Experimental Vibration Analysis of Internal Combustion Engine by using Biodiesel

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***Abstract*: The I. C engine vibration is one of the important factors in engine design and engine maintenance. The engine vibrations can be measured by using the displacement sensor, the vibrometer and the vibrometer as time domain. Vibrations can decrease by using springs and dampers to sustain the engine. In diesel engine, the different fuels are used to mix with diesel oil as the dual fuels for reducing diesel oil consumption. With increasing significance on use of biodiesel in compression ignition engines, the long term effects are yet to be assessed. Through many researches, the suitability of biodiesel blends up to 20% is full-fledged and is being considered by many organizations with suggested use of biodiesel. A straightway is recommended in this study using the vibration signatures of the engine cylinder and head vibrations. The effects of vibrations on C.I Engine is studied by using Soya-Biodiesel(B20) by varying C.R, Load and Various Blend ratio and comparison is done with diesel by taking same parameters. The technique is based on fundamental relationship within the engines vibration pattern and the relative features of the combustion process under different operating conditions. Vibration leads to knocking, by using biodiesel blends knocking can be reduced.**

***Index Terms*: Biodiesel, I.C. Engine, Vibrations, Compression Ratio.**

I. Introduction

Oscillations in mechanical dynamic systems are known as vibrations. Although any system can oscillate when external forces are applied, the term "vibration" is typically used in mechanical engineering to refer to systems that can oscillate freely without external forces. In engineered systems, these vibrations can cause minor or major performance or safety issues. Vibrations in machines and structures can cause excessive deflections and failure. Vibration is the motion of a particle, a body, or a system of related bodies that has been displaced from its equilibrium position. Most vibrations in machines and buildings are undesirable because they cause greater stresses, energy losses, additional wear, increased bearing loads, fatigue, passenger discomfort in vehicles, and energy absorption. Vibrational damage to rotating machine parts need careful balancing. When a system is shifted out of its stable balance, vibration occurs. Under the influence of restoring forces, the system tends to return to this equilibrium condition (such as the elastic forces, as for a mass attached to a spring, or gravitational forces, as for a simple pendulum). The system is constantly shifting back and forth across its equilibrium point. A system is a collection of parts designed to work together to achieve a goal. A vehicle, for example, is a system made up of wheels, suspension, the car body, and other components. A static element's output at any one time is solely dependent on the input at that time, but a dynamic element's current output is dependent on previous inputs. A static system is made up of all elements, whereas a dynamic system is made up of at least one dynamic element.
Vibrations can be categorized into three categories based on the actuation force: Free, forced, and self-excited vibrations are the three types of vibrations. A system's free vibration happens when there is no external force acting on it. Forced vibrations are caused by an external force acting on the system. In this instance, the system is constantly supplied with energy by the exciting force. Vibrations that are forced can be deterministic or random. Periodic and predictable oscillations characterize self-excited vibrations. The equilibrium state of such a vibration system becomes unstable under certain conditions, and every disturbance causes the perturbations to rise until some influence restricts their growth. Unlike forced vibrations, the exciting force is independent of the vibrations and can continue to exist even if the system is not vibrating.

II. Literature Review

Abhilash B Rao1, Shikher S Bhandary, Shramanth R Rajarathnam, Prof. Rajesh S4 & Dr. Dinesh PA
The experimental evaluation and mathematical verification of Cashew Nut Shell Liquid (CSNL) derived biofuel blended with diesel in varying proportions as an alternative to conventional fossil fuel as the working substance in a single cylinder, mechanically loaded four stroke Kirloskar diesel engine are the primary goals of this paper. The biodiesel's performance is assessed against conventional diesel for everyday feasibility in terms of fuel economy and brake power. [12]

B. Tesfa. R. Mishra, F. Gu, A. D.
At all operating circumstances, the engine running on biodiesel produced significantly higher cylinder pressure and peak heat release rate than the engine running on regular diesel. Furthermore, the brake specific fuel consumption estimates for the engine running on biodiesel are up to 14% higher than for the engine running on regular diesel. However, the thermal efficiency of a biodiesel-powered engine is 10% lower than that of a diesel-powered engine. Both diesel and biodiesel fuels have nearly identical power output values at 1300rpm and torque values of 105, 210, 315, and 420 Nm.. [13]

A.K. Goswami, G. A. Usmani
The current research focuses on soybean oil methyl ester as an alternative diesel fuel and its various blends with petroleum diesel. Soybean oil is an important oil for biodiesel production from an economic standpoint, and it is mostly used for edible purposes in countries like India. The methyl ester was made from soybean oil using the trans-esterification technique. 10 percent biodiesel plus 90 percent Petro-diesel, 20 percent biodiesel plus 80 percent Petro-diesel, 30 percent biodiesel plus 70 percent Petro-diesel, 40 percent biodiesel plus 60 percent Petro-diesel, 60 percent biodiesel plus 40 percent Petro-diesel, and 80 percent biodiesel plus 20 percent Petro-diesel were blended with diesel fuel..[16]

Hossain A. B. M. S., Nasrulhaq Boyce A., Salleh A. and Chandran S.
The purpose of this study was to create biodiesel from waste/recycled oils in order to reduce biodiesel costs, waste, and pollution. To obtain a high grade biodiesel fuel within the standards of the American Standard for Biodiesel Testing Method (ASTM D 6751) and European Norm, some critical variables such as volumetric ratio, types of reactants, and catalytic activity were chosen (EN 14214). Under the parameters of a 1:1 volumetric oil-to-methanol weight ratio, 0.5 percent NaOH catalyst, 50°C reaction temperature, and 320 rpm stirring speed, the maximum biodiesel production (71.2%) was attained. [18]

M. Canakci, J. H. Van Gerpen
Vegetable oil esters are gaining popularity as a non–toxic, biodegradable, and renewable diesel replacement. Biodiesel is the name given to these esters. Many investigations have found that biodiesel's qualities are quite similar to those of diesel fuel. As a result, biodiesel can be used in diesel engines with minimal or no changes. Biodiesel has a higher cetane number than petroleum diesel fuel, has no aromatics, and has a weight-based oxygen content of 10% to 11%. When compared to diesel fuel, these features of biodiesel reduce carbon monoxide (CO), hydrocarbons (HC), and particulate matter (PM) emissions in the exhaust gas. [17]

V.Manieniyan1 and S.Sivaprakasam
The study discusses the knocking problem in internal combustion engines and how vibration analysis and biodiesel helped to solve it (Mahua). The growing number of automobiles has resulted in high demand for diesel and gasoline in recent years. As a result, renewable energy has grown in popularity. One of the opportunities that could span the future is energy from biomass and, more specifically, bio-diesel. Vegetable oil bio-diesel and transesterified vegetable oil bio-diesel are viable alternative fuels for diesel engines. [10]

Heidary1, S. R. Hassan-beygi1, B. Ghobadian2, A. Taghizadeh3
The vibration study of an internal combustion engine employing a diesel-biodiesel combination is the subject of this research work. In today's society, research on the alternative fuel "Biodiesel" is considered critical. Biodiesel is a term that describes fatty acid methyl or ethyl esters generated from vegetable oils or animal fats that have qualities suitable for use in diesel engines. Six gasoline blends were developed and tested in this investigation. B5, B10, B15, B20, pure biodiesel (B100), and pure diesel were among the blends. The diesel "D2" utilized in this study was refined and manufactured in Iran in accordance with ASTM D975. The biodiesel employed in this study was created in the Bioenergy Research Center's biodiesel laboratory at Tarbiat Modarres University (TMU) in Tehran, Iran. Biodiesel is made from vegetable oils, animal fats, and waste oil at this facility using ASTMD 6751-09 standard instructions and processes. [9]

III. NEED OF VIBRATION ANALYSIS OF INTERNAL COMBUSTION ENGINE

The internal combustion (IC) engine is the vehicle's concentrated mass, but if it's not designed appropriately, vibrations and transmission to the supporting structures will occur. Engine vibrations affect ride comfort, driving stability, and drivability, all of which are essential considerations in a vehicle's performance. Because of environmental concerns and shifting customer tastes, the amount of vibration induced must be decreased. Unbalanced reciprocating and rotating parts, cyclic fluctuation in gas pressure, shaking forces owing to reciprocating parts, and structural characteristics of the mounts all contribute to the vibration behavior of an IC engine. The reciprocating and rotational masses of the engine create engine vibrations. The fluctuations in inertial forces are caused by the piston cylinder arrangement's combustion and compression variances during operation. The imbalanced forces of the engine are caused by the engine's inertial forces, which change with speed, fuel supply, and the fuel's combustion properties. A strong and accurate design and simulation model is required to forecast an engine's vibration output and to minimize the potential durability and customer perceived quality issues connected with engine vibration. To reduce engine vibration, suitable mounting as dampers must be installed at the engine-chassis interface. There are two types of vibrations created by the engine: torsional and longitudinal vibrations. Because of their reciprocating nature, engines usually exhibit some torsional vibration during operation. As the piston approaches top dead center (TDC) on the compression stroke, the crankshaft of an engine rotates, increasing cylinder pressure. When the piston moves down to bottom dead center, ignition and combustion raise the pressure, and when the piston drops down to TDC, the pressure begins to decrease. During the combustion stroke, the tangential force generated by the piston does productive work and increases the rotating speed of the crankshaft, whereas the compression stroke decreases the engine's angular velocity. The crankshaft's speed fluctuates as the rotational speed changes, resulting in torsional vibrations at the crankshaft. During operation, the reciprocating and rotating components of the engine are subjected to variations in inertial motion and combustion pressure, and the variations in inertial motion of the parts during upward motion and variation in combustion pressure during downward motion produce unbalanced forces at the engine block, which are measured as longitudinal vibrations in three orthogonal direction.

IV. EXPERIMENTAL SETUP AND VIBRATION ANALYSIS

Fig.1. Engine Setup

Table no.1. Engine Specifications

Make	Kirloskar
Model	TV1
Type	Single cylinder, DI, Four stroke
Cooled	Water
Bore and Stroke	87.5 mm x 110 mm
Cubic capacity	0.661 litres
Compression ratio	12-1 to 18-1
Rated power	3.5 kW at 1500rpm
Load at rated power	12 kg
Injector opening pressure	210 bars
Peak pressure	77.5 kg/cm^3
Injection timing	25° BTDC static (diesel)
Modified compression ratio range	12 to 18

The study was done with an objective of studying the effects of the engine operating parameters viz. compression ratio and injection pressure on the vibrations of the engine, when the engine is running with pure diesel and biodiesel blends. In this study, an engine was used and vibrations of the engine were recorded at two places i.e. (1) on the head of the cylinder placed vertically and (2) on the cylinder block placed horizontally in perpendicular direction to crank axis.

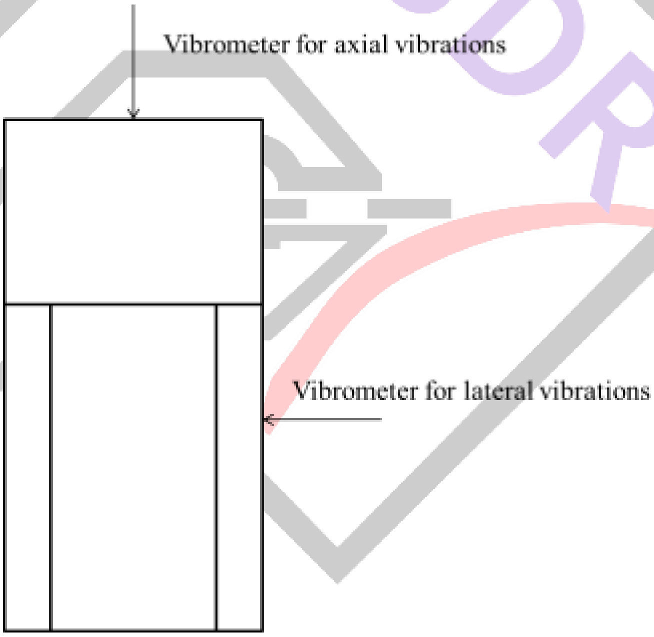

Fig no.2. Position of vibrometer

Fuel Used

Standard Diesel was acquired from nationalized distribution network from local outlet. Biodiesel fuel was prepared in laboratory from soyabean seed vegetable oil. The blends were prepared by mixing biodiesel and diesel in required proportions on volume basis.

Vibration Analysis using FFT Analyzer:

Following graph shows that variation in RMS value for different CR with varying load of CI engine by using pure diesel and bio-fuel respectively.

Compression ratio 13

Pure Diesel

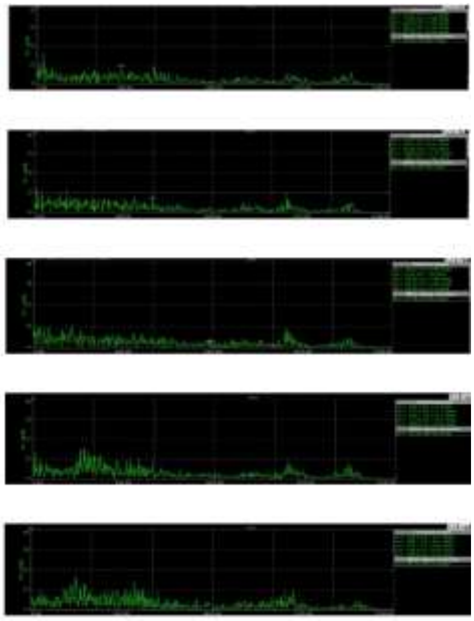

Fig.no.3 (Load 2, 4, 6, 8, 10 Kg for Diesel)

Soya-Biodiesel

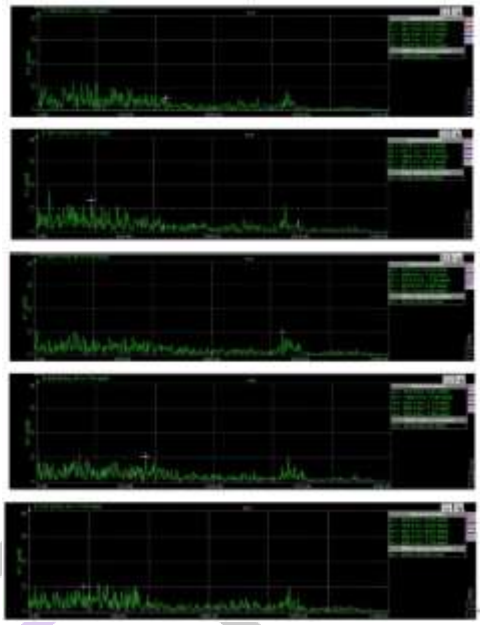

Fig no.4 (Load 2, 4, 6, 8, 10 Kg for Biodiesel)

Compression ratio 14

Pure Diesel

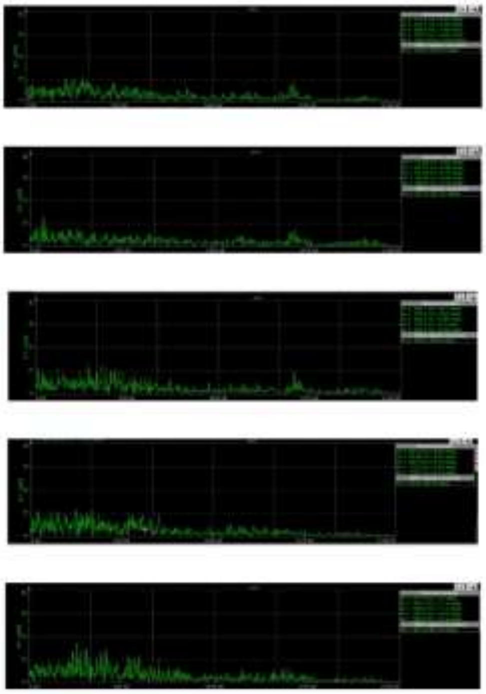

Fig.no.5 (Load 2, 4, 6, 8, 10 Kg for Diesel)

Soya-Biodiesel

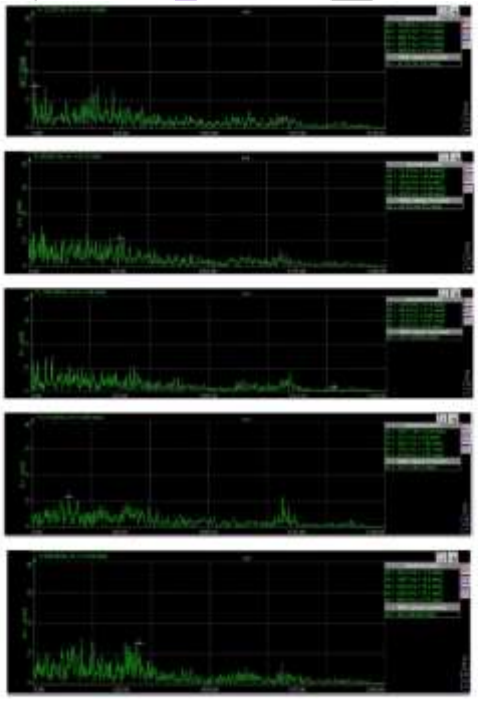

Fig.no.6 (Load 2, 4, 6, 8, 10 Kg for biodiesel)

Compression ratio 15

Pure Diesel

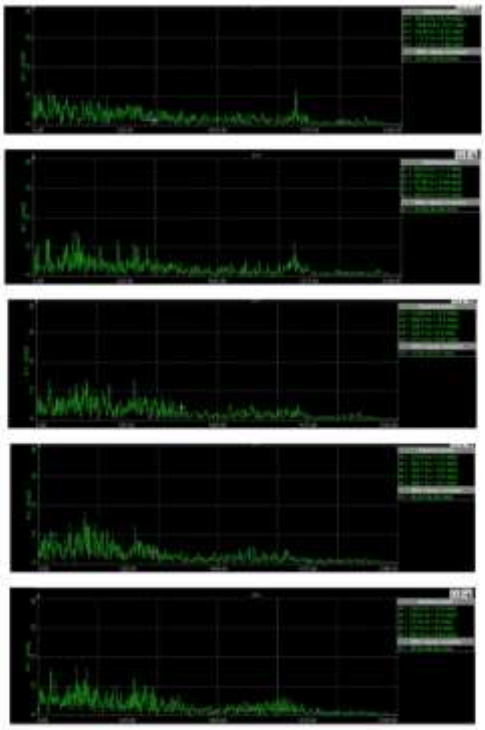

Fig.no.7 (Load 2, 4, 6, 8, 10 Kg for Diesel)

Soya-Biodiesel

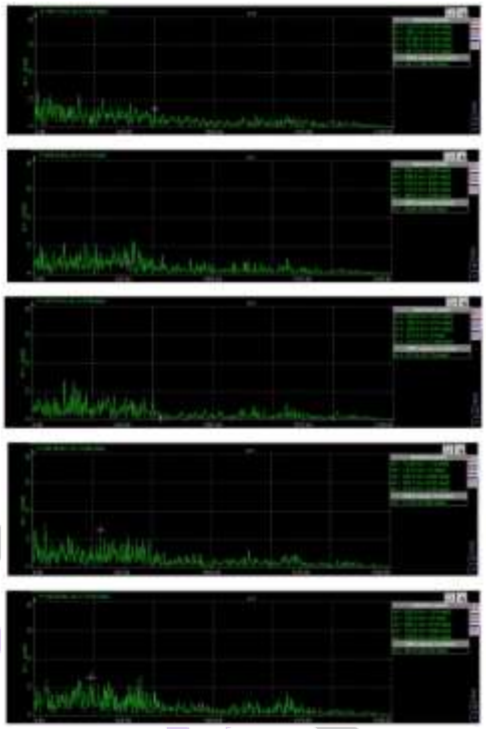

Fig.no.8 (Load 2, 4, 6, 8, 10 Kg for Biodiesel)

Compression ratio 16

Pure Diesel

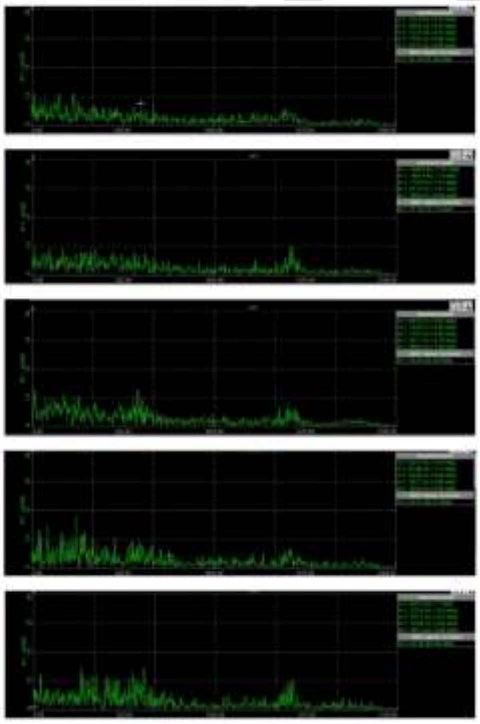

Fig.no.9 (Load 2, 4, 6, 8, 10 Kg for Diesel)

Soya-Biodiesel

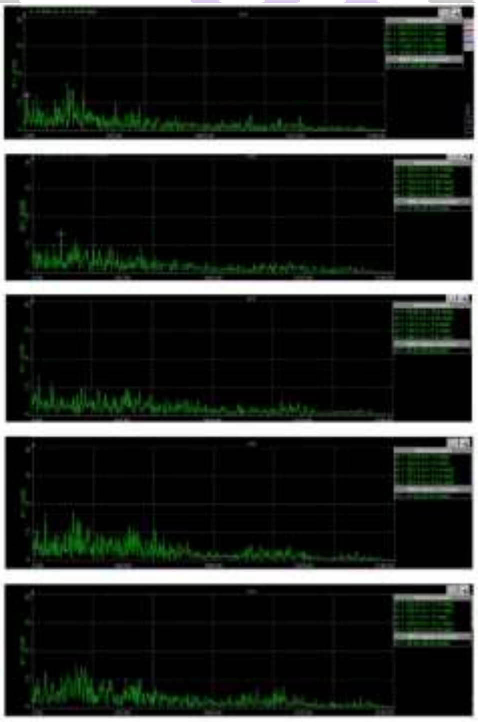

Fig.no.10 (Load 2, 4, 6, 8, 10 Kg for Biodiesel)

Compression ratio 17

Pure Diesel

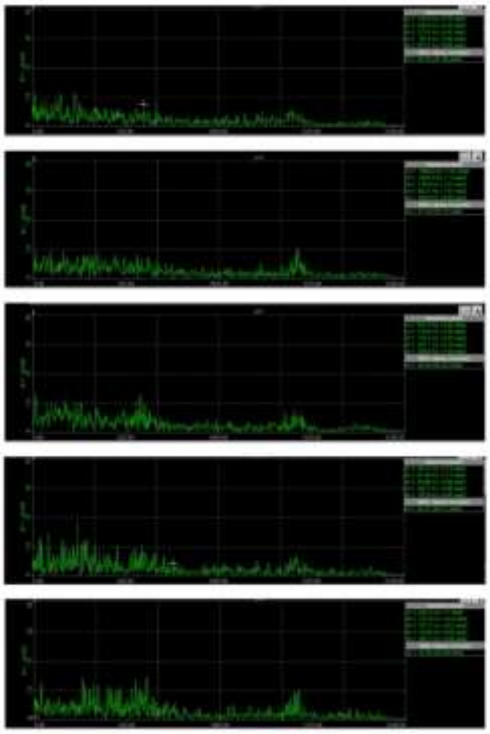

Fig.no.11 (Load 2, 4, 6, 8, 10 Kg for Diesel)

Soya-Biodiesel

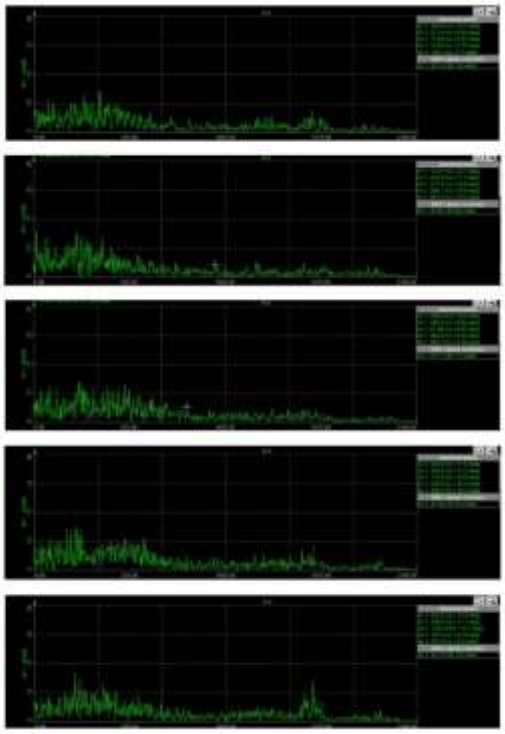

Fig.no.12 (Load 2, 4, 6, 8, 10 Kg for Biodiesel)

Compression ratio 18

Pure Diesel

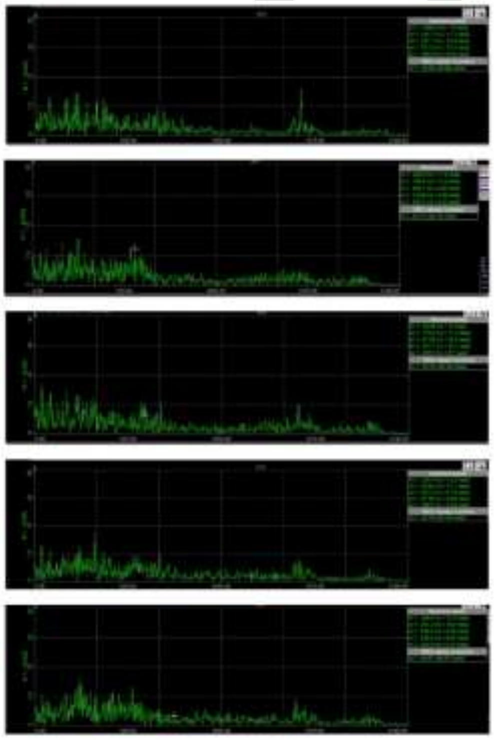

Fig.no.13 (Load 2, 4, 6, 8, 10 Kg for Diesel)

Soya-Diesel

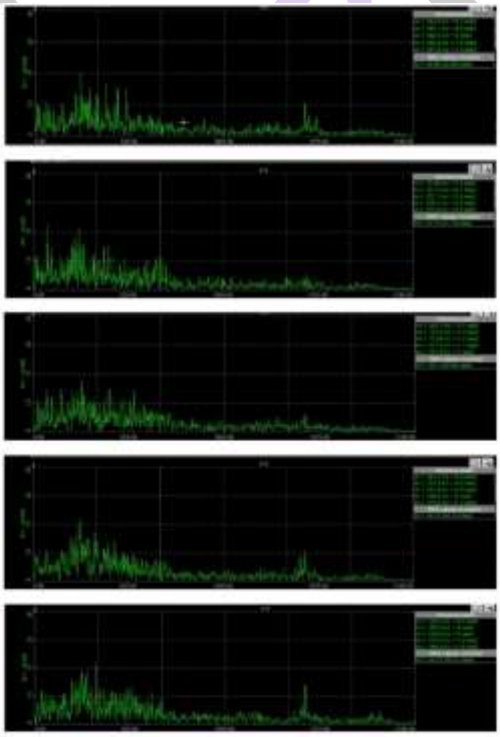

Fig.no.14 (Load 2, 4, 6, 8, 10 Kg for Biodiesel)

DISCUSSION:

Compression ratio 13

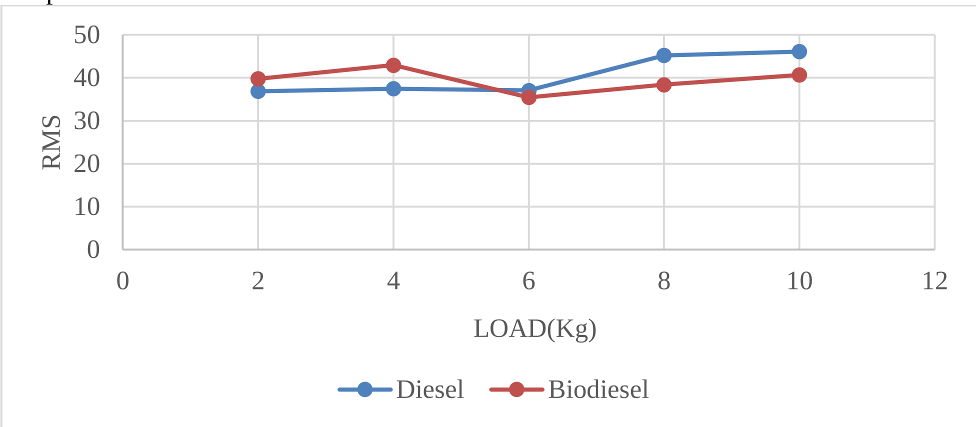

Fig no.15. RMS Vs Load

Compression ratio 14

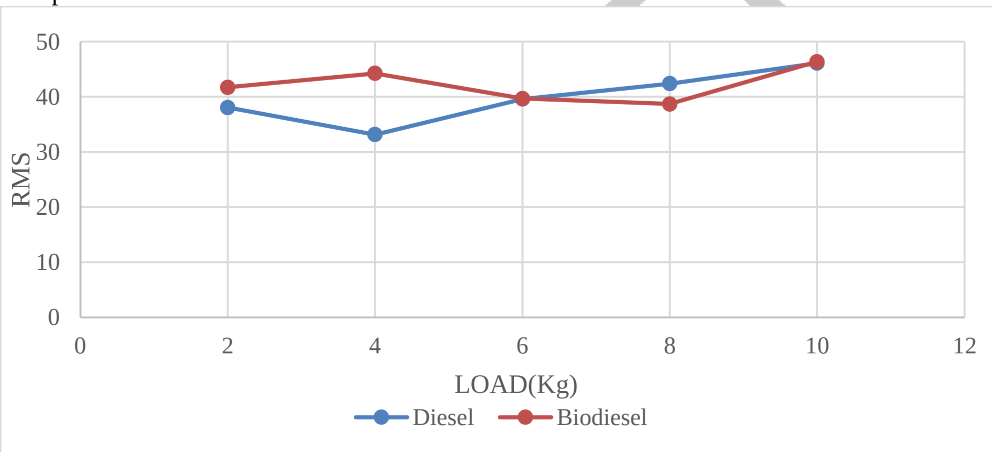

Fig no.16. RMS Vs Load

Compression ratio 15

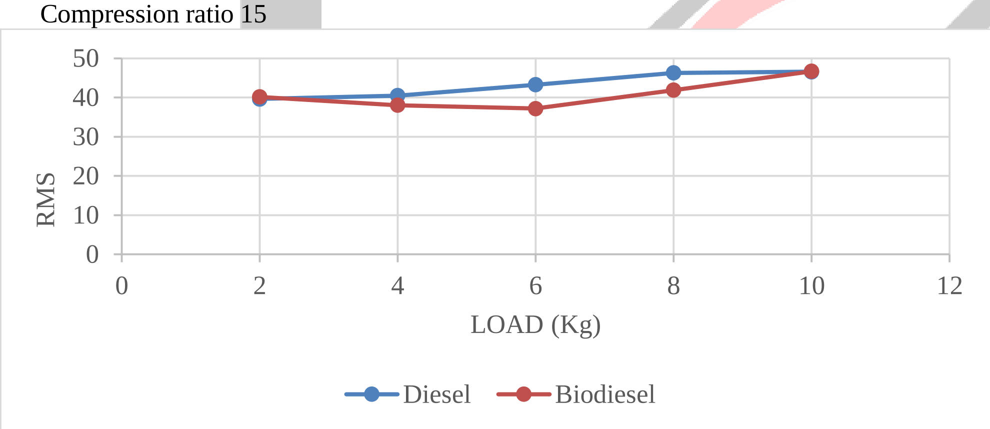

Fig no.17. RMS Vs Load

Compression ratio 16

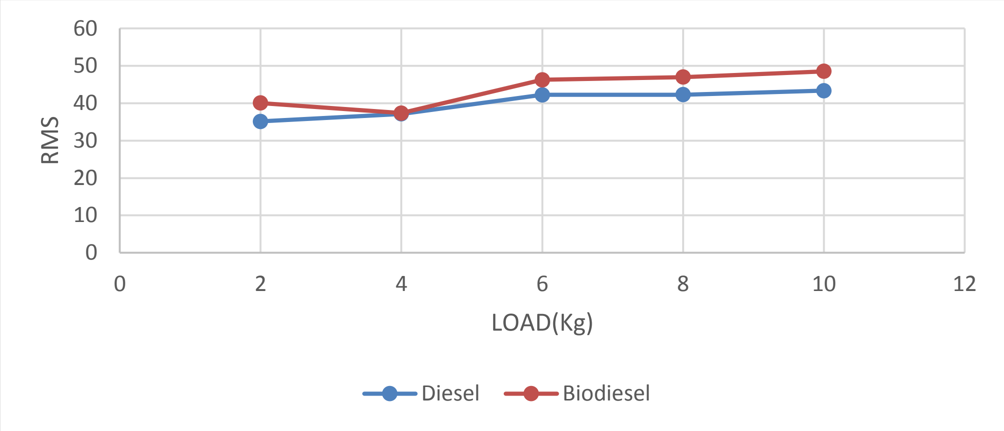

Fig no.18. RMS Vs Load

Compression ratio 17

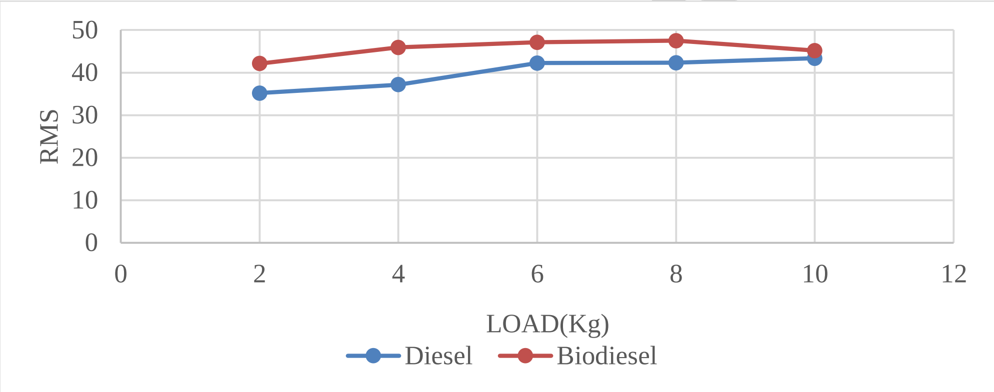

Fig no.19. RMS Vs Load

Compression ratio 18

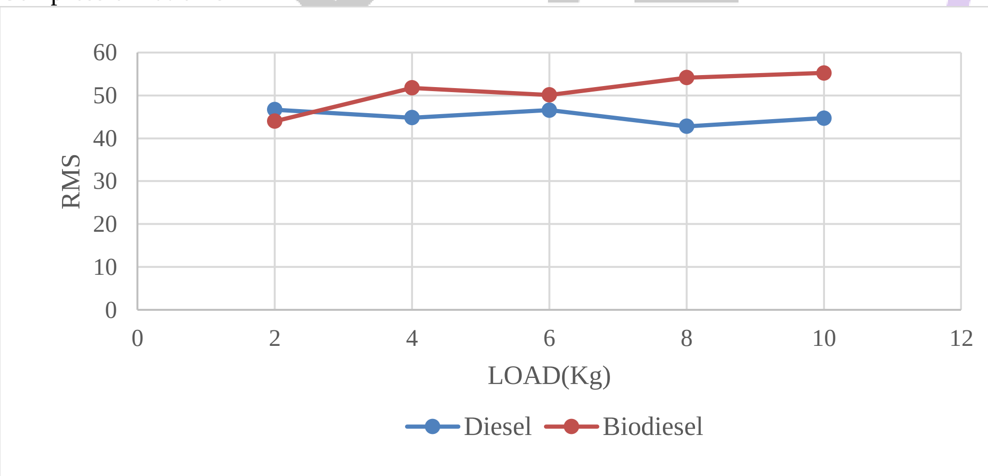

Fig no.20. RMS Vs Load

From all the graphs it can be seen that, for compression ratio 15 there is minimum vibration for soya-biofuel as compared to pure diesel.

V. CONCLUSION

The research in the area of biodiesel and vegetable oil based fuels recommended that a 20 percent blend of biodiesel works well in the CI engines without any changes. Apart from that, the engine's design and operating parameters need to be adjusted. Because of its environmental benefits and the fact that it is derived from renewable resources, biodiesel has grown more appealing as an alternative fuel for diesel engines in recent years. Several methods are available for producing Biodiesel. The transesterification of crude oils and fats are currently the method of choice. Commonly effects of varying compression ratio and injection pressures have been researched for better performance and emissions. Changes in these factors may have an impact on the engine's life and maintenance needs. To assess these effects, a vibration signature analysis measurement approach was chosen. The aim of this research was to explore dependence relationships between the engine vibrations and engine parameters. From results and graphs plotted for varying various parameters like compression ratio, load and blend ratio for Soy-biodiesel (B20) as well for diesel, it can be concluded that Biodiesel (B20) with compression ratio 15 shows less vibrations in both directions, lateral as well as axial as compared to Diesel. So it can be concluded that Biodiesel (B20) can be used in I. C. Engine as fuel.

Future Scope

1. To study the efficiency of biodiesel with different blends of biodiesel.
2. To Study Emission characteristics by using Biodiesel.

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