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Performance Characteristics of a Diesel Engine with Mustard-Honge Biodiesel

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ABSTRACT

The Increased rate of energy consumption around the world due to industrialization and modernization has been the major cause for the drastic decline in the fossil fuel. The drastic rate of depletion of fossil fuel could overcome by good alternative, that should also meet the demand of future energy requirement. In this context, biodiesel was found to be one of the best alternatives to fossil fuel. Which has the characteristics almost nearer to the conventional diesel fuel. Though there are different resources, from which Biodiesel can be extracted, yet for the present work, a Biodiesel sample has been extracted from Honge and Mustard oils in 1:1 ratio, by means of the transesterification process. 2% of ethanol is added to enhance the ignition quality. Three different samples are produced as B10, B20, and B30 when biodiesel is blended with diesel at three different proportions (10%, 20%, and 30%). These samples are applied to a 4S single cylinder diesel engine of 3.67kW @1500 RPM.

The above samples of biodiesel are tested on the engine at different injection pressures of 180bar, 200bar, and 220bar respectively. The performance characteristics include BSFC and BTE are studied for the said CI engine and are found almost nearer to the values of conventional diesel as fuel, at an injection pressure of 180bar. Out of the three mentioned pressures, 200bar for the sample B10 found to be an optimal, irrespective of efficiency and economy. Further, the samples are investigated for emissions characteristics at the mentioned injection pressures. The sample B10 is found showing optimum emissions characteristics at a 200bar injection pressure compared to the rest two samples.

Keywords: Pressure injectors, Biodiesel blends, Honge oil, Mustard oil, Engine performances, and Emissions characteristics.

1. INTRODUCTION

Energy is considered to be the most important factor for better quality life, economic growth of the nation, people and social development. Since many years' fossil fuels have been the important form of conventional energy source and serving as the main form of energy resource. Due to modernization and industrialization around the world, there is an increased rate of energy requirement. This leads to the depletion of the fossil fuel to a major extent and Fossil fuels are the main reason for global warming as they show increased Carbon dioxide (CO_2) Emissions. This situation encouraged to focus on the Biofuel research. Since Biofuels are the best alternative source of energy and they are environment -friendly. No poisonous emissions are produced from biodiesel due to lack of Sulfur content. Bio-oils have the advantages because its chemical structure can easily have modified, the yield of the biodiesel from the bio-oil is structurally similar to that of petroleum, therefore, fuels produced from the bio-oil are the renewable sources, can be used in present diesel engines. Most of the research works is in progress in search of best biofuel, some of the works relevant to vegetable oils as an alternative to diesel fuel are illustrated as follows

Goering C E et al. (1981) [1] conducted research on 11 different bio-oils to study the characteristic properties. Of all the bio-oils it was found that sesame, corn, rapeseed, soybean, and cottonseed oils had the better and favorable fuel properties. **Auld D, L, et al. (1982)** [2] carried research on diesel engine filled with rape seed bio oil, concluded that its performance is almost similar to that of diesel fuel used in the engine. **Royan D et al.** [3] Studies the enzymatic production of biodiesel by methanol analysis of cotton oil by using immobilized candidly Antarctica lapses catalyst in t-butanol solvent. **Suppose I et al.** [4] Conducted a study on the catalytic hydroprocessing of cotton oil in petroleum and diesel. The studies reveal that hydroprocessing of vegetable oil not only contributes to the production of fuel from renewable feedstock, but also results in the production of diesel like hydrocarbons of superior quality. **Abolle Abolle et al.** [5] Conducted experiments on diesel oil blends with the other oil to change several physical properties. **Umer**

Rashid et al. [6] Carried out the evaluation of transmethylated jatropha oil obtained from jatropha seeds under the optimized set of reaction conditions H-NMR and thermogravimetric analysis are also checked and came to a conclusion that the fuel properties of biodiesel produced are as per standard specification of the ASTM D 6751 and EN 14214. **Xiaohu Fan et al.** [7] Studied parameters affecting the transesterification process of cottonseed oil by response surface methodology, the suggestion has been given to use methanol/oil molar ratio of 6 for biodiesel production from crude cottonseed oil. **Arjun. s et al** [8] – have studied the Extraction of Biodiesel from the waste cooking oil. By using a method called Transesterification processes. Which depends on the amount of free fatty acid and water content in the sample. **Bruwer J J et al. (1980)** [9] conducted the research on the use of sunflower seed oil as an alternative source of energy. It was noted that there was a drop of 8% power loss compared to diesel. This power loss is recovered by introducing fuel injectors and injector pump. With this change when operated for 1300 hours' equivalent amount of carbon deposition as that of diesel except for the injector tips was found. **Sergio C. Capareda et al.** [10] Conducted engine power tests using a 14.2 kW diesel engine fueled with petroleum diesel DF500 and cottonseed oil biodiesel blends B5, B20, B40, B60, B80, and B100. This usage of cottonseed biodiesel blends showed CO, total HC, NOx and SO_2 Emissions decreased compared to petroleum diesel. **GVNSR Ratnakara Rao et al.** [11] carried out an engine test on four-stroke diesel engine at injection pressures of 160, 200 and 250 bar and also for injection timing of 11 and 14^0 BTDC. From the test they concluded that BTE will be better for IP of 200 bar and IT of 11^0 BTDC and BSFC is lesser at IP of 200 bar and IT of 11^0 BTDC. However, there is a slight increase in frictional power at 200 bar pressure. **Anganathan L et al.** [12] studied the different parameters affecting transesterification process for biodiesel production from cottonseed oil. **Thangavelu Elango et al.** [13] compared combustion, performance and emission characteristics of a single cylinder diesel engine with blends of jatropha and diesel at different loads. **Jinlin Xue et al.** [14] investigated the effect of biodiesel on engine power, economy, durability and emissions, including regulated and non-regulated emission corresponding effect factors are surveyed and made an analysis in detail with the help of reports about biodiesel engine performances and emissions Later **K. Ashok et al**. [15] studied the Combustion Characteristics and Performance of a direct injection diesel engine fueled with Rice-Bran oil derived biodiesel/diesel blends.

Further, the above study encouraged to concentrate on the extraction of biodiesel from the resource of different vegetable oil combination as an alternative such as Honge oil combined with mustard oil and also made to study its utilization on 4stoke single cylinder diesel engine.

2. BIODIESEL PREPARATION

2.1 Preparation of biodiesel

Though there are different methods for the extraction of biodiesel from vegetable oils, namely Dilution method, Micro emulsification, Pyrolysis (Thermal cracking), yet Transesterification process is found easier and less expensive process compared to other . Hence it is chosen for the extraction process.

This process enables the conversion of different vegetable oils into usable biofuels in the presence of a catalyst (i.e., ethyl or methyl-ester). This converts vegetable oil to methyl esters, ethyl esters, 2propyl esters, and butyl esters in the presence of KOH or NAOH as catalysts, by reducing the viscosity of the vegetable oil. Biodiesel esters have the notable fuel properties which include density, viscosity, acid value, iodine value, pour point, cloud point, the gross heat of combustion, and volatility. Biodiesel fuels consume more fuel per power and torque outputs compared to diesel fuel. When compared to diesel, biodiesel has few good properties such as flash point, sulfur content, aromatic content, and biodegradability. Hence, without any alterations to the existing engines, biodiesel can be used as fuel.

Since Viscosities of the vegetable oils are usually higher than that of the conventional diesel fuel. Fuel atomization reduces and penetration increases with the increase in the viscosity. Due to this there forms deposits in the engine, injector coking, piston ring sticking and the oil thickening. Hence, selection of suitable method plays a vital role in the extraction process.

2.2 Transesterification process

When Honge oil and mustard oil are compared with conventional diesel, pumping and atomization are difficult due to high viscosity. The conversion of methyl or ethyl esters by the transesterification process of oils requires 3 moles of alcohol psychometrically. Even though it is an equilibrium reaction, additional alcohol is required to obtain the reaction close to the formation. The edible and non- edible oils are chemically reacted with the methanol or ethanol (alcohol) in the presence of NaOH/KOH (catalysts) to produce methyl or ethyl esters. The mixture was stirred continuously at a temperature range of 60^0-65^0C and then allowed to settle in a separating funnel. Two clear layers are found due to density variation, the top layer is of methyl/ethyl esters and the bottom layer is of glycerol. The

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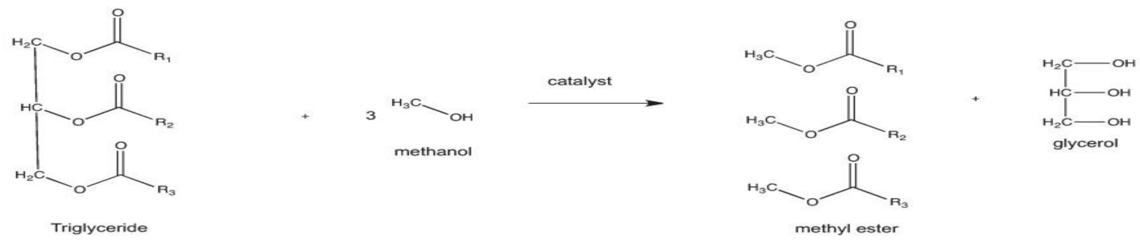
bottom layer was separated out after the separation esters are mixed with distilled warm water to remove the catalyst presented in the esters and allowed to settle under gravity. When the water reacts with catalyst, soap formation is observed and gets separated from the Esters. When the distilled water is added to the esters for the removal of the catalyst, there is a chance of water molecules retained in the methyl esters. To remove the water molecules trapped, the esters are further heated above the 100^0C till the water molecules get evaporated. The process is referred as a drying process. Finally, at the end of process glycerin is produced as a byproduct.

Transesterification is also known as alcoholysis. Animal fats or vegetable oil reacts with an alcohol produces esters and glycerin. The rate of reaction and yield of the biodiesel can be improved by the use of a catalyst. Methanol and ethanol are most common alcohols used for transesterification reaction methyl alcohol and ethyl alcohol are commonly used. This is due to the reason that they react very fast with tri-glycerides and these catalysts (NaOH/KOH) can be easily dissolved and removed by a water wash. Transesterification process can be completed by using 3:1 molar ratio of alcohol. Enzymes, alkalis or acids can use as the catalyst for the reaction process i.e. Lipases are an enzyme, NaOH a base catalyst and sulfuric acid an acid catalyst used in the reaction process. The common base catalyst is used for transesterification reaction as they have a faster reaction rate and are hence commercially used.



$$\text{Triglyceride} + \text{ROH} \leftrightarrow \text{Diglyceride} + \text{RCOOR}_1$$

$$\text{Diglyceride} + \text{ROH} \leftrightarrow \text{Monoglyceride} + \text{RCOOR}_2$$

$$\text{Monoglyceride} + \text{ROH} \leftrightarrow \text{Glycerol} + \text{RCOOR}_3$$

Figure 1: Transesterification of Triglycerides with Alcohol

3. FIGURES AND TABLES

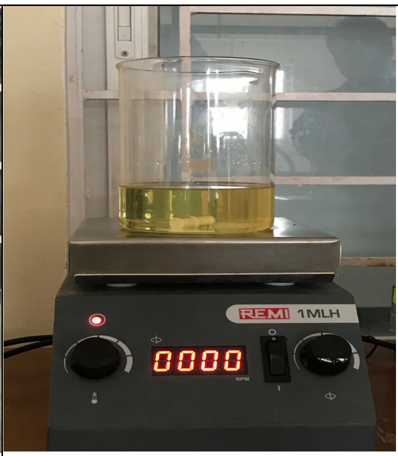
		
Extraction process.		Diesel Engine Test Rig

FIGURE 2

3.1ENGINE SPECIFICATIONS:

1. Engine	4 Stroke Single Cylinder Diesel Engine	**6. Stroke**	110mm
2. Fuel	Diesel	**7. Dia. Of brake drum**	300mm
3. Rated power	3.675kW	**8. Rope diameter**	15mm
4. Rated speed	1500 RPM	**9. Cooling**	Water cooled
5. Bore	80mm	**10. Temperature measurement**	Digital Thermocouple

Table 1

3.2 Properties of Diesel, Bio-oils and Ethanol:

Properties	Diesel	Mustard	Honge	Ethanol
Density at 15^{0}C (Kg/m^3)	830	940	915	790
Kinematic viscosity At 40^{0}C (cst)	1.81	10.3	8	1.4
Flash point (^{0}C)	53	145	155	14
Fire point(^{0}C)	58	150	160	20
Calorific value (MJ/Kg)	42.34	32.43	38.43	29.7

Table 2

3.3 *Properties of Mustard-Honge Biodiesel with 2% Ethanol:*

Properties	B10D88E2	B20D78E2	B30D68E2
Density at 15^{0}C (Kg/m^3)	838.9	848.6	858.3
Kinematic viscosity At 40^{0}C (cst)	2.52	3.25	3.99
Flash point (^{0}C)	62	72	81
Fire point(^{0}C)	67	77	86
Calorific value (MJ/Kg)	41.39	40.7	40.01

Table 3

4. RESULTS AND DISCUSSION

4.1 Engine Performance Results:

4.1.1 Brake Specific Fuel Consumption (BSFC):

Brake specific fuel consumption is one of the most important performance characteristics to be studied to understand the performance of an IC engine. Brake specific fuel consumption is defined as the amount of fuel consumed per unit power output. In this work BSFC values for Honge –Mustard Biodiesel samples B10, B20 and B30 were noted at three different injection pressures of 180bar, 200 bar, and 220bar respectively at 25%, 50%, 75% and 100% loading on the engine test rig. From the test data, it is found, that BSFC values decreased with the increase in brake power. And these values for Honge-Mustard Biodiesel were found comparatively more than the conventional diesel fuel. This is due to the lower calorific value and high viscosity of the biodiesel. For the extracted Biodiesel sample (Honge-Mustard) compared to conventional diesel, BSFC found optimum at an injection pressure of 200bar. Because at optimum pressure, fuel-air mixing and spray atomization is improved and hence BSFC decreased. Hence out of three injection pressures for the Honge –Mustard bio diesel, 200bar found to be optimal for the sample B10 with BSFC value as 0.22kg/kW-hr. Compared to B20 and B30. For Honge-Mustard B10 biodiesel at full load, when injection pressure was increased from 180 bar to 200bar BSCF decreased by 18%. And for 220 bar it is found BSFC increased by 32%.

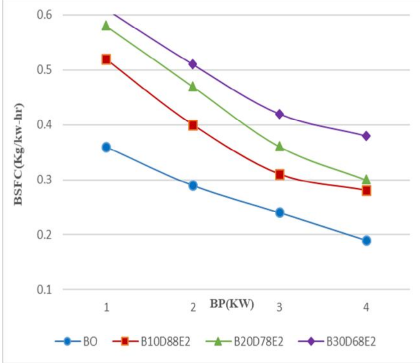


Figure 3: Variation of Brake Specific Fuel Consumption for Mustard Honge biodiesel at 180bar Injection Pressure

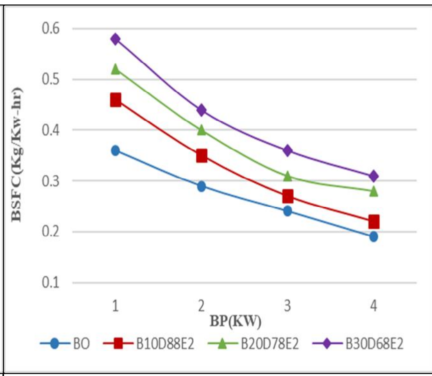


Figure 4: Variation of Brake Specific Fuel Consumption for Mustard Honge Biodiesel at 200bar Injection Pressure

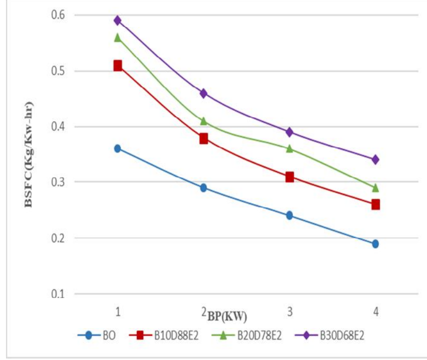


Figure 5: Variation of Brake Specific Fuel Consumption for Mustard-Honge Biodiesel at 220bar Injection Pressure

4.1.2 Brake Thermal efficiency (BTE):

Brake thermal efficiency is defined as the ratio of the heat equivalent of the brake output to the heat supplied to the engine. BTE of Mustard-Honge biodiesel B10, B20 and B30 were taken at three different injection pressures of 180bar, 200bar and 220bar. Variations in BTE were noted at 25%, 50%, 75% and 100% loads. BTE increases with the increase in brake power. At all the different injection pressures BTE of Mustard-Honge biodiesel were comparatively less than pure diesel. This is because of a lower calorific value of biodiesel. For Mustard-Honge biodiesel in comparison to Diesel, maximum BTE is observed at an injection pressure of 200bar. 200bar is found to be an optimum pressure. At this optimum pressure, fuel-air mixing and spray atomization will be improved thereby increases BTE. Hence in this case the injection pressure of 200bar is found optimum compared to 180bar and 220bar. Thus for a Mustard-Honge biodiesel, maximum BTE of 24.6% was found for B10 sample at 200bar. The following graphs show variations of BTE at different injection pressures.

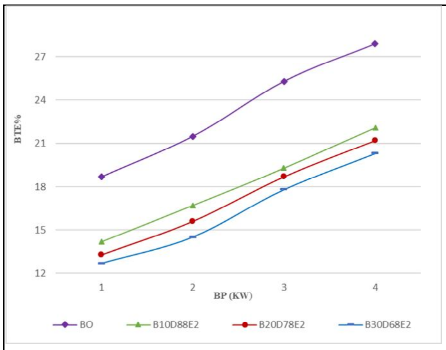


Figure 6: Variation of Brake Thermal Efficiency with Brake Power For Mustard-Honge Biodiesel at 180bar Injection Pressure

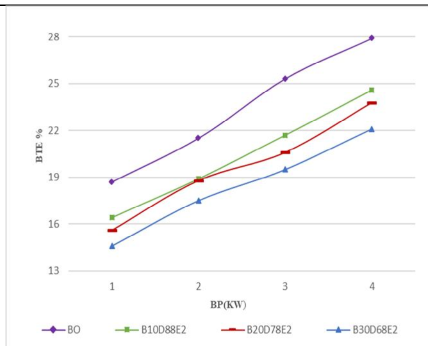


Figure 7: Variation of Brake Thermal Efficiency with Brake Power for Mustard-Honge Biodiesel at 200bar Injection Pressure

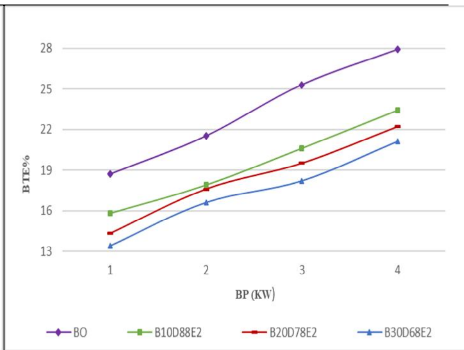


Figure 8: Variation of Brake Thermal Efficiency with Brake Power for Mustard-Honge Biodiesel at 220bar Injection Pressure

4.2 EMISSION RESULTS:

4.2.1 Unburnt Hydrocarbons (UBHC):

Unburnt hydrocarbons are the result of incomplete combustion of the carbon components. The variation of UBHC emission for different injection pressures. The amount of Hydrocarbon in the emission decreases with the increase of biodiesel proportion if the fuel blends. When compared to diesel emissions, HC emission for biodiesel blends are lower. This may be due to the reason that the biodiesel has a high cetane number, the more oxygen content and have more gas temperature compared to diesel. As the cetane number increases, ignition delay reduces and hence reduced hydrocarbon emission. Condensation of higher HC is prevented as the temperature is high in the case of biodiesel.

4.2.2 Carbon Monoxide (CO):

Carbon monoxide is an odorless, colorless and toxic gas and it is emitted due to combustion of fuel. With the increase in the proportion of biodiesel in the blend CO emission decreases. CO emission for biodiesel is less compared to diesel. This may be due to the reason that biodiesel has a high cetane number to that of diesel. It is found that with the increase in the BP, CO emission increases. The highest cetane number will reduce the “%CO” content in emissions.

4.2.3 Carbon Dioxide (CO_2):

Carbon dioxide is a colorless, odorless, incombustible gas formed during respiration, combustion, and organic decomposition. Carbon dioxide emissions are less as compared to diesel emission. It was found that with an increase in injection pressure CO_2 Emission reduces. This is due to the fact that, at low injection pressure the combustion rate will be low, resulting in high carbon dioxide emission. whereas at high injection pressure the combustion rate will be higher, resulting in low carbon dioxide emission.

4.2.4 Nitrogen Oxides (NO_X):

Nitrogen oxides are the direct result of combustion in the presence of atmospheric nitrogen and oxygen. Nitrogen oxides emission increases with increase in injection pressure and an increase of the proportion of biodiesel in fuel blends. Higher injection pressure results in high temperature and thereby NO_X Emission increases. Biodiesel shows slow burning nature, due to which there is a delay in energy released, due to this high amount of energy would be liberated at the end of power stroke, the temperature is high, hence increase NO_X Emission.

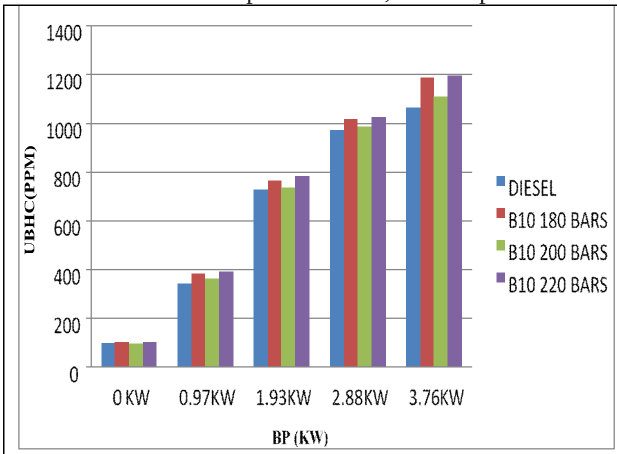


Figure 9: Variation of Unburnt Hydrocarbon with Brake Power for Mustard-Honge Biodiesel

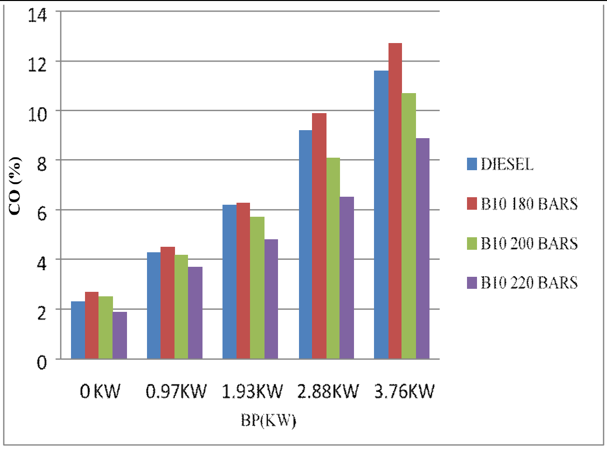


Figure 10: Variation of Carbon Monoxide with Brake Power for Mustard-Honge Biodiesel

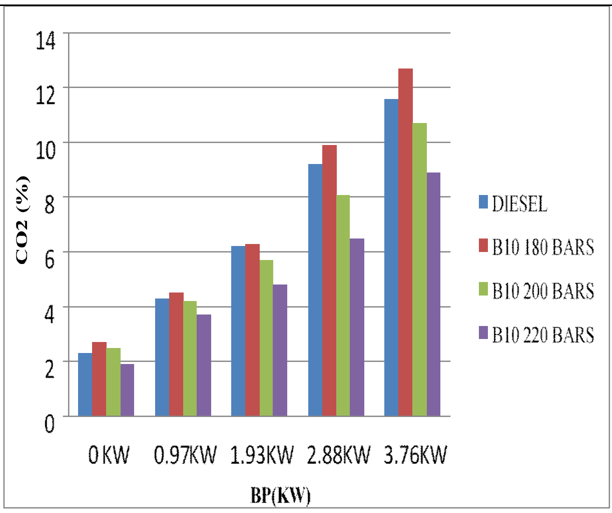


Figure 11: Variation of Carbon Dioxide with Brake Power for Mustard -Honge Biodiesel

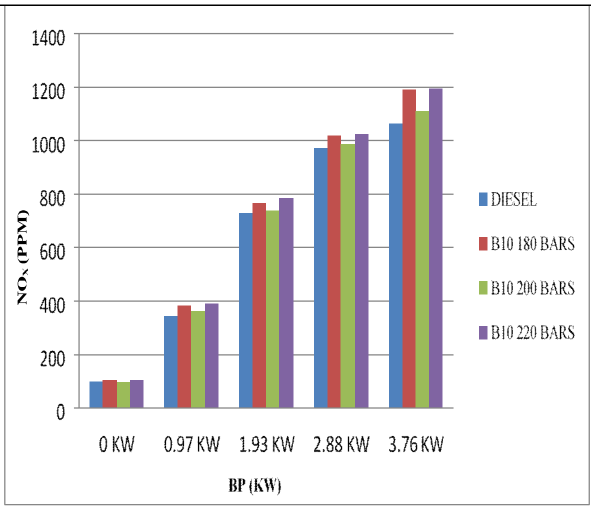


Figure 12: Variation of Nitrogen Oxide with Brake Power for Mustard- Honge Biodiesel

5. CONCLUSION

Biodiesel, a renewable source of energy, which is a very promising alternative to fossil Fuel and to fulfill the energy requirements of the future. Since Biodiesel has the properties closer to the conventional Diesel fuel, many research works are focusing on this area to produce the best alternative to conventional diesel. In this context a Biodiesel sample has been produced from Honge oil and Mustard oil in 1:1 ratio and blended with 2% of ethanol, further some samples are obtained as B10, B20 and B30 by blending the above said Biodiesel with conventional Diesel fuel, to enhance the performance characteristics. The present work illustrates 1) Extraction of Biodiesel from transesterification process, 2) Performance characteristics of a 4S singe cylinder Diesel engine of 3.675kw @1500 RPM with B10, B20 and B30 samples as fuels at 0%, 25%, 50%, 75% and 100% loading, at an injection pressures of 180bar, 200bar and 220bar respectively. From the above investigations, it is found that Biodiesel sample with “B10” designation found optimum at an injection pressure of 200bar, in performance as well as in emissions characteristics, compared to the rest two designations. From the investigation, Mustard-Honge sample B10 shown BSFC as 0.22kg/kW-hr and BTE as 24.6% at 200bar of injection pressure that is almost near to the values of conventional diesel fuel at its regular injection pressure of 180bar.

The emissions characteristics revealed, that the biodiesel samples of Honge -Mustard produces reduced % of UBHC, CO and CO_2 Compared to conventional Diesel fuel, where as NOx % in emissions found to be increased compared to conventional Diesel fuel. It is clearly observed that the average NOx emission in case of conditioned biofuel is 1108 PPM, which is slightly higher than the conventional Diesel fuel (1062). Further scope of this work could be, the study of reduction of NOx % in emissions by introducing EGR (exhaust gas recirculation) technique.

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