IMPACT OF COMBUSTION ON IGNITION DELAY AND HEAT RELEASE CURVE OF A SINGLE CYLINDER DIESEL ENGINE USING NEAT SARDINE OIL AS A FUEL

V.Narasiman[1], S.Jeyakumar[2], M. Mani[3]
[1]Research Scholar, Department of Mechanical Engineering,
Kalasalingam University, Sriviliputhur, Tamilnadu, India.
[2]Department of Mechanical Engineering, Kalasalingam University,
Sriviliputhur, Tamilnadu, India.
[3]Department of Mechanical Engineering,
Rajalakshmi Engineering College, Tamilnadu, India.

ABSTRACT
Today energy crisis is worldwide because conventional forms of energy supply and consumption are causing serious economical as well as environment problems. In our country consumption of petroleum products is increasing day to day resulting in huge gap of demand and supply. Diesel engines are the primary sources of power for the heavy duty vehicles. Cylinder pressure is an important parameter in diesel engine combustion analysis. In the present investigation test were conducted using neat sardine oil and diesel in a single cylinder, four stroke air cooled diesel engine at various loads. The results show that at full load peak cylinder pressure, peak heat re-lease rate and Ignition delay is lower for neat sardine oil when compared with diesel at full load.

KEYWORD: *Biodiesel, Diesel engine, Neat Sardine oil, combustion.*

I. INTRODUCTION

The demand for new energy efficient power trains has become significantly stronger in the last couple of years. It started with the rapid increase in oil price and grows even stronger during the green house gas debate where carbon dioxide, one of the major combustion products, is in focus. India has very vast coastline and fisheries industry well developed. All along the coastal line there is no dearth of fish and fish oil which are easily available and also cost of production of biodiesel from fish oil is quite economical other than land based tree bearing oil. A number of industries and entrepreneurs are using fish oil to produce biodiesel at an economical cost as compared to other non-edible oil sources. Amba Prasad rao and Rama mohan [1] studies the performance of DI and IDI engines with jatropia oil based biodiesel and concluded that DI engine operation with biodiesel under supercharged condition the performance are very close to diesel fuel operation. Araya et al [2] converted sunflower and fish oil to their methyl esters, tested in a single cylinder diesel engine and concluded that, the maximum output with both methyl esters was higher (0.11 kW, 3%) than the diesel fuel. Cherng-yuan Lin and Rong-ji Li [3] studied the trasesterified fish oil to produce biodiesel and they used discarded parts of mixed marine fish species as the raw material to produce biodiesel. They reported that Commercial biodiesel from waste cooking oil when compared with marine fish oil biodiesel had a large gross heating value elemental carbon and hydrogen content, cetane index, exhaust gas temperature, NOx, and O2 emission and black smoke opacity with lower elemental oxygen content. Dilip kumar Bora [4] studied the performance of single cylinder diesel engine using blends of karabi seed biodiesel by using potassium hydroxide as catalyst to facilitate estarification process and concluded B20 fuel showed better break thermal efficiency than B100 fuel, B100 also showed maximum NOX emission however B100 emitted least CO emission in comparison with B20 and diesel. Hulya [5] analyzed qualitatively and quantitatively, the crude commercial fish oil, by gas liquid chromatography. The major fatty acids detected in this oil were as follows: 24.8% stearic, 23.6% palmitic, 9.84% myristic, and 6.56% octadecatetraenoic acids. The physical and chemical properties of crude commercial fish oil were established. karthikeyan et al [6] studied the diesel Performance with fish oil biodiesel and its blends with diesel in proportion of 20:80, 40:40, 60:40 and 100% by volume on single cylinder water cooled four stroke diesel engines and reported that break thermal efficiency of B60 blend and B100 was close to break thermal efficiency of diesel at all loads. Qi et al [7] have compared the combustion characteristics of diesel and biodiesel from soybean oil in a single cylinder, naturally aspirated Diesel engine and concluded that the peak cylinder pressure of biodiesel is close to that of diesel. They also reported that the peak rate of pressure rise and peak heat release rate during premixed combustion phase are lower for biodiesel. Sahoo et al [8] have experimented with jatropha, karanja and polanga biodiesel in a Diesel engine. They reported higher peak cylinder pressure and shorter ignition delay for all biodiesels when compared with diesel. Rajesh Guntur and Ravikumar [9] have studied about the performance and emission characteristics of a diesel engine fuelled with plastic pyrolysis oil-diesel blends and conclude that break thermal efficiency is less than diesel fuel operation and higher at part loads.

II. EXPERIMENTAL SETUP AND PROCEDURE

Tests have been conducted on a Kirloskar Engine TAF1, four strokes, single cylinders, air-cooled direct injection, and naturally aspirated diesel engine with displacement of 2826 cc, bore 87.5 mm, stroke 110 mm, rated power 4.4 KW, compression ratio of 17.5:1 and runs at constant speed of 1500 rpm and the layout of experimental setup with instrumentation is shown in figure **1**.

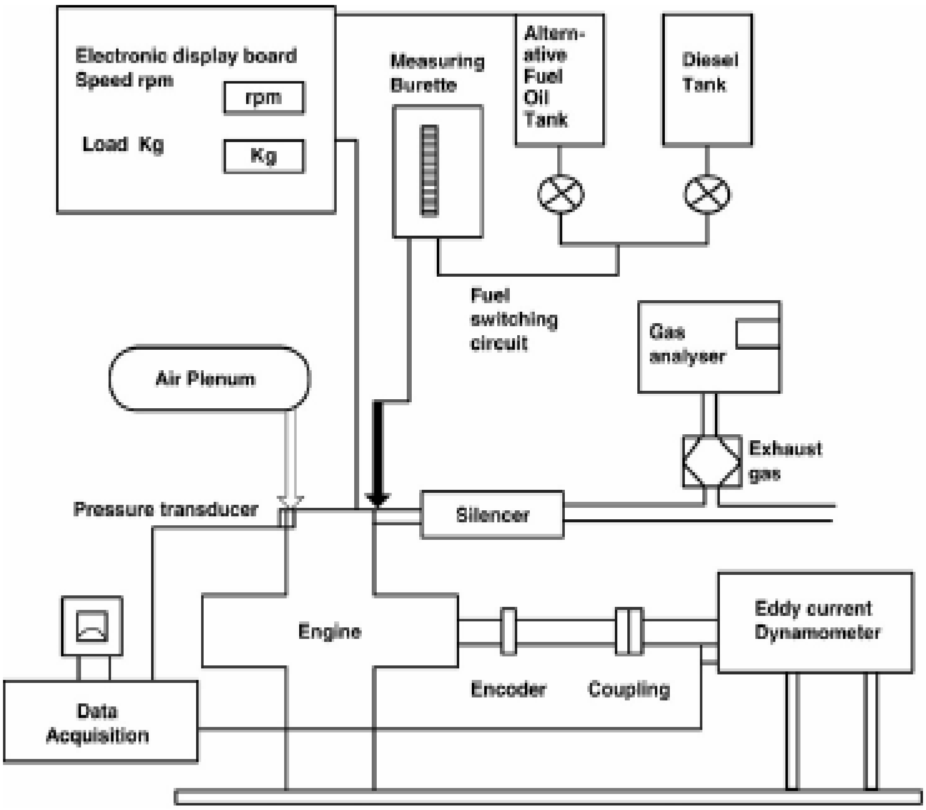

Figure 1, Layout of experimental setup with instrumentation.

A mechanical unit pump of helical plunger type made by Bosch is used to deliver the fuel to the multi hole orifice. Two separate fuel tanks with a fuel switching system are used. The fuel consumption can be measured with the aid of an optical sensor. The fuel from the tank was connected by way of a solenoid valve to a glass burette and the same is connected to the engine through a manual ball valve. The fuel solenoid of the tank will open and stay open for 30 seconds, during this time fuel is supplied to the engine directly from the fuel tank and also fills up the burette. After 30 seconds the fuel solenoid closes the fuel tank outlet, and then the fuel in the burette is supplied to the engine. When the fuel level crosses the high level optical sensor, the sequence running in the computer records the time of this event. Likewise when the fuel level crosses the low level optical sensor, the sequence running in the computer records the time of this event and immediately the fuel solenoid opens filling up the burette and cycle is repeated. Now, volume of the fuel between high level and low level optical sensors is known. The air flow to the engine is routed through cubical air tank. The rubber diaphragm fixed on the top of the air tank takes care of neutralizing the pulsation for air-flow measurement. The inlet air tank is provided with an orifice. The differential pressure of air is measured in the computer using a differential pressure transducer calibrated to indicate volume air flow. The pressure ports are connected to instrumentation panel using smooth flexible hose. The pressure drop across the orifice is measured using a differential pressure transducer. The output of the differential pressure transducer is amplified using an instrumentation amplifier and fed to the data acquisition system. The engine is coupled with an eddy current dynamometer which is used to control the engine torque. Engine speed and load are controlled by varying excitation current to the eddy current dynamometer using dynamometer controller. A kistler piezoelectric transducer is installed in the cylinder head in order to measure the combustion pressure. Signals from pressure transducer are fed to charge amplifier. A high precision crank angle encoder is used for delivering signals for top dead center and crank angle. The signals from charge amplifier and crank angle encoder are acquired using Kistler data acquisition system. In-cylinder pressure and top dead center signal are acquired and stored on a high speed computer based digital data acquisition system. There are filters present in the pressure signal. The data from different consecutive cycles are recorded. These are processed with specially developed software to obtain the pressure crank angle data. The combustion parameters such as cylinder pressure, ignition delay, rate of heat release and exhaust gas temperature has been analyzed from the graphs. The important properties of Neat Sardine Oil are shown in Table **1**.

Table 1, Fuel properties of Neat Sardine Oil.

Serial Number	Properties	Sardine Oil
1	Density (kg/m3)	933
2	Specific gravity	0.93
3	Kinematic viscosity at 40 C (Cst)	22
4	Calorific value (KJ/kg)	38,006
5	Flash point (C)	226
6	Fire point (C)	236
7	Oxygen contents	0.56%
8	Iodine value	172
9	Moisture	0.03%
10	Carbon	89.95%
11	Hydrogen	9.31%
12	Nitrogen	0.08%
13	Sulphur	0.02%

III. RESULT AND DISCUSSION

3.1 Cylinder pressure with crank angle

The variation of cylinder pressure with crank angle at full load is shown in figure **2**. In a CI engine, the cylinder pressure characterizes the ability of fuel to mix well with air and burn. It is observed that Neat Sardine Oil has a lower peak pressure than diesel. Due to shorter ignition delay of Neat Sardine Oil compared to Diesel, less fuel is accumulated in the combustion chamber which leads to less peak pressure at the time of premixed combustion stage. The lower peak pressure for Neat Sardine Oil as compared to diesel may also be due to dynamic injection delay, which results in initiation of combustion before top dead center and the pressure drop quickly. On the other hand, while running with diesel, due to longer ignition delay, the combustion starts later for diesel compared to Neat Sardine Oil , which leads to higher peak cylinder pressure. The locations of the peak pressures for Neat Sardine Oil are comparable with that of diesel and are within 1-10 crank angle degree aTDC. The peak pressure for Neat Sardine Oil is 64.5 bar occurring at 9.9 °CA aTDC, while in the case of diesel, it is 70 bar occurring at 9 °CA aTDC.

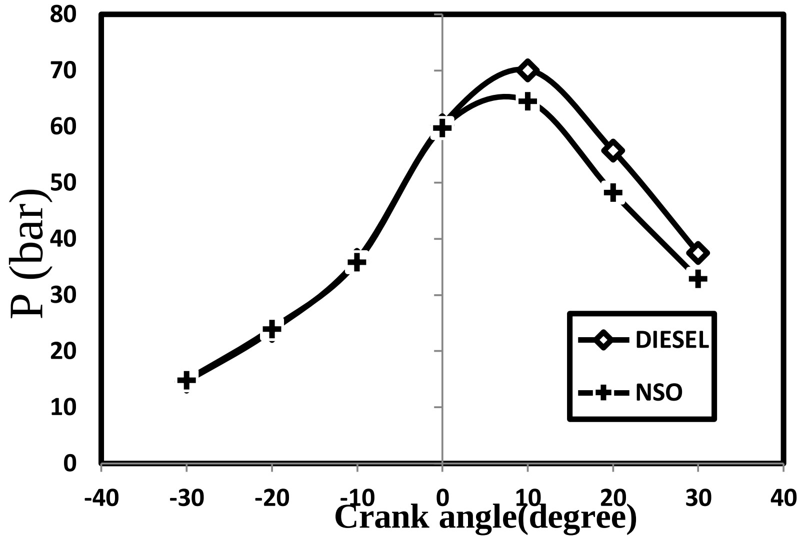

Figure 2, Comparison of Cylinder Pressure vs Crank Angle with Neat sardine oil

3.2 Ignition delay

The variation of ignition delay at different loads for Neat Sardine Oil and diesel is shown in figure **3**. The ignition delay in a Diesel engine is defined as the time between the start of fuel injection and the start of combustion. The start of fuel injection is usually taken as the time when the injector needle lifts off its seat. Since needle lift sensor is not available, the timing at which fuel injection line pressure reaches the injector nozzle opening pressure is taken as the start of injection. The ignition delays for the fuels are defined as an interval between 23 °CA bTDC (standard injection timing) and fuel ignition. It is observed that ignition delay is shorter for Neat Sardine Oil as compared to diesel.

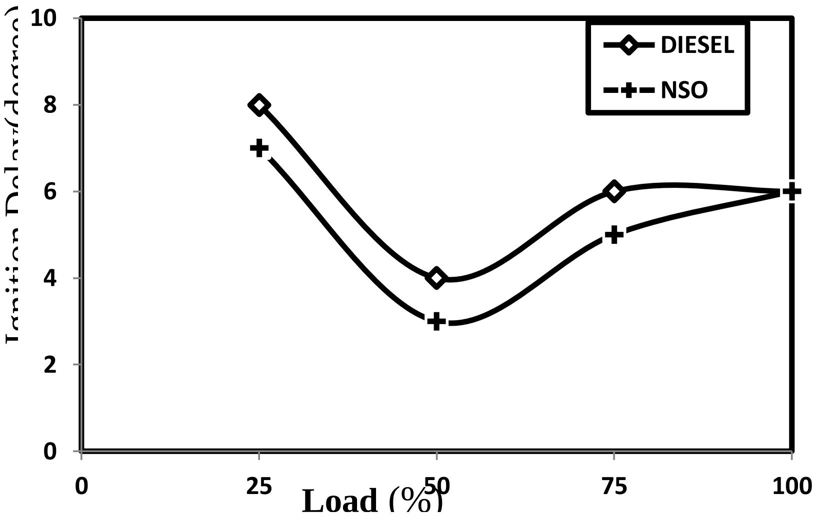

Figure 3, Comparison of Ignition Delay vs Load with Neat sardine oil

3.3 Heat release rate

The variation of heat release rate with crank angle at different loads for Neat Sardine Oil and diesel is shown in figure **4**. Due to heat loss from the cylinder and the cooling effect of the fuel vaporizing as it is injected into the cylinder, the heat release rate is slightly negative during the ignition delay period. After the combustion is started, this becomes positive. The initial phase of combustion, called the premixed combustion. The final combustion phase is called late combustion. It can be observed that peak heat release rate is higher for diesel than Neat Sardine Oil. This may be due to higher volatility and better mixing of diesel with air.

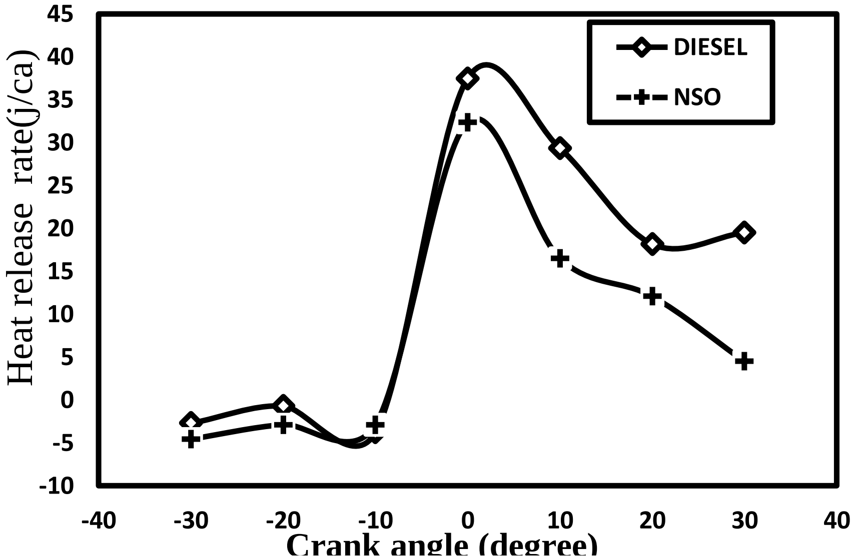

Figure 4, Comparison of Heat Release Rate vs Crank Angle with Neat sardine oil

3.4 Exhaust gas temperature

The variation of exhaust gas temperature with different loads for Neat Sardine Oil and diesel is shown in figure **5**. The result shows that exhaust gas temperature increases with increase in loads for Neat Sardine Oil. At all loads diesel was found to be the lowest temperature compare to Neat Sardine Oil. The exhaust gas temperature is higher due to more oxygen content.

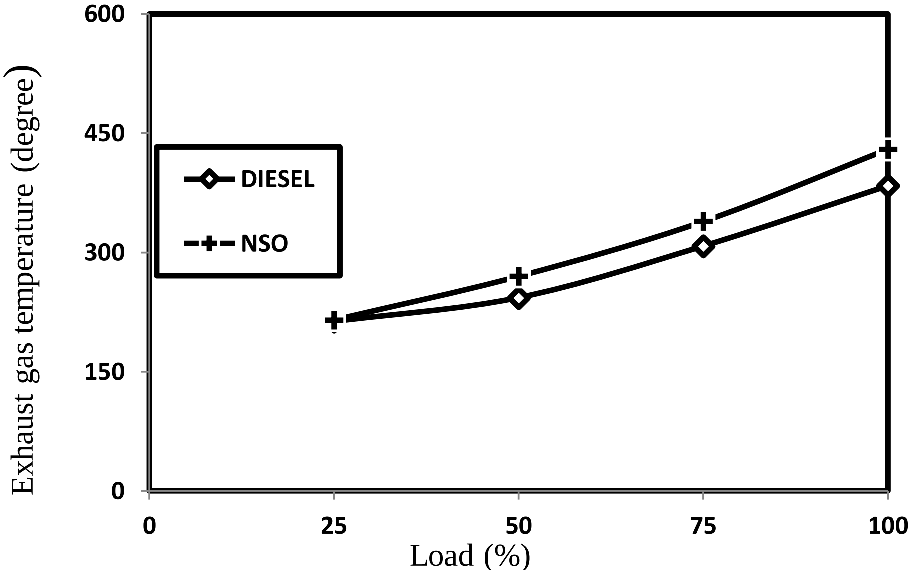

Figure 5, Comparison of Exhaust Gas Temperature vs Load with Neat sardine oil

IV. CONCLUSIONS

A single cylinder diesel engine is operated successfully on Neat Sardine Oil. The following conclusions are drawn based on the experimental results.

1. At full load, peak cylinder pressure for Neat Sardine Oil is lower as compared to diesel due to less fuel is accumulated in the combustion chamber which leads to less peak pressure at the time of premixed combustion stage.
2. The peak heat release rate during the premixed combustion phase is lower for Neat Sardine Oil as compared to diesel due to higher volatility and better mixing of diesel with air.
3. Ignition delay is observed to be lower for Neat Sardine Oil compared with diesel over the entire engine operating conditions. The reason may be that a complex and pre flame reaction takes places at higher temperatures.
4. The future scope of the work is to do some modification in the engine to get better performance.

V. ACKNOWLEDGEMENT

We would like to express my thanks to my Guide who helped me to develop the new ideas and put forward here.

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BIOGRAPHY

V. Narasiman, Bachelor Degree from Madras University and Master's Degree from Madurai kamaraj university, Tamil Nadu, India. He is pursuing his Ph.D.in Kalasalingam University. He has published 4 Journals. He is a Member in Combustion Institute (Indian Section), Member in Indian Society of Technical Education and System society of India, at present he is working as an Assistant professor [Senior Scale] in the Department of Mechanical Engineering, Vinayaka missions University.

S. Jeyakumar did his PhD in Mechanical Engineering in 2007 from Manonmanium Sundararnar University, Tirunelveli, India. Currently he is working as Professor in Department of Mechanical Engineering, Kalasalingam University, Krishnankoil, Tamilnadu, India. His research areas are high-speed flows and combustion.

M.Mani obtained his B.E degree in Mechanical Engineering at P.S.N.A College of Engineering and Technology, Dindigul, in May 1997 and M.E degree in Thermal Engineering from Karunya Institute of Technology, Coimbatore, in Dec. 1999. He obtained his Ph.D degree in I.C.Engine from Anna University, Chennai, in June. 2010. At present, he is working as Professor in the Department of Mechanical Engineering, Rajalakshmi Engineering College, Chennai. Based on his research work, he has published 8 papers in the International Journal of Applied Thermal Engineering, International Journal of Energy and International Journal of Fuel.