

Vibration Analysis of Diesel Engine Fueled with Diesel and Fish oil Blends at Different Loading Condition

Rawanang Rutuja S¹ Rawool Rushabh V² Sakharkar Pallavi R³ Prof. Yadav Milind S⁴

^{1,2,3}Student ⁴Professor

^{1,2,3,4}Finolex Academy of Management and Technology, MIDC, Mirjole, Ratnagiri, Mumbai University, India

Abstract— Diesel engine is a very important prime mover and to run diesel engine fuels are required. Due to the shortage of conventional fossil fuels there is need to use alternative fuels extracted from waste like fish oil which contains discarded body parts of fish. To check the performance of internal combustion engine vibration analysis plays an important role. In this paper using lab view setup vibration signals are collected through data acquisition system by attaching accelerometer on cylinder head of internal combustion engine by considering statistical factors like kurtosis, crest factor, RMS, skewness and FFT. By considering these factors we compare vibrating signals for diesel-fish oil blends viz, B1 (15% fish oil + 85% diesel), B2(30% fish oil + 70% diesel) and B3(45% fish oil + 55% diesel). The experimentation was carries out at different loading condition, load 0kg to 12kg in step of 3 in three different directions for cylinder head. After experimentation it is concluded that use of diesel-fish oil blends in internal combustion engine will reduce the vibration as compare to no blend condition, where kurtosis isa better criterion for vibration analysis.

Key words: Fish Oil, Vibration, Internal Combustion Engine, Accelerometer, Kurtosis, Skewness, Crest Factor, RMS, FFT, Lab View

I. INTRODUCTION

Dr. Rudol Diesel was responsible for the development of the diesel engine. Compression ignition engine posses' higher thermal efficiency with less running cost as compare to spark ignition engine. Vibration of compression ignition engine is a disadvantage which is suffered by majority of diesel engines. Due to lack of conventional fossil fuels it is necessary to find out alternative fuels for diesel engine. As compared to 1990 world biodiesel production increased by more than 20 times in 2012. Vegetable oil, animal fat, fish oil etc are the sources of biodiesel. Biodiesel is a better alternative fuel because of its advantages like reduction of unburned hydrocarbons, carbon monoxide, particulars and sulphur oxide exhaust and ease of production [1, 2]. Where, fish oil is the one which requires minimum processing to convert it into fuel. In order to determine engine performance vibration analysis plays a vital role with the use of biodiesel [3]. Rao and Rao [4] studied FFT spectrum indicating knocking frequency and acceleration amplitude. The experimentation was carried out to investigate the effect triacetin addition to the coconut oil methyl ester on vibration of cylinder where vibration of cylinder block is proven to reduce with improvement in performance. Sheikh and Umale [5] carried out vibration and noise analysis of diesel engine fuelled with diesel and jatropha biodiesel and result was reduction in vibration. Taghizadeh-Alisarael et al. [6] studied effect of biodiesel from 4 strokes6-cylinder diesel engine where he observed 20% and 40% blending had thw lowest

vibration. Jatropha and cooking oil by Asif and Surya Kurmi [7] also showed studies related to blending of conventional diesel, biodiesel and natural gas.

II. MATERIAL AND METHODS

A. Fuel preparation

After the chemical reaction between methanol, potassium hydroxide and oil from fish waste i.e. transesterification biodiesel fuel was produced from fish oil in the presence of catalyst to yield glycerin and methyl esters. This process is comparatively simple where 1:4 is the ratio of catalyst and alcohol with the fish oil on the volume basis. Then the fish oil biodiesel is mixed with conventional diesel on volume basis to form blend1, blend2 and blend3. Blend1 is mixture of 15% fish oil and 85% diesel. Blend2 contains 30% fish oil and 70% diesel and blend3 contains 45% fish oil and remaining 55% diesel.

Sr no	Test description	Diese 1	Fish oil		
		B00 %	B15 %	B30 %	B45 %
1	Density (gm/cc)	0.830	0.834	0.841	0.844
2	Calorific value (MJ/Kg)	42.5	42.2	41.79	41.35
3	Cetane no.	49	49.7	49.7	50.1
4	Viscosity(mm2/se c)	2.7	2.9	3.1	3.46
5	Flash point (°c)	64	88	96	111
6	Fire point (°c)	71	92	102	117

Table 1: properties of fuel

B. Engine test set up and Methodology



Fig. 1: Experimental test setup and position of accelerometer on cylinder head

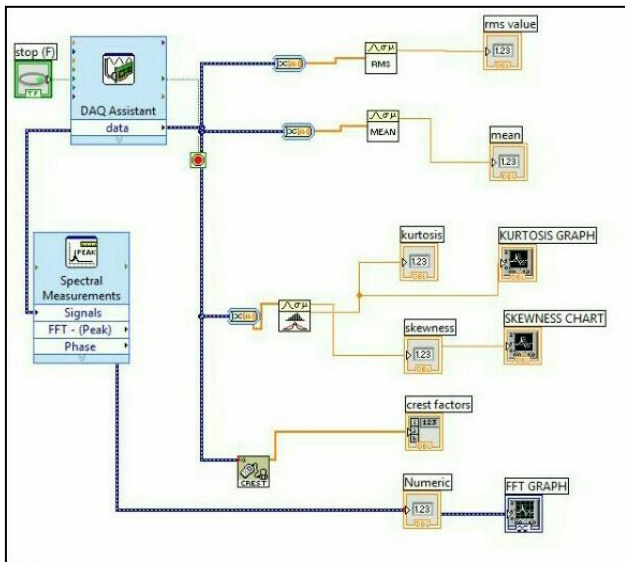


Fig. 2: Block diagram for signal extraction and analysis using Lab-View

In the experimentation the piezoelectric accelerometer is mounted on cylinder head. The vibrations are recorded in three orthogonal directions X, Y and Z with the help of lab view set up. The vibration analysis is done for no blend condition and then for blends B1, B2 and B3 respectively by varying load from 0 to 12 in the step of 3. The respective graphs and reading are taken for the statistical parameters, which are skewness, kurtosis, RMS, crest factor and FFT. The specifications of engine are prescribed in table2.

Parameters	Values
Make	Comet Engineering
Number of cylinders	2(twin cylinder)
Type	4 stroke, water cooled
Stroke length	110mm
Bore diameter	85mm
Compression ratio range	18:1
Power	13 BHP at 1600 RPM
Dynamometer	Water brake dynamometer

Table 2: engine specifications

III. RESULT AND DISCUSSION

A. Effect of fish oil blend on skewness of vibration signals

Mathematically skewness is defined as the ratio of averaged cubed deviation from mean and cube of standard deviation

$$\text{Skewness} = \frac{\sum_{i=1}^N (X_i - \bar{X})^3}{N\sigma^3}$$

Basically skewness is a dimension less number with zero value. When the distribution is not symmetric around mean it is said to be skewed [6]. Recorded amplitudes of vibration signals from cylinder head for each blend of diesel and fish oil are as follows.

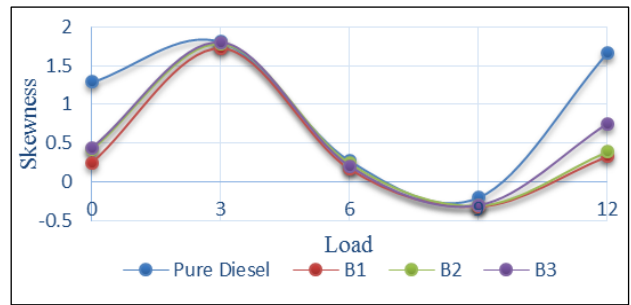


Fig. 3: Recorded skewness of acceleration signals from cylinder head in X-direction

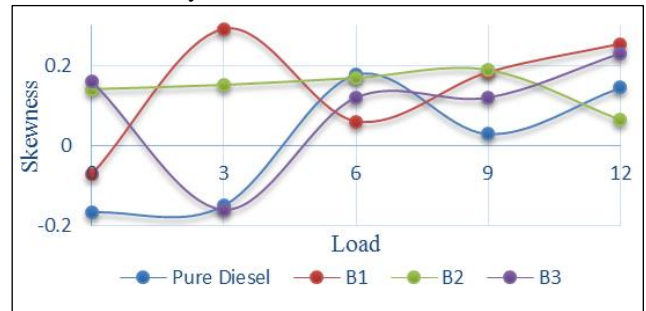


Fig. 4: Recorded skewness of acceleration signals from cylinder head in Y-direction

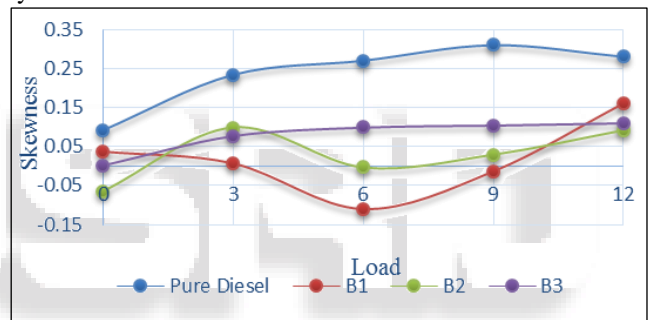


Fig. 5: Recorded skewness of acceleration signals from cylinder head in Z-direction

From the above graphs we get 80.62 % reduction in average skewness value for blend B1 at load 0kg in X-direction. While for Y and Z direction 80.66% and 57% reduction at load 3kg and 0 kg respectively for blend B1 as we compare with no blend condition. For blends B2 and B3 it increases but still greater reduction as compare to no blend condition.

B. Effect of fish oil on RMS

The RMS (root mean square) value of the vibration acceleration can be used for the primary health investigation of the machine. Root mean square is the square of root of average of squared values of vibration signal waveform and mathematically expressed as:

$$\text{RMS} = \sqrt{\frac{\sum_{i=1}^N (X_i)^2}{N}}$$

With increase in RMS value vibration increases [8]. It is used to study engine vibrations as it gives idea about the energy of waveform. Recorded amplitudes of vibration signals from cylinder head for each blend of diesel and fish oil are as follows

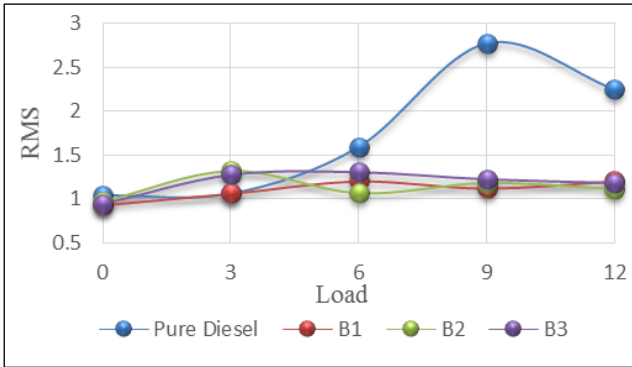


Fig. 6: Recorded RMS of acceleration signals from cylinder head in X-direction

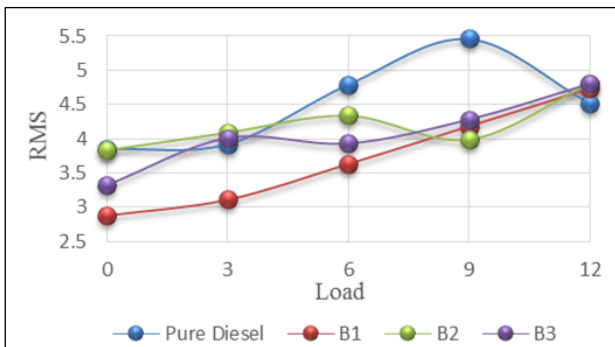


Fig. 7: Recorded RMS of acceleration signals from cylinder head in Y-direction

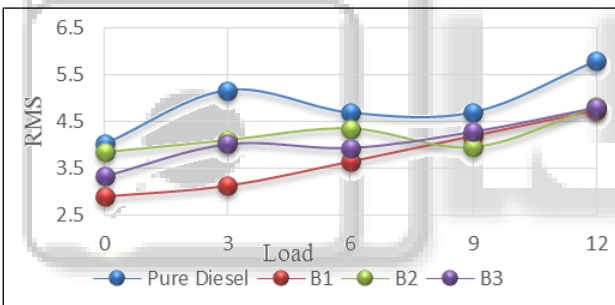


Fig. 8: Recorded RMS of acceleration signals from cylinder head in Z-direction

From the above graph it is found that there is 59.56% reduction in RMS value of vibration signals as compare with the diesel for blend B1 in X-direction. At load 0kg for y and z direction 25.19% and 39.72% reduction is observed in RMS value. RMS value increases with blend B2 and B3 but still lesser than no blend condition.

C. Effect of fish oil on Crest Factor

Crest factor is a ratio of peak amplitude and RMS value of vibration signal. As the value of crest factor increases degree of impacting increases [8]. Recorded amplitudes of vibration signals from cylinder head for each blend of diesel and fish-oil are as follows

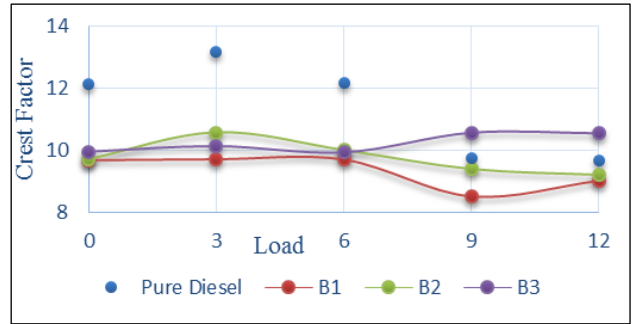


Fig. 9: Recorded Crest factor of acceleration signals from cylinder head in X-direction

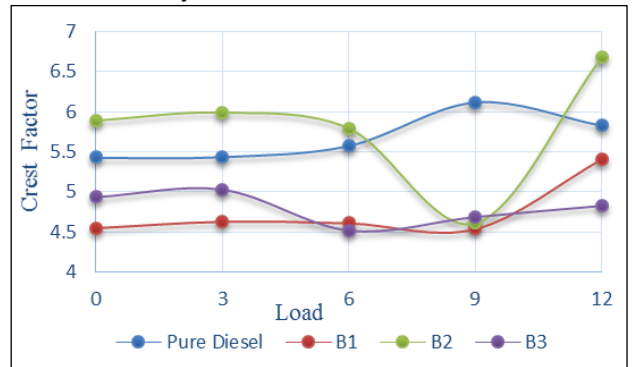


Fig. 10: Recorded Crest factor of acceleration signals from cylinder head in Y-direction

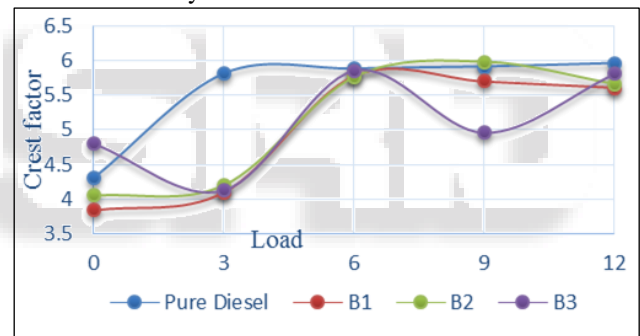


Fig. 11: Recorded Crest factor of acceleration signals from cylinder head in Z-direction

From the above graphs it is clear that the value of crest factor is more than 1.4144. It means that there is strong impacting of vibration signal. Maximum reduction in crest factor is for blend B1 in Z-direction at 3kg which is 29.43%. in X and Y direction it is 26.15% and 17.38% respectively for blend B1. As compare to blend B2 and B3, maximum reduction is for blend B1.

D. Effect of fish oil on kurtosis

Kurtosis is an indication of the degree of flatness or peakedness of a distribution. It is a ratio of fourth moment to the square of variance [7].

$$\text{Kurtosis} = \frac{\sum_{n=1}^N (X - \bar{X})^4}{N\sigma^4}$$

There are three types of distribution- leptokurtic, platykurtic and mesokurtic distribution. Normal distribution possesses kurtosis value equal to 3 and the one with more than 3 is called leptokurtic. Platykurtic has value less than 3 and mesokurtic possesses value equal to 3. Lesser the value of kurtosis smoothly the engine will run [8]. Recorded

amplitudes of vibration signals from cylinder head for each blend of diesel and fish oil are as follows

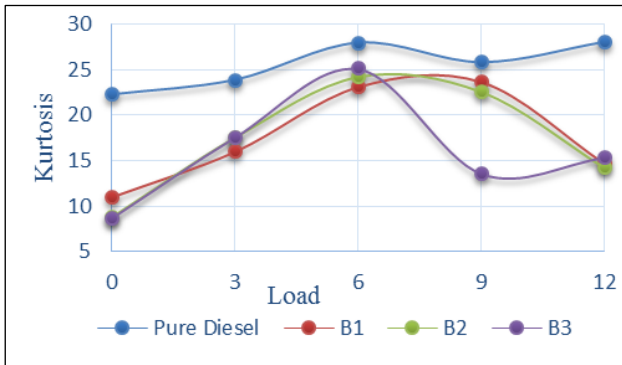


Fig. 12: Recorded Kurtosis of acceleration signals from cylinder head in X-direction

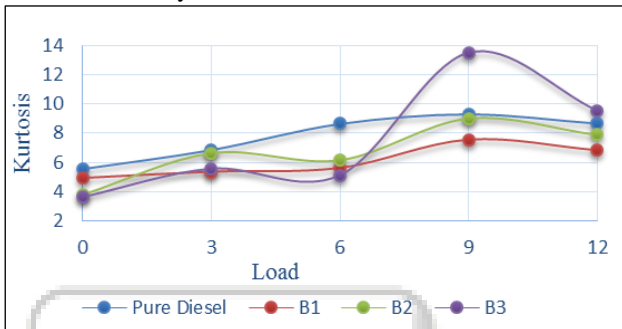


Fig. 13: Recorded Kurtosis of acceleration signals from cylinder head in Y-direction

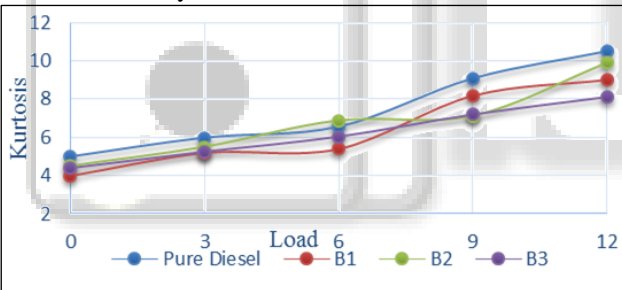


Fig. 14: Recorded Kurtosis of acceleration signals from cylinder head in Z-direction

From the graph it is clear that use of blends helps to reduce the pickiness of vibration signal distribution. 27.95% reduction in kurtosis value is recorded for blend B1 in X-direction at the load of 6kg. For blend B1 at 9kg load 7.55% and 9.09% reduction is seen in Y and Z direction respectively.

E. Effect of fish oil on FFT

To convert the time domain signal in frequency domain signal Fast Fourier Transform is used. The abnormal working of the system is recognized by sudden peak in the frequency spectrum than normal behavior. Recorded amplitudes of vibration signals from cylinder head for each blend of diesel and fish oil are as follows

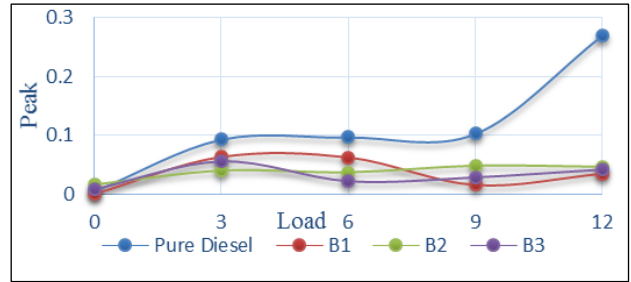


Fig. 15: Recorded amplitudes of vibration signals from cylinder head in X-direction

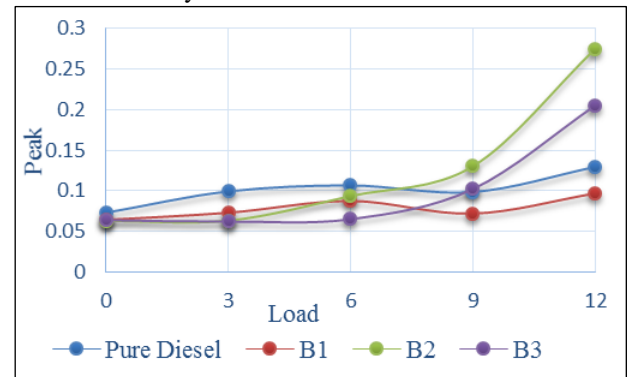


Fig. 16: Recorded amplitudes of vibration signals from cylinder head in Y-direction

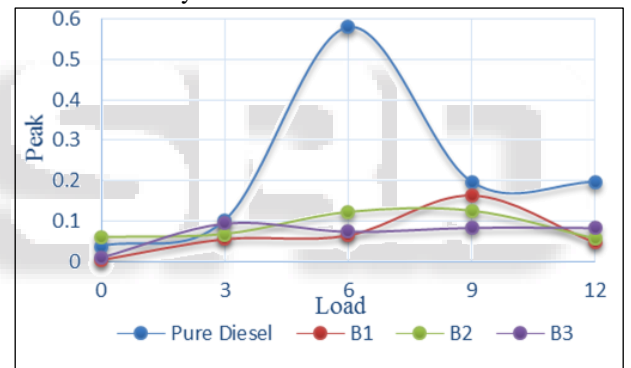


Fig. 17: Recorded amplitudes of vibration signals from cylinder head in Z-direction

From the above graphs it is clear that at blend B1 highest 72.44% drop in average amplitude is recorded in X-direction for no load condition. Blend B1 seems to be more effective in reducing the peak amplitude than blend B2 and B3.

IV. CONCLUSION

- Value of skewness of vibration signal distribution reduces with blends B1, B2 and B3 respectively. Maximum drop is 80.62% for blend B1 in X-direction at no load condition.
- 59.56% reduction in RMS value of vibration signal from cylinder head is recorded for blend B1.
- Kurtosis drops down by 27.95% for blend B1 which is maximum than B2 and B3.
- As compared to blend B2 and B3, blend B1 gives maximum reduction in crest factor which is 29.43% in Z-direction.

- 72.4% reduction in peak amplitude of vibration signal distribution from cylinder head with blend B1 is observed.
- Blend B1 (15% fish oil + 85% diesel) seems to be a good alternative fuel for diesel engine.

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