Transesterification of WCO with different Acid Catalyst and Its effect on the Performance of Diesel engine: Using Variation of Peak Pressure Vs CAD Approach

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Abstract — Biodiesel is the most valuable form of renewable energy that can be used directly in any existing, unmodified diesel engine. In this paper the performance of biodiesel Produced from WCO using different acid catalysts is studied. The Acid catalysts are sulfuric acid, hydrochloric acid and nitric acid used in present work. The optimum combination for production of biodiesel using each acid catalyst is established. The potency of established biodiesel is analyzed using the Variation of peak pressure Vs CAD graph approach along with the parameters like Brake power, Brake Thermal Efficiency and Brake Specific Fuel Consumption.

Keywords: Acid catalyst, P-theta , Biodiesel.

I. INTRODUCTION

Biodiesel is a liquid biofuel obtained by chemical processes from vegetable oils or animal fats and an alcohol that can be used in diesel engines, alone or mix formation (i.e. blending) with diesel.

ASTM International (originally known as the American Society for Testing and Materials) defines biodiesel as a mixture of long-chain monoalkylic esters from fatty acids obtained from , to be used in the sources wish are renewable, biodiesel is denoted as “Bx” where ‘‘x’’ implies the percentage of biodiesel in the blend. For instance, ‘‘B10’’ indicates a blend with 10% biodiesel and 90% diesel fuel, B0 indicates the pure diesel.

Merits of the utilization of Biodiesel

1) Biodiesel is renewable, non degradable, cleaner and efficient fuel for IC Engines.

2) Low toxicity, compared with diesel oil.

3) Degrades more rapidly than diesel fuel, harmful to the environmental consequence.

4) Lower emissions of contaminants like PM, HC, CO gas, and aldehydes.

5) Lower health risk, due to reduced emissions of cancerous substances.

6) No sulfur dioxide (SO2) emissions.

7) Higher flash point (1000C minimum).e

8) could also be intermingled with diesel oil at any proportion; each fuels could also be mixed throughout the fuel offer to vehicles.

9) It has good potency as a lubricator.

10) it's the sole different fuel that may be employed in a traditional diesel motor , while not modifications.

11) Used cookery oils and fat residues from meat process could be used as raw materials.

Demerits of the utilization of Biodiesel

1) Slightly higher fuel consumption as a result of the lower hot price of biodiesel.

2) Slightly higher Nitogen Oxide (NOx) emissions than diesel oil.

3) Less Cold Storage potency than diesel oil. This could be inconvenient in cold climates.

4) It is less stable than diesel oil, and so long-run storage (more than six mts) of biodiesel isn't counseled.

5) Could degrade plastic and natural rubber gaskets and hoses once employed in pure type, during which case replacement with Teflon parts is favoured.

Present work is related to the performance of BD produced by using diferent acids is analyzed. The formations of Biodiesel and Diesel are Produced as B20 (20% BD and 80% Diesel), B30 (30 % BD and 70% Diesel) & B40 (40% BD and 60% Diesel) on account of Peak pressure Vs CAD variation graphs approach.

II. II. SYSTEM MODEL : BIODIESEL PRODUCTION & PROCESSING

A) Transesterification of Waste Coocking Oil

All the chemical used are of Analytical Reagent (AR) quality which includes use of conc.hydrocloric acid (HCL),conc.nitric acids (HNO3),conc.sulphuric acids (H2SO4).

-Initially the raw waste coocking oil is heated upto 600 C which improves the reactivity of oil and gives better results .

-Then the oil is pretreated to reduce FFA content by treating it one by one with strong Acids e.g. HCL,HNO3,H2SO4 etc these solution is heated and stirred vigoursly at constant temperature of 700 C for 60 minutes for maintaining the constant temperature water bath is used and mechanical stirer used for stiring .

-Then the PH of pretreated oil is check which is must be 6 to 7 if it is not then the heating time of solution is extended . The PH is checked by PH analyser by simply inserting its probes in solution The digital meter gives the reading of PH .Pretreated oil is ready to use now.

- TAN is checked should be less than 1 mg/gm of pretreated oil .

-The Centrifuging machine is used to remove the FFA from raw oil . the centrifuging machine is operated at 5200 RPM for 20 Minutes. The FFA level formed at upper portion which can easily remove. These is pioneering step for researchers working on biodiesels. The lower portion can now be used for biodiesel production.

-Sodium Hydroxide pallets is added in Methanol and stirred vigoursly for some time to form sodium Methoxide .The Magnetic Rotor Machine is used for these purpose in which magnetic rotor is dipped in methanol contained beaker the machine frequently changes magnetic field which tends to rotate the magnetic rotor which then stirred the mixture vigoursly.

TABLE I. Properties of Diesel & Biodiesel Fuels.

S.N.	Properties	Diesel	B1	B2	B3
1	Density (Kg/m^3)	823	845	850	863
2	Calorific value (MJ/kg)	43	40.9	40.3	38.52
3	Viscosity @40°C (cst)	3.9	5.2	5.78	4.99
4	Flash point (°C)	72	120	130	135
5	Fire Point	78	126	137	141
6	TAN	0.175	0.335	0.3585	0.451

- These produced Sodium Methoxide is treated with Pretreated oil which having less FFA contents e.g.by alkali catalysis method at constant temperature of 600 C and stirred vigoursly in water bath by mechanical stirrer. Generally the biodiesel formation starts from first 20 min the biodiesel samples taken for testing after each five min onwords to analysed the properties to check quality and meet ASTM fuel Requirements .Then the best samples are choosen on the basis of properties obtained through impirical analysis.

-The Centifuging machine used finnaly to remove glycerin and if any catalysts.impurity and foreign particals are presents .

-The tastes are taken one by one for Hydrocloric Acid , Nitric Acid And Sulfuric Acid.

The optimum combination obtained for Each BD Via acids is selected to produce blends with diesel. Three Bioiesels are used 1) BD Via Sulfuric Acid (BD1). 2) BD Via Hydrocloric Acid (BD2). 3) BD Via Nitric Acid (BD3).

FiG.2.1 Waste Coocking Oil Biodiesel Produced from WCO

B) Preparation And Properties of Blends of Biodiesel and Diesel.

The different blends of diesel and Biodiesel were prepared on volume basis. The blends were prepared in blender. The various blends prepared are given as follows.

1) B20 (80% diesel 20% BD)

2) B30 (70% diesel 30% BD)

3) B40 (60% diesel 40% BD)

The three Blends are prepared from each Acid Biodiesels. We have BD Via Sulfuric Acid (BD1), BD Via Hydrocloric Acid (BD2) & BD Via Nitric Acid (BD3). Total Nine Blends are Prepared .

C) Experimental fuels

The fuel Properties are as Follows

Table II. Properties of Blends of BD1 ,BD2 & BD3

S N	**Blends**	**Density (Kg/m³)**	**Calorific value (MJ/kg)**	**Viscosity @40°C (cst)**	**Flash point (˚C)**
Blends of BD Via Sulfuric Acid (B1)					
1	B20	825	42.600	4.16	81
2	B30	829	42.380	4.30	86
3	B40	833	42.150	4.45	92
Blends of BD Via Hydrocloric Acid (B2)					
4	B20	827	42.500	4.22	83
5	B30	832	42.300	4.35	88
6	B40	835	41.150	4.65	96
Blends of BD Via Nitric Acid (B3)					
7	B20	831	41.900	4.12	85
8	B30	835	41.656	4.23	91
9	B40	840	40.208	4.60	98

D) Experimental Set Up

Fig. 2.2. Data Acquisition System

"NIYO ENGINEER SOFTWARE Model :HMT07" is used to analyze the output data of the A/D Card .This Software has 16 channel in which each channel has specific function. Channel 11 indicates the fuel level with the help of fuel level sensor. The Load Indicator indicates the Load after Switching on Load switch. This Software can also indicates pressure crank-angle diagram that indicates the pressure variation at every crank angle. Hence the combustion parameters such as cylinder pressure, Peak pressure and crank angle is obtained. It gives directly the Brake power, Brake Thermal Efficiency, Brake Specific Fuel Consumption after calculation. It also indicates the Exhaust Gas Temperature in degree Celsius.

Testing was conducted at various loads starting from No Load up to rated Load. The engine was operated for 15 minutes at each load, to stabilize the Engine under new conditions. The tests were conducted at the rated engine speed. The engine was first fuelled with diesel oil, and the under steady state conditions, combustion parameters were recorded at various load, the engine was then fuelled with different biodiesel blends and the tests were performed.

Temperature measurement

The Niyo Software indicates the direct Reading on output monitor. It is the temperature T_2 indicated on monitor

Fuel measuring system

The Niyo Software indicates the direct Reading on channel 11 of control panel Fuel measurement sensor is situated below the fuel tank. Which has function to measure Fuel Consumption by radiating laser beam on fuel. It supplies these data to DAS which indicates output on monitor.

Dynamometer

To calculate load on the engine the rope brake dynamometer mounted on the shaft of the engine. The load indicates Control Panel of DAS . The load is applied by the switching on load switch on control panel . Water is used cool brake drum. To calculate the brake power of the engine the load is to be given to the engine.

Fig 2.3. Control Panel to apply Load on Dynamometer

E) Experimental Procedure

1. The engine used for the study was single cylinder, four-stroke, water cooled, constant speed, direct injection diesel engine. Test will conduct using constant speed.

2. The engine was started by moving hand lever to output shaft of engine, at no load by pressing fuel supply valve to attain rated speed still the steady state condition was reached.

3. After attaining constant engine speed the load was applied by switching on the Load switch and increasing it gradually by pressing F-Key & ↑-Key.

4. Open the water inlet valve and allow the water to flow through the brake drum to cool the brake drum while it is in operation.

5. All readings of fuel consumption, rpm, temperature of exhaust gas were taken From NIYO Software. The data for no load condition was includes brake power (kW) brake thermal efficiency (%) and brake specific fuel consumption (kg/kW-hr). load was increased gradually from no load to peak load condition. The engine was loaded gradually keeping the speed within the permissible range and the observations of different parameters were evaluated after attaining steady state by running up to15 minutes for each observations.

6. The Pressure Crank Angle Diagram is obtained after each steady state. The pressure CAD is obtained & saved for each condition of full load.

7. Short term performance tests were carried out on the engine diesel to generate base line data and subsequently Biodiesel blends were used to evaluate its suitability as fuel. The load was varied within the interval of 0 kW to 3.35 kW. Eddy current dynamometer was used to load the engine. All the observed data for each load conditions were noted.

8. The same procedure was applied for each blends. The Pressure Theta variation is obtained for each blend.

III RESULTS & DISCUSSIONS

A) *Brake Thermal Efficiency (%)*

1) Brake thermal efficiency of Biodiesel Produced from WCO for B20 Blend.

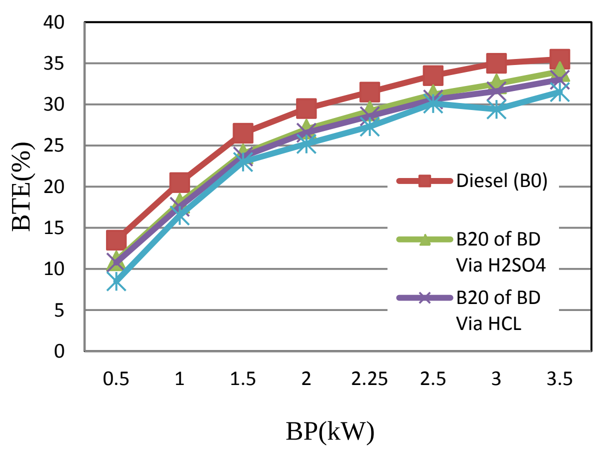


Fig 3.1):- Variation of BTE Vs BP For B20

The Figure (3.1) shows the variation of brake thermal efficiency with respect to brake power for blend B20. The increased in Brake power (BP) with reduction in Total Fuel Consumption (TFC) helps to increase the Brake Thermal Efficiency (BTE). The Brake Thermal Efficiency is almost equal for all the Biodiesel blends due to increase in ignition delay. At higher load condition BTE slightly increases due to longer ignition delay leads to rapid increase in premixed heat release rate that affect BTE favorably. It was seen that the BTE is higher for diesel and decreases significantly for Biodiesels BD1, BD2 and BD3 for blend B20.This is due to the lower Calorific value of Biodiesels with respect to the diesel. At higher Loads, The reduction in Max BTE of Biodiesels BD1, BD2 and BD3 with respect to diesel is by 2.25%, 2.80% & 3.25% Resp. According to literature review the difference of peak BTE between diesel and BD1 is nearly 2% which can be accepted. The performance of BD1 & BD2 is Similar but the result of BD1 is more pronounced and better than BD3. At lower and part load the BTE is Similar but at high load the BD1 takes peak than BD2. The BD1 has Higher Peak BTE than BD2 & BD3 by 1.72% & 2.33% resp.

2) Brake thermal efficiency of Biodiesel Produced from WCO for B30 Blend

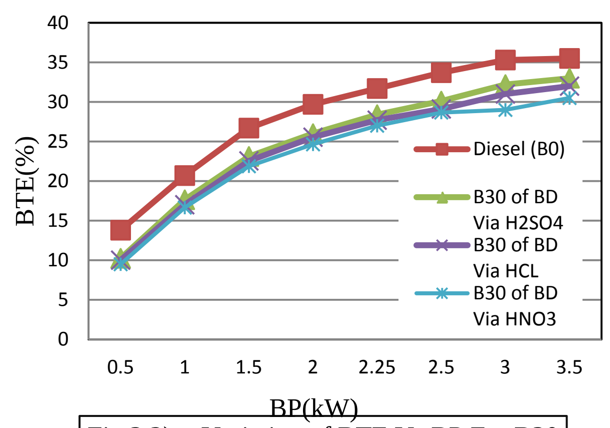


Fig 3.2) :- Variation of BTE Vs BP For B30

The Figure (3.2) shows the variation of brake thermal efficiency with respect to brake power for blend B30. The increased in Brake power (BP) with reduction in Total Fuel Consumption (TFC) helps to increase the Brake Thermal Efficiency (BTE). It was seen that the BTE is higher for Diesel and decreases significantly for Biodiesels BD1, BD2 and BD3 for blend B30. At higher Loads, The reduction in Max BTE of Biodiesels BD1, BD2 and BD3 with respect to diesel is by 4.52%, 5.12% & 5.75%. The performance of BD1 & BD2 is Similar but the result of BD1 is more pronounced and better than BD3. At lower and part load the BTE is Similar but at high load the BD1 takes peak than BD2. The BD1 has Higher Peak BTE than BD2 & BD3 by 1.81% & 2.47% resp.

3) Brake thermal efficiency of Biodiesel Produced from WCO for B40 Blend

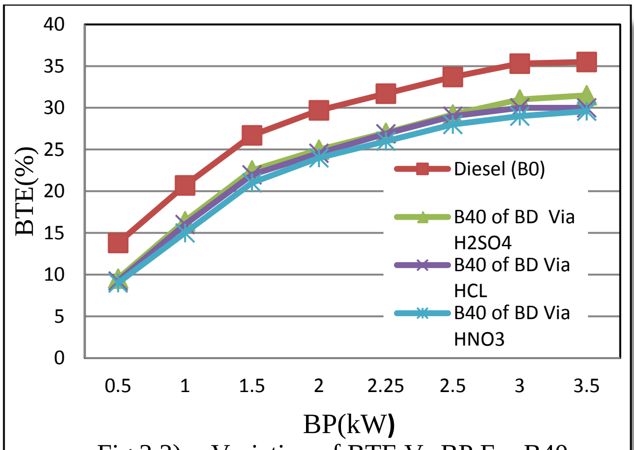


Fig 3.3) :- Variation of BTE Vs BP For B40

The Figure (3.3) shows the variation of brake thermal efficiency with respect to brake power for blend B40. The increased in Brake power (BP) with reduction in Total Fuel Consumption (TFC) helps to increase the Brake Thermal Efficiency (BTE). It was seen that the BTE is higher for Diesel and decreases significantly for Biodiesels BD1, BD2 and BD3 for blend B40. At higher Loads, The reduction in Max BTE of Biodiesels BD1, BD2 and BD3 with respect to diesel is by 5.10 %, 5.89 % & 6.40 %. The performance of BD1 & BD2 is Similar but the result of BD1 is more pronounced and better than BD3. At lower and part load the BTE is Similar but at high load the BD1 takes peak than BD2. The BD1 has Higher Peak BTE than BD2 & BD3 by 1.90 % & 2.66 % resp.

The inflated in Brake power (BP) with reduction in Total Fuel Consumption (TFC) helps to increase the Brake Thermal efficiency (BTE). The Brake Thermal efficiency is nearly equal for all the Biodiesel blends attributable to increase in ignition delay.. The BTE is higher for Diesel and reduces considerably with increase in mixing propertion. From Fig (3), Fig (4) & Fig (5) shows that the performance of BD1 & BD2 is nearly similar however the results of BD1 is a lot of pronounced and higher than BD3 . At lower and half load the BTE is similar however at high load the BD1 takes peak than BD2. At higher load condition BTE slightly will increase attributable to longer ignition delay ends up in fast increase in premixed heat rate that have an effect on BTE favorably

Comparison of BTE

1) Brake Thermal efficiency

Graph shows the variation of brake thermal efficiency with respect to brake power of different blends. It was seen that BTE of diesel is higher than biodiesels for each blend. The increased in Brake power (BP) with reduction in Total Fuel Consumption (TFC) helps to increase the Brake Thermal Efficiency (BTE). The Brake Thermal Efficiency is almost equal for all the Biodiesel blends due to increase in ignition delay. At higher load condition BTE slightly increases due to longer ignition delay leads to rapid increase in premixed heat release rate that affect BTE favorably.

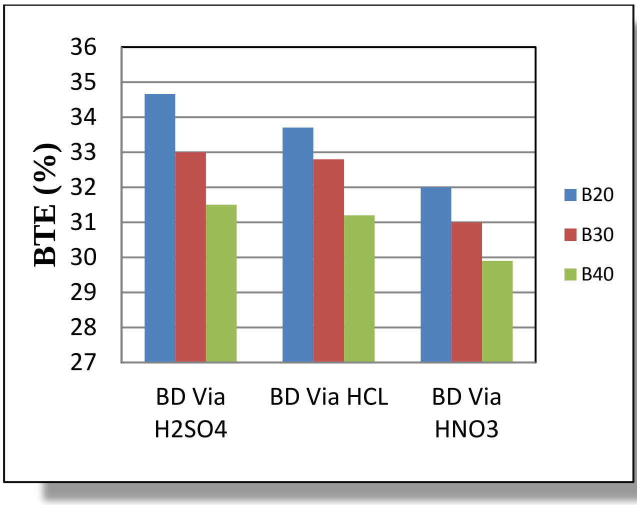


Fig.3.4 BTE Graph Plot for Various Blends

For blend B20 it was seen that the BTE is higher for diesel and decreases significantly for Biodiesels BD1, BD2 and BD3 for blend B20.This is due to the lower Calorific value of Biodiesels with respect to the diesel. At higher Loads, The reduction in Max BTE of Biodiesels BD1, BD2 and BD3 with respect to diesel is by 2.25%, 2.80% & 3.25% Resp. The BTE of blend B20 is closer to that diesel. According to literature review the difference of peak BTE between diesel and BD1 is nearly 2% which can be accepted. The performance of BD1 & BD2 is Similar but the result of BD1 is more pronounced and better than BD3. At lower and part load the BTE is Similar but at high load the BD1 takes peak than BD2. The BD1 has Higher Peak BTE than BD2 & BD3 by 1.72% & 2.33% resp.

For the blend B30 it was seen that the BTE is higher for Diesel and decreases significantly for Biodiesels BD1, BD2 and BD3 for blend B30. At higher Loads, The reduction in Max BTE of Biodiesels BD1, BD2 and BD3 with respect to diesel is by 4.52 %, 5.12 % & 5.75 %. The performance of BD1 & BD2 is Similar but the result of BD1 is more pronounced and better than BD3. At lower and part load the BTE is Similar but at high load the BD1 takes peak than BD2. The BD1 has Higher Peak BTE than BD2 & BD3 by 1.81% & 2.47% resp.

It was seen that the BTE is higher for Diesel and decreases significantly for Biodiesels BD1, BD2 and BD3 for blend B40. At higher Loads, The reduction in Max BTE of Biodiesels BD1, BD2 and BD3 with respect to diesel is by 5.10 %, 5.89 % & 6.40 %. The performance of BD1 & BD2 is Similar but the result of BD1 is more pronounced and better than BD3. At lower and part load the BTE is Similar but at high load the BD1 takes peak than BD2. The BD1 has Higher Peak BTE than BD2 & BD3 by 1.90 % & 2.66 % resp.

Comparison of BTE for blends B20, B30 & B40

The decrease in brake thermal efficiency of biodiesel BD1 with respect to diesel for blends B20, B30 & B40 was found to be 2.25 %, 4.52 % & 5.10 % resp.

The decrease in brake thermal efficiency of biodiesel BD2 with respect to diesel for blends B20, B30 & B40 was found to be 2.80 %, 5.12 % & 5.89 % resp.

The decrease in brake thermal efficiency of biodiesel BD3 with respect to diesel for blends B20, B30 & B40 was found to be 3.25 %, 5.79 % & 6.40 % resp.

B) **Smoke emission**

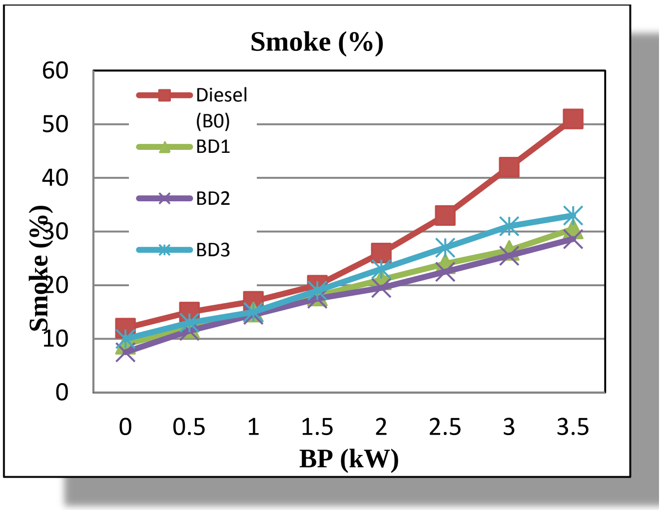


Fig.3.5 Variation of Smoke Opacity with respect to Brake Power

Smoke intensity with diesel fuel was higher than biodiesel. Smoke is formed due to incomplete combustion of fuel. This is because of oxygen content in fuels. Oxygen content of biodiesel is higher than diesel. Smoke emission observed lower with biodiesel BD2 and BD1. Improved and complete combustion could be the reason for obtaining lower smoke emission values with biodiesel BD1 and BD2. Smoke emission was slightly lower at all part load but gives more difference at peak load. Smoke emission with BD1 and BD2 gives lower value smoke and it was lower by 33.33 % & 37.25 % with respect to diesel. Smoke emission of BD3 is lower with respect to diesel by only 17%.

Comparison of Smoke Opacity (%)

Smoke intensity with diesel fuel was higher than biodiesel. Smoke is formed due to incomplete combustion of fuel. This is because of oxygen content in fuels. Oxygen content of biodiesel is higher than diesel. Smoke emission observed lower with biodiesel BD2 and BD1. Improved and complete combustion could be the reason for obtaining lower smoke emission values with biodiesel BD1 and BD2. Smoke emission was slightly lower at all part load but gives more difference at peak load. Smoke emission with BD1 and BD2 gives lower value smoke and it was lower by 33.33 % & 37.25 % with respect to diesel. Smoke emission of BD3 is lower with respect to diesel by only 17%.

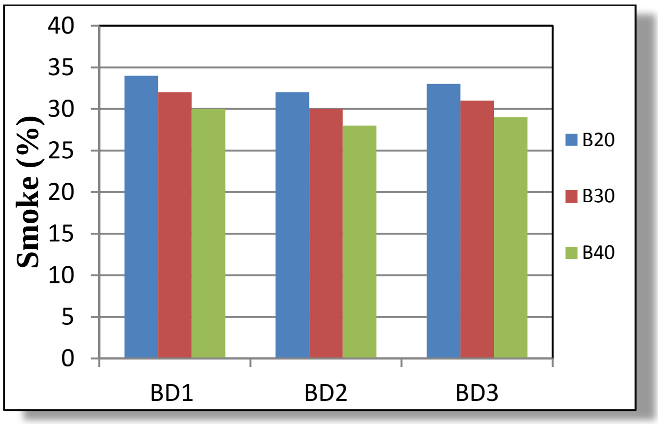


Fig.3.6 Smoke (%) Graph Plant for various Blend

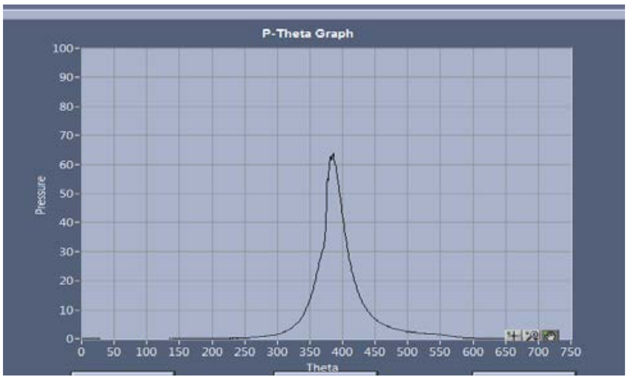
C) Variation of Peak pressure Vs CAD for various Blends

The pressure crank angle variation clearly showing the different phases of combustion.

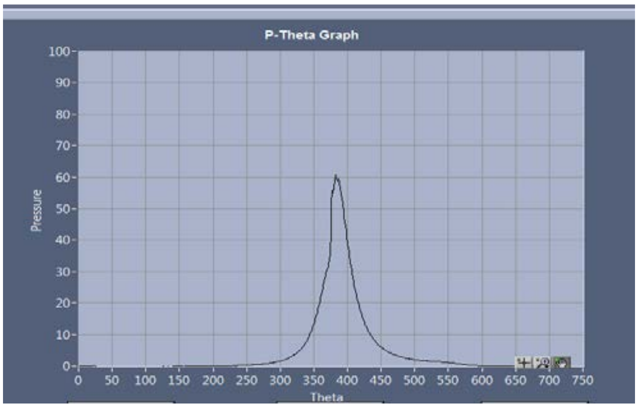
1. Ignition Delay.
2. Period of uncontrolled Combustion.
3. Period of controlled Combustion.
4. After Burning.

The pressure Vs crank angle variation is recorded for various blends of biodiesels. The Max Pressure obtained for the Biodiesel produced via sulfuric acid is highest than the Biodiesel produced via hydrochloric acid and Biodiesel produced via nitric acid at high load.

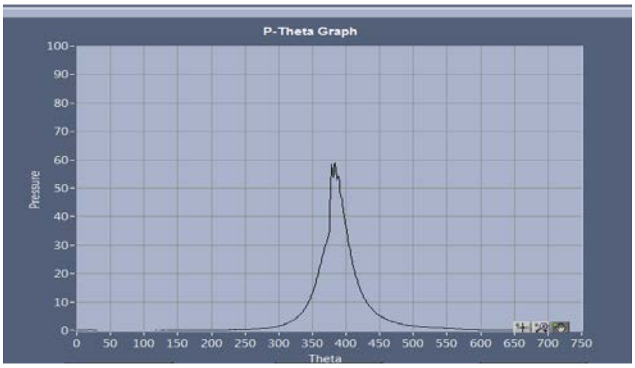
1) Variation of Peak Pressure Vs CAD for Various Blends



Graph 1 Variation of Peak pressure Vs CAD of B20 for BD via H2SO4



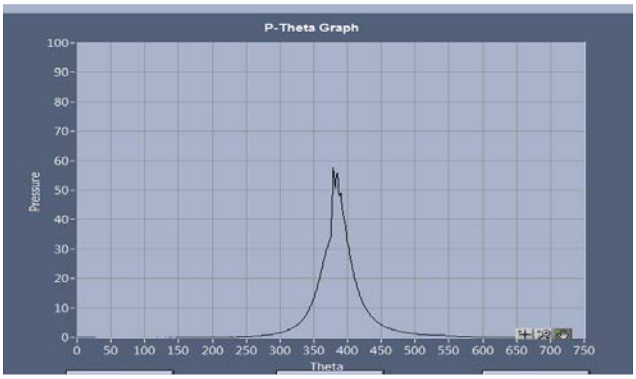
Graph 2 Variation of Peak pressure Vs CAD of B20 for BD via HCL



Graph 3 Variation of Peak pressure Vs CAD of B20 for BD via HNO3

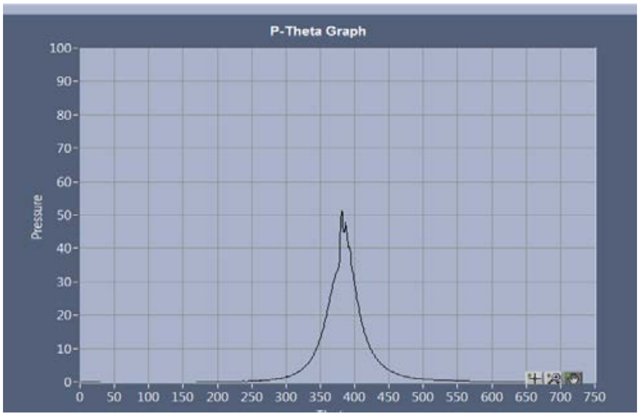
From the figures it was seen that for the blend of B20 peak pressure for BD1 (Biodiesel via H2SO4), BD2 (Biodiesel via HCL) & BD3 (Biodiesel via HNO3) was found to be 63 bar, 60 bar and 57 bar at higher load . The max peak pressure is essential which indicates proper combustion of fuel, burning of fuel and fuel potency for application. From above discussion it is clear that the Biodiesel BD1 and BD2 has higher fuel Potency compared to the biodiesel BD3

2)Variation of Peak Pressure Vs CAD for Blends B40

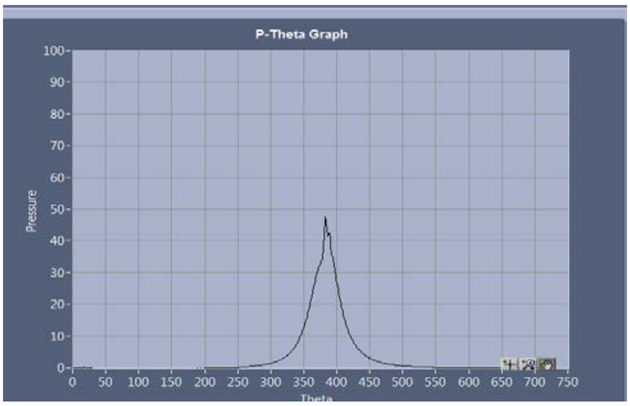


Graph 4 Variation of Pressure-Theta for B40 for BD via H2SO4

It is conclude from the figures that for the blend of B40 peak pressure for BD1 (Biodiesel via H2SO4), BD2 (Biodiesel via HCL) & BD3 (Biodiesel via HNO3) was found to be 58 bar, 52 bar and 49 bar at higher load .



Graph 5 Variation of Pressure-Theta for B40 For BD Via HCL.



Graph 6 Variation of Pressure-Theta for B40 for BD via HNO3

The max peak pressure is essential which indicates proper combustion of fuel, burning of fuel and fuel potency for application. From above discussion it is clear that the Biodiesel BD1 and BD2 has higher fuel Potency compared to the biodiesel BD3.

IV. CONCLUSIONS

1) The Variation of Pressure with Respect to Crank Angle Shows Max Pressure for BD via Sulfuric than Hydrochloric and Nitric acids at high load.

2) The Max Pressure obtained for the Biodiesel produced via sulfuric acid is highest than the Biodiesel produced via hydrochloric acid and Biodiesel produced via nitric acid.

3) The engine performance of engine decreases with increase in concentration of biodiesel.

4) The brake Thermal Efficiency of Blends BD-1 and BD-2 is higher than BD-3. At lower load and Part load the performance of blend BD-1 and BD-2 is similar but at max load BTE performance of BD-1 is more pronounced.

5) The Brake Specific Fuel Consumption of Blends BD-1 and BD-2 is lowest than BD-3. At Lower Load and Part Load the Performance of Blends BD1 & BD2 is similar but at max load BSFC Performance of BD1 is more Pronounced than BD2.

6) The decrease in peak brake thermal efficiency of biodiesel BD1 with respect to diesel for blends B20, B30 & B40 found to be 2.25 %, 4.52 % & 5.10 % resp. Therefore the blend B20 is having acceptable difference of BTE with diesel compared to other blends so it should be utilize in IC engine.

7) Smoke emission with BD1 and BD2 gives lower value of smoke and it was lower by 33.33 % & 35.25 % with respect to diesel. Smoke emission of BD3 is lower with respect to diesel by only 17%. Therefore the Biodiesel BD1 and BD2 are less harmful to environment than petro-diesel

V. REFERENCES

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