogen emission that occurs with brake power is depicted in Figure.4 for all the catalysts and diesel fuel. It can be clearly observed from the graph, the results obtained with alumina 300 are better than that of other catalyst and diesel fuel.

3.4 IMPACT ON HYDROCARBON

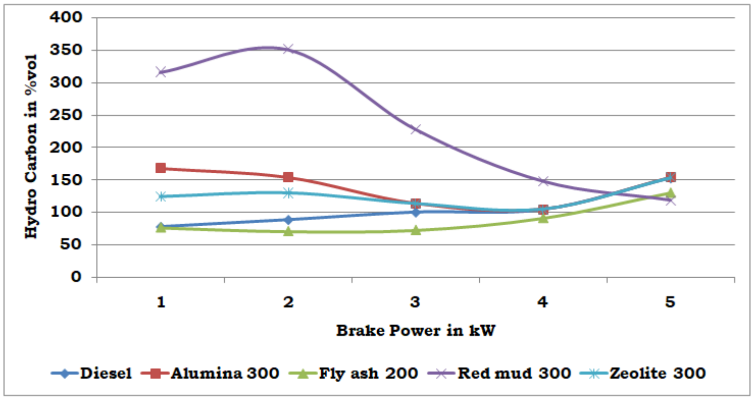

Figure.5 Variation of Hydrocarbon with BP

The figure.5 illustrates hydrocarbon emissions with BP The conclusion drawn from the analysis of the graph is that fly ash 200 is shows better reduction for all loads to that of diesel fuel. In contrast, alumina 300 has greater emission levels at low and medium loads, but it shows the greatest reduction in emissions when subjected to the highest load when compared to the other catalysts and diesel fuel.

3.5 IMPACT ON CARBONMONOXIDE

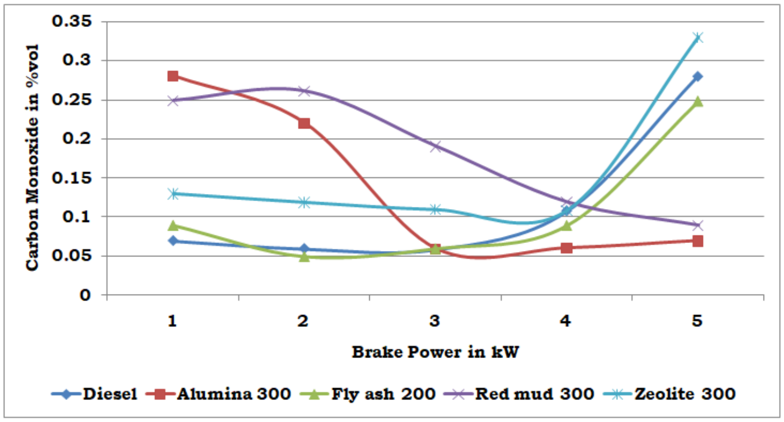

Figure.6 Variation of CO with BP

The variation of carbon monoxide emissions with brake power was depicted in Figure.6 for all of the catalysts and diesel fuel. It is clear from the graph that although fly ash 200 shows a better reduction across all the loads, alumina 300 exhibits the maximum reduction in maximum load.

4.CONCLUSIONS

This section compares engine parameters with different catalysts on a typical diesel engine by altering parameters and analysing power and pollution. The optimal settings for minimum emission and highest efficiency are determined by results data. Implementing the optimal settings reduces harmful carbon monoxide emissions with fly ash 200 at all loads, alumina 300 at the maximum load, nitrogen oxides with alumina 300 better than all other catalysts, and diesel fuel. This study shows that pyrolysis increased biodiesel production. The engine's environmental impact is greatly reduced. Optimal values reduce emissions and boost efficiency due to full and enhanced combustion, as shown by studies. The proper settings will also save users money owing to efficiency.

For making biodiesel from WCO, Alumina 300 appears to be the most appropriate choice. Alumina 300 has also been shown to reduce maximum load and nitrogen oxides in biodiesel production more effectively than other catalysts. The findings also showed that high-quality biodiesel could be produced from waste cooking oil using alumina 300 catalyst, which could eventually make diesel engines obsolete.

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