STUDY OF PERFORMANCE AND EMISSION OF DIESEL ENGINE WITH BIODIESEL SUBSTITUTES OF DIFFERENT PROPORTIONS

Project Report

Submitted in partial fulfillment of the requirements for the award of

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CERTIFICATE

This is to certify that this project report entitled ***"STUDY OF PERFORMANCE AND EMISSION OF DIESEL ENGINE WITH BIODIESEL SUBSTITUTES OF DIFFERENT PROPORTIONS "*** is a bonafide record of the Project work done by **CHARANRAJ K, BADEEL, SHAMEEM P K and SHAHABAS T** of 8th semster B.Tech under our guidance towards the partial fulfillment of the requirements for the award of **B.Tech Degree in Mechanical Engineering** of the APJ Abdul Kalam Technological University during the year 2019.

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ABSTRACT

The world is presently confronted with the twin crises of fossil fuel depletion and environmental degradation. Search for an alternative fuel, which promises a harmonious correlation with sustainable development, energy conservation, efficiency and environmental preservation, has become highly pronounced in the present scenario. Vegetable oil's physical and chemical properties are close enough to mineral diesel and may be used as alternative to diesel, but long-term use of vegetable oils or their blends pose various operational and durability problems in the engine, and need to be modified (biodiesel). Transesterification is found to be an effective technique for the vegetable oil formulation as a fuel. The present work involves comparing the performance and emission characteristics of diesel and biodiesel of different blends such as B10 and B20.

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Chapter 1

INTRODUCTION

1.1 Background

As the fossil fuels are depleting day by day, there is a need to find out an alternative fuel to fulfill the energy demand of the world. Biodiesel is one of the best available sources to fulfill the energy demand of the world. The petroleum fuels play a very important role in the development of industrial growth, transportation, agricultural sector and to meet many other basic human needs. However, these fuels are limited and depleting day by day as the consumption is increasing very rapidly. Moreover, their use is alarming the environmental problems to society. Hence, the scientists are looking for alternative fuels. India is importing more than 80% of its fuel demand and spending a huge amount of foreign currency on fuel. Bio diesel is gaining more and more importance as an attractive fuel due to the depleting nature of fossil fuel resources. The purpose of transesterification process is to lower the viscosity of the oil. The main drawback of vegetable oil is their high viscosity and low volatility, which causes poor combustion in diesel engines. The transesterification is the process of removing the glycerides and combining oil esters of vegetable oil with alcohol. This process reduces the viscosity to a value comparable to that of diesel and hence improves combustion. Biodiesel emits fewer pollutants over the whole range of air–fuel ratio when compared to diesel. Biodiesel can produce by using different techniques such as ultrasonic cavitation, hydrodynamic cavitation, microwave irradiation, response surface technology, two-step reaction process etc. Experiments had been conducted for different types of combustion chambers. It was found that spherical combustion chamber gives better results than other type of combustion chambers. The scientists tested a number of different raw and processed vegetable oils like rapeseed oil, sunflower oil, palm oil, soybean oil. In this paper, the results of some of the researchers has compared and summarized.

1.2 Objectives

- To find the performance and emission characteristics of Diesel engine with different proportions of biodiesel as a substitute.
- To compare the performance and emission characteristics of Biodiesel and Diesel.
- To compare the experimental result with the result of International journals.

1.3 Scope

- Biodiesel is a safe alternative fuel to replace traditional petroleum diesel. It has high-lubricity, is a clean-burning fuel and can be a fuel component for use in existing, unmodified diesel engines. This means that no retrofits are necessary when using biodiesel fuel in any diesel powered combustion engine. It is the only alternative fuel that offers such convenience. Biodiesel acts like petroleum diesel, but produces less air pollution, comes from renewable sources, is biodegradable and is safer for the environment. Producing biodiesel fuels can help create local economic revitalization and local environmental benefits.
- Due to increased population ,the demand for power requirement goes on increasing day by day.So for satisfying the power requirement an alternative power source is to be found .Biodiesel production in general preserves the fossil fuel to the future generation.

Chapter 2

History

Trans-esterification of vegetable oil was conducted as early as 1853 by scientists E. Duffy and J. Patrick, many years before the first diesel engine became functional. Rudolf Diesel's prime model, a single 10 ft (3 m) iron cylinder with a flywheel at its base, ran on its own power for the first time in Augsburg, Germany, on 10 August 1893 running on nothing but peanut oil. In remembrance of this event, 10 August has been declared "International Biodiesel Day".

It is often reported that Diesel designed his engine to run on peanut oil, but this is not the case. Diesel stated in his published papers, "at the Paris Exhibition in 1900 (Exposition Universelle) there was shown by the Otto Company a small Diesel engine, which, at the request of the French government ran on arachide (earth-nut or pea-nut) oil, and worked so smoothly that only a few people were aware of it. The engine was constructed for using mineral oil, and was then worked on vegetable oil without any alterations being made. The French Government at that time thought of testing the applicability to power production of the Arachide, or earth-nut, which grows in considerable quantities in their African colonies, and can easily be cultivated there." Diesel himself later conducted related tests and appeared supportive of the idea. In a 1912 speech Diesel said, "The use of vegetable oils for engine fuels may seem insignificant today but such oils may become, in the course of time, as important as petroleum and the coal-tar products of the present time."

Interest in vegetable oils as fuels for internal combustion engines was reported in several countries during the 1920s and 1930s and later during World War II. Belgium, France, Italy, the United Kingdom, Portugal, Germany, Brazil, Argentina, Japan and China were reported to have tested and used vegetable oils as diesel fuels during this time.

Some operational problems were reported due to the high viscosity of vegetable oils compared to petroleum diesel fuel, which results in poor atomization of the fuel in the fuel spray and often leads to deposits and coking of the injectors, combustion chamber and valves. Attempts to overcome these problems included heating of the vegetable oil, blending it with petroleum-derived diesel fuel or ethanol, pyrolysis and cracking of the oils. In 1977, Brazilian scientist Expedito Parente invented and submitted for patent, the first industrial process for the production of biodiesel. This process is classified as biodiesel by international norms, conferring a "standardized identity and quality. No other proposed bio-fuel has been validated by the motor industry."

Chapter 3

Literature Survey

BP increased until 3000 rpm where it reached a maximum regardless of the fuel used. After that, BP decreased, although a slight increase occurred again at 4000 rpm. Small differences were observed in the values of this parameter working with different fuels. Petroleumderiveddiesel (D) produced the highest power at the lowest enginespeeds (1500–2500 rpm), which was in agreement with the results found by other authors [7, 8]

Moreno et al. [6] observed that the BSFC of sunflower biodiesel was 10-12% higher than that of Diesel. This increase in BSFC was attributed to lower calorific value of Sunflower based Biodiese,l.

Varatharajan et al. [3] observed that the BSFC value of Doped Sunflower Biodiesel was 1% higher than Pure Sunflower biodiesel. This is due to the fact the heating value of Doped Sunflower Biodeiesel decreased due the presence of Phenolic Anti oxidant additive.He also observed that the BSFC was slightly higher when ascorbic acid and tocopherol were added to jatropha biodiesel.

Man et al. [9] found a higher BTE for biodiesel produced from waste cooking oil and attributed this result to a better combustion process because of the oxygen present in the biodiesel chemical structure,as well as to the lower friction loss in the injection system.

Haşimoğlu et al. [11] investigated the performance of biodiesel prepared from sunflower oil in a 4-cylinder turbocharged DI diesel engine and observed that BTE was 3% higher for biodiesel with respect to diesel. He also observed that addition of 10% Sunflower biodiesel to diesel provoked a negligible rise in BTE (0.1–0.9%) at 1500, 2000 and 4000 rpmcompared to D.

BTE values for Doped Sunflower Biodiesel, which contained the antioxidant additive from bio-oil, decreased by 0.1–0.8% with respect to the neat biodiesel, SB, suggesting that the presence of the additive did not significantly impact on the performance of the diesel engine. This reduction in BTE values were attributed to an incomplete and improper combustion resulting from the antioxidant addition [12, 13].

Average NOx specific emissions for biodiesel fuels were higher than those for diesel. It was observed that the NOx emission of Sunflower Biodiesel was 7.3% higher than that of Diesel [1, 10, 14].

Hoekman el al. reviewed several properties of diesel and biodiesel, finding values of cetane number for sunflower biodiesel of 51 ± 3.2, whereas it ranges between 40 and 45 for petroleum diesel [15]. This higher Cetane number of Sunflower Biodiesel shows that it has less Ignition Delay compared to Diesel.

Rashed et al. [8] observed that the NO_x formation was slightly reduced by 0.1 g/kW·h when Sunflower Biodiesel was treated with the antioxidant additive obtained from bio-oil solvent extraction (DSB). This is due to the fact that the antioxidants act as radical quenching agents and therby, diminishes NO_x formation.

According to Man et al. [16], NO_x production was directly proportional to the engine load, independent of the fuel used and the engine speed. An increase in the engine load led to more fuel injected. This caused a rise in the temperature and promoted NO_x formation.

It was observed that the CO emissions of SB10 was reduced by 4.6% compared to that of pure diesel. CO formation is attributed to incomplete combustion of fuel. The reduction of CO emissions with biodiesel is mainly due to the oxygen content in the fuel structure that helps to get complete combustion of CO to CO_2 [2, 17].

Average CO specific emissions of DSB slightly increased by 0.6% in comparison to that of SB without additive and were 29.3% below diesel emissions. This is due to the fact that during oxidation, the formation of several radicals such as peroxyl (HO2) and hydrogen peroxide (H2O2) takes place.These radicals are further converted into hydroxyl radicals (OH), which aids in the conversion of CO into CO2, by absorbing heat from the combustion chamber. Antioxidant additives reduce the concentration of peroxyl and hydrogen peroxide radicals and as a consequence, the formation of OH radicals, affecting CO oxidation [2, 4].

It was observed that the CO emissions were less at lower engine loads(25% to 50% of full load), but increased as the engine load rose to full load condition. This is due to the fact that at higher engine load, the fuel-air ratio was higher [9].

CO2 specific emissions of Sunflower Biodiesel (SB) were 1.7% higher than that of diesel (D) emissions. Availability of oxygen in the biodiesel chemical structure and its lower carbon content improve combustion and enhance CO2 formation [18].

An increase in CO2 emissions was observed with increase in engine load at any engine speed due to a higher fuel consumptionAt the lowest load (25%), lowest CO2 formation took place at 3250 rpm using any fuel. The highest emissions were observed at 50% load at 2500 rpm[13].

HC emissions of SB10 was found to be 32,5% less than that of pure diesel. This shows that the presence of biodiesel significantly decreased HC emissions. The higher amount of oxygen in biodiesel and its higher Cetane number may create some advantageous conditions during air-fuel interactions, which result in the reduction of the ignition delay and enhance the oxidation of unburned HC with a significant emission decrease [2, 5, 15]. Moreover, the lower carbon content in biodiesel also enables complete combustion to a greater extent[18].

Most of the research works about the effect of amine and phenolic antioxidants on the emissions from diesel engines presented an increase in HC emissions when biodiesel was treated with such compounds. Reduction of peroxyl and hydrogen peroxide radicals, responsible for the conversion of CO into CO2 and HC into H2O and CO2, in the presence of the antioxidant additives causes a significant increase in the amount of HC present in the exhaust gases [3, 13].

Chapter 4

Methodology

- Production of Bio diesel from cooking oil which is used once by using Bio diesel reactor.
- Verification of Ester(Bio diesel) by Thin Layer Chromatography Method.
- Obtaining the Performance Characteristics and Emission Characteristics of Diesel in Atul Single Cylinder Diesel Engine.
- Obtaining the Performance Characteristics and Emission Characteristics of Biodiesel of different blends(B10 and B20) in Atul Single Cylinder Diesel Engine.
- Comparing the Performance Characteristics and Emission Characteristics of Diesel and Biodiesel.
- Comparing the obtained data with the reference data in the International journal.

Chapter 5

Theory

5.1 Bio Diesel

Biodiesel is an alternative fuel similar to conventional or 'fossil' diesel. Biodiesel can be produced from straight vegetable oil, animal oil/fats, tallow and waste cooking oil. The process used to convert these oils to Biodiesel is called transesterification. Most biodiesel produced at present is produced from waste vegetable oil sourced from restaurants, chip shops, industrial food producers etc. Though oil straight from the agricultural industry represents the greatest potential source, it is not being produced commercially simply because the raw oil is too expensive. After the cost of converting it to biodiesel has been added on it is simply too expensive to compete with fossil diesel. Waste vegetable oil can often be sourced for free or sourced already treated for a small price. (The waste oil must be treated before conversion to biodiesel to remove impurities). The result is Biodiesel produced from waste vegetable oil can compete with fossil diesel.

5.2 Transesterification Reaction

The process used for converting the raw material into biodiesel is Transesterification. In this process, trigycerides react with alcohol (methanol or ethanol) in the presence of a base catalyst such as sodium hydroxide or potassium hydroxide to produce glycerol and alkyl esters.

Then Glycerol has to be separated from alkyl esters. Since glycerol is more denser than alkyl ester, glycerol will settle down at the bottom of the separator unit and the less dense alkyl ester(Bio oil) will float on the surface. Bio diesel is prepared by blending diesel with bio oil in different proportions.

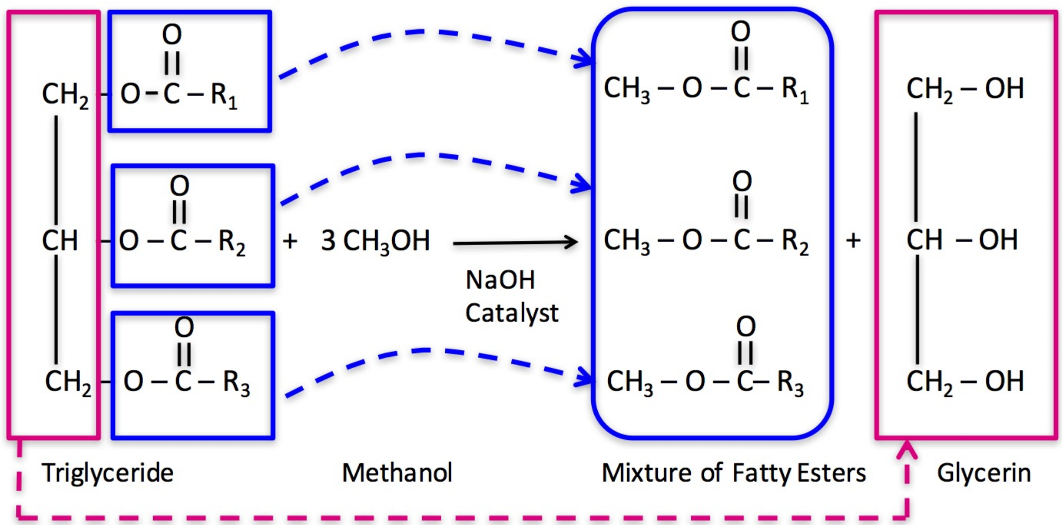

Figure 5.1: Transesterification Reaction

5.3 Advantages and Disadvantages

5.3.1 Advantages

- Renewable, biodegradable, non toxic and essentially free of Sulphur and aromatics, emits less air pollutant and green house gases other than nitrogen oxides.
- Bio diesel is simple to use(no vehicle modification or any fueling equipment needed)
- It has a very good lubrication property when compared to diesel. So, it increases the engine life.
- Bio diesel reduces the use of foreign oils.

- Less harmful impact on human health, decreased levels of hydrocarbon and nitrated compounds that have been identified as potential cancer causing compounds.
- Bio diesel have comparatively high cetane number and therefore, knocking will be less.
- High quality bio diesel cleanout the contaminants and carbon residue.

5.3.2 Disadvantages

- At present, bio diesel fuel is about one and a half more expensive than petroleum and diesel.
- It has less 5-10% less energy density than petroleum diesel. This will result in a slight loss in power.
- It has more gelling issue than petro diesel. It begins to cloud at a temperature of 4.4°C.
- B100(100% Biodiesel) can corrode rubber lines, seals and gaskets.
- As biodiesel cleans the dirt from engine, this dirt can get collected in the fuel filter and clogging occurs, so filters should be changed regularly.
- Bio diesel fuel distribution infrastructure needs improvements.

5.4 Brake Horse Power (BHP)

It is the power measured at the crankshaft just outside the engine, before the losses of power caused by the gear box efficiency and drive train efficiency.

$$\text{B.P} = \frac{2\pi NT}{60}\ KW$$

5.5 Indicated Horse Power (IHP)

It is the amount of power developed by an engine.

$$\text{IP} = \text{BP} + \text{FP}\ KW$$

5.6 Friction Power (FP)

Power lost especially in an internal combustion engine through friction between parts(connecting rod, crank, crankshaft, camshaft etc) of the machine itself.

5.7 Total Fuel Consumption (TFC)

Total fuel consumption is the quantity of fuel consumed by the engine per unit time while a certain power is developed by the engine.

$$\text{TFC} = \frac{v \times 3600}{t \times 1000} \text{ Kg/hr}$$

5.8 Special Fuel Consumption (SFC)

It is the amount of fuel consumed for producing unit brake power.

$$\text{SFC} = \frac{\text{TFC}}{\text{BP}} \text{ Kg/KWhr}$$

5.9 Indicated Thermal Efficiency (ITE)

It gives an idea of power generated by the engine within the cylinder w.r.t heat supplied(theoretically calculated calorific value of the fuel in the form of fuel)

$$ITE = \frac{I.P \times 3600}{TFC \times CV} \times 100$$

5.10 Brake Thermal Efficiency (BTE)

It is defined as the brake power of a heat engine as a function of the thermal input from the fuel. It is used to evaluate how well an engine converts the heat from a fuel to mechanical energy.

$$BTE = \frac{B.P \times 3600}{TFC \times CV} \times 100$$

5.11 Mechanical Efficiency (η_{mech})

It is a parameter which gives the effectiveness of an engine in transforming it's input energy to output energy. For an internal combustion engine, it is the ratio between the brake power and indicated work.

$$\eta_{mech} = \frac{B.P}{I.P} \times 100$$

Chapter 6

Experimental Work

6.1 Materials

1. Sunflower Oil (3 litres)
2. Methanol(600mL)
3. KOH(20g)
4. Distilled Water(warm)
5. Chromatographic Plate
6. Ethyl Acetate

6.2 Equipments and Machinery

1. Biodiesel Reactor

Bio diesel reactor is used for the production of biodiesel through transesterification process,this involves vegetable or animal fats and oils being reacted with short chain alcohols (typically methanol or ethanol) to produce bio oil. Here we are using sunflower oil and methanol. It consists of a stirrer,oil tank and water bath where oil tank is partially immersed in the water bath.Stirrer is operated by external power. Water in water batch is heated upto 65°C and the mixture of methanol and sunflower oil along with KOH as catalyst is poured in the oil tank and is continuously stirred using stirrer for about 3hrs keeping the temperature of water constant at about 65°C using external heater.

Figure 6.1: Biodiesel Reactor

2. Conical Separator

A conical separator is used to separate the products of transesterification, that is to separate bio oil and glycerol. Glycerol will settle on the bottom of conical separator because of its higher density.

Figure 6.2: Conical Separator

3. TLC UV Cabinet

TLC is used for confirming the product is an ester. TLC is a chromatography technique used to separate nonvolatile mixtures.

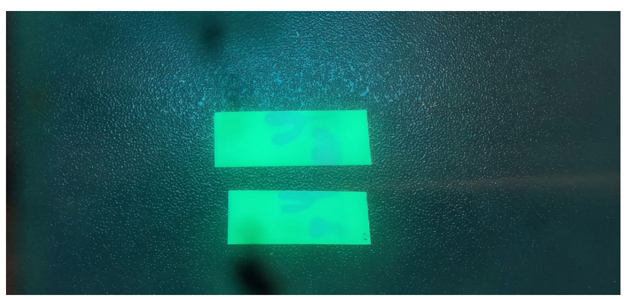

Figure 6.3: TLC

Figure 6.4: Chromatographic Plate and UV Cabinet

4. Gas Analyzer

GasAnalyzer is meant for monitoring CO,CO_2,HC,O_2 and NO_x in automotive exhaust.It is used to analyze exhaust gases in atul single cylinder diesel engine.

Figure 6.5: 5 Gas Analyzer

5. Atul Single Cylinder Diesel Engine

BHP=5	Stroke of Engine=110mm	Dia of Brake Drum=300mm
RPM=1500	Dia of Piston=85mm	Orifice Dia=15mm

Figure 6.6: Atul Single Cylinder Diesel Engine

6.3 Bio Oil Production

- We started our project with the production of Bio oil by mixing 3 liters of Sun flower oil with 600mL Methanol and 20 g KOH as catalyst in Bio diesel reactor at a temperature of 65°C.
- The mixture was stirred for about 3.5 hours continuously. Then, we transferred the product (Alkyl Ester + Glycerol) into a conical separator. After 12 hours, glycerol got separated at the bottom of the conical separator due to its high density. Then, the glycerol was separated from the bio oil. To remove excess Glycerol, we poured hot water into the Seperator. Glycerol got dissolved in water and then it is removed.

- Then we heated the Bio oil at 100°C to remove water from Bio oil by vapourisation and we got pure Bio oil.
- To make different blends of Biodiesel, we first mixed 100 mL Bio oil with 900 mL Diesel and we got 1 litre of B10.
- Then, we mixed 200 mL bio oil with 800 mL Diesel and we got 1 litre of B20.

6.4 Ester Verification of Bio Oil

Ester verification is done by using a technique called TLC (Thin Layer Chromatography). TLC is a chromatography technique used to separate non volatile mixtures. It is performed on a sheet of glass pastic or aluminium foil which is coated with thin layer of absorbent material usually silica gel aluminium oxide or cellulose.

We took a drop of Bio oil and normal Sunflower oil at one end of a chromatographic plate and then we dipped it in ethyl acetate solvent. Due to adsorption, the ethyl acetate rises along the chromatographic plate carrying both bio oil and normal sunflower oil along with it. Bio oil got raised up more along with the solvent than normal sunflower oil. This is due to the fact that bio oil is less denser than normal sunflower oil. Hence, ester verification is done.

6.5 Bio Diesel Production

- To make different blends of Biodiesel, we first mixed 100 mL Bio oil with 900 mL Diesel to get 1 litre of B10.
- Then, we mixed 200 mL bio oil with 800 mL Diesel to get 1 litre of B20

6.6 Load Test and Emission Test

6.6.1 Load Test Procedure

Loading is done to obtain the performance of the engine under load. It is done by using a brake drum dynamometer. It is a power absorbing device. The action of all power absorbing device used for testing engine results is converting the rotational tendencies of the crankshaft into tangential force acting at some established distance from the center of the rotation. BHP of an engine is the net horse power available at its crankshaft for doing useful work. Usually it is measured with the help of some brake arrangement and hence named as brake horse power. Rope Brake Dynamometer is the simplest method and consist of a rope making one complete turn around the rim of the brake drum. One end of the rope carries a dead load whereas the other end is connected to the spring balance. This spring balance is hooked to an iron frame of the engine. The direction of rotation of the brake drum is always against the pull of the dead load. The brake drum is generally water cooled and the power absorbed by friction is converted into heat and hence the temperature of brake drum will go high if it is not cooled.

(i) Load Test on Diesel (CV= 45.5 MJ/Kg)

Table 6.1: Load Test on Diesel

SL NO	LOAD(KG)			time for 10CC consumption	B.P	I.P	TFC	SFC	BTE	ITE	MECH EFFICIENCY
	W	S	$W-S$	(sec)	(K.W)	(K.W)	(Kg/hr)	(Kg/KWhr)	(%)	(%)	(%)
1	0	0	0	85	0	0.38	0.4235	∞	0	7.1	0
2	2	0.6	1.4	71	0.323	0.703	0.507	1.57	5.04	10.97	44.94
3	4	0.7	3.3	60.01	0.763	1.143	0.6	0.786	10.06	15.07	66.75
4	6	0.8	5.2	52	1.201	1.581	0.692	0.576	13.732	18.07	75.96
5	8	0.9	7.1	46	1.641	2.021	0.783	0.477	16.582	20.42	81.2

(ii) Load Test on B10 (CV= 44.4 MJ/Kg)

Table 6.2: Load Test on B10

SL NO	LOAD(KG)			time for 10CC consumption	B.P	I.P	TFC	SFC	BTE	ITE	MECH EFFICIENCY
	W	S	$W-S$	(sec)	(K.W)	(K.W)	(Kg/hr)	(Kg/KWhr)	(%)	(%)	(%)
1	0	0	0	102	0	0.38	.353	∞	0	8.72	0
2	2	0.55	1.45	78	0.335	0.715	0.461	1.376	5.89	12.57	46.85
3	4	0.625	3.375	60.06	0.78	1.16	0.6	0.77	10.54	15.67	67.24
4	6	0.7	5.3	55	1.225	1.605	0.649	0.53	15.3	20.05	76.32
5	8	0.8	7.2	48	1.664	2.044	0.75	0.451	17.98	22.1	81.41

(iii) Load Test on B20 (CV= 44.1 MJ/Kg)

Table 6.3: Load test on B20

SL NO	LOAD(KG)			time for 10CC consumption	B.P	I.P	TFC	SFC	BTE	ITE	MECH EFFICIENCY
	W	S	$W-S$	(sec)	(K.W)	(K.W)	(Kg/hr)	(Kg/KWhr)	(%)	(%)	(%)
1	0	0	0	101.5	0	.38	0.355	∞	0	8.74	0
2	2	0.525	1.475	80.5	0.341	0.721	0.447	1.311	6.23	13.17	47.29
3	4	0.625	3.375	60.07	0.786	1.166	0.6	0.763	10.69	15.86	67.41
4	6	0.7	5.3	56.5	1.225	1.605	0.637	0.52	15.69	20.57	76.32
5	8	0.75	7.25	50	1.675	2.055	0.72	0.43	19	23.3	81.5

6.6.2 Emission Test Procedure

Emission characteristics are obtained by performing emission test. The Exhaust gases coming out from the engine is sensed by the Gas Analyzer and the proportions of different gases(NO_x, CO, CO_2, HC, O_2) in the exhaust is obtained.

(i) Emission Test on Diesel

Table 6.4: Emission Test on Diesel

SL NO	LOAD			CO (%)	HC (ppm)	CO_2 (%)	O_2 (%)	NO_x (ppm)
	W	S	$W-S$					
1	0	0	0	0	0	0.0.05	20.41	0
2	2	0.6	1.4	0	10	0.4	17.58	357
3	4	0.7	3.3	0	10	0.4	18.3	270
4	6	0.8	5.2	0	10	0.4	18.29	255
5	8	0.9	7.1	0	81	2.64	17.4	314

(ii) Emission Test on B10

Table 6.5: Emission Test on B10

SL NO	LOAD			CO	HC	CO_2	O_2	NO_x
	W	S	$W-S$	(%)	(ppm)	(%)	(%)	(ppm)
1	0	0	0	0.0135	2	0.4	18.42	127.5
2	2	0.55	1.45	0.019	2	1.115	18.07	147
3	4	0.625	3.375	0.018	2.5	1.005	18.32	129.5
4	6	0.7	5.3	0.018	2	0.4	18.345	123.5
5	8	0.8	7.2	0.018	3	0.4	18.35	127

(iii) Emission Test on B20

Table 6.6: Emission Test on B20

SL NO	LOAD			CO	HC	CO_2	O_2	NO_x
	W	S	$W-S$	(%)	(ppm)	(%)	(%)	(ppm)
1	0	0	0	0	0	0	21.225	0
2	2	0.525	1.475	0.001	0	0	21.33	0
3	4	0.6	3.4	0.0025	0	0	21.38	0
4	6	0.7	5.3	0.007	0	0	21.295	0
5	8	0.75	7.25	0.009	0	0	21.33	0

Chapter 7

Results and Discussions

7.1 Performance Characteristics

7.1.1 TFC v/s BP

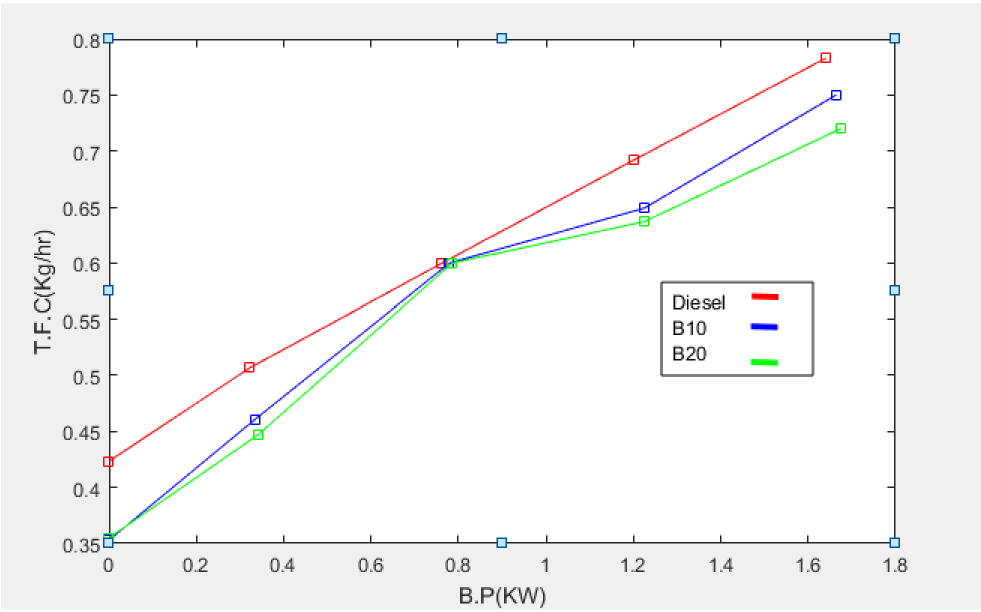

Figure 7.1: TFC v/s BP

- TFC of B20 is comparatively lesser than that of B10 and biodiesel.
- B20 is more economic than Diesel in terms of fuel consumption.

7.1.2 SFC v/s BP

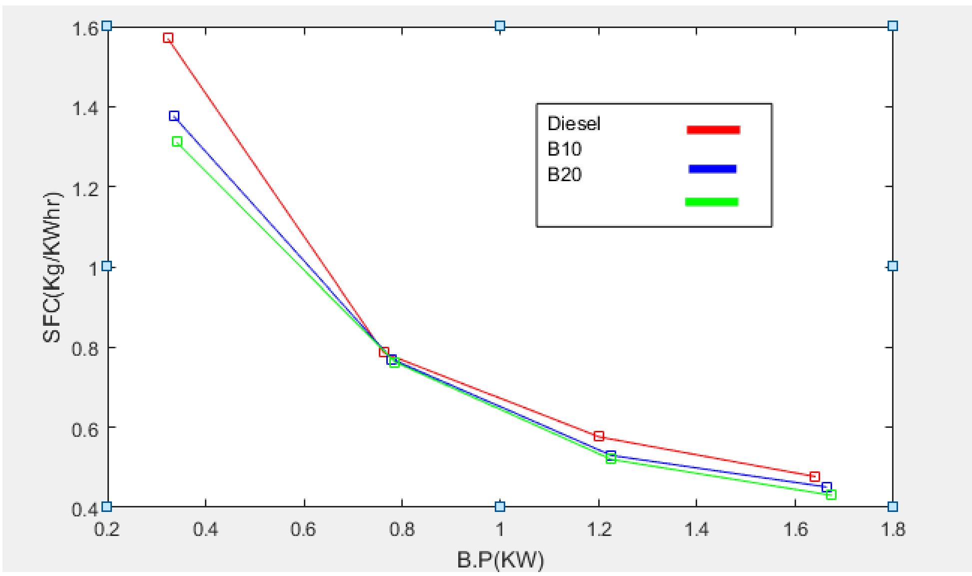

Figure 7.2: SFC v/s BP

- Quantity of fuel required for producing unit brake power is higher for diesel than B10 and B20.

7.1.3 BTE v/s BP

- B20 has higher brake thermal efficiency ,it means that in the case of B20 a large part of heat input is converted into useful work.

7.1.4 ITE v/s BP

- ITE of B10 and B20 is comparable which is higher than diesel ,B20 has higher ITE.

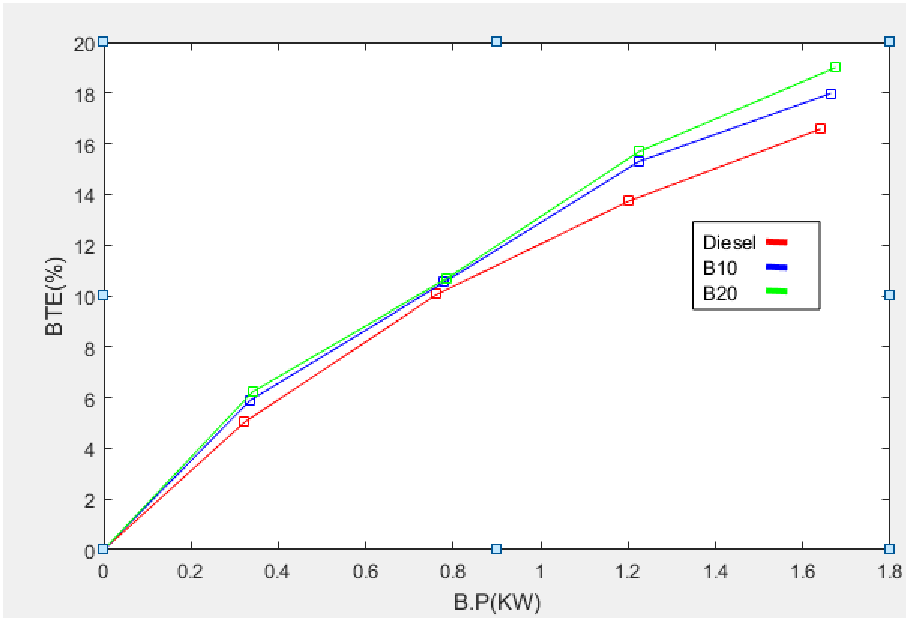

Figure 7.3: BTE v/s BP

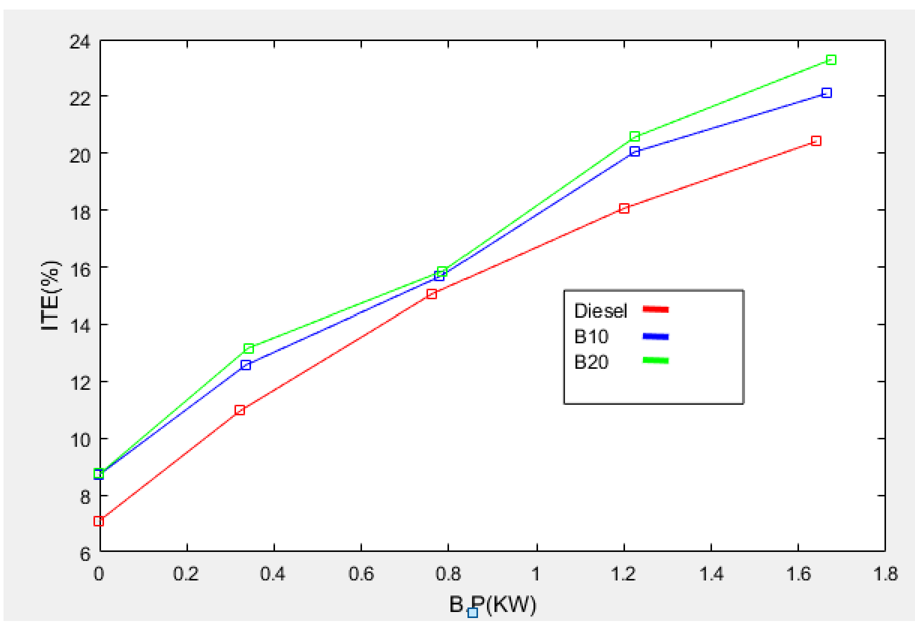

Figure 7.4: ITE v/s BP

7.1.5 η_{mech} v/s BP

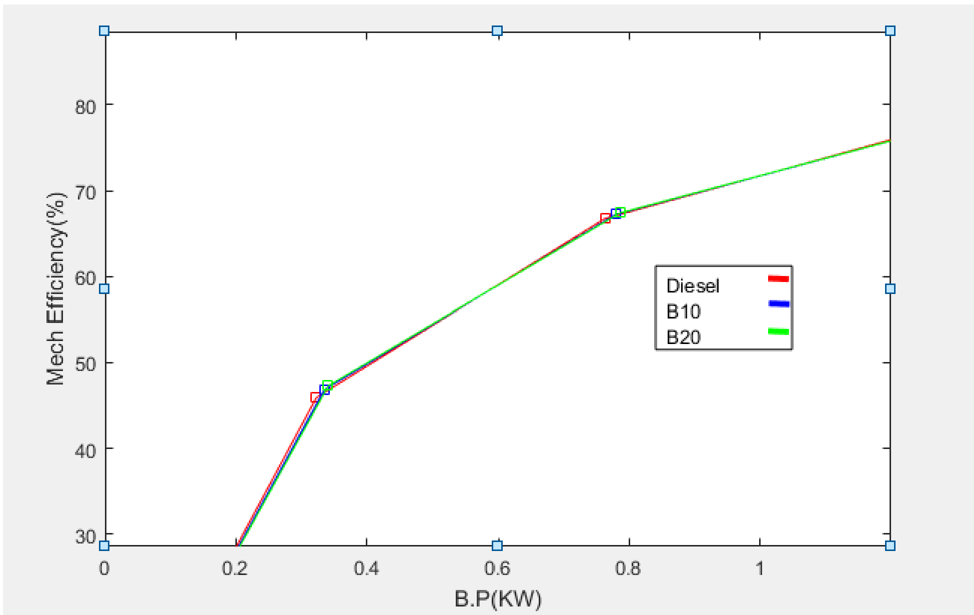

Figure 7.5: η_{mech} v/s BP

- Mechanical efficiency of B20 is slightly larger than the other two ,but all the three are comparable.

7.2 Emission Characteristics

7.2.1 CO v/s B.P

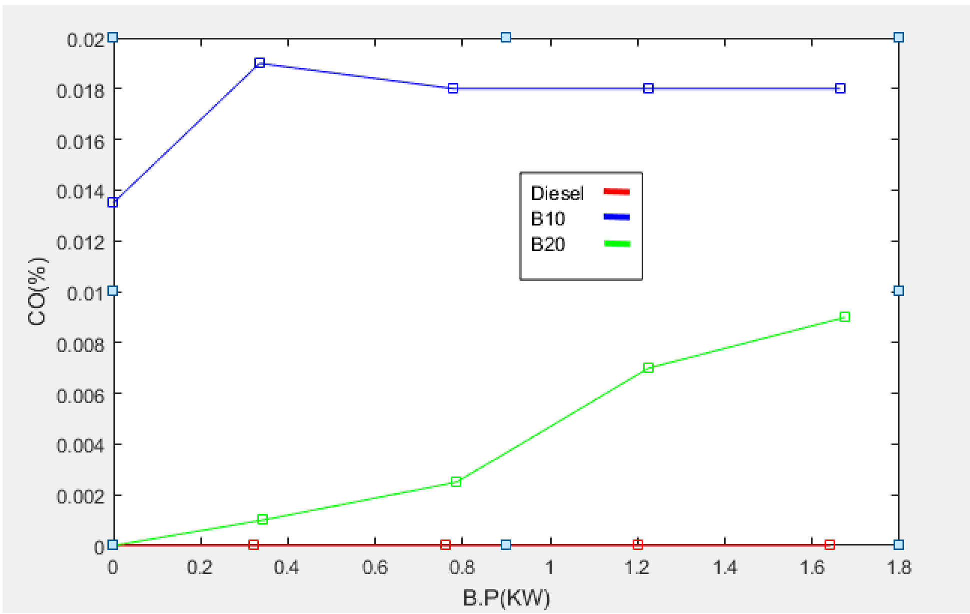

Figure 7.6: CO v/s B.P

- CO emission is higher in B10 than B20 and Diesel has lower CO emission.

7.2.2 HC v/s B.P

- HC emission of B10 and B20 is lower and that of diesel is comparatively higher .
- Since the Oxygen content is higher in B20 ,it undergoes complete combustion and so the fever HC emission.

7.2.3 CO_2 v/s B.P

- Diesel has comparatively higher CO2 emission than the combustion of other two fuels.

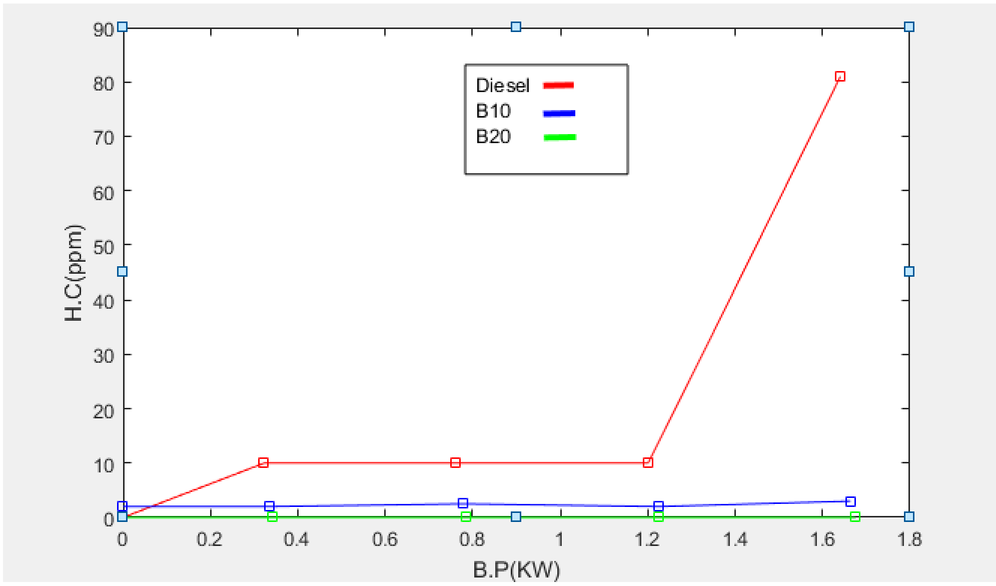

Figure 7.7: HC v/s B.P

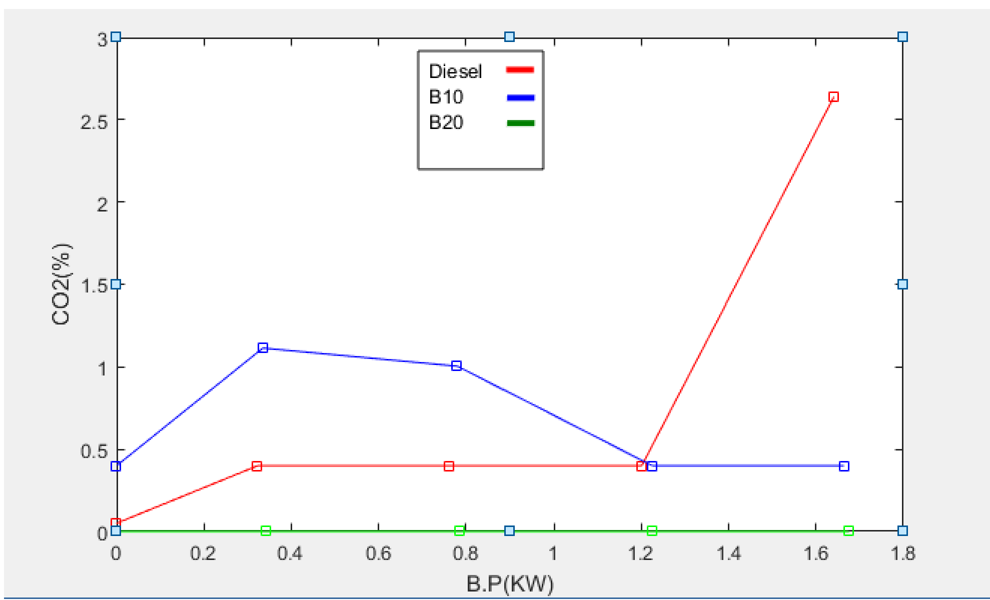

Figure 7.8: CO_2 v/s B.P

7.2.4 O_2 v/s B.P

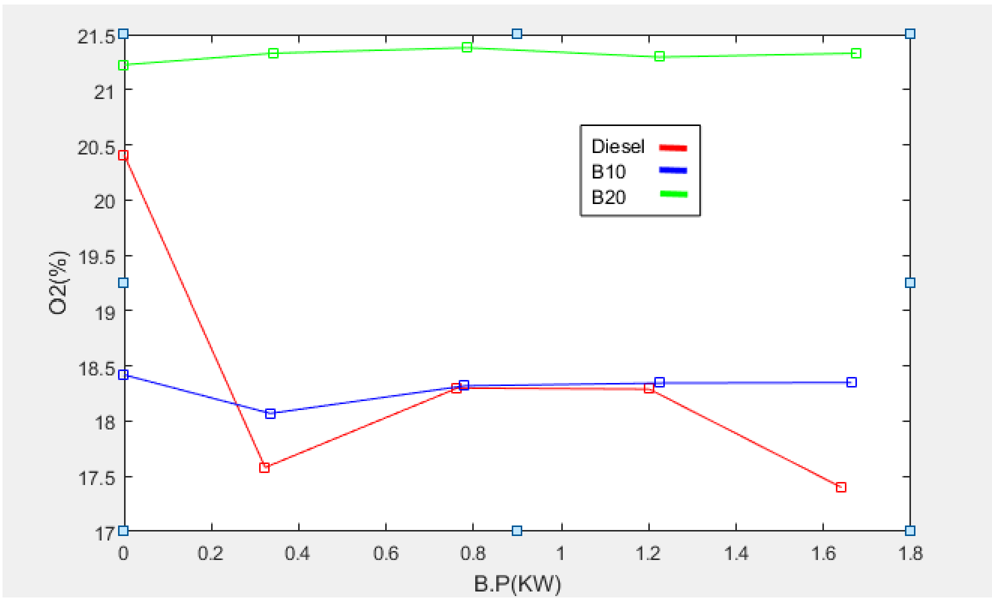

Figure 7.9: O_2 v/s B.P

- Higher Oxygen emission takes place during the combustion of B20 than B10 and diesel.

7.2.5 NO_x v/s B.P

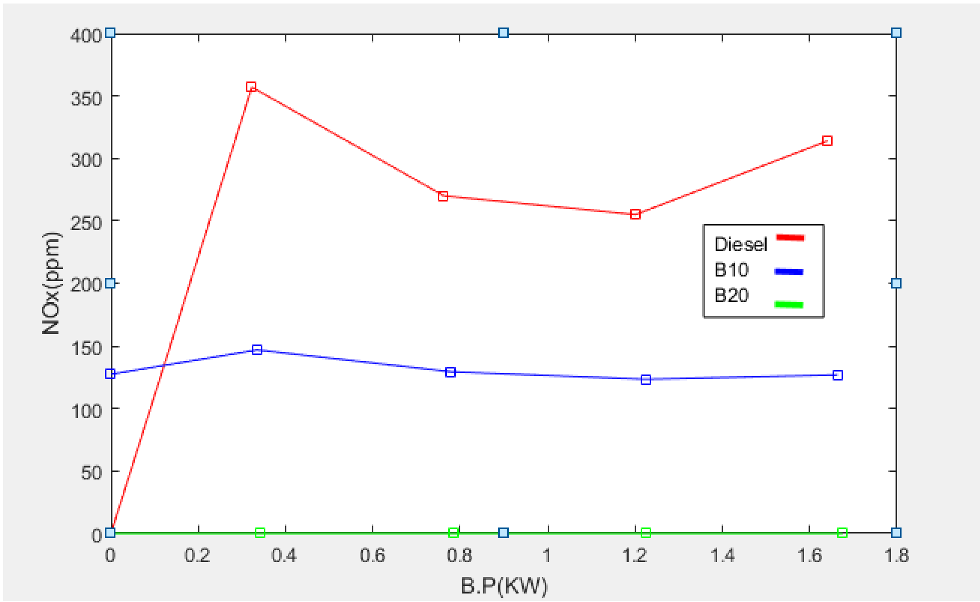

Figure 7.10: NO_x v/s B.P

- Higher NOx emission is found in diesel than B10 and B20.

Chapter 8

CONCLUSIONS

- B20 is more economic than diesel because the TFC nad SFC of B20 is less than that of Diesel. This means that only less quantitiy of fuel has to be burnt to produce the same output power, if the fuel used is B20.
- B20 has higher ITE and BTE than Diesel. This means that a large portion of the heat input obtained by burning the fuel is converted into useful work, if the fuel used is B20.
- B20 has slightly higher mechanical efficiency than diesel. This means that a large portion of the indicated power developed in the cylinder is converted into useful brake power, if the fuel used is B20.
- B10 and B20 have higher CO emission than Diesel. This is the only emission which is higher for B20 than that for Diesel.
- HC, CO2 and NOx emission of B20 is less than that of Diesel. This is the main reason why Biodiesel is considered as a clean energy source with less environmental impact compared to Diesel.

Chapter 9

SCOPE FOR FUTURE STUDIES

- NOx formation was slightly reduced by 0.1 g/kW·h when Sunflower Biodiesel was treated with the antioxidant additive obtained from bio-oil solvent. This is because antioxidants can act as radical quenching agents and therefore, diminish NOx formation.
- Blending Biodiesel with nano particles can reduce the emission of toxic gases to a greater extent, thereby making it more environment friendly.Owing to the higher surface area by volume ratio of nano particles, the degree of mixing and chemical reactivity are enhanced during the combustion, leading to better performance and combustion.
- Increasing injection pressure can lead to better atomization of Biodiesel which improves the mixing of fuel and air. This leads to better combustion and hence heat release rate and pressure increases.

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