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Effect on the Activation Energy of Pongamia Oil with Emissions and Performance in a Diesel Engine

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Abstract: In diesel engines, biofuel has been converted into a substitute fuel to replace fossil diesel. In this study, we focus on the effect on the activation energy of Pongamia oil with emissions and performance in a diesel engine. Activation energy is determined using the mathematical relation of cetane number using experimental data of various fuel properties measurements. The sharp decrease in the activation energy (2.33%) undergoes diminishment in carbon monoxide (CO), nitrogen oxide (NO_x), and carbon dioxide (CO_2) emissions were observed to be 30.13%, 18.18%, 25.67%, adding BKO from 10% to 40%. The diminishment in brake thermal efficiency (BTE) having slope and intercept: Ea = -0.01475BTE + 8.40851. Also, the decrease in the activation energy was observed to be 2.33% undergoes diminishment in the performance (BTE) in diesel engine.

***Keywords**: Diesel, Pongamia Oil, Emissions, Performance, Activation Energy.*

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I. INTRODUCTION

Nitrogen oxides (NO_x) are precursors of a few natural issues such as photochemical smog, corrosive rain, global warming along with ozone layer destruction. The most pollutant has the combustion source and can be classified into two groups such as stationary and mobile. Biofuels consumption may be a capable elective to expand and supplant either all or incompletely fossil fuel without changes in diesel engines. Additionally, a vital highlight, the performance of biofuels consumption is comparable or superior to diesel fuel.

Diesel engine has emissions, combustion, and economy which are caused by developing concerns about energy resources with the environment. Currently, it has been considered in numerous parts of the world as a substitution for the spark ignition in a regular manner, or S.I. (gasoline or petrol) engine in the applications of a few traveler cars. It has also achieved many popular applications including heavy and medium-duty vehicles, and is the most inexpensive recognized power plant.

Combustion radiated oxides of nitrogen (NO, NO_2, and N_2O) frameworks give essentially environment contamination. NO_2 and NO are collectively known as NO_x and these are fundamental supporters of corrosive rain and smog issues. Incite, warm, and fuel are three known components of NO_x arrangement [1]. Nitrogen reacts with atmospheric air formed NO_x at high temperatures [2]. Oxygen dissociates into atomic oxygen which starts the arrangement of nitrogen oxide chain reaction at high temperatures of combustion [3]. Principally Amyris Inc. (NASDAQ: AMRS), the production of isoprenoids for biofuel applications having a family of hydrocarbons, which features an obvious farnesane (a C15 isoprenoid) [4- 5]. The cetane number measures the fuel ignition quality which is an important feature when using compression ignition engines and also measures the ignition delay. Fossil fuel has the properties of cetane number. However, according to ASTM D 613, it is also used for biofuel [6-7].

Biodiesel of *helianthus annus* and its blends (10%) accompanied by intake air and was supplemented with hydrogen as well as HHO fuel independently adding diesel fuel according to Baltacioglu et al., 2017 [8]. Therefore, the engine performed better than the intake air even with pure hydrogen along with diesel fuel. The exhaust emission of pure diesel and hydrogen increases on every occasion [9]. Diesel engines using fossil fuels produce exhaust emissions like smoke, CO, NO_x etc., [10]. The injection time and

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compression ratio have diesel engine properties that plays an effect on operation and emission that work by the addition of a mixture of biodiesel. The latest engine needs modification since many issues are notified by cutting-edge technologies [11-12].

Additionally, it is advised that biodiesel can be used in place of diesel for known fatty acids of methyl esters. The derivatives of vegetable oil have been evaluated as a optional fuel for diesel engines [13]. Murugesan et al., 2009 show the comparison of thermo physical properties of diesel and biodiesel and also discuss formation of biodiesel through optimization in diesel engines [14]. A study found that using biodiesel in CI engines significantly reduces hazardous emissions. The biodiesel separation and further its quality development technology have been mentioned by Atadashi et al. [15]. Tyre Pyrolysis oil (TPO) mixes and Jatropha methyl ester (JME) biodiesel has been used by Sharma and Murugan to study the behavior of diesel engines [16].

The present study shows the utilization of fossil fuels for internal combustion (IC) engines is an important source of various gases such as NO_x, CO_2, CO, and HC emissions. Activation energy, emissions and performance of that gases adding pongamia oil or biodiesel of Karanja oil (BKO) show an effect on the cetane number in internal combustion (IC) engines.

II. MATERIALS AND METHODS

A Kirloskar TV1 model dual fuel mode with a four-stroke single-cylinder diesel engine having 3.5 KW @ 1500 rpm power is used for experimental analysis. A dynamometer with eddy current and set-up were connected to a diesel engine. An air box, a manometer, a panel box, a fuel tank with a measuring unit, and software with MS Excel were connected. In the present paper, BKO was experimentally analyzed at a speed (1500 rpm) in a diesel engine at a high load. The pilot diesel fuel amount was controlled automatically with the aid of the governor. The different percentages of biodiesel and corresponding activation energy, cetane number, emission, and performance are mentioned in Table 1 & Table 2.

Table 1: Activation Energy (Ea) with Calculated Value of Cetane Number using Different Percentages of Biodiesel.

Biodiesel (%)	Cetane number	Ea (J/mol)
D100	51	8.14
B10	51.35	8.12
B20	51.7	8.07
B30	52.26	8.01
B40	52.82	7.95

Table 2: The Activation Energy (Ea) with the Experimental Value of Emissions of Different Gases and Performance using Different Compositions of BKO.

Biodiesel (%)	Ea (kJ/mol)	NO_x (ppm)	CO (%)	CO_2 (%)	HC (ppm)	BTE (%)
D100	8.14	2071	0.22	7.4	25	21.02
B10	8.12	1633	0.14	5.1	15	24.21
B20	8.07	1590	0.14	5	18	24.66
B30	8.01	1565	0.16	5.3	22	25.96
B40	7.95	1447	0.18	5.5	20	22.97

❖ *Various Fuel Properties Measurement*

The standard method was used for finding the cetane number of BKO with some essential chemical and physical properties. The biodiesel of Karanja oil and its blends have been measured by an experimental method as follows:

A. Measurement of Viscosity

Viscosity measures the resistance of oil flow and fluid motion due to internal fluid friction and an inherent inclination to resist any dynamic change. The viscosity of oil decreases with increase and hence oil flows rapidly. Reducing the viscosity of the oil allows for easier atomization and pumping of finer droplets. Viscosity is measured with Redwood viscometers. The value of Redwood viscosity is the time it takes for 50 milliliters of oil to flow out of a standard viscosimeter at a given temperature.*

B. Calorific Value

The full combustion of the fuel yields the calorific value, which determines the suitability of BKO as a replacement of diesel fuel by releasing thermal energy of the fuel per unit quantity. Vegetable oil contains methyl esters that were measured using bomb calorimeter with standard ASTMD240 protocol.

C. Flash and Fire Point

A minimum temperature at which fuel ignites. The flash point shows inverse relation to the fuel’s volality. To handle diesel fuel safely, a minimum flash point temperature is

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required. It is very important for figuring out the fire hazard. The temperature between 60-190 °C has been used to calculate the samples' flash points using closed cup apparatus (automated Pensky-Martens).

D. Relative Density

Density is the ratio of mass to the volume at a certain temperature. One major factor to consider is the density of the biofuel was measured through a pycnometer at 312 K.

E. Cetane Number

Fuel has a tendency to show physicochemical properties that play a major role in delay time calculation. Cetane Number (CN) is a critical component that explains the duration of the delay. A fuel with a high cetane number speeds up engine operation and cuts down on delay periods. Biodiesel has more CN than diesel fuel because it includes more oxygen. Cetane number is directly correlate with BKO characteristics with constants K_1, K_2, K_3, K_4, and K_5 calculated by multiple linear regression model as-

$$CN = k_5 + K_4\nu + k_3 HV + k_2 FP + K_1\rho \tag{1}$$

Where, ν, HV, FP, and ρ are viscosity, heating value, flash point, and density with unit mm^2/sec, MJ/sec, °C, and Kg/l.

III. RESULTS AND DISCUSSION

In Figure 1, the diminishment in the activation energy linearly with increasing the cetane number adding BKO from 10% to 40% in contrast to pure diesel due to increment in the different properties of fuel measurement like fire point, calorific value, viscosity and relative density (Table 1). The slope and intercept were obtained in equation (2) as follows:

$$Ea = 1 \times CN + 0 \tag{2}$$

$$Ea = CN$$

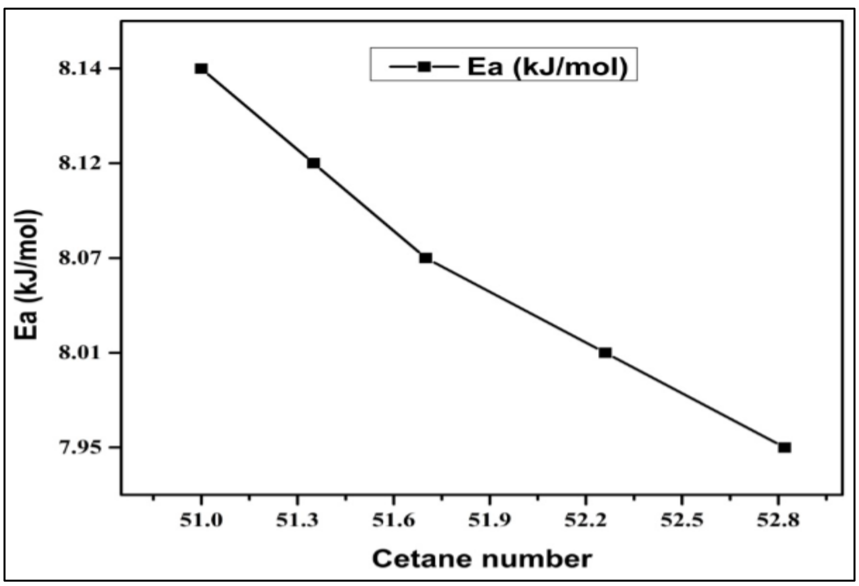

Fig 1: Deviation of Activation Energy Versus Cetane Number

In Figure 2, activation energy reduced to 0.25%, diminishing NO_x emission was observed to be 21.14% adding 10% BKO in contrast to pure diesel as fuel (Table 1). Moreover, the sharp decrease in the activation energy (2.33%), diminishing the NO_x emission was observed to be 30.13% adding BKO from 10% to 40% in contrast to pure diesel as fuel due to the vaporous fuel's and the burning rate is faster when BKO contains CO_2 and that CO_2 brings up the intake fluid's oxygen content. It raises the working fluid's particular warm capacity adding BKO in contrast to diesel fuel during the combustion route which moderates the spread of fire as well as brings down the combustion temperature [17-20]. The slope and intercept were obtained in equation (3) as follows:

$$Ea = 2.5663 \times 10^{-4} NOx + 7.63169 \tag{3}$$

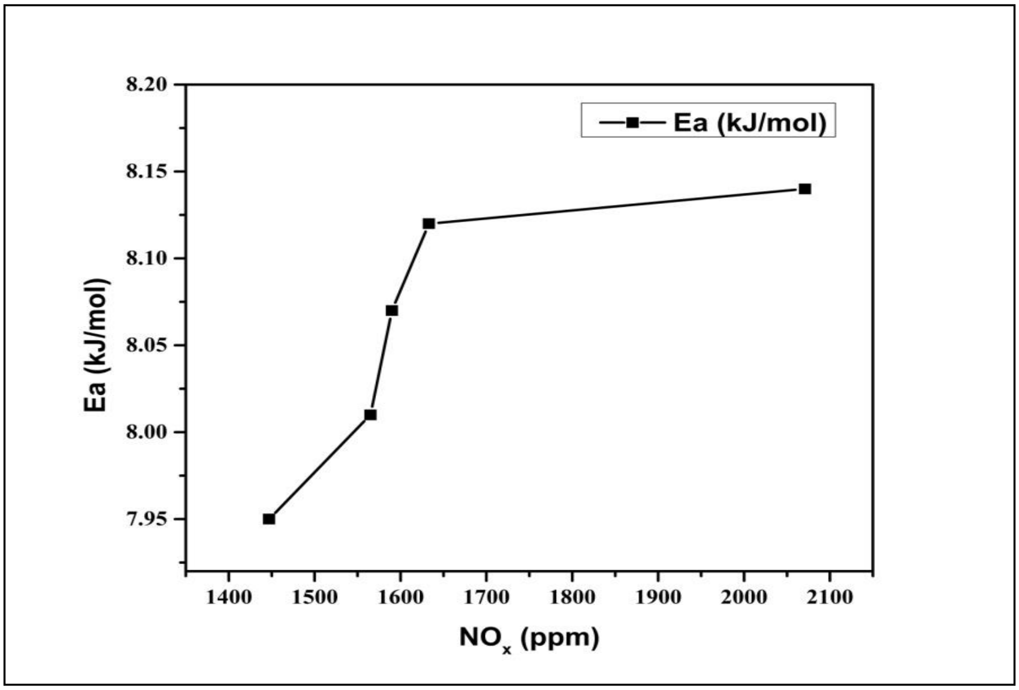

Fig 2: Deviation of activation energy versus NO_x

In Figure 3, the decrease in the activation energy (0.25%), diminishing the CO emission was observed to be 36.36% adding 10% BKO in contrast to pure diesel as fuel (table 1). Moreover, the diminishment in the activation energy (2.33%), diminishing the CO emission was observed to be 18.18% adding BKO from 10% to 40% as compared to pure diesel due to poor concentrations of CO emission and usually biodiesel includes a decreased oxygen content and it experiences complete combustion and diminishes the plausibility of incomplete combustion, CO as much CO from being changed over to CO_2 [21-22]. The slope and intercept were obtained in equation (4) as follows:

$$Ea = 0.29CO + 8.01 \tag{4}$$

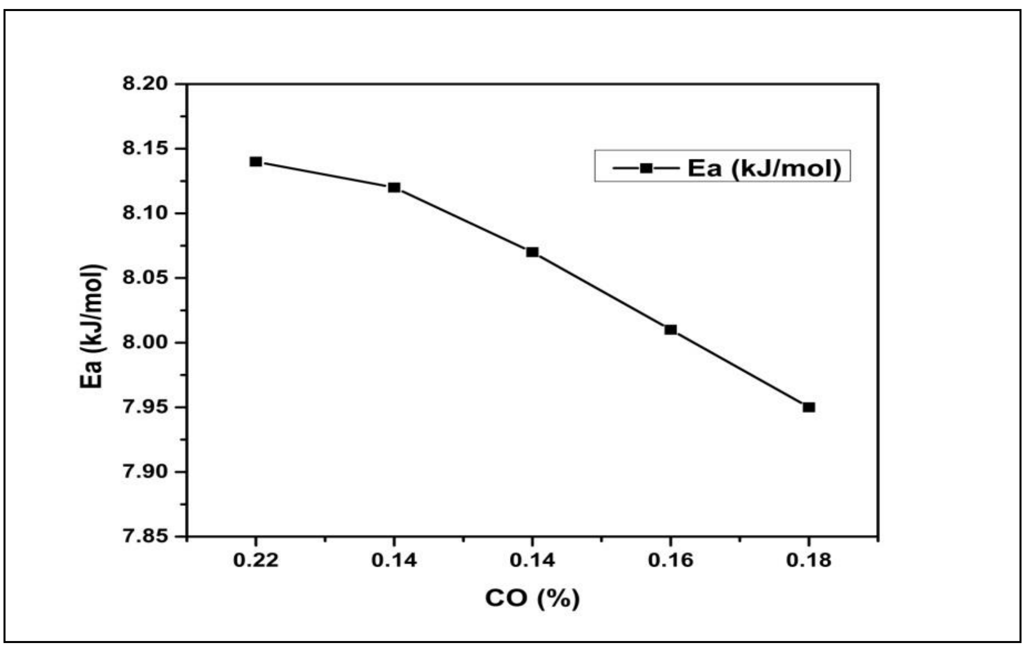

Fig 3: Variation of Activation Energy with CO (%)

In Figure 4, the decrease in the activation energy (0.25%), diminishing the CO_2 emission was observed to be 31.08% adding 10% BKO in contrast to pure diesel as fuel (table 1). Moreover, the diminishment in the activation energy (2.33%), diminishing the CO_2 emission was observed to be 25.67% adding BKO from 10% to 40% as compared to pure diesel, due to poor concentrations of CO emission and usually biodiesel includes a decreased oxygen content and it experiences complete combustion and diminishes the plausibility of incomplete combustion, CO as much CO from being changed over to CO_2. The slope and intercept were obtained in equation (5) as follows:

$$Ea = 0.034CO_2 + 7.86 \quad (5)$$

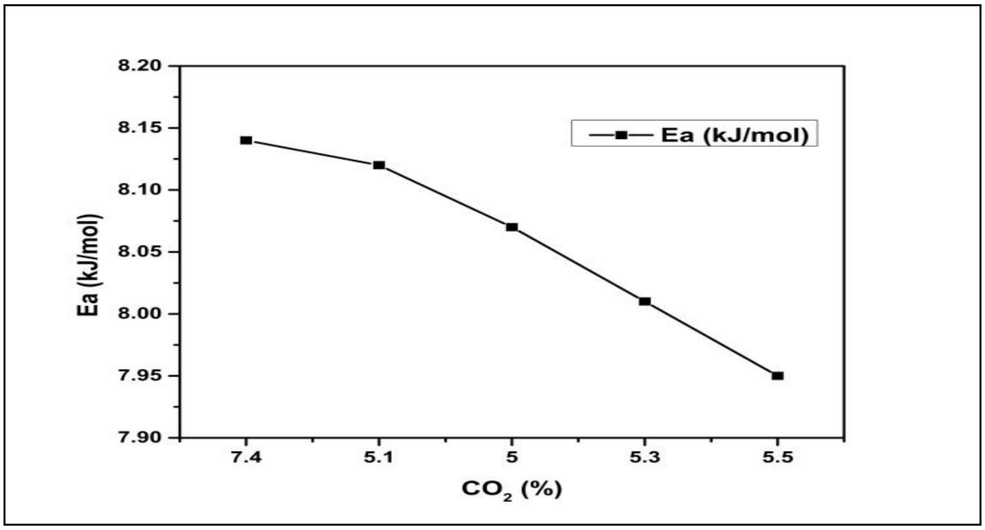

Fig 4: Variation of Activation Energy with CO_2 (%)

In Figure 5, the decrease in the activation energy (0.25%), diminishing the HC emission was observed to be 40% adding 10% BKO in contrast to pure diesel as fuel (table 1). Moreover, the diminishment in the activation energy (2.33%), diminishing the CO emission was observed to be 20% adding BKO from 10% to 40% as compared to pure diesel due to diminish in the amount of oxygen by weight as well as low cetane value, in the combustion chamber, BKO produced more greenhouse gases as it endorse less burning [23].

The slope and intercept were obtained in equation (6) as follows:

$$Ea = (-3.45) \times 10^{-4}HC + 8.06 \quad (6)$$

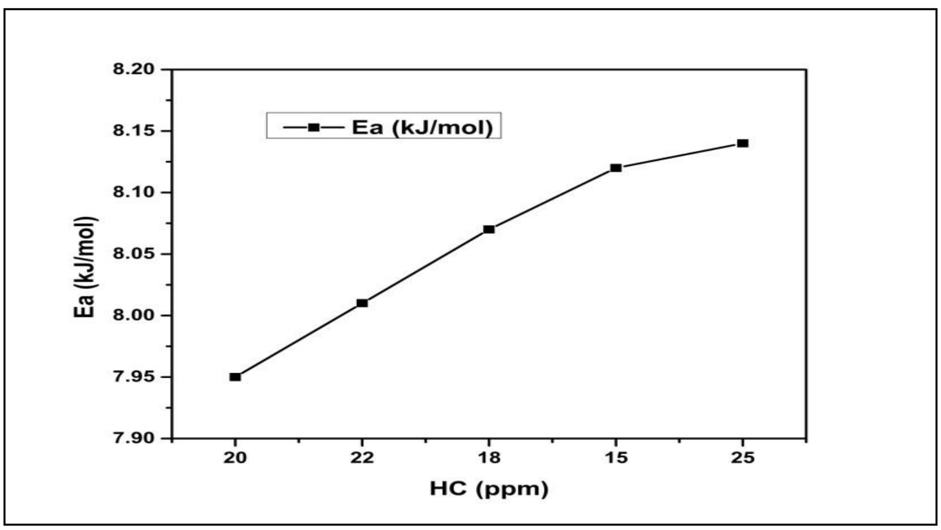

Fig 5: Variation of Activation Energy with HC

In Figure 6, the decrease in the activation energy (1.597%), enhancing the BTE was observed to be 19.03% adding BKO from 10% to 30% in contrast to pure diesel as fuel (table 1). However, the diminishment in the activation energy (0.74%), diminishing the BTE was observed to be 11.5% adding BKO from 30% to 40% in a diesel engine due to cetane number (CN) advancement of BKO features and their blends enhanced in the BTE. The slope and intercept were obtained in equation (7) as follows:

$$Ea = -0.01475BTE + 8.40851 \quad (7)$$

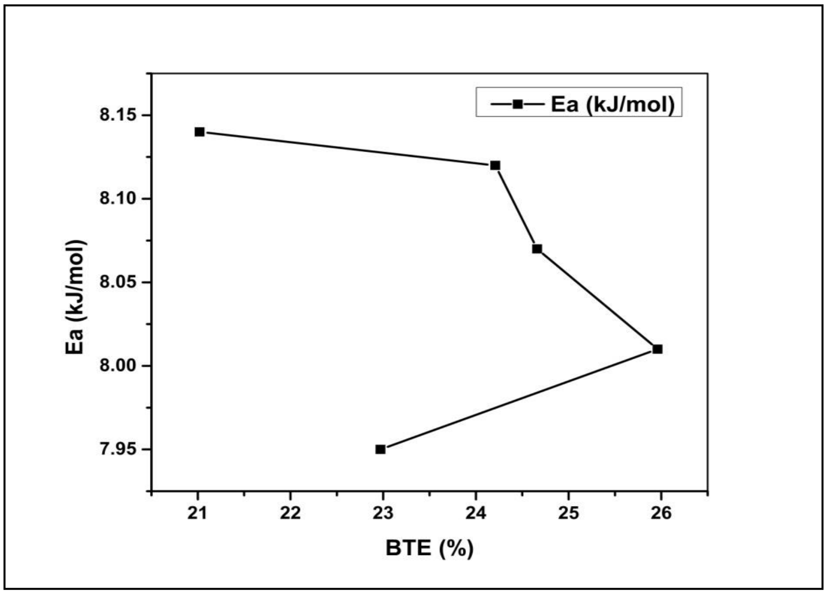

Fig 6: Variation of Activation Energy with BTE

IV. CONCLUSION

- The diminishment in the activation energy linearly with increasing the cetane number.
- The decrease in the activation energy was observed to be 2.33% adding biodiesel of Karanja oil from 10% to 40% undergoes diminishment in the NO_x, CO, CO_2, and HC emission in contrast to pure diesel as fuel.
- The decrease in the activation energy was observed to be 1.597% adding biodiesel of Karanja oil from 10% to 30% undergoes enhancement in the performance (BTE) in contrast to pure diesel as fuel.

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