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Biodiesel Production from Rabbit Fat Oil Using Transesterification and Experimental Evaluation

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Abstract : The global energy consumption is expected to grow at a faster rate than the population growth. By 2030, an increase of 53% of global energy consumption and 39% of greenhouse gases emissions from fossil fuels is anticipated. Therefore, it becomes a global agenda to develop clean alternative fuels, which are domestically available, environmentally acceptable and technically feasible. Energy consumption is constantly increasing all over the world in spite of the rationalization measures that have been undertaken. Liquid fossil fuels are the main and most frequently used fuels for automobile and mobile machinery. The studies have been focused on discovering the fuel that would be adaptable to the existing engine constructions and that would meet the criteria regarding renewability, ecology and reliability of use. During the last decade biodiesel has become the most common renewable liquid fuel. As an alternative fuel, biodiesel seems as one of the best choices among other sources due to its environment friendly behavior and similar functional properties with diesel. Nowadays, the production of biodiesel from Animal Fat oil is gaining more attention to replace diesel fuel. Biodiesel, a clean, renewable fuel, has recently been considered as the best for a diesel fuel substitution because it can be used in any compression ignition engine without any modification.

The main objective of this work is to discuss the impact of biodiesel from Rabbit fat oil. In this study, the effect of bio-diesel from Rabbitfat, oil and its blends on a single cylinder Kirloskar TV-1 diesel engine were investigated. In this work, the performance and emission analysis were conducted. The test fuel was prepared in the ratio of B25, B50, B75 and B100, which represent the blend ratio of Rabbit fat oil biodiesel and the rest diesel fuel. The aim of this investigation was to reformulate the fuel to utilize the biodiesel and its blend to enhance the fuels performance, characteristic and to reduce the pollution from the engine.

The experimental results reveal a marginal decrease in brake thermal efficiency when compared to that of sole fuel. In this investigation, the emission test was conducted with the help of the AVL DI gas analyzer, in which CO HC and smoke density are marginal increased on the other hand CO_2, O_2, and NOx are appreciable reduced when compared to that of sole fuel. Cylinder pressure and H.R.R. We also perform with the help of AVL DI Gas Analyzer.

Key words : RB : Rabbit fat, oil, Transesterification, Biodiesel, Oxides of nitrogen, Smoke

I. Introduction

Biodiesel is described as fatty acid methyl or ethyl esters from vegetable oils or animal fats as an alternative fuel of diesel. It is renewable, biodegradable, non toxic and oxygenated fuel [1,2]. Even though many researches pointed out that it might help to decrease greenhouse gas emissions, improve income distribution and promote sustainable rural development [3-6]. The primary cause is being deficient in of new knowledge about the influence of biodiesel in diesel engines. For instance, the reduction of engine power, as well as the increase of fuel consumption for biodiesel, is not as a large amount as anticipated; the early research conclusions have been reserved, it is more prone to oxidation for biodiesel, which may result in mysterious gums and sediments that can plug the fuel filter, and thus it will influence engine durability [7,8]. In the automotive sector, the higher oxides of nitrogen (NOx) and HC emission from the diesel engine are its main problems with respect to air pollution. In this perspective, the reductions in HC and CO emissions from the engine can be obtained by the use of biodiesel. But, NOx emissions are slightly increased for the biodiesel blended diesel fuel [9-13].High viscosity, surface tension and density of biodiesel influence atomization by increasing the mean fuel droplet size, which in turn increases the spray tip penetration. Many researchers have found that the viscosity and density are affected the atomization, where as density is the lowest on mean droplet size and consequently to get better fuel atomization viscosity should be the first alternative of a fuel's physical property to be decreased [15-17]. The above mentioned problem can be solved by blending biodiesel with diesel fuel, which will decrease the viscosity of the fuel. Introduce some literature review related to animal fat oil – biodiesel and also performances and emission analyzer. The present investigation is carried out to describe complete production process, analysis of thermophysical properties and working characteristics of Rabbit fat oil, biodiesel in a direct injection compression ignition engine.

II. Biodiesel Production and Property Analysis

2.1 Transesterification

The reaction mechanism for alkali catalyzed transesterification was formulated as three steps. Transesterification is the process of conversion of the triglyceride with an alcohol in the presence of a catalyst to form esters and glycerol. Animal fat oil is subjected to chemical reactions with alcohol like methanol in the presence of a catalyst. Since the reaction is reversible, excess methanol is required to reduce the activation energy, thereby shifting the equilibrium to the product side. The triglyceride present in the animal fat oil is converted into biodiesel. Among the alcohols used for the transesterification reaction is methanol and ethanol. However, when methanol is processed, methyl esters are formed, these compounds are biodiesel fuels in different chemical combinations. The mechanism of the transesterification reaction scheme is illustrated by Figure 1.Transesterification of Rabbit fat, oil produces ester whose properties is comparable with those of diesel fuels. Schematic diagram of biodiesel plant is shown in Figure 2. The properties of the diesel fuel and the Rabbit Fat oil biodiesel are summarized in Table 1.

Table 1 Properties of diesel and biodiesel blends

Sample Name	Specific gravity	Density Kg/m^3	Calorific values KJ/ kg
Sole Fuel	0.822	822	44,710.66
B 25	0.824	824	44,229.27
B 50	0.835	835	43,747.88
B 75	0.850	850	43,266.49
B 100	0.867	867	42,785.10

CH_2OOCR CH_2OH

$CHOOCR$ + $3CH_3OH$ -------> $3CH_3OOCR$ + $CHOH$

CH_2OOCR CH_2OH

TriglycerideMethanol Methyl Esters Glycerol

Figure 1 Mechanism of transesterification process

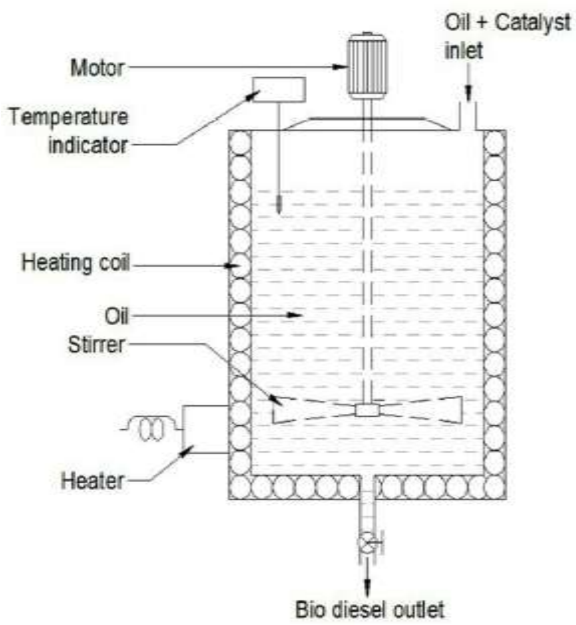

Figure 2 Schematic diagram of Biodiesel Plant

2.2 FTIR Analysis

The FTIR spectrum of diesel and Animal fat, oil methyl ester are shown in Figure 3 and 4. From the Figures, there are two bands that correspond to the methyl and methylene groups in the area between 2920 and 2856 cm^{-1}; the first peak is recognized to the stretching vibrations of the terminal CH_2 group in the olefins. The second peak corresponds to stretching, vibration and contraction of the C-H and CH_2 bonds of the ethylene and methyl groups. These bands show similarity between diesel fuel and methyl esters. The most pertinent folding vibrations of the methyl groups are consistent with the phase folding deformation (between 1350 - 1400 cm^{-1} bands) and the beyond degenerate phase folding deformation (between 1450 - 1470 cm^{-1} bands). The folding ascends from twisting and matching that seem at low frequencies. The methylene group offerings scissors vibrations at 1457 cm^{-1}. Based on the above discussion, it is clear that both diesel and Animal fat, oilmethyl ester are saturated hydrocarbons and the presence of hydrocarbon group C-H indicates that it has a potential as a fuel for diesel engine.

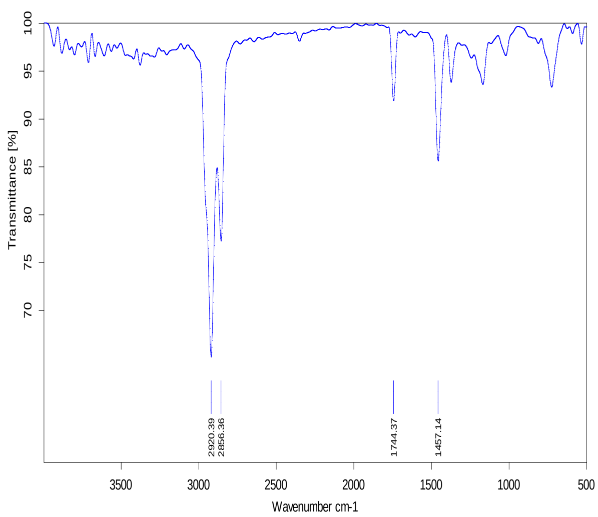

Figure 3 FTIR spectra of diesel fuel

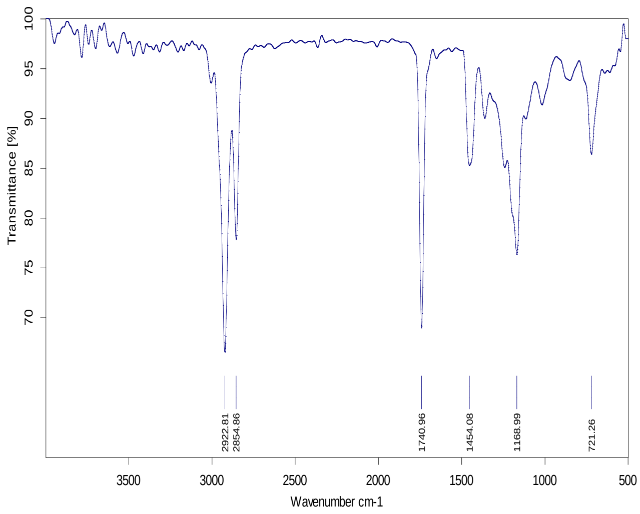

Figure 4 FTIR spectrum of Rabbit Fat methyl ester

III. Experimental Setup

The diesel engine used for experimentation is Kirloskar TV1, single cylinder, water cooled engine coupled to eddy current dynamometer with computer interface. The detailed specification of the engine is shown in Table 2. A data acquisition system is used to collect and analyze the combustion data like in-cylinder pressure and heat release rate during the experiment by using AVL transducer. The tests are conducted at the rated speed of 1500 RPM. In every test, exhaust emission such as nitrogen oxides (NOx), hydrocarbon (HC), carbon monoxide (CO) and smoke are measured. From the initial measurement, brake thermal efficiency (BTE) and specific fuel consumption (SFC) with respect to brake power (BP) for different blends are calculated. The blends of biodiesel and diesel used were B25 and B50. B75 and B100 means 25 % biodiesel fuel and 100% of diesel fuel by volume. In order to study the effect of biodiesel blends on the engine combustion and emission characteristics, the injection timing was kept constant at 23° TDC. The effect of biodiesel blends was studied and the results were compared with sole fuel diesel.

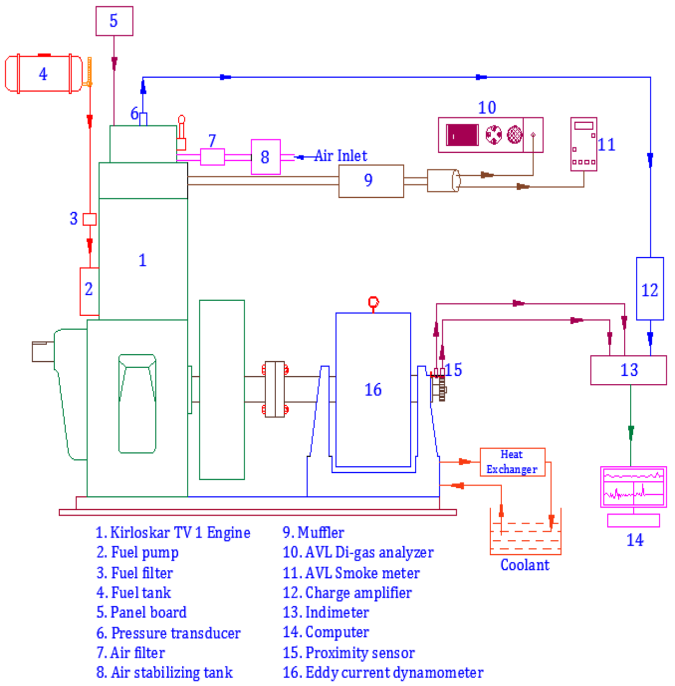

Figure 5 Schematic diagram of the experimental setup

Table 2 Specification of test engine

Type	Vertical, Water cooled, Four stroke
Number of cylinder	One
Bore	87.5 mm
Stroke	110 mm
Compression ratio	17.5:1
Maximum power	5.2 kW
Speed	1500 rev/min
Dynamometer	Eddy current
Injection timing	23° before TDC
Injection pressure	220kg/cm^2

4. Result and Discussion

4.1 Brake Thermal Efficiency

The effect of Rabbitfat, oil Biodiesel blend on brake thermal efficiency is shown in figure 4.1. It can be seen from the figure that Brake thermal efficiency in general reduced with the increasing proportion of biodiesel in the test fuels. The brake thermal efficiency for all the samples was less than that of sole fuel by about approximately 1.7% to 2.4% for all the samples in the maximum load of 5.2 kW. This is due to the effect of biodiesel blend.

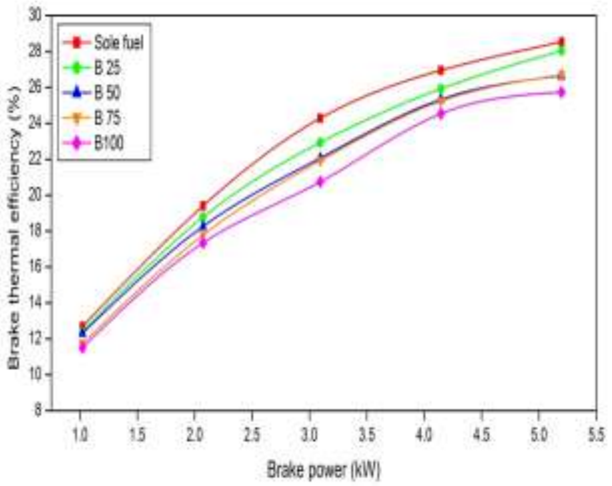

Figure 4.1 Brake thermal efficiency against brake power

4.2 Exhaust Gas Temperature

The effect of biodiesel blend on exhaust gas temperature is shown in figure4.2. It can be seen from the figure) that the exhaust gas temperature is reduced for all the biodiesel blend with the decreasing proportion of biodiesel in the test fuels. Due to the effect of biodiesel blend the minimum exhaust gas temperature is 145 (C at 20% load for B100, which is minimized when compared to that of other samples.

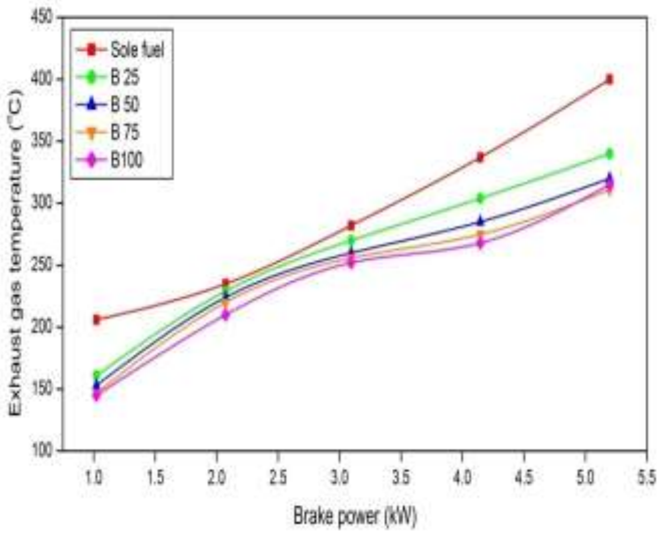

Figure 4.2 Brake thermal efficiency against brake power

4.3 Co Emission

The effect of the Rabbit fact oil biodiesel blend on the CO emission is shown in figure 4.3 for the biodiesel and its blends, the CO emissions were less than that of sole fuel. The least CO emissions have been obtained for the B50 with the value of 0.19 % by volume at 100% load. The reduction of CO emission is due to the oxygen content on the biodiesel.

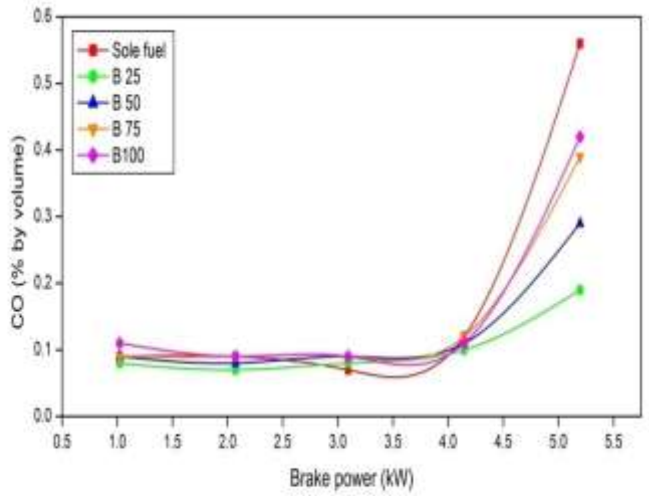

Figure 4.3CO emission against Brake power

4.4 CO_2 Emission

The effect of the biodiesel blend on the CO_2 emission is shown in figure 4.4for the biodiesel and its blend, the CO_2 emission is less for all the samples when compared to the sole fuel. The CO_2 emission is minimum for B50 at maximum load with a value of 6.5 % by volume. This is due the effect of biodiesel characteristics.

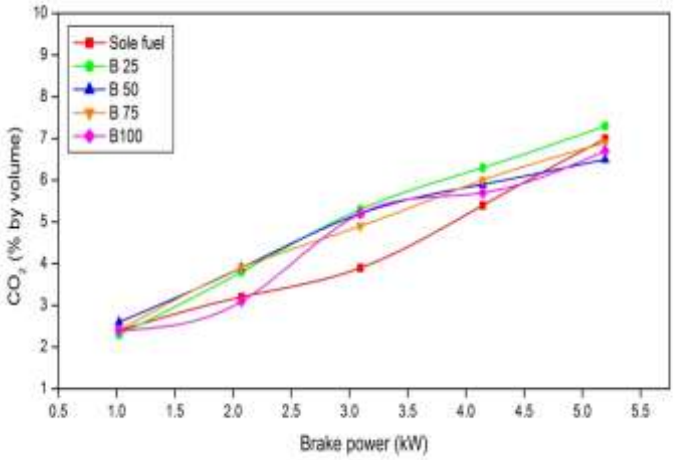

Figure 4.4 Oxides of nitrogen emission against brake power

4.5 HC Emissions

The effect of Biodiesel on hydrocarbon emission is shown in figure 4.5. It is observed that the HC emission is minimum for sole fuel with a value of 154 ppm at maximum load. The HC emission is lower when compared to that of the sole fuel for all the samples. There is a marginal decrease of HC emission for all the samples. But for the B100 HC emission is decreased effectively when compared to other samples. This may be due to the oxygen content of the biodiesel.

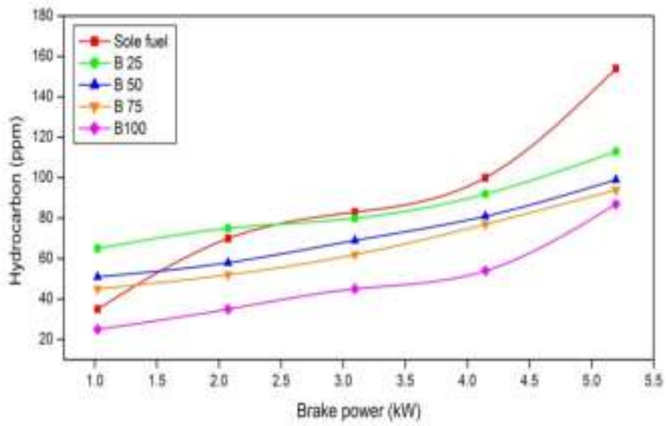

Figure 4.5 Hydrocarbon emission against brake power

4.6 O_2 Emission

The effect of biodiesel in O_2 emission is shown in figure 4.6it is observed that there is a marginal increase in O_2 emission for all the samples. The O_2 emission is maximum for B100 at maximum load with the value of 12.14 % by volume.

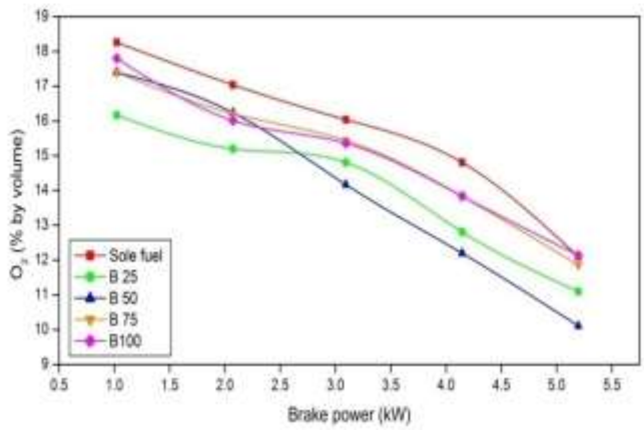

Figure 4.6Dio Oxide emission against brake power

4.7 NOx Emission

The effect of biodiesel on NOx emission is shown in figure 4.7for the biodiesel and its blend the NOx emission were less than that of sole fuel. The NOx emission is minimum for B100 with a value of 164 ppm at 20%. Similarly for B100 at maximum load is 841 ppm which is less when compared to all other samples at maximum load. This is due to the effect of oxygen content in the biodiesel.

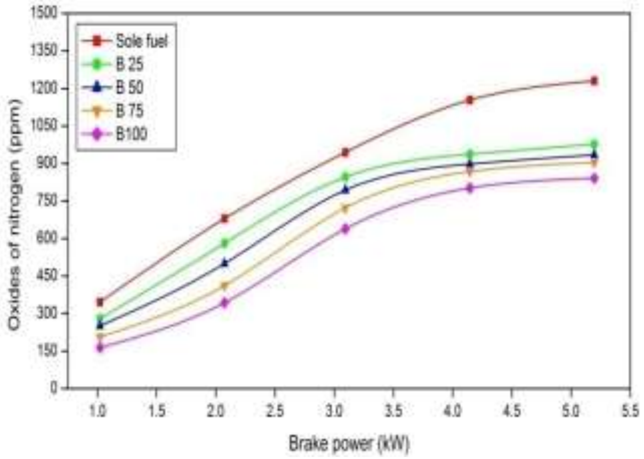

Figure 4.7 Carbon-monoxide emission against brake power

4.8 Smoke Emission

The effect of biodiesel on smoke emission is shown in figure 4.8 for the biodiesel and its blends the smoke emission is higher when compared to the sole fuel. It is observed in all the samples the smoke emission is higher than that of sole fuel. The maximum smoke value is 92.8 HSU for B100 at maximum load.

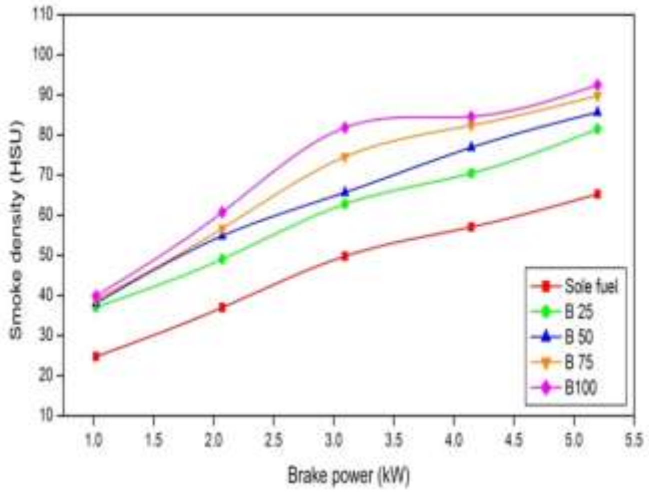

Figure 4.8Smoke density against brake power

4.9 Combustion Characteristics

The variation in in-cylinder pressure against crank angle is shown in Figure 4.9. The peak pressure for the Rabbit fat oil biodiesel and its blends is lower than that of the diesel fuel due to the poor atomization, which decelerates the combustion and cause for the lower cylinder gas pressure. However, the variation between the B25 and diesel fuel is marginal. It is observed that the occurrence of peak pressure is advanced with the addition of Rabbit fat oil biodiesel, which supplies oxygen and promotes the complete combustion of fuel. The maximum in-cylinder pressure of 50.862 barwas found in the case of diesel fuel and it was 44.644 kg/kW-HRfor B100 fuel.

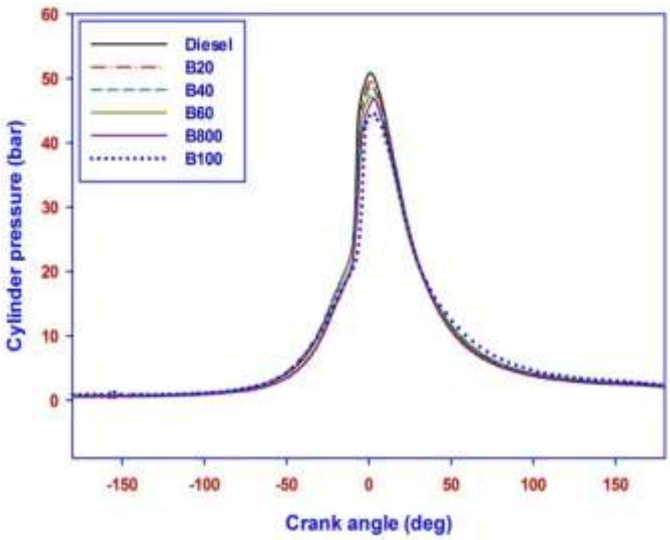

Figure 4.9In-cylinder pressure against crank angle

The addition of Rabbit fat, oil biodiesel blends advances the occurrence of the peak heat release rate when comparing with the diesel fuel and the variation of heat release rate with the crank angle is shown in Figure 4.10. After the combustion starts, the heat release rate increases and reaches to the maximum value. The addition of Rabbit fat oil biodiesel decreases the ignition delay and accelerates earlier start of combustion, which results in the lower heat release rate and progression of the peak heat release rate. The maximum heat release rate is observed as 118.32 kJ/m^{3}deg for the diesel fuel, whereas it is 94.32 kJ/m^{3}deg for the B100.

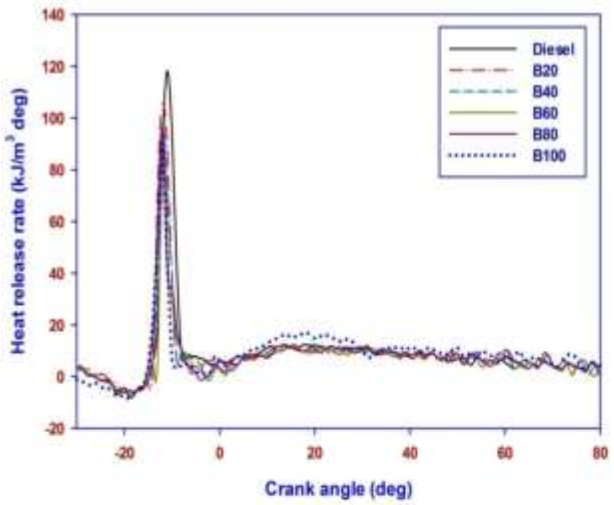

Figure 4.10 Heat release rate against crank angle

V. Conclusions

The Rabbit fat, oil biodiesel (B25) and its blends with sole fuel, B50, B75 and B100 and sole fuel were investigated and the results were compared with diesel and reported on this project.

1. The brake thermal efficiency is marginally decreased for the biodiesel and its blend.
2. The exhaust gas temperature is lower for B75 is 311°C at maximum load
3. The emission analysis for the biodiesel and its blend gave the best result when compared to the sole fuel.

- ☆ The CO emission is increased by 0.88% by volume at 20% of load for B25
- ☆ The CO_2 emission is increased by 7.3 % by volume at 100% of load for B25
- ☆ The HC emission is reduced by 87 ppm at 100 % of load for B100
- ☆ The O_2 emission is increased by 12.04% by volume at 100% of load for B100
- ☆ The NOx emission is reduced by 841 ppm at 100% of load for B100
- ☆ Smoke density is increased by 92.5 HSU at 100% of load for B100

References

1. A.M. Ashraful, H.H.Masjuki, M.A. Kalam, I.M. Rizwanul Fattah, S.A. Shahir, H.M. Mobarak, " Production and comparison of fuel properties, engine performance, and emission characteristic of biodiesel from various non-edible vegetable oils",Energy Conversion and Management 80 (2014) PP202 – 228
2. Steven Lim, KeatTeong Lee "Process intensification biodiesel production from jatrophacurcas L.seeds: Supercritical reactive extraction process parameters study" Applied Energy 103 (2013) pp712 – 720
3. Yixin Zhu [a,b] , Jianchu Xu[a,b], Qiaohong Li[a,b], Peter E.Mortimer[a,b] "Investigation of rubber seed yield in Xishuangbanna and estimation of rubber seed oil based biodiesel potential in southeast Asia" Energy 69 (2014) pp 837 – 842.

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