

Noise and Vibration Analysis of Diesel Engine Using Diesel and Jatropha Biodiesel

Mohammed Faizan Shaikh¹, Sudhakar Umale²

¹ M.E. Student, Mechanical Engineering

² Associate Professor in Mechanical Engineering
Sardar Patel College of Engineering
Mumbai-400058, Maharashtra, India.

Abstract— Biodiesel is an alternative fuel which can be used in place of diesel in diesel engines either in pure form or by blending it with diesel fuel. The most important advantage of the biodiesel is that, it is a renewable source of energy. In addition, it also has a tendency to reduce the pollution level which in turns reduces the global warming effect. The physical behaviour of a compression ignition engine plays very important role in case of an automobile. The paper involves, comparison of vibro-acoustic behaviour for diesel engine using conventional diesel, biodiesel and its blends at different load conditions. Single cylinder four stroke engine is used for the experimentation. Results of the investigation shows that, with increase in percentage of biodiesel blends, noise and vibration reduces comparably for most of the conditions. The detailed investigation is described in the subsequent literature and the results obtained are validated against previous literature study.

Keywords— Diesel, Biodiesel, Biodiesel Blends, C.I. Engine, Noise, Vibration.

I. INTRODUCTION

A. General

Today replacing the non-renewable energy resources by renewable once is not possible at 100% certainty. Indiscriminate extraction and lavish consumption of fossil fuels have led to a tremendous depletion in carbon fuel. The search for an alternative fuel, which promises a harmonious correlation with sustainable development, energy management, efficiency etc. are the major areas in which the running world and young bloods find its future [1]-[3]. For the developing countries of the world, fuels of bio-origin can provide a feasible solution to this crisis. The fuels of bio-origin may be alcohol, vegetable oils, bio mass, and biogas. Some of these fuels can be used directly while others need to be modified. Since the power used in the major agricultural, industrial and transportation sector is essentially based on diesel fuels, hence alternative is a must [4].

B. Need for Alternative Fuels

In the upcoming century, it is believed that the crude oil and petroleum products will become very scarce and costly. Day-to-day, fuel economy of engine is getting increased. However, enormous increase in number of vehicles has demanded a huge increase in fuel consumption. Tremendous use of gasoline and diesel today will lead to scarcity tomorrow and

will challenge cost in the upcoming age. Hence invention of alternate fossil fuel is the biggest challenge in the coming era [5]. Emission from diesel and gasoline engine causes greenhouse effect, which is another challenging task to be tackle, alternative and eco-friendly fuel may be the solution. Biodiesel is one of the best alternatives among other sources having high potential to reduce levels of emissions such as HC, CO and smoke when used in engines. Carbon dioxide, one of the greenhouse gases that causes global warming, has been reported to be reduced by using biodiesel in diesel engines. Presence of oxygen molecules within the biofuels such as alcohol, vegetable oils, biomass or biogas promotes better oxidation and combustion [6]. Considering financial analysis of fuels used, India is producing only 30% of the total petroleum fuels required and the remaining 70% is being imported at a cost of Rs. 80,000 crore every year. It is an astonishing fact that mixing of 5% biodiesel fuel to the present diesel fuel when made available in our country, can save about Rs. 4000 crore every year [7].

C. Biodiesel

Dr. Rudolph Diesel first developed the diesel engine in 1895 with the full intention of running it on a variety of fuels, including vegetable oil. He demonstrated his engine at the Paris Exhibition of 1900 using peanut oil as fuel. In 1911 he stated “The diesel engine can be fed with vegetable oils and would help considerably in the development of agriculture of the countries which use it”. Also in 1912, Diesel stated, “The use of vegetable oils for engine fuels may seem insignificant today. But such oils may become in course of time as important as petroleum and the coal tar products of the present time” [8].

Biodiesel is a fatty acid of ethyl or methyl ester made from virgin or used vegetable oils (both edible and non-edible) and animal fats. Biodiesel contains no petroleum, but it can be blended at any level with petroleum diesel to create a biodiesel blend or can be used in its pure form. Just like petroleum diesel, biodiesel operates in compression engine which essentially requires very little or no engine modification, because biodiesel has properties similar to petrodiesel [9]. Biodiesel is represented in terms of percentage, known as the BXX nomenclature. Where XX is the percentage volume of the biodiesel in the blend. For

example, B2, B5, B20 and B100 are fuels with a concentration of 2%, 5%, 20% and 100% biodiesel, respectively [10].

D. Jatropha Biodiesel

It is non-edible oil being singled out for large-scale plantation on wastelands. Jatropha plant can thrive under most hazardous and adverse conditions. It is a drought-resistant, perennial plant, living up to fifty years and is capable to grow on marginal soils. It requires very little irrigation, maintenances and grows in all types of soils (from coastline to hill slopes). The production of Jatropha seeds is about 0.8 kg per square meter per year. The oil content of Jatropha seed ranges from 30% to 40% by weight and the kernel itself ranges from 45% to 60%. Fresh Jatropha oil is slow-drying, odourless and colourless oil, but it turns yellow after aging. Jatropha oil cannot be used for nutritional purposes without detoxification, but is the most promising oil that can be used for energy generations etc. In Madagascar, Cape Verde and Benin, Jatropha oil was used as mineral diesel substitute during the Second World War [4].

II. MATERIALS AND METHODS

A. Test Engine Specification

In this study, single cylinder four stroke diesel engine is used for the experimentation, connected to an eddy current type of dynamometer in order to change the load conditions. Fig. 1 shows the experimental setup of engine used for testing. Technical specification of the engine is shown in TABLE I.

TABLE I
ENGINE SPECIFICATION

Make	Kirloskar
No of cylinder	1
No of stroke	4
Rated power	5.2kW@1500rpm
Cylinder diameter	87.5mm
Stroke length	110mm
Compression ratio	17.5:1



Fig. 1 Experimental Setup

B. Fuels used and its Properties

For this research work, Jatropha biodiesel is used. Experiment involves use of six types of fuel blends. These blends were B5, B10, B20, B50, pure biodiesel (B100) and pure petrodiesel (B00). Biodiesel used in the study was produced in “INDIAN BIO-DIESEL CORPORATION”, at BARAMATI. Biodiesel is produced by transesterification method using vegetable oil obtained from Jatropha seeds, based on ASTM D6751-9B standard. The blends were prepared by mixing biodiesel and diesel in required proportion on volume basis. The properties of diesel and biodiesel are listed in the TABLE II.

TABLE II
PROPERTIES OF FUELS

Property	Diesel (B00)	Biodiesel (B100)
Density(kg/mm ³)	832	872
Viscosity (Cst)	2.65	5.2
Cetane Number	49	50.7
Calorific Value (MJ/kg)	42.5	38.6
Flash Point (°C)	67	134
Fire Point (°C)	70	142
Cloud Point (°C)	-4	6
Pour Point (°C)	-9	1

C. Measuring Instruments

Instruments used for noise and vibration measurement are listed below;

Vibrations: FFT Analyser model PL-31(Make SKF, USA) (Sr. No 960902).

Noise: Sound Level Meter model 325(CENTER Make) (Sr. No. 040902526).

III. METHODOLOGY

This study was done with an objective of studying the noise and vibration behaviour of diesel engine using Jatropha biodiesel and conventional diesel fuel. For this, noise and vibrations are measured at different working loads. The working load conditions are 0kg, 5kg, 10kg and 15kg respectively. Also a comparative study of noise and vibration is performed at different loads. Vibrations were recorded in two directions i.e. on the cylinder block placed horizontally in perpendicular direction to engine cylinder axis as shown in Fig. 2 and Fig 3, and the noise were recorded using sound level meter at 1m distance away from the engine.



Fig. 2 R1 Direction



Fig. 3 R2 Direction

IV. RESULTS AND DISCUSSION

The signals of noise and vibration were measured for CI engine running with diesel and biodiesel blends at specified working conditions, data obtained from experiment were analysed and detail discussion was carried out.

Fig. 4 shows the amplitude of noise of an engine using diesel and biodiesel blends at different load conditions. It can be seen that as we increase the percentage of biodiesel in the biodiesel blend, noise level reduces up to 0.2 to 1.8dB. The noise level ranges from 87.6dB to 94.9 dB for diesel, and for biodiesel its range is 85.8dB to 94.7dB. For the same fuel, the amplitude of noise increase from 8% to 10% with increase in load from 0kg to 15kg. Maximum noise was recorded at 15kg load for diesel which is 94.9dB.

Fig. 5 and Fig. 6 show the result of amplitude of overall vibration in R1 and R2 direction at different load conditions respectively. The individual graphs of vibration for B20 blend against working load conditions are shown from fig. 7 to fig. 10. X-axis represents frequency of vibration in terms of Hz and the Y-axis shows the amplitude of vibration in mm/s. All the vibrations were recorded in terms of RMS velocity. At the given load condition, as we increase the percentage of biodiesel in the biodiesel blend, amplitude of vibration reduces up to 15% to 27% in R1 and R2 direction respectively. For a fuel, amplitude of vibration increases as the load on the engine increases. Amplitude of vibration in R2 direction is 39% to 74% less than as that of in R1 direction. The amplitude of vibration for R1 and R2 ranges from 11.21-17.89mm/s and 2.93-6.89mm/s respectively. The maximum vibration was recorded at 15kg load for B05 biodiesel, which is 17.89 in R2 direction.

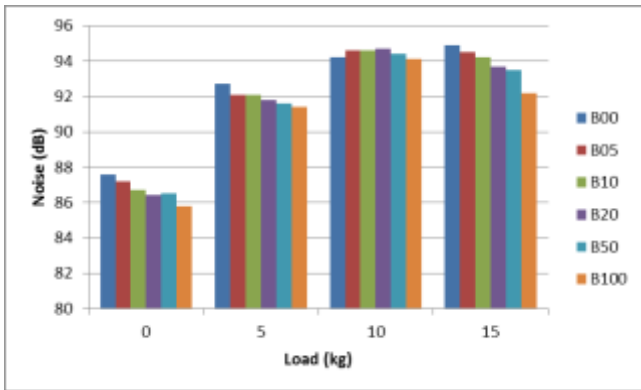


Fig. 4 Noise Level of Diesel and Biodiesel Blends

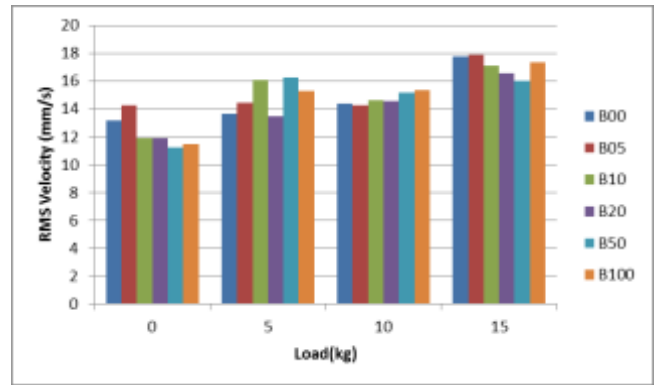


Fig. 5 Overall Vibration in R1 Direction

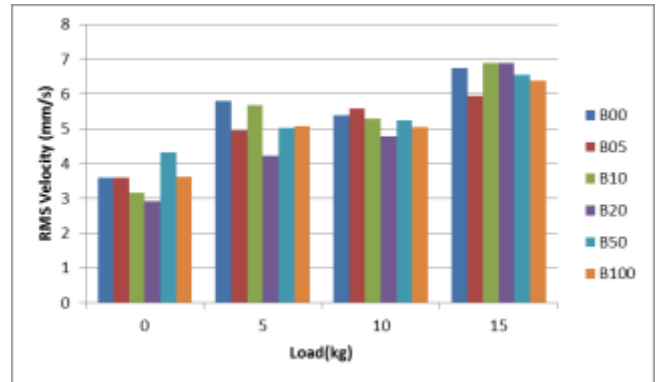


Fig. 6 Overall Vibration in R2 Direction

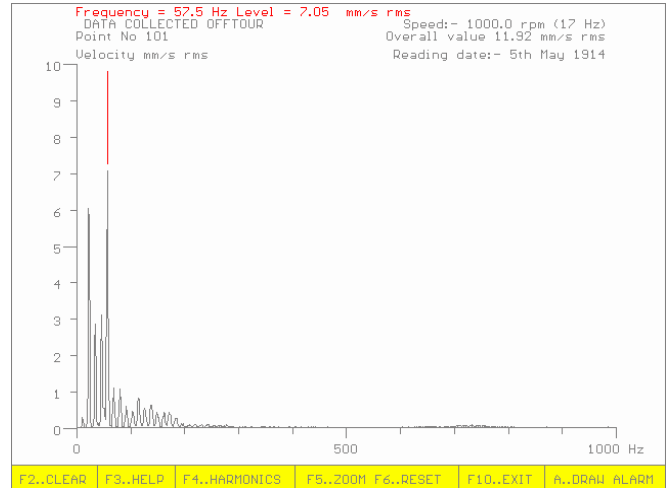


Fig. 7 Vibration at 0 kg load in R1 direction

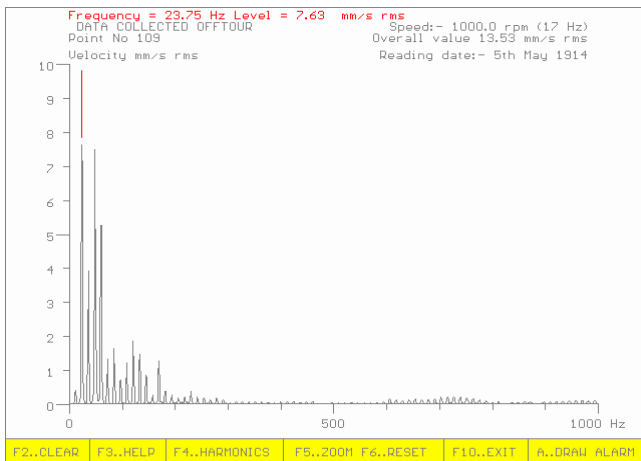


Fig. 8 Vibration at 5 kg load in R1 direction

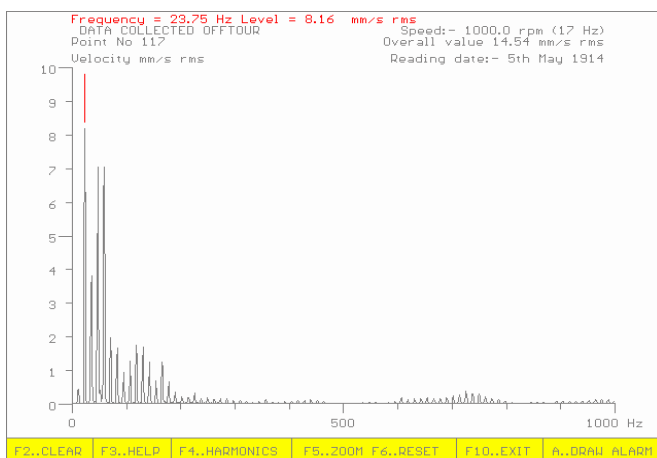


Fig. 9 Vibration at 10 kg load in R1 direction

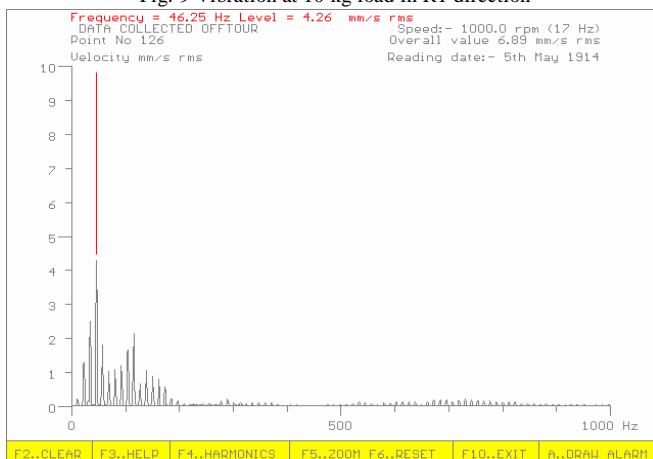


Fig. 10 Vibration at 15 kg load in R2 direction

V. CONCLUSIONS

From the experimental results, following conclusions are made;

- The maximum vibration reduction observed is 15% at 0kg load, and 27% for at 5kg load in R1 and R2 directions respectively.

- Vibration in R2 direction is 39% to 74% less as compared to in R1 direction.
- The vibration is less for Jatropha biodiesel than that of conventional diesel, this is because of more power development in the case of diesel fuel, since it has higher calorific value than biodiesel.
- 0.2 to 1.8dB noise reduction is observed as we increase the percentage of biodiesel in biodiesel blend. The maximum noise reduction recorded is 3% at 15kg load using pure biodiesel (B100).
- The amplitude of the noise signal increase by 8% to 10% with increase in engine load, due to higher engine vibration.
- Hence for biodiesel, reduction in noise and vibration is observed as compared to the conventional diesel fuel. This is due to the higher oxygen content in biodiesel, which provides sufficient oxygen for complete combustion. All these reasons make the biodiesel feasible to use as an alternative fuel.

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