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Determination of Cetane Number for Palm Based Biodiesel and Petro-Diesel Blends

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Abstract: Biodiesel is a potential resource which can work as a blend with petrodiesel as an alternative for currently working Internal Combustion Engine without doing any modification. Cetane number is an important property to evaluate the quality of biodiesel. Measurement of cetane number is a cumbersome process. In this study, the process of determination of cetane number using thermo-chemical properties is shown. The engine performance of the currently working diesel engine can be compared with the engine characteristics by knowing Cetane number. Cetane number is determined using its correlation with the kinematic viscosity, flash point, calorific value and density. For this, correlation is developed using properties at room temperature (298 K), to determine the cetane number. It is observed that the cetane number is having a linear correlation with all the above-mentioned properties. For Palm-based biodiesel and petrodiesel blends, it is observed that with an increase in blend percentage the cetane number is increasing.

Keywords* — *Biodiesel, Calorific value, Cetane number, Flash point, Kinematic viscosity.

I. INTRODUCTION

It is observed that the consumption of diesel is increasing day by day and the production has limitation. Sooner or later the quantity of diesel will become the problem. It was necessary to find out the alternative source for diesel. With decrease in the oil reservoirs quantity and increase in environmental pollution, it is mandatory to find out the alternate source for the energy generation through fuel energy [1–3]. For diesel, as it is used in internal combustion engine, the potential alternative source is Biodiesel. The mixture of methyl esters with long chain fatty acids commonly known as the biodiesel made up from vegetable oils or animal fats. For current study we have considered Palm based biodiesel[2,4]. The closed carbon cycle is the biggest advantage of biofuels. But as biodiesel is higher viscous and having higher density compared to petro-diesel, the current internal combustion engine is not suitable for it. To overcome this disadvantage, it is advisable to blend biodiesel to the petro-diesel[5].

Cetane number is useful characteristics to determine the quality of fuel for ignition. In auto-ignition engine the ignition delay was measured in terms of the Cetane number[6]. The Cetane number was calculated as the volume percentage of n-cetane in the mixture of n-cetane and α-methyl naphthalene which will give the same ignition performance as the fuel under test.

The properties needed for the determination of the Cetane are Density, Kinematic viscosity, flash point and calorific value[7,8].

II. MATERIAL AND METHODS

A. Materials

For the current experimental purpose Palm based biodiesel was taken and blended with petrodiesel available in the market. The mixture blends were prepared in different volume ratio with B00, B05, B10, B15, B20, B25, B30, B35, B40, B45, B50, B55, B60, B65, B70, B75, B75, B80, B85, B90, B95 and B100. Here B15 means 15 vol% of biodiesel is blended with 85 vol% of petrodiesel.

1) Methods [9–11]

For the testing of biodiesel following methods were utilized:

a) Flash Point and fire point

Flash Point and fire point are the indirect measures of the volatility of product. The flash point temperature of biodiesel fuel is the lowest temperature at which the fuel will ignite (flash) on application of an ignition source. The fir point is the lowest temperature at which the oil ignites and continuously burn for five seconds. Flash point varies inversely with the fuel's volatility. Minimum flash point temperatures are required for proper safety and handling of diesel fuel. These two parameters have great importance while determining the fire hazard (temperature at which fuel will give off inflammable vapor). Flash points of the samples were measured in the temperature range of 60 to 190°C by Pensky-Martens closed cup apparatus.

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b) Calorific Value:

Calorific value of a fuel is the thermal energy released per unit quantity of fuel when the fuel is burned completely and the products of combustion are cooled back to the initial temperature of the combustible mixture. This quantity of heat will include the heat of condensation of the water vapor formed by the combustion of the hydrogen in the fuel, as it cools to ambient conditions. This is an important property of the bio-diesel blends that determines the suitability of the material as alternative or supplement to diesel fuels. The calorific value of vegetable oils and their methyl esters were measured in a bomb calorimeter according to ASTM D240 standard method. An oxygen-bomb was pressurized up to 25 atm a with an oxygen container. The bomb was fired when spark is given from control panel. The bomb calorimeter was calibrated using benzoic acid sample. The different blends were taken and the temperature rise was measured which was used to calculate the calorific value. [12]

c) Density:

Density is the mass per unit volume of any liquid at a given temperature. Density measurements were carried out using a specific gravity bottle (ASTM D41) at a temperature of 298 K. The samples of blends of biodiesel with petrodiesel were prepared and mass were calculated of empty and filled specific gravity bottle and density was measured for known volume.

d) Kinematic Viscosity:

Kinematic viscosity is determined using Redwood viscometer (Type-1). Viscosity is measured using Anton Parr Rheometer (MCR 52). Kinematic viscosity is calculated from ratio of viscosity to density. Various samples of blends of Palm based biodiesel with petrodiesel were prepared. In Redwood viscometer the samples of known volume were passed and time was measured for collection of 50 ml sample. Kinematic viscosity is determined from the calibration chart. In case of Anton Parr Rheometer, the sample of 60 ml is inserted in the sampling crucible. The rotating float was inserted in the crucible. The heating is done with the external oil heating system. The sample was allowed to get equilibrium at the given temperature. For current Biodiesel- petro diesel blend viscosity was measured at constant shear rate. Number of set point was taken as the constant points. For each sample reading were taken at 298 K.

e) Cetane Number:

Cetane number of a fuel is defined as the percentage by volume of n-cetane in a mixture of n-cetane and α-methyl naphthalene which has the same ignition characteristics (ignition delay) as the test fuel, when combustion is carried out in a standard engine under the same operating condition. A fuel of higher cetane number gives lower delay period and provides smoother engine operation. Biodiesel has a higher Cetane Number than petrodiesel because of its higher oxygen content. Measuring method and instrument for testing is mentioned in Table 1.

Table 1: Measuring methods and instruments for testing

Property	**Measuring Instrument**	**Standard Test Method**
Flash point	Penksy – Martin Apparatus	ASTM D43
Calorific Value	Bomb Calorimeter	ASTM D240
Kinematic viscosity/Viscosity	Redwood viscometer/ Rheometer	ASTM D445/ ASTM D2196
Density	Specific Gravity	ASTM D941

III. RESULT AND DISCUSSION

The properties such as flash point, calorific value, viscosity and density were analyzed as per described procedure. The readings of each property are plotted against the volume fraction of palm based biodiesel in blend of biodiesel and petro diesels are given Table 2.

Table 2: Experimental Data at 298 K

Volume Fraction	**Kinematic Viscosity (mm^2/s)**	**Flash Point (^0C)**	**Density (kg/l)**	**Calorific Value (MJ/kg)**
0.00	3.68	74	0.817	43.60
0.05	3.71	76	0.819	43.07
0.10	3.74	77	0.822	42.64
0.15	3.78	79	0.823	41.66
0.20	3.82	80	0.825	41.17
0.25	3.85	81	0.828	40.71
0.30	3.91	82	0.829	40.30
0.35	3.95	83	0.832	39.80
0.40	4.01	84	0.835	39.42
0.45	4.08	85	0.836	39.03
0.50	4.14	85	0.840	38.82
0.55	4.23	86	0.842	38.60
0.60	4.32	87	0.845	38.37
0.65	4.42	90	0.849	38.20
0.70	4.50	93	0.853	38.03
0.75	4.61	95	0.857	37.85
0.80	4.71	97	0.860	37.67
0.85	4.83	100	0.864	37.51
0.90	4.94	103	0.868	37.36
0.95	5.07	106	0.871	37.23
1.00	5.20	110	0.875	37.11

It is observed from Figure 1 that the viscosity of pure biodiesel is higher than the petro diesel. Figure 2 shows the increasing trend in the density of the diesel with the increase in the volume fraction of the biodiesel in the blend of biodiesel and petrodiesel. The flash point of biodiesel is higher than the diesel as shown in Figure 3. The heating

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value of the pure biodiesel is lesser as compared to currently working petro diesel as depicted in Figure 4.

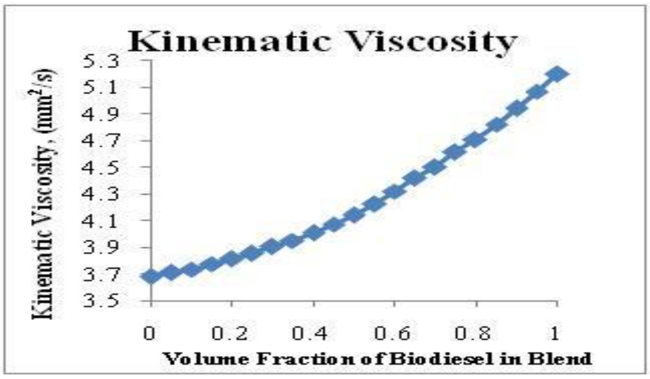

Figure 1: Experimental Data of Viscosity

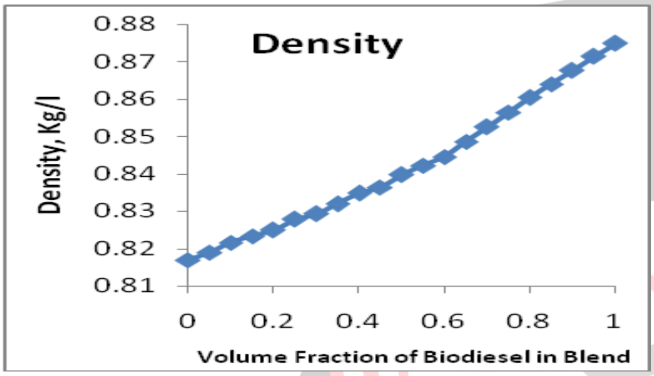

Figure 2: Experimental Data of Density

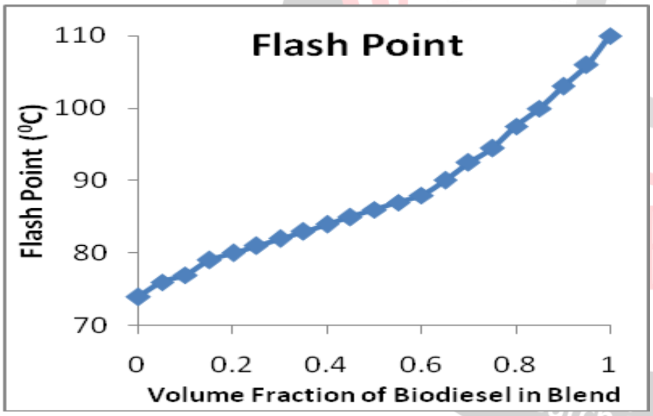

Figure 3: Experimental Data of F.P.

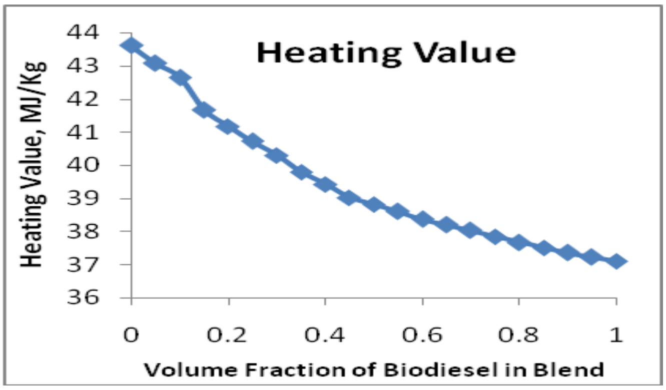

Figure 4: Experimental Data of C. V.

IV. CETANE NUMBER

Based on the experimental data shown in Figure 5 and tabulated in Table 3, the correlation generated for the each property, the Cetane number was calculated using MATLAB® program and correlation is:

$$CN = K_5 + K_4 \times \gamma + K_3 \times H.V. + K_2 \times F.P. + K_1 \times \rho \quad 1$$

Where,
CN = Cetane Number,
γ = kinematic viscosity (mm^2/s),
H.V. = Calorific Value (KJ/kg),
F.P. = Flash Point (^0C),
ρ = Density (Kg/m^3).

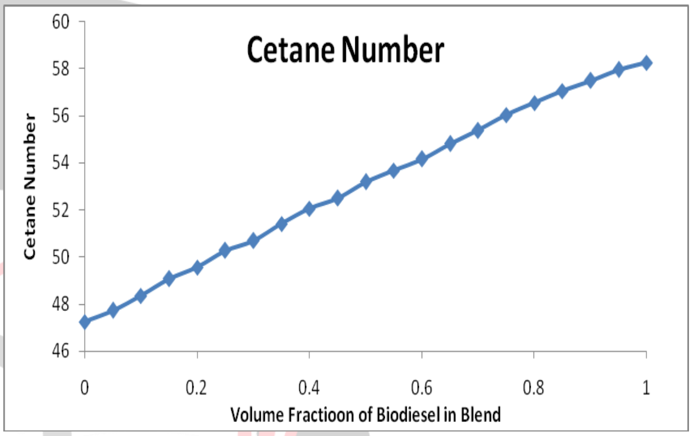

Figure 5: Predicted Values for Cetane Number

Table 3: Predicted Values of Cetane Number

Biodiesel Blend	Cetane Number
B00	47.26
B05	47.73
B10	48.37
B15	49.07
B20	49.57
B25	50.27
B30	50.70
B35	51.41
B40	52.07
B45	52.51
B50	53.18
B55	53.67
B60	54.17
B65	54.82
B70	55.38
B75	56.04
B80	56.54
B85	57.05
B90	57.51
B95	57.95
B100	58.25

The linear rise in the Cetane number with increase in biodiesel fraction in the biodiesel – petrodiesel blend not just suggests that biodiesels are better fuel but it also

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implies that various fractions can be identified for varying engine models for different types of vehicles.

V. CONCLUSION

The experimental values clearly suggest that the biodiesel is viscous as compared to petro diesel. The density of biodiesel is also very high at the given room temperature conditions, which suggests that the there need to be better pumping and fuel ignition system required for the engine running. The blend of the biodiesel suggests that the Cetane number is increasing with increase in the biodiesel fraction for the given Palm oil based biodiesel. Cetane number has linear relationship with kinematic viscosity, density, flash point and calorific value. The predicted values of Cetane number for pure component are very nearer to the reported values. So we can say it gives high accuracy prediction correlation. This correlation for identifying cetane number can be easily used to get clear understanding how the palm oil blends will work under several types of engines. Further, these correlations can be used to optimize the engine performance for blends for various types of vehicles.

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