Analysis of Performance And Emission Characteristics of Biodiesel Using Cotton Seed Oil

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Abstract- *Vegetable oil has become more attractive recently because of its environmental benefits and better quality exhaust emission. A well-known trans-esterification process made biodiesel, Cotton seed oil is selected for biodiesel production. Nanoparticles were added in difference concentration levels with cotton oil – diesel fuel blend [BD20] to study their effects on engine performance. It was observed that the presence of Nanoparticles reduces the ill effects of Cotton seed oil in diesel. The experimental investigations were carried out in a Variable Compression Ratio (VCR) Engine and the performance and the emission of the VCR engine (Diesel) is tested with different blend percentages of B20, B30, &B50 with the optimized blend percentage of cotton seed Oil-Diesel (Biodiesel).Hence with Cotton seed oil – Diesel fuel could be one of the potential substitutes for diesel in running CI engines.*

Keywords- Cotton seed oil, Transesterification, VCR (Diesel) engine

I. INTRODUCTION

Biodiesel is a non-toxic, biodegradable, renewable fuel that can be produced from a range of organic feedstock including fresh or waste vegetable oils, animal fats, and oilseed plants. Biodiesel has significantly lower emissions than petroleum-based diesel when it is burned, whether used in its pure form or blended with petroleum diesel. It does not contribute to a net rise in the level of carbon dioxide in the atmosphere and leads to minimize the intensity of greenhouse effect. In addition, biodiesel is better than diesel fuel in terms of sulfur content, flash point, aromatic content and biodegradability.

Vegetable oils are becoming a promising alternative to diesel fuel because they are renewable in nature and can be produced locally and environmental friendly as well. Edible vegetable oils like canola, soybean and corn have been used for biodiesel production and found to be good as a diesel substitute. The edible vegetable oil such as cotton seed oil are found to be suitable for biodiesel production under the experimental conditions investigated. In view of the several advantages, vegetable oils have a great potential to replace petroleum-based fuels in the long run.

In the recent years, systematic study has been done on the different edible and non-edible vegetable oils as fuel in a compression ignition engine.

Transesterification of cotton seed oil using supercritical methanol in the absence of catalyst under different temperature condition. The most probable pathway and the rate determining step in Transesterification of cotton seed oil are estimated from molecular orbital calculation. In the optimization study found that the yield of methyl ester from cotton seed oil under the optimal condition is 97–98%.Biodiesel production from high free fatty acid oil needs a two-step Transesterification process, i.e., acid esterification followed by alkali Transesterification to get high biodiesel yield. Extensive work has been done on the Transesterification of non edible and edible vegetable oils; however, no significant work has been done on the optimization, oil characterization and fuel analysis on cotton seed oil. An optimization study on biodiesel production for the edible vegetable oil were done in detail with one-step alkali Transesterification process and two-step acid esterification process, respectively with fuel property analysis of these oils.

Vegetable oils occupy a prominent position in the development of alternative fuels although, there have been many problems associated with using it directly in diesel engine. These include:

1. High viscosity of vegetable oil interferes with the injection process and leads to poor fuel atomization.
2. The inefficient mixing of oil with air contributes to incomplete combustion, leading to high smoke emission.
3. The high flash point attributes to lower volatility characteristics.
4. Lube oil dilution.
5. High carbon deposits.
6. Ring sticking.
7. Scuffing of the engine liner.
8. Injection nozzle failure.
9. Types and grade of oil and local climatic conditions.

10. Both cloud and pour points are significantly higher than that of diesel fuel. These high values may cause problems during cold weather.

These problems are associated with large triglycerides molecule and its higher molecular mass, which is avoided by chemically modified to vegetable oil in to bio-diesel that is similar in characteristics of diesel fuel

There has been greater awareness on Biodiesel in India in the recent times due to shortage of fuel and increasing prices. Significant activities have picked up for its production especially with a view to reduce the huge cost involved in import of petroleum products. In addition, the process of production of Biodiesel from non edible vegetable oil will boost the rural economy and it will provide non-polluting, bio degradable.

About Cotton Seed Oil:

Cotton (*GossypiumarboreumL.*), belongs to the Malvaceae family.It is an important crop that yields the natural fibres used by the textile industry. It is considered as the second best potential resources after the soybean and also it is the ninth best oil-producing crop (Gunstone et al 2007).Cottonseed oil is extracted from the seeds of the cotton plant after the removal of cotton lint. Cottonseed oil is one of the oldest vegetable oils used in the industries like soap and glycol lubricants besides the usage as an edible oil. Itis widely produced and consumed in Brazil. Consumption of cotton seed oil is reduced with the increase in the soybean oil production, but still it occupies residence of countless financial reputation. Compared with the other oils like soybean oil (Kouzu et al 2009), palm oil (Canakci et al 2009; Kansedo et al2009a) and colza oil, cotton seed oil is a suitable raw material for biodiesel production since it grasps the reward of origin and uses.

Fatty Acid Distribution in Cotton Seed Oil:

The average oil content of the cottonseed is about 14–25 %. Significantly the cottonseed oil contains differential quantity of saturated fatty acids. The most common fatty acid is palmitic acid about 22–26 %, stearic acid is in smaller amounts of 2–5 % as well as the traces of muriatic, arachidicand behenic acids being found in the cottonseed oil. Monounsaturated fatty acids are found to be in lesser volume, the Oleic acid being the major content accompanied about 17–38 % approximately with the traces of palmitoleicacid. The most prominent fatty acid is diunsaturated linoleic acid of about 49–58 % with the traces of linolenic acid (Cardello et al 1995).

II. PROBLEM DEFINITION

Bio-diesel has become more attractive recently because of its environmental benefits and it is derived from renewable resources, bio degradable and non-toxic in nature. Several bio-diesel production methods have been developed, among which Transesterification using alkali catalyst gives high level of conversion of triglycerides to their corresponding methyl ester in short reaction time. The process of Transesterification is affected by the reaction condition, molar ratio of alcohol to oil, type of alcohol, type and amount of catalysts, reaction time and temperature, purity of reactants free fatty acids and water content of oils or fats. In this work, an attempt has been made on review of bio-diesel production from Cotton seed, methods of analyzing bio-diesel standard, resources available, process developed performance in internal combustion engines, recommendation for development of bio-fuels by using Nanoparticles as additives, environmental considerations, economic aspects and advantages.

Objective:

- To optimize the effective parameters of cotton seed Biodiesel using Taguchi method .
- To carry out an experimental investigation in VCR engine (Diesel) to check the performance and combustion and emission characteristics of cotton seed biodiesel by blending at different ratio with Cotton Seed-Diesel blend ratio B20,B30,B50.

III. METHODOLOGY

Process Of Bio-Diesel Production

Transesterification Reaction :

Transesterification also called alcoholysis is the displacement of alcohol from an ester by another alcohol in a process similar to hydrolysis except that an alcohol is used instead of water. This has been widely used to reduce the viscosity of the triglycerides. The Transesterification is represented as:

$$\underset{\text{Ester}}{RCOOR'} + \underset{\text{Alcohol}}{R''OH} \rightleftharpoons \underset{\text{Ester}}{R'COOR''} + \underset{\text{Alcohol}}{ROH}$$

Equation 1. Transesterification process

$$\begin{array}{llllll} CH_2\text{-}COOR^1 & & & CH_2OH & & R^1COOCH_3 \\ | & & & | & & + \\ CH\text{-}COOR^2 & +3CH_3OH & \rightleftharpoons & CH\ OH & + & R^2COOCH_3 \\ | & & & | & & + \\ CH_2\text{-}COOR^3 & & & CH_2OH & & R^3COOCH_3 \\ \text{Vegetable oil} & \text{Alcohol} & & \text{Glycerol} & & \text{Methyl-ester} \end{array}$$

Equation 2. Methanolysis of Tri-glycerides

If methanol is used in this process then it is called methanolysis. Methanolysis of triglycerides represented in Eq. (2).

Transesterification is one of the reversible reactions and proceeds essentially by mixing the reactants. However, the presence of a catalyst (a strong acid or base) accelerates the conversion.

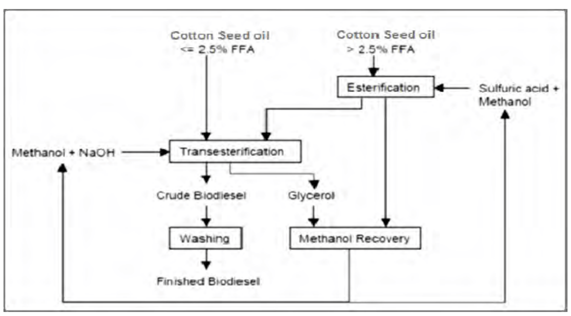

Fig.3.1.Process flow chart for bio-diesel production

Fig.3.2.Preheating of oil and Transesterification

Chemistry Of Transesterification Process:

The overall Transesterification reaction is given by Eq. (2). However, three consecutive and reversible reactions are believed to occur. These reactions are represented in Eq. (3). The process flow chart for bio-diesel production from

$$\text{Triglycerides} + ROH \rightleftharpoons \text{Diglycerides} \quad +R^1COOR$$

$$\text{Diglycerides} + ROH \rightleftharpoons \text{Monoglycerides} + R^2COOR$$

$$\text{Monoglycerides} + ROH \rightleftharpoons \text{Glycerol} \quad +R^3COOR$$

Equation 3 Chemistry of transesterification

The first step in the conversion is triglycerides to diglycerides followed by the conversion of diglycerides to monoglycerides and of monoglycerides to glycerol yielding one methyl ester molecule from each glycerides at each step.

Variables Affecting Transesterification Reaction:

Effect of Free Fatty Acids and Moisture:

The free fatty acid and moisture content are key parameters for determining the viability of the vegetable oil Transesterification process. To carry the base catalyzed reaction to complete; the three free fatty acid (FFA) value lower than 3% is needed. The higher the acidity of the oil, smaller is the conversion efficiency. Both, excess as well as insufficient amount of catalyst may cause soap formation. The starting materials used for base catalyzed alcoholysis should meet certain specifications. The triglycerides should have lower acid value and all material should be substantially anhydrous. The addition of more sodium hydroxide catalyst compensates for higher acidity, but the resulting soap causes an increase in viscosity or formation of gel, that interferers in the reaction as well as with separation of glycerol .

When the reaction conditions do not meet the above requirements, ester yields are significantly reduced. The methoxide and hydroxide of Na and K should be maintained in anhydrous state, prolonged contact with air would diminish the effectiveness of these catalysts through interaction with moisture and CO2.

Catalyst type and Concentration:

Catalyst used for the Transesterification of triglycerides is classified as alkali, acid, enzyme or heterogeneous catalysts, among which alkali catalysts like NaOH, NaOMe, KOH and KOMe are more effective. If the oil has high free acid content and more water, acid catalyst is suitable. The acids could be H2SO4, H3PO4 HCl or organic sulfonic acids. Methanolysis of beef tallow was studied with catalyst NaOH and NaOMe. Comparing the two catalysts, NaOHwas significantly better than NaOMe.

Alkali metal alkoxides are most effective Transesterification catalyst compared to the acid catalyst. Sodium alkoxides are the mostly efficient catalysts, although KOH and NaOH can also be used. Transmethylation occurs approximately 4000 times faster in presence of an alkaline catalyst than the same amount of acidic catalyst. As they are less corrosive to industrial equipments, alkaline catalysts are preferred in industrial processes. The concentration in the range of 0.5–1.0% (w/w) has found to yield 94–99% conversion of vegetable oils into ester and further increase of catalyst concentration does not affect the conversion but add to extra cost, as the catalyst needs to be removed from the reaction mixture after completion of reaction.

Molar ratio of Alcohol to Oil and type of Alcohol

Another important variable affecting the yield of ester is the molar ratio of alcohol to vegetable oil. The stoichiometry of the Transesterification reaction required 3 mol of alcohol per mol of triglyceride to yield three mol of fatty ester and 1 mol of glycerol. However, Transesterification is an equilibrium reaction in which a large excess of alcohol is required to drive the reaction to the right. A molar ratio of 6:1 is normally used in industrial process because the yield of ester is higher than 98% by weight. The molar ratio has no affect on acid, peroxide, soaponification and iodine value of methyl esters.

However, the high molar ratio of alcohol to vegetable oil interferes with separation of glycerin because; there is an increase in solubility. When glycerin remains in solution, it helps drive the equilibrium to back to the left, lowering the yield of esters. The transesterification of Cynara oil with ethanol was studied at molar ratios between 3:1 and 15:1. The ester yield used as the molar ratio increased up to a value of 12:1. The best results were for molar ratios between 9:1 and 12:1. For molar ratios less than 6:1, the reaction was incomplete.

For a molar ratio of 15:1 the separation of glycerin is difficult and the apparent yield of ester decreased because a part of the glycerol remains in the bio-diesel phase. Therefore molar ratio 9:1 seems to be the most approximate. The base catalyzed formation of ethyl ester is difficult compared to the formation of methyl esters. In the case of methanolysis, formation of emulsions quickly and easily breaks down to form a lower glycerol rich layer and upper methyl ester rich layer

Effect of Reaction Time And Temperature:

The literature (Freedman et al. 1984) has revealed that the rate of reaction is strongly influenced by the temperature. However, given enough time, the reaction will proceed to near completion even at room temperature. However, the reaction is conducted close to the boiling point of methanol (60–70°C) at atmospheric pressure for a given time. Such mild reaction conditions require the removal of free fatty acids from the oil by refining or pre esterification. Therefore degummed and de acidified oil is used as feedstock. Pre treatment is not required if the reaction is carried out under high pressure (9000 kPa) and high temperature (240°C). Under these conditions simultaneous esterification and Transesterification take place. The maximum yield of esters occurs at a temperatures ranging from 60 to 80°C at a molar ratio of (alcohol to oil) 6:1. Further increasing temperature, the yield of esters have a negative effect on the conversion.

Mixing Intensity:

Mixing is very important in the Transesterification reaction, as oils or fats are immiscible with NaOH–MeOH solution. Once the two phase are mixed and the reaction is started stirring is no longer needed. Methanolysis was conducted with different rate of stirring such as, 180, 360 and 600 revolution per minute (rpm). The reaction is incomplete with 180 rpm and rate of mixing was insignificant for methanolysis.

The yield of methyl esters at 360 rpm and 600 rpm was same after 3 h of reaction.Reaction time is the controlling factor for determining the yield of methyl esters. This suggested that the stirring speeds investigated exceeded the threshold requirement of mixing.

Separation of Bio-Diesel:

Murugesan et al. [11] reported that, after completion of the reaction the product is kept for a certain time interval for separation (approx. 12 h) of bio-diesel & glycerol layer as shown in Fig.6.3. The mixture of KOH and methonal settles at the bottom of the funnel because of higher density compare with bio-diesel. Where as small amount of catalyst, methanol & glycerol are in the upper bio-diesel layer. The upper layer is collected for further purification by washing.

Washing of Bio-Diesel:

Washing is a process to remove entrained glycerol, catalyst, soap & excess methanol. The excess methanol in biodiesel corrodes the fuel injection system and hence it should be separated from the bio-diesel.

Bubble-Washing And Oxidation:

Without oxygen the oil can't oxidise and polymerize. Everyone knows that a fish-tank aerator pump the water with oxygen so the fish can breathe. Bubble washing does the same thing to bio-diesel, pumping it with oxygen. We are using a small air pump, usually an aquarium aerator pump with a bubble-stone. Water is added to the bio-diesel in the separating funnel (usually a quarter to a half as much water as bio-diesel). The water sinks to the bottom, throw in the bubble-stone, which also sinks to the bottom, and switch on the pump. Air bubbles (smaller size are best) rise through the water and into the bio-diesel, carrying a film of water around them, which washes the bio-diesel around the bubble.When it reaches the surface, the bubble burst, leaving the water to sink back down again, washing the fuel again. Usually three or four times the water wash is done with a time interval of one hour between each wash. After the water is settled it is removed via bottom-drain of the separating funnel and replaced with fresh water. The distilled water is used always for washing the bio-diesel to avoid the contamination of oil. The clear water settled at the bottom of the separation funnel and bio-diesel is formed at top layer

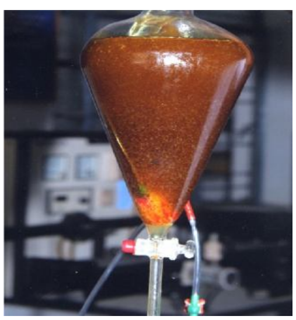

Fig.3.3.Bubble Wash

Drying Bio-Diesel:

Drying is ascertained by heating the washed fuel approximately to 110°C in an open container until there is no more steam from in the fuel, which should be a clear, amber-colored liquid as shown in Fig.6.5. This heating process will also drive off any traces of remaining alcohol as well. Then it is allowed to cool to room temperatures, it can be pumped directly into vehicles, or into storage containers. If the fuel still appears somewhat cloudy after drying. The drying cycle should be repeated but the likely culprit is probably the presence of non-water soluble contaminants in the fuel (such as mono and Di-glycrides). The pure Bio-diesel is collected and stored in the separating funnel

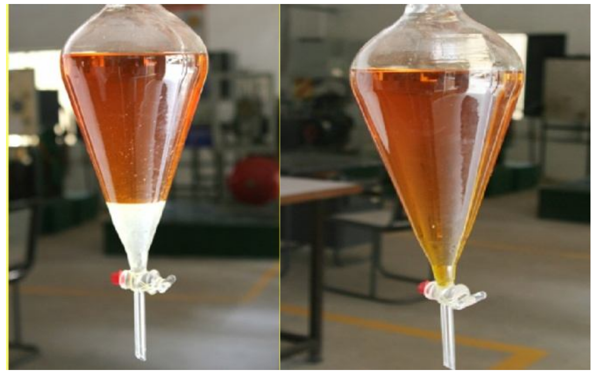

Fig.3.4..Pure biodiesel at top layer and Pure Biodiesel clear water at bottom layer

Table 3.1. Properties of Cotton seed oil and Diesel

Property	Cotton Seed Oil	Diesel	Is For Biodiesel
Density (Kg/m^3)	917.8	836	860-900
Kinematic Viscosity	69.6	3.8	4.5
Flash point (°C)	235	56	120
Fire point (°C)	265	63	130
Calorific Value KJ/Kg	36610	42800	39542.98

IV. EXPERIMENTAL METHODS

The engine is coupled with an eddy current dynamometer. The ester of oil will be blended with the diesel[BD20].With this nano particles at different ppm is blended with the biodiesel blend. Both the fuels were injected at the room temperature only. A fuel changing arrangement was provided to change one fuel mode to another.

Ultrasonic Shaker

The equipment used for mixing diesel fuel with Nanoparticles is an ultra-sonic shaker. The catalytic Nanoparticles added diesel was agitated for about 30 minutes in an ultrasonicator to obtain a stable Nanofluids. The dosing level of Nanoparticles samples (by weight) in diesel is varied from 100 to 900 ppm.

Fig.4.1. Ultrasonic Shaker

APPARATUS USED IN ESTIMATION OF PROPERTIES

The following equipments were used for the estimation of the properties of transesterified :

- Bomb Calorimeter
- The Redwood Viscometer
- Pensky Mart.

Equipment Used For Performance Characteristic Of The Engine

- VCR Engine
- Engine Diesel Mode

The Experimental Procedure:

Performance and emission tests experiments were conducted using the different proportions of iron oxide Nanoparticles and PDO blends. Important operating parameters such as engine shaft speed, generator output, fuel consumption rate, airflow rate, exhaust gas temperature and engine cooling water temperature were measured and performance characteristics such as brake thermal efficiency, specific fuel consumption etc were determined using fundamental relations. The test engine was coupled with an eddy current dynamometer as loading device.

A Photo sensor with a digital rpm indicator was used to measure the engine speed. The load of the engine was obtained from dial gauge reading with five discrete load conditions, varied from 0% to 100% insteps of 20%.During each run, the engine was allowed to run with neat diesel and blends at a constant speed of 1500 rpm for nearly 30 min, to attain the steady state conditions at the lowest possible load. The temperature of the lubricating oil and temperature of the engine cooling water were maintained constant at 65°C and 70°C respectively to eliminate their influence on the results.

The flow rate of cooling water was maintained at 7l/min. Temperature of the exhaust gas was measured using Chromel-Alumel (k-Type) thermocouples. A digital indicator with automatic room temperature compensation facility was used. Carbon mono oxide (CO),hydrocarbon (HC), Carbon-di oxide (CO2), Oxygen (O2) and NOx were measured using exhaust gas analyzer.AVL smoke meter was used to measure the smoke density of exhaust gas. The exhaust gas sample was allowedto pass through the cold trap (moisture separator) and filter element to prevent water vapour and periodically calibrated with standard gas as per the instruction provided by the manufacturer. Smoke density was measured in terms of Hart ridge Smoke Unit (HSU) and Oxides of nitrogen was measured in terms of ppm.*All the measurements were recorded by a data acquisition system. Each experiment was conducted thrice and average values were taken for further calculations. The possibilities of errors that could arise during the experiments were measured to prove the accuracy of the measurements. Hence the error analysis was carried out based on the accuracy and percentage uncertainties of the instruments used in these experiments. The total percentage of uncertainties of these experiments was calculated to be ± 3%.

Precautions Taken During Experiment:

- Before turning on the engine all the bolts and nuts are properly checked out.
- It is to be ensured that there is an adequate amount of oil present in the engine before turning it ON.
- The engine was checked out continually so that at the time of power failure, the supply of cooling water to dynamometer and engine may not be stopped.
- It was ensured that the fuel line and fuel tank were properly cleaned.
- The water supply was turned on before starting the engine

V. RESULTS AND DISCUSSIONS

Reading are taken in the VCR Diesel engine with the specifications as mentioned above with diesel, Cotton seed oil-diesel blend and with the B20,B30,B50 are mixed at two different proportions by varying the load from zero to maximum load and the results are tabulated and compared.

Performance Characteristics:

Brake Power

The part of power developed in the engine cylinder is used to overcome the local friction. The net power output is available at the shaft is known as brake power and it is denoted by B.P. It depends on speed of engine (R.P.M) and the load. All the readings were taken at constant R.P.M by varying the load on the engine.

Table 5.1 Performance of Brake Power

Sl.No	Load (Kg)	Diesel	B20	B30	B50
1	0	0.08	0.06	0.03	0.02
2	2	0.62	0.60	0.61	0.54
3	4	1.18	1.20	1.16	1.17
4	6	1.77	1.71	1.69	1.68
5	8	2.16	2.18	2.25	2.21
6	10	2.76	2.69	2.74	2.68
7	12	3.30	3.24	3.19	3.16

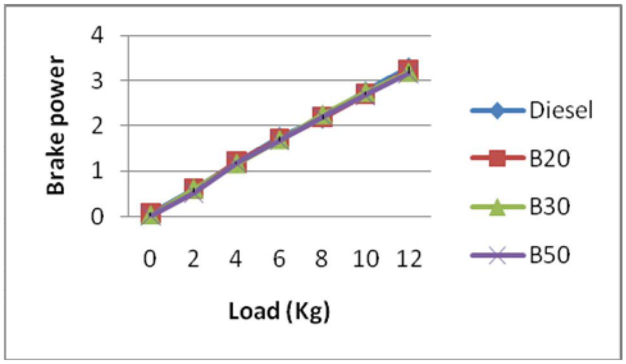

Fig 5.1 Load vs. Brake power

Brake Thermal Efficiency

It is the ratio of the thermal power available in the fuel to the power the engine delivers to the crankshaft. It is the ratio of brake power developed by engine to the heat supplied to the engine.

At full load condition it is clear from the graph that Brake Thermal Efficiency is slightly higher than that of diesel for B20,B30,B50.

Table 5.2 Performance of Brake Thermal Efficiency

Sl.No	Load (Kg)	Diesel	B20	B30	B50
1	0	2.16	1.99	1.10	0.64
2	2	14.57	14.25	14.54	12.81
3	4	21.49	22.23	21.55	21.55
4	6	26.36	26.02	25.68	25.34
5	8	28.51	28.09	28.89	28.20
6	10	30.33	29.99	30.49	31.87
7	12	32.15	31.86	31.34	30.88

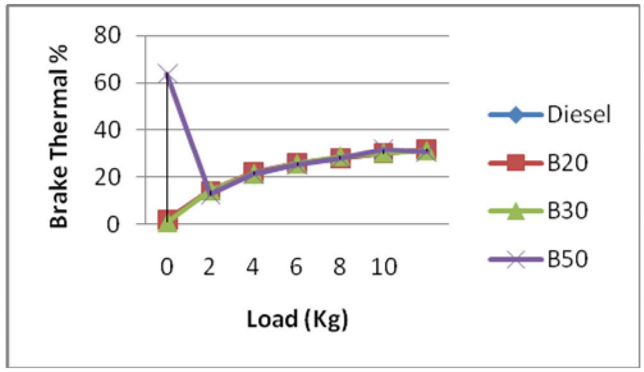

Fig No.5.2 Load vs BTHE

Specific Fuel Consumption (SFC):

It is defined as the fuel flow rate per unit power output. It is a measure of the efficiency of the engine in using the fuel supplied to produce work. It was desirable to have a lower value of SFC which means that the engine uses less fuel to produce the same amount of work. This is one of the most important parameters to compare when testing various fuels.

Table No.5.3 Performance of SFC

Sl.No	Load (Kg)	Diesel	B20	B30	B50
1	0	0.79	4.28	7.75	13.59
2	2	0.56	0.60	0.59	0.68
3	4	0.38	0.38	0.40	0.40
4	6	0.34	0.33	0.33	0.34
5	8	0.31	0.30	0.30	0.31
6	10	0.29	0.28	0.28	0.27
7	12	0.26	0.27	0.27	0.28

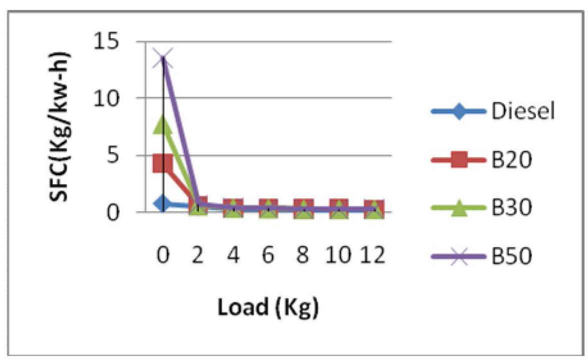

Fig.No.5.3 Load vs SFC(kg/kw-h)

Mechanical Efficiency (η_{mech})

Mechanical Efficiency is higher for the B20 blend compared to Diesel

Table No.5.4.Mechanical Efficiency (η_{mech})

SI.No.	Load (Kg)	Diesel	B20	B30	B50
1	0	4.20	1.16	0.94	0.58
2	2	26.20	21.14	24.98	14.09
3	4	41.55	42.59	35.17	26.00
4	6	51.63	53.44	43.76	33.72
5	8	59.34	60.55	50.96	40.44
6	10	65.61	66.45	56.08	45.45
7	12	70.10	71.97	65.61	49.01

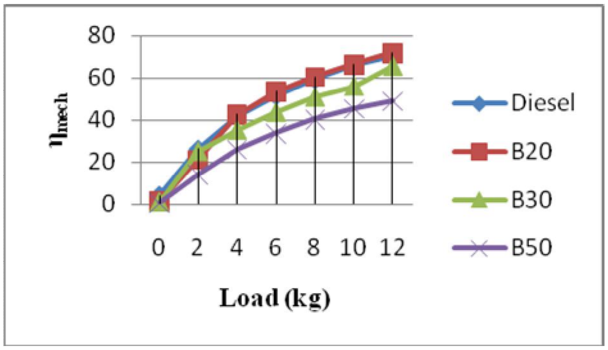

Fig.No.5.4 η_{mech} vs Load(Kg)

Volumetric Efficiency(η_{vol})

As the load increases Volumetric efficiency of B20,B30,B50(40ppm,60ppm) is nearly comparable to that of the diesel.

Table.No.5.5 Comparison of Volumetric Efficiency(η_{vol})

SI.No	Load (Kg)	Diesel	B20	B30	B50
1	0	78.12	74.67	75.01	75.12
2	2	77.98	75.29	75.74	74.95
3	4	78.11	75.18	75.20	75.01
4	6	78.00	74.85	75.61	75.28
5	8	78.01	75.31	74.98	75.10
6	10	77.67	75.00	75.09	74.70
7	12	76.90	74.84	74.92	74.50

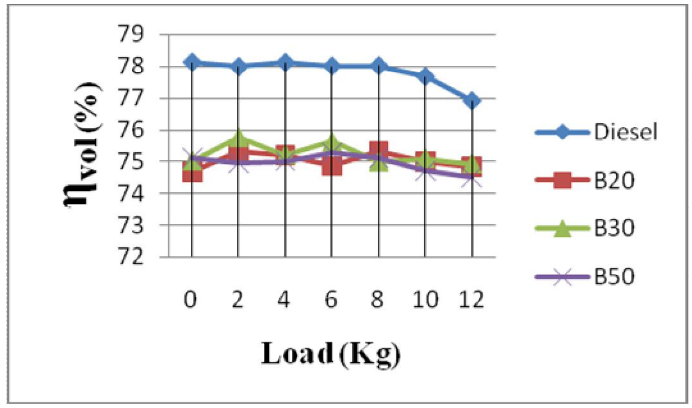

Fig.No. 5.5 η_{vol} vs Load (Kg)

Emission of Co from Biodiesel Blending B20, B30, B50 compare with Diesel (ppm):

Table No.5.6 Emission of Co

SI.No	Load (Kg)	Diesel	B20	B30	B50
1	0	0.02	0.03	0.03	0.02
2	2	0.03	0.02	0.02	0.02
3	4	0.03	0.02	0.02	0.02
4	6	0.02	0.03	0.02	0.01
5	8	0.01	0.01	0.01	0.01
6	10	0.01	0.01	0.01	0.01
7	12	0.01	0.01	0.01	0.01

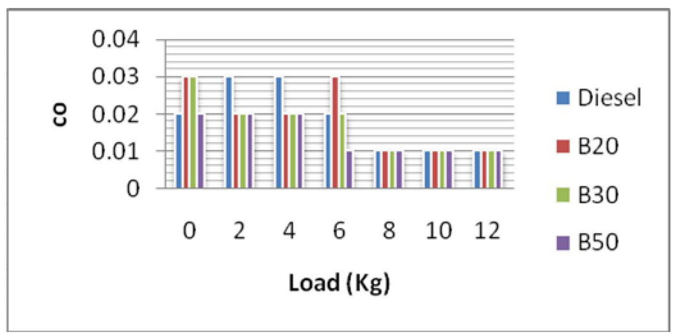

Fig.No.5.6 Load vs Co

Emission of HC from Biodiesel Blending B20, B30, B50 compare with Diesel (ppm):

Table.No.5.7 Emission of HC

SI.No	Load (Kg)	Diesel	B20	B30	B50
1	0	17	14	17	14
2	2	9	1	9	9
3	4	8	2	6	8
4	6	7	4	1	5
5	8	3	1	1	1
6	10	4	0	0	1
7	12	6	0	0	1

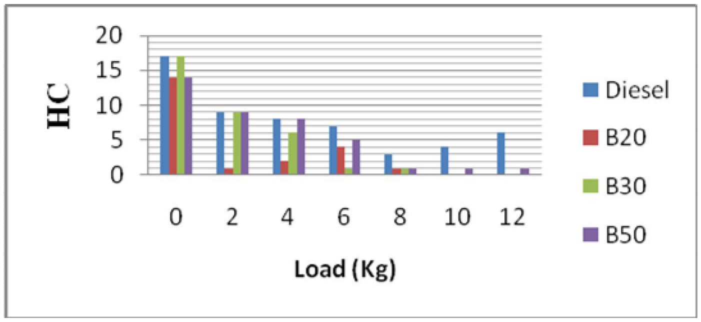

Fig.No.5.7 Load vs. HC

Emission of NO from Biodiesel Blending B20, B30, B50 compare with Diesel(ppm):

Table.No.5.8.Emission of NO

Sl.No	Load (Kg)	Diesel	B20	B30	B50
1	0	3	5	10	9
2	2	7	10	16	13
3	4	12	17	19	25
4	6	23	33	33	21
5	8	19	43	34	32
6	10	27	28	37	29
7	12	26	31	37	35

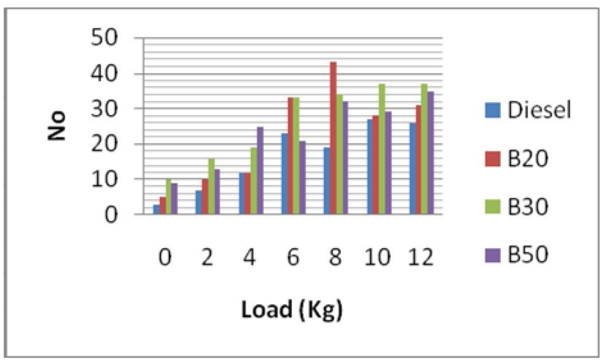

Fig.No.5.8.NO vs. Load (Kg)

Emission of CO_2 from Biodiesel Blending B20, B30, B50 compare with Diesel(ppm):

Table 5.9 Emission of CO_2

Sl.No	Load (Kg)	Diesel	B20	B30	B50
1	0	0.5	0.4	0.5	0.4
2	2	0.5	0.4	0.4	0.5
3	4	0.4	0.4	0.5	0.6
4	6	0.4	0.5	0.5	0.4
5	8	0.3	0.6	0.4	0.4
6	10	0.4	0.4	0.4	0.4
7	12	0.4	0.5	0.4	0.5

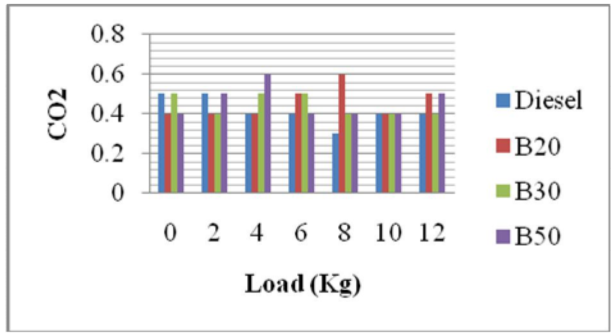

Fig.No.5.9 Load vs. CO_2

VI. CONCLUSION AND FUTURE WORK

6.1. CONCLUSION

In this study a complete methodology for optimization of effective parameters of cotton seed biodiesel and experimentally investigating the performance of the VCR engine(diesel) using cotton as biofuel by different Blending B20, B30, B50.as additives is discussed. The specifications and working of different apparatus and the instruments used for the Transesterification of biodiesel and investigation of VCR engine(diesel) is discussed elaborately in this study.The parameters to be investigated to check the performance and emission characteristics of VCR engine (diesel) while using cotton seed oil biodiesel.

6.2. FUTURE WORK

As a continuity of my project we are going to carry out the Transesterification of cotton seed biodiesel and optimize the effective parameters to obtain a better yield of cotton biodiesel using Taguchi method.

Then we are going to blend nanoparticles with Cotton seed-diesel blend at different ppm and going to carry out the experiment in VCR engine(diesel) and the results are tabulated.

From the results performance, combustion and emission characteristics of the VCR engine (diesel) is analyzed.

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