Experimental Vibration Analysis of I.C. Engine by Using Biodiesel

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***Abstract*— the engine vibration is one of the important factors in engine design and engine maintenance. The engine vibration can measure by using the displacement sensor, the vibrometer and the accelerometer as time domain and by using FFT analyzer as frequency domain. We can decrease it by using springs and dampers to sustain the engine. In diesel engine, the different fuels are using 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% are full-fledged and are 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 differentiation between the vibration signatures of an engine fueled with diesel and biodiesel blends under various compression ratios and injection pressures show remarkable changes in the vibration patterns and the difference can be used to evaluate the long term effects. 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 we can reduce the knocking also.**

Index— Vibration,Biodiesel,I.C.Engine,FFT Analyser

I. INTRODUCTION

Biodiesel is considered an hopeful alternative fuel for the diesel engines. Compared to fossil diesel fuel, biodiesel has several better combustion characteristics. In addition, since biodiesel does not carry carcinogens such as poly-aromatic hydrocarbons and nitrous poly-aromatic hydrocarbons, it generates pollutants that are less injurious to human health when burned. Biodiesel has much less air pollution due to its higher oxygen content and less aromatic compounds and sulfur. One exception to this is nitrogen oxide (NOx) emissions, which is much higher during the biodiesel usage Many researchers have tested biodiesel and its blends in direct injection compression ignition engines.[1]

The fuel characteristics of biodiesel are about the same as those of fossil diesel fuel and thus may be now used as a fuel for diesel engines without any advance adaption of the design up to a blend ratio of 20 with refinement in emissions with a slight loss in thermal efficiency. Although biodiesel has many benefits when it comes to fuel properties, it still has several difficulties that need to be mentioned, such as its lower calorific value, higher viscosity leading to poor atomization, lower power output, and its relatively higher emission of nitrogen oxides. Also, the use of higher blends is restricted by the improper combustion and harmful effects on engine life. 100% Biodiesel can be used only after some operating parameter variation like the compression ratio, injection pressure, injection timing etc. It has been shown that higher blends execute well with higher compression ratio and increased injection pressure.

The vibration occurs in any machine because of its moving parts is only of lower frequency. But some high frequency vibrations are also there in IC engine because of abnormal combustion of charge (fuel-air mixture). Vibrations take place in diesel engine in mainly two directions:

1. Vibrations in lateral direction.
2. Vibrations in longitudinal (axial) direction

A vibration is indicating the break-down of engine. That is varying the injection profile intensely affect the bulk motion settling inside the combustion chamber. The large amplitude of the vibration gives information about combustion intensity, high amplitude may mention early ignition or presence of a large amount of fuel in the cylinder prior to ignition, and lower amplitude may specify late ignition, injection fault or engine compression breakdown.

The piston impact on the cylinder liner is familiar as piston slap. This piston slaps reason of the vibrations in lateral direction. Lateral vibrations leads to greater wear of piston and liner surface and structural break -down and the wear due to this is higher than axial vibrations. During abnormal combustion, multi point ignition appears. This ignition causes rise in in-cylinder pressure. The rise in in-cylinder pressure forces on piston, and due to this parting force some high frequency vibrations are occurred in longitudinal direction. This study is therefore focused on finding the effect of varying the compression ratio and injection pressures on vibration signatures of a direct injection compression ignition engine and also the effects of biodiesel fueling.

II. MATERAILS AND METHODS

The research 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 operated with pure diesel and biodiesel blends. In the study, a small C.I engine was used and vibrations of the engine were measured at two places i.e. (1) on the head of the cylinder situated vertically and (2) on the cylinder block situated horizontally in perpendicular direction to crank axis (Fig. 1). The sensors were attached to the engine by a magnet without an intrusive approach.

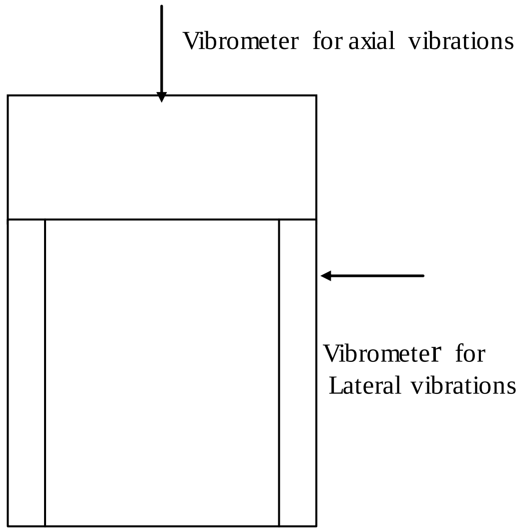

Fig. 1. Position of Vibrometer

A. Fuels used and their properties

Standard Diesel fuel was received from nationalized distribution network from a local outlet whereas the biodiesel fuel was prepared in laboratory from soya bean seed vegetable oil. The blends were prepared by mixing biodiesel and diesel in needed proportions on volume basis.

B. Experimental set-up

The study perform in the I.C Engine laboratory on an advanced fully computerized experimental engine test rig including of a single cylinder, water cooled, four stroke, VCR (Variable Compression Ratio) Diesel engine connected to eddy current type dynamometer for loading. The conditions of the engine used for research are given in Table 1

C. Vibration measurement

An eight channel, portable hand held vibration monitoring instrument was used with piezoelectric accelerometers for monitoring the engine vibrations (Make- PCB piezotronics Model- VIBXPERT Data collector and FFT analyzer). It is a high performance, full-featured FFT data collector and signal analyzer and collects field data including vibration information, etc. and integrates with Pruftechnik‟s OMNITREND maintenance information platform.

TABLE I
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Make	Kirloskar
Model	TV1
Type	Single cylinder, DI, Four stroke
Cooled	Water
Bore and stroke	87.5 mm × 110 mm
Cubic capacity	0.661 liters
Compression ratio	12-1 to 18-1
Rated power	3.5 kW at 1500 rpm
Load at rated power	12 kg
Injector opening pressure	210 bar
Peak pressure	77.5 kg/cm^2
Injection timing	25° BTDC static (diesel)
Modified compression ratio range	12 to 18

D. Experimental Procedure

For diesel, the test were conducted at rated condition of 17.5 compression ratio and injection pressure of 210 kg/cm^2 at rated speed of 1500 rpm under different brake loads. Then tests were carried out at five different compression ratios (16, 16.5, 17, 17.5 and 18). For all settings, the vibration velocity signals were recorded in axial and lateral directions for Peak to peak (P-P), Zero to Peak (O-P) and mean (RMS) values.
FFT analysis was by done using 'Omnitrend' software for velocity amplitude with frequency. For studying the effect of blend, seven blends were done (B0, B10, B20, B30, B40, B50, B75 and B100) for engine tests at full brake load.

Fig. 2. Experimental Set-up

III. RESULT AND DISCUSSION

The effects of engine operating parameters on the vibration were assessed with different settings and are denoted as correlation curves in the figures to follow. Figures 3 and 4 represent the relationship between vibration velocity and brake load with diesel as fuel. The relation between vibration velocity and compression ratio are shown in Figures 5 and 6. The results of blending ratio on engine vibration at rated values of compression ratio and injection pressure with full brake load are shown in Figures 7and 8.Effect of fluctuating Load

It is obtained that the lateral vibrations are reducing continuously with increase in load from no load to over load (Fig 3). Vibrations velocity is registered highest at no load (P-P 138.2 mm/sec) and lowest at overload conditions (P-P 119.2 mm/sec). The reason may be for which may be that at no load condition there is torque imbalance in the engine, but as load is increased the torque gets balanced resulting in decrease in engine vibrations in lateral direction.

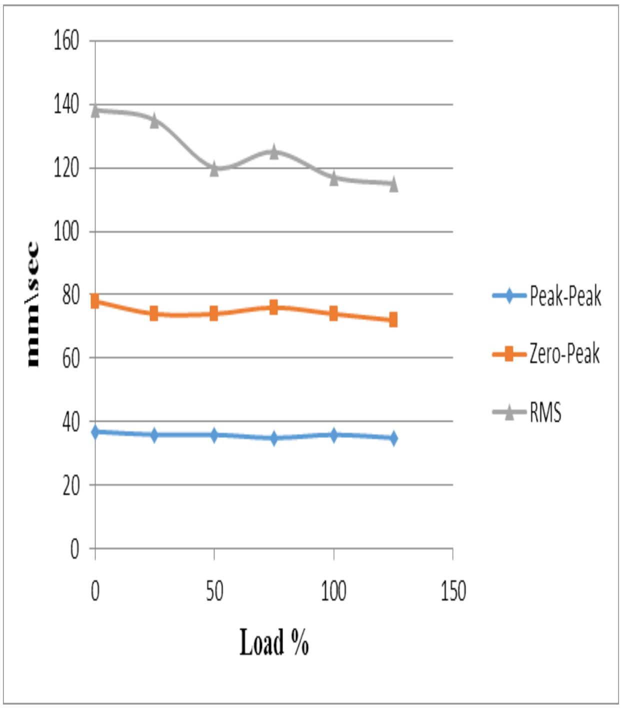

Fig. 3. Effect of brake load on vibrations (Lateral)

The axial vibrations (fig.4) increases with rise in load from 0% to 75% load, and after that it reduces. Maximum vibrations occur at 75% load (P-P 115.7 mm/sec) and minimum at 0% load (P-P 64.2 mm/sec). The reason for this are associated with cylinder pressure and temperature. As the load increases, the peak pressure also increases up to 75% load after which it falls negligibly. Also, high operating temperatures related to higher load decreases the ignition delay resulting in a decrease in knocking.

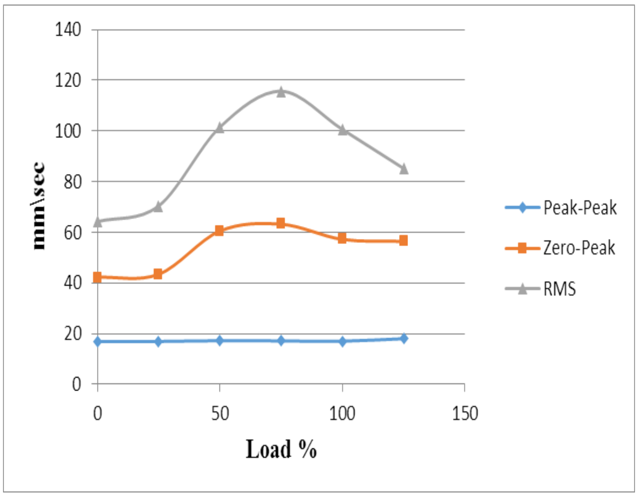

Fig. 4. Effect of brake load on vibrations (Axial)

A. *Effect of varying compression ratio*

The vibration velocity in the lateral direction (Fig. 5) is found to reduce with increase in compression ratio from 16 to 17.5 (135.4 to 121.2 mm/sec) after which it increases strongly (145.5). Thus the lowest vibrations are displayed a compression ratio of 17.5, which is also the advised compression ratio by the manufacturer.

Axial vibrations are noted decreasing continuously (Fig. 6) with increase in compression ratio from 16 to 18. Vibrations are maximum at 16.5 (163.1 mm/sec) and minimum at 18 (115.6 mm/sec). As compression ratio is raised, the delay period decreases causing decrease in knocking. The reason for decrease in knocking at higher compression ratio is that air pressure and temperature increases and auto ignition temperature decreases at higher compression ratio.

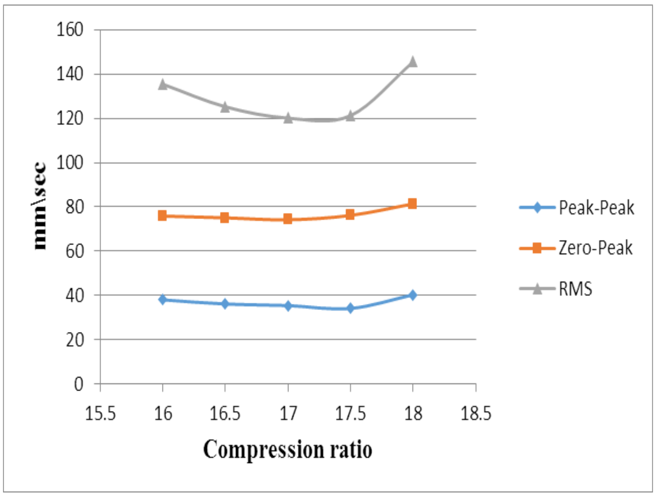

Fig. 5. Effect of compression ratio on vibrations (lateral)

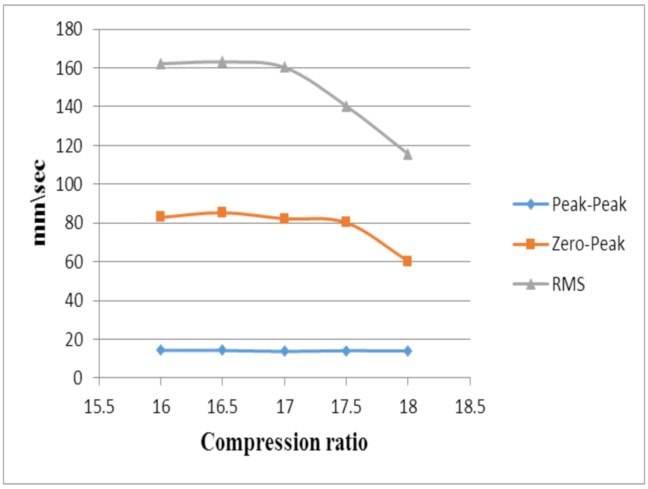

Fig. 6. Effect of compression ratio on vibrations (axial)

B. *Effect of blend ratio*

While taking trial on engine with different blends of biodiesel and diesel, the lateral vibrations are observed, vary in a design which seems to be erratic (Fig. 7), but repeated trials showed similar behavior. Interestingly, it is found that the most promoted blend (B20) is related with high vibrations (125.3 mm/sec) whereas B50 with lowest (97.4 mm/sec). With biodiesel in diesel, the combustion appear erratic but its higher lubricity leads to decrease vibration with higher concentration upto a explict level beyond which lubricity gains are offset by poor combustibility

Almost same design is recorded for axial vibrations also (Fig.8). In this direction also, lowest vibrations are apparent at B50 blend (110.1 mm/sec). The B0 blend (pure diesel) arises highest vibrations in axial direction (150.5 mm/sec).

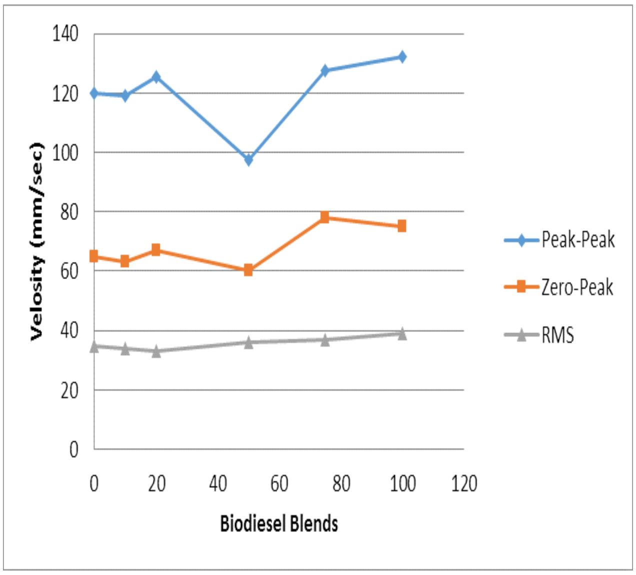

Fig. 7. Effect of blend ratio on vibrations (lateral)

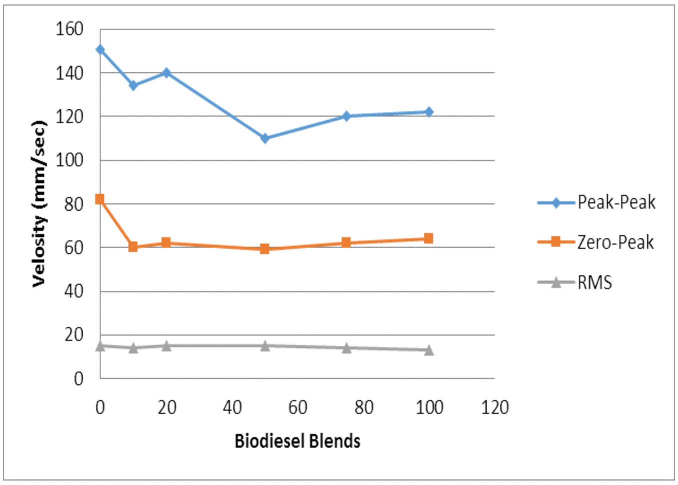

Fig. 8. Effect of blend ratio on vibrations (axial)

IV. 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. Beyond this, engine needs some modifications in design and operating parameters. Commonly effects of varying compression ratio and injection pressures have been researched for better performance and emissions. Changes in these parameters may affect the engine life and the maintenance requirements. To evaluate these effects, measurement technique based on vibration signature analysis was selected. The aim of this research was to explore dependence relationships between the engine vibrations and engine parameters (compression ratio and injection pressure) and the result of different blends of biodiesel on vibrations in a small diesel engine.

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