

# Performance and Emission Analysis of Date Seed Oil as Bio-Diesel

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**Abstract-** The study is made to replace the existing diesel fuel with the bio – fuels, for this fruit like Date seed oil as bio – diesel is utilized. The main objective of this work is to discuss the impact of biodiesel from Date fruit seed oil bio-diesel on performance, combustion and emission characteristics diesel. In this study, the effect of bio-diesel from fruit seed oil [Date seed oil] and its blends on a single cylinder Kirloskar TV-1 diesel engine were investigated.

In this work, the performance, combustion and emission analysis were conducted. The tests were performed at steady state conditions with the blend ratio of B25, B50, B75 and B100. These represent the ratio of biodiesel in the blend and the rest diesel. The aim of this investigation was to reformulate the fuel to utilize the biodiesel and its blend to enhance the fuels performance, combustion characteristic and to reduce the pollution from the engine. In this work only Date seed oil bio-diesel is utilized for the experimental work. The experimental results reveal a marginal decrease in brake thermal efficiency when compared to that of sole fuel. In this investigation, the emission test were done with the help of AVL DI gas analyzer, in which CO, HC and NOx are appreciably reduced on the other hand Smoke, CO<sub>2</sub> have marginal increased when compared to that of sole fuel. In this work combustion analysis also made with the help of AVL combustion analyzer in which bio diesel blend Shows the better result when compared with diesel.

**Key words:** Fruit seed oil, DS – Date seed oil Biodiesel, NOx - Oxides of nitrogen, Smoke.

## 1. INTRODUCTION

In the past few decades, fossil fuels, mainly petroleum-based liquid fuels, natural gas and coal have played an important role in fulfilling this energy demand. However, because of their non-renewable nature, these fossil fuels are projected to be exhausted in the near future. This situation has worsened with the rapid increase in energy demand with significant worldwide population growth. Therefore, the demand for clean, reliable, and yet economically feasible renewable energy sources has led researchers to search for new sources. Global energy demand is increasing dramatically because of rising population. According to the International Energy Agency estimation, global energy demand is expected to increase by 53% by 2030. Currently, a major part of energy demand is fulfilled by fossil fuels, globally; we consume the equivalent of more than 11 billion tons of oil in fossil fuel every year. Crude oil reserves are vanishing at a rate of 4 billion tons a year. If this rate continues, oil deposits will

be exhausted by 2052. Therefore, fossil fuel stock will run out in the near future. Consequently, the world is moving toward an energy crisis; driving the world to look for alternatives many renewable energy sources have drawn the attention of researchers. Among these sources, biodiesel is the most popular choice. Biodiesel is derived from renewable resources that can be produced by a simple chemical process Many potential feed Stocks are available for biodiesel production. Moreover, 60–80% of biodiesel production cost depends on feedstock cost. The demand for both food and bio fuel has increased rapidly because of population growth. Bio diesel is useable in diesel engines in pure form (or) by blending it with petroleum diesel. Biodiesel is environment friendly and non – toxic, it emits lesser pollutants. [1].

The issue of global climate change is currently a main focus of debate and will remain as an imperative issue within the next few decades. Emissions of greenhouse gases [GHGs] from combustion of fossil fuels due to anthropogenic activity are the prime suspect for the exacerbated Situation. [2]

Biodiesel has been proposed as a viable option for the supplementation of fossil fuels and is likely to be a key contributor to the global energy demand. The primary constraint for the production of biodiesel is the lack of available feedstock to produce biodiesel on a large enough scale. However, due to competition for land use space with food crops, edible oils are less of a viable option, and currently microalgae production is too expensive to be produced on a large scale, leaving non-edible oils as the best source of oils for biodiesel.[3].

Fang-xia yang et al (4) have investigated the feasibility of producing biodiesel from *Idesia polycarpa* var. *vestita* fruit oil was studied A maximum yield of over 99% of methyl esters in *I. polycarpa* fruit oil biodiesel was achieved using a 6:1 molar ratio of methanol to oil, 1.0% KOH (% oil) and reaction time for 40 min at 30 °C. The fuel properties of the *I. polycarpa* fruit oil biodiesel obtained are similar to the No. 0 light diesel fuel and most of the parameters comply with the limits established by specifications for biodiesel. R.Sathish kumar et al (5) have studied, the optimization of transesterification process parameters for the production of Manilkara Zapota Methyl Ester (MZME) has been studied. The experimental study

revealed that 50 °C temperature of reaction, 90 min of time of reaction, 6:1 M ratio of methanol to oil and 1 wt% of concentration of catalyst are the optimal process parameters. Also the study revealed that out of the four parameters considered, methanol to oil molar ratio is most effective in controlling the optimal biodiesel production.

Jibrail Kansedo et al (1) have studied the feasibility of converting *Cerbera odollam* (sea mango) oil into biodiesel. The transesterification reactions were carried out using three different catalysts; sodium hydroxide (NaOH) as a homogenous catalyst, sulfated zirconia alumina and montmorillonite KSF as heterogeneous catalysts. The seeds were found to contain high percentage of oil up to 54% while the yield of FAME can reach up to 83.8% using sulfated zirconia catalyst.

Mortadha A. Ali et al (7) have studied the Oil extraction from date palm seeds (Iraqi date palm) is done by standard Solvent extraction method using a Soxhlet apparatus. This work is aiming to investigate the extraction of palm seed oil as a cheap feedstock for producing bio-oil and determine the fatty acid composition of bio-oil. The extraction process was carried out on a laboratory scale with particle size 2mm, 1mm and 0.425mm for different time 1h, 2h, 4h and 6h. Particle size of 2 mm was chosen in order to study the effect of solvent type. The optimal conditions to obtain the highest oil yield of 8.5 % (w/w) were 120 min, 0.425 mm and n-hexane extracted time, particle size of grounded Seed and type of solvent, respectively.

Silitonga et al., (2) have examined the engine performance and emission characteristic of *C. pentandra* biodiesel diesel blends in internal combustion. The experimental results showed that CPB10 blend give the best results on engine performance such as engine torque and power at 1900 rpm with full throttle condition. Besides, the brake specific fuel consumption at maximum torque (161g / kWh) for CPB10 is higher about 22.98% relative to diesel fuel (198 g/kWh). This is shown that the lower biodiesel diesel blends ratio will increase the performance and reduce the fuel consumption. Moreover, the exhaust emissions showed that CO, HC and Smoke opacity were reduced for all biodiesel diesel blends.

Orkun Ozener et al., (3) have studied the combustion, performance and emission characteristics of conventional diesel fuel and biodiesel produced from soybean oil and its blends (B10, B20, B50) were compared. The experimental results, showed that, relative to diesel, biodiesel had a 1–4% decrease in the torque and an approximately 2–9% increase in the brake-specific fuel consumption (BSFC) due to the lower heating value (LHV) of the biodiesel. However, biodiesel significantly reduced carbon monoxide (CO) (28–46%) and unburned total hydrocarbons (THCs), while the nitric oxides (NO<sub>x</sub>) (6.95–17.62%) and carbon dioxide (CO<sub>2</sub>) emissions increase slightly 1.46–5.03%. The combustion analyses showed that the addition of biodiesel to conventional diesel

fuel decreased the ignition delay and reduced the premixed peak. These results indicated that biodiesel could be used without any engine modifications as an alternative and environmentally friendly fuel.

## 2. EXPERIMENTAL PROCEDURE

### A. Experimental fuels

The commercial diesel fuel employed in the tests was obtained locally. The biodiesel produced from Date seed oil was prepared by a method of alkaline-catalyzed transesterification.

### B. Preparation of Biodiesel

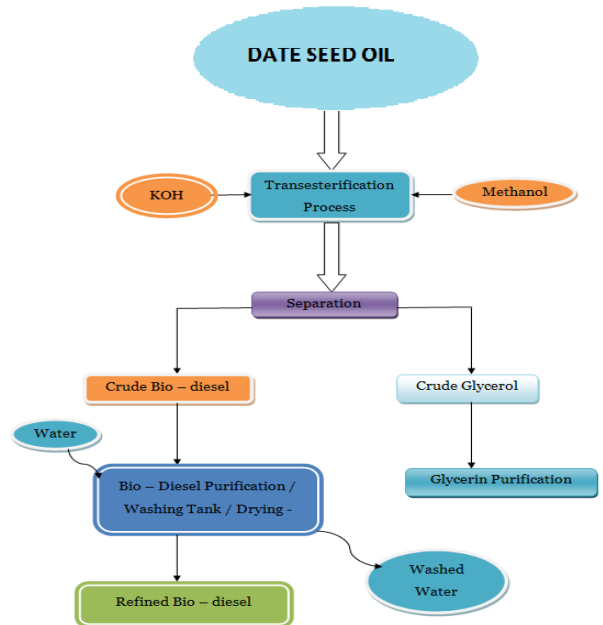


Figure – 1 Date Seed Oil – Bio-diesel Production Process Flow Chart.

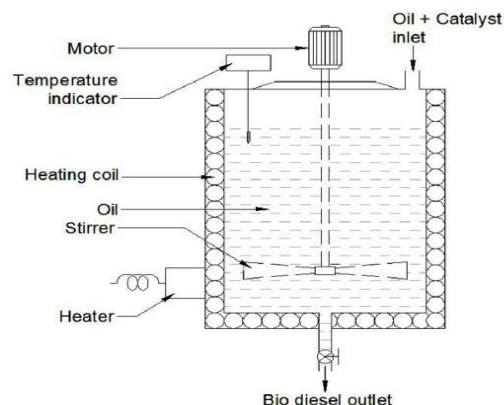


Figure - 2 Schematic diagram of Biodiesel Plant

Raw Date seed oil has been purchased from local market. Biodiesel is prepared from raw oil by transesterification process. ‘Alcohol mixture’ is produced by mixing 200 ml of methanol with 18 grams of Potassium Hydroxide (KOH). Raw Date seed oil is heated. When the temperature reaches around 60°C ‘Alcohol mixture’ is added to the raw oil. Then temperature is maintained at around 65°C and the mixture is stirred for about 30 minutes.

Chemical reaction took place and biodiesel got yielded. The resultant product contained biodiesel and Glycerol. The products were allowed to settle down in an inverted beaker. Separation took place and glycerol which is heavier got settled down at the bottom. Glycerol was removed and pure biodiesel was collected.

Table – 1 Properties of samples

Sample Name	Specific gravity	Density kg/m <sup>3</sup>	Calorific values kJ/ kg
Sole Fuel	0.822	822	44,710.66
Sample 1	0.830	830	44,121..27
Sample 2	0.840	840	43,532.30
Sample 3	0.852	852	42,943.12
Sample 4	0.872	872	42,353.94

C. Experimental Setup

The investigation was carried out in Kirloskar TV I Engine. The eddy current dynamometer is coupled with the engine and is used to load the same. AVL smoke meter, AVL Di - gas analyzer and AVL combustion analyzer are connected with the engine suitably.

The engine was allowed to run using diesel at various percentages of loads (20%, 40%, 60%, 80% and maximum possible load). At each percentage of load readings related to fuel consumption, smoke density, CO, CO<sub>2</sub>, O<sub>2</sub>, HC, NO<sub>x</sub> and EGT were recorded. The same procedure is repeated with various blends of biodiesel (B25, B50, B75 & B100). With each blend the engine is run at various percentages of loads (20%, 40%, 60%, 80% and maximum possible load). At each load readings corresponding to performance, emission and combustion characteristics are recorded. The results of these experiments are analyzed and discussed.

Table – 2 Specification of the 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 <sup>2</sup>

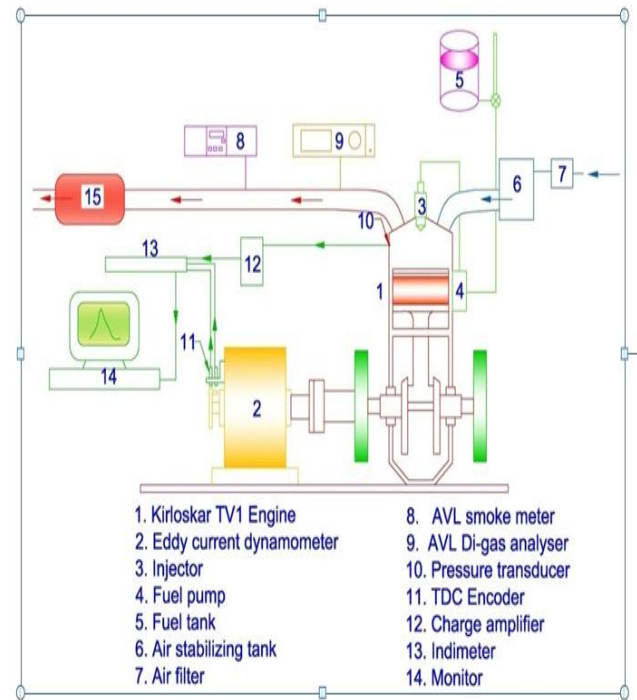


Figure – 1 Experimental setup

3. Results and Discussion

Engine performance with biodiesel or its blends with diesel fuel depends largely on the combustion, air turbulence, air-fuel mixture quality, injector pressure, actual start of combustion and many other singularities that make test results vary from one engine to another. In addition, it can vary depending on the quality and origin of biodiesel as well as engine operating parameters like speed, load, etc. Generally, the blend of non-edible biodiesel with mineral diesel can be applied directly to CI diesel engines. However, the effect of using this biodiesel must be evaluated by determining engine power/torque, brake thermal efficiency, brake specific fuel consumption and emissions production. Extensive research has been conducted worldwide to utilize non-edible biodiesel as a possible fuel for use in a diesel engine. Series of experiments by using blended non-edible bio-diesel for compression ignition engines have focused on engine performances and emissions. This section reviews the effects of blending non-edible biodiesel on engine performance, emission and combustion characteristics in DI diesel engine.

The experiment is performed for Date seed oil biodiesel. The results of the experimental investigations carried out have been furnished hereunder for Date seed oil biodiesel.

A. Brake Thermal Efficiency

The effect of Date seed oil biodiesel blend on brake thermal efficiency is shown in figure 3.1. It can be seen from the figure 3.1 that Brake thermal efficiency in general reduced with the increasing properties of biodiesel

in the test fuels. Break thermal efficiency in general reduced with.

The increasing proportion of biodiesel in the test fuels. The break thermal efficiency for B25,B50

And B75 date seed oil biodiesel was higher than that of sole fuel. This is due to the effect of low calorific value of biodiesel blend.

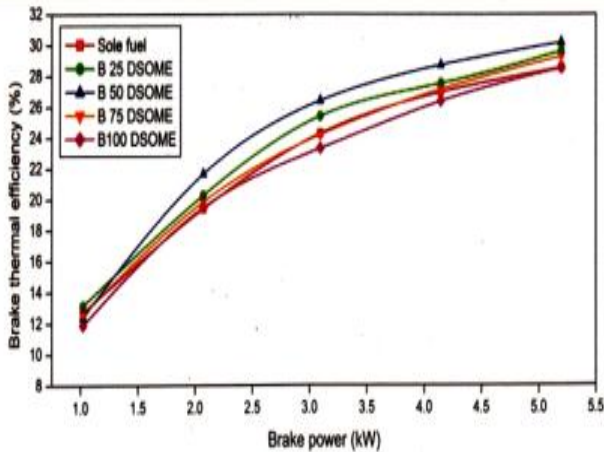


Fig 3.1 Brake Thermal Efficiency against Load

**B. Exhaust Gas Temperature**

The variation of exhaust gas temperature with break power is shown in figure 3.2 Exhaust Gas temperature is an indication of the extent of conversion of heat in to work .Which happens inside the cylinder. It is noted that the exhaust gas temperature using different fuels at various load levels are nearly the same. Exhaust gas temperature increase with increase in power for all the fuels. As the bio fuels concentration is decreased the exhaust gas temperature also decreased B75 date seed oil biodiesel indicates that lower exhaust gas temperature than other fuels The lower exhaust gas temperature is 329°C at higher power for B75 date seed oil bio diesel. This decreased in the exhaust gas temperature may be due to the lower calorific value of the biodiesel, changing the injection characteristics

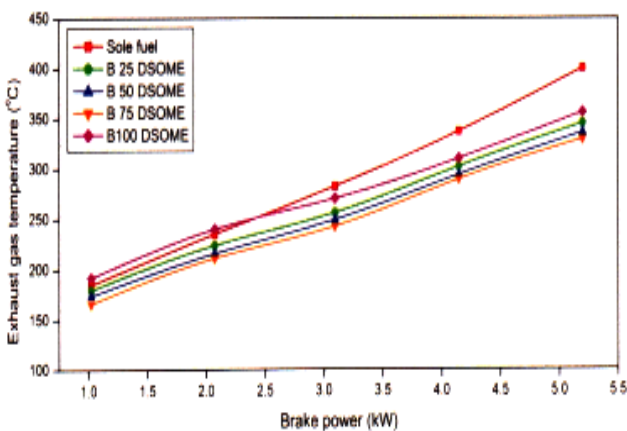


Fig 3.2 Exhaust Gas Temperature against Load

**EMISSION CHARACTERISTICS**

**C. CO emission**

The effect of the biodiesel blend on the CO emission is shown in figure 3.3 for the biodiesel and its blends, the CO emissions increases with increase in load The emission is found to increase with increase in the concentration of biodiesel blends as the fuel B100 date seed oil biodiesel emits more carbon dioxide which indicates the complete combustion of fuel.

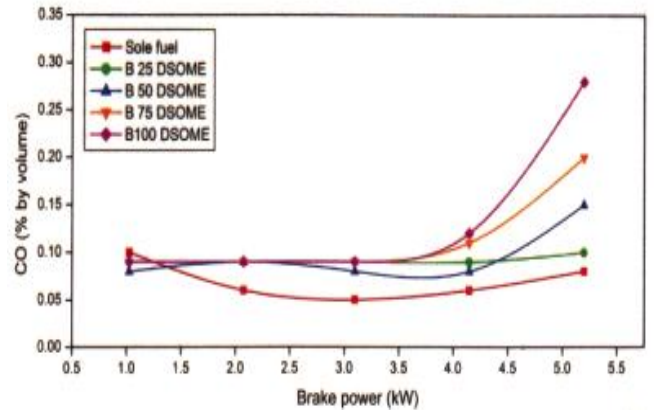


Fig 3.3 CO against brake power

**D. CO<sub>2</sub> emission**

The effect of the date seed biodiesel blend on the CO<sub>2</sub> emission is shown in figure 3.4 for the biodiesel and its blend, the CO<sub>2</sub> emission is reduced for all the biodiesel blends. The CO<sub>2</sub> Emission is minimum for B100 date seed oil biodiesel at maximum load with a level of 6.1% by Volume. This due the effect of biodiesel characteristic.

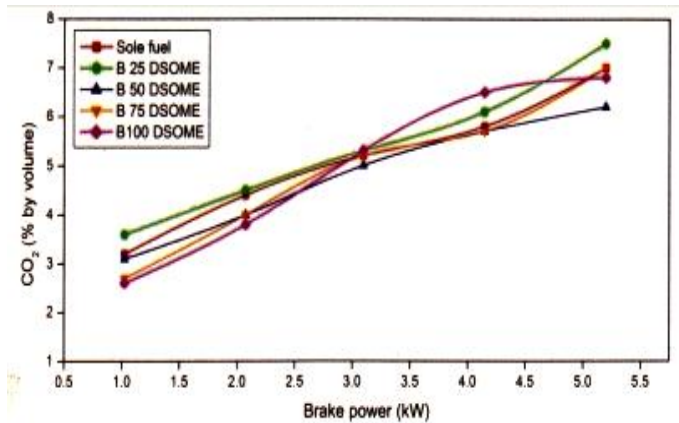


Fig 3.4 CO<sub>2</sub> against Load

**E. HC Emissions**

The effect of the date seed oil biodiesel blends on the HC emission in figure 3.5 The biodiesel blends have more oxygen content than that of standard diesel. So it involves in complete combustion Process. The hydrocarbon emission of the biodiesel blends are higher than the standard diesel due to complete combustion process, it can be due to improved combustion because of increased injection pressure and advanced injection timing.

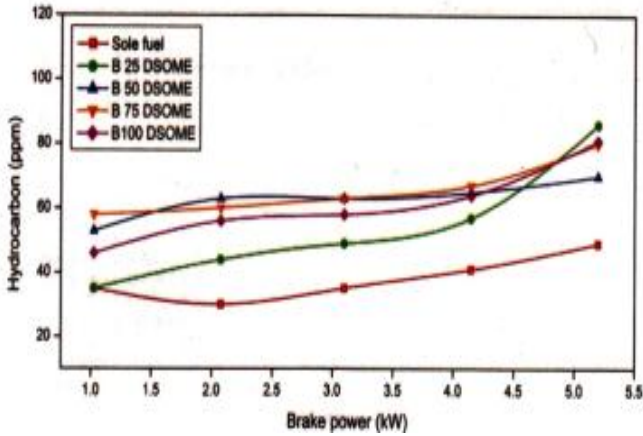


Fig 3.5 HC against Load

F. NOx Emission

The effect of date seed oil biodiesel on NOx emission is shown in figure 3.6. It is observed that there is a marginal decrease in NOx emission. NOx emission depends on the oxygen concentration and the combustion time. At all load conditions, NOx emission of biodiesel is always lower than that of standard diesel due to the oxygen concentration and combustion timing. The cetane number of the biodiesel blends is lower than that of standard diesel. This causes a decrease in the NOx emission of the biodiesel blend, when compared to biodiesel fuel (376-451 ppm)

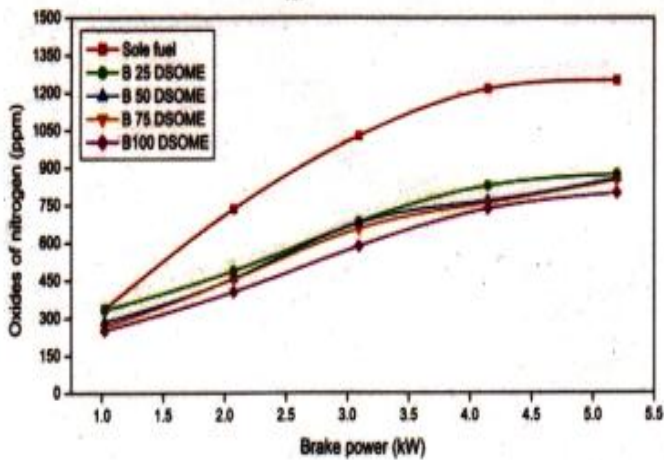


Fig 3.6 NOx Emission against Load

G. Smoke Density

Figure 3.7 shows the variation of smoke density with brake power. The increase in smoke density is due to the pressure of residual gases which affects the efficiency of the combustion process. The smoke density increases with an increase in viscosity, which results in a decrease of fuel-air mixing rate. When the percentage of blends of biodiesel increases, smoke density also increases. The smoke density was higher for B100 date seed oil biodiesel compared with that of diesel at high power.

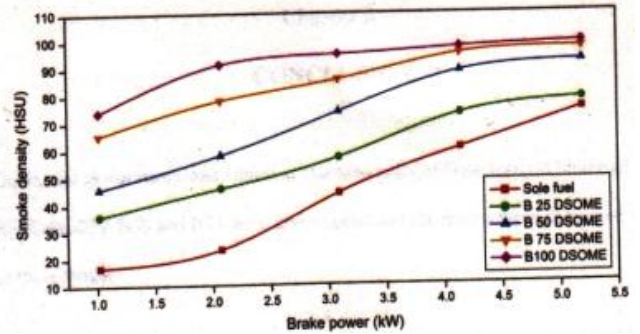


Fig 3.7 Smoke Density against Load

4. COMBUSTION PARAMETERS

A. Cylinder Pressure

Fig 4.1 shows cylinder pressure for various values of crank angle. The peak pressure within the cylinder is 70.634 bar. The maximum peak pressure for B100. It is clear that the peak cylinder pressure is increased with the increase of engine load. The peak cylinder pressure does not vary significantly with the increase of engine speed. The combustion process of the test fuels is similar, consisting of a phase of premixed combustion followed by a phase of diffusion combustion. At low engine load, only a small amount of fuel is burned and the fuel is burned mainly in the premixed burning phase. As the engine load decreases, the residual gas temperature and wall temperature decrease, which leads to lower charge temperature at injection timing, and lengthens the ignition delay. Ignition delay represents the time taken in physical and chemical reactions and does not change much on a time scale of milliseconds. However, it will increase in terms of crank angle degrees with engine speed increase as a high engine speed will correspond to a larger crank angle for the same time duration. Fig 4.1 shows the pressure rise rate of the tested fuels at different engine operating conditions. It is clear that the peak of pressure rise rate increases with the increase of engine load, and does not vary significantly with the increase of engine speed.

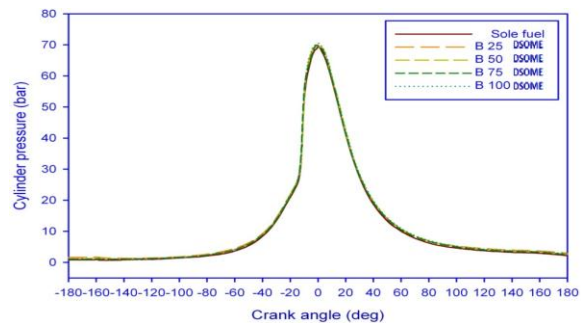


Fig 4.1 Cylinder Pressure against Crank angle

B. Heat Release Rate

Fig 4.2. Shows heat release rate for various values of crank angle. The heat release rate of conventional combustion chamber is higher than that of sole fuel. The maximum heat release rate is 148.093 kJ/m<sup>3</sup>deg for B75. The variation of heat release rate at different engine operating conditions is shown in Fig 4.2. Because of the evaporation of the fuel accumulated during ignition

delay period, at the beginning a negative heat release rate is observed. After combustion is initiated, this becomes positive. After the ignition delay, premixed fuel-air mixture burns rapidly, followed by diffusion combustion, where the burn rate is controlled by fuel-air mixing velocity. At high engine load, the peak of heat release rates of B75 are evidently higher than that of other and the crank angle of the peak of heat release rate is almost the same. The reason may be that the premixed burning heat release is higher for B75.

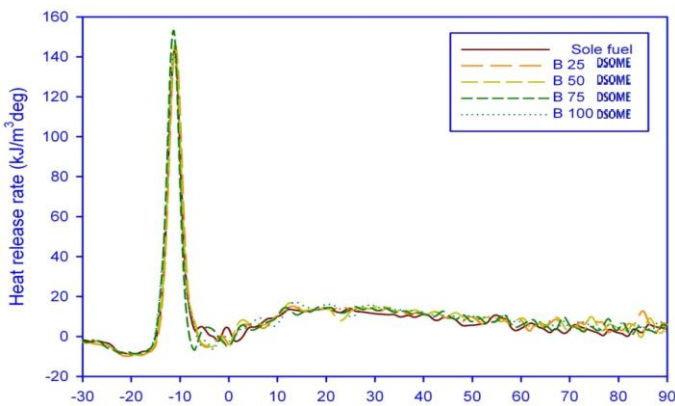


Fig 4.2 Heat release rate against Crank angle

## 5. CONCLUSION

Bio-diesel has attracted much research because of its economic and environmental benefits as well as its renewable origin. Bio-diesel produced from non-edible oil resources can defy the use of edible oil for Bio-diesel production. Therefore, its demand is growing steadily, and researchers are looking for possible newer sources of non-edible oil. This review concludes that non-edible oil is a promising source that can sustain Bio-diesel growth.

From the study this is deduced that

1. The brake thermal efficiency is marginally decreased for the biodiesel and its blend.
  2. The exhaust gas temperature is lower for DS75 is 180°C
  3. The emission analysis for the biodiesel and its blend gave the best result when compared to the sole fuel.
- The CO emission is reduced by 0.37% by volume at 100% of load for DS25.
  - The CO<sub>2</sub> emission is increased by 7.1% by volume at 100% of load for DS100.
  - The HC emission is reduced by 34 ppm at 100 % of load for DS100.
  - The O<sub>2</sub> emission is reduced by 10.87% by volume at 100% of load for DS100.

- The NO<sub>x</sub> emission is reduced by 1012 ppm at 100% of load for DS100.
- Smoke density is increased by 94.1 HSU at 100% of load for DS100.
- 4. The combustion parameters for the biodiesel and its blends gave the best result.
- The maximum cylinder pressure is 70.634 bar for DS 100.
- The maximum heat release rate is 148.093 kJ/m<sup>3</sup>deg for DS 75.
- The peak cylinder pressure is 74.187 bar for DS 25 at 59<sup>th</sup> cycles.

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