ISSN (e): 2250 – 3005 || Volume, 07 || Issue, 04|| April – 2017 ||
International Journal of Computational Engineering Research (IJCER)

Investigation of Vibration on Suspension Systems at Different Load and Operating Conditions

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ABSTRACT
A suspension system is an important part of a two wheeler since it reduces the effects of travelling over rough ground, leading to improved ride quality, and increase in comfort due to substantially reduced amplitude of disturbances. Recently, vibration isolation and reduction techniques have become an integral part of machine design/vehicle design and hence the need for accurate measurement and analysis of mechanical vibration has grown. In this study vibration measurement has been carried out in two different suspension systems of two wheelers (nitrox & normal) using accelerometer with Fast Fourier Transforms (FFT) on DEWEsoft software. The amplitude vs time graph for the shock absorbers are measured and analyzed for the two different loads and three road conditions. The result shows that the nitrox suspension system is efficient and gives the best results.

Keywords: *Shock absorber, FFT Analyser, Nitrox suspension, Vibration, DEWEsoft*

I. INTRODUCTION

A vehicle is a machine usually with wheels and engines used for transporting people or cargo. A motorcycle (also called a motorbike, bike) is a two or three-wheeled motor vehicle. Vibration is the back and forth or repetitive motion of an object from its point of rest. The two wheeler riders are subjected to extreme vibrations due to the vibrations of its engine, improper structural design of the two wheeler and bad road conditions. These vibrations are most hazardous to the health and may cause the illness of the spine, musculoskeletal symptom in the lower back, the neck and upper limbs, if it exceeds the permissible limit. [1]

A suspension system or shock absorber is a mechanical device designed to smooth out or damp shock impulse, and dissipate kinetic energy. The shock absorbers duty is to absorb or dissipate energy[2]. When a vehicle is traveling on a level road and the wheels strike a bump, the spring is compressed quickly. The compressed spring will attempt to return to its normal loaded length will rebound past its normal height, causing the body to be lifted. The weight of the vehicle will then push the spring down below its normal loaded height. [3]

Vibration analysis is used to determine theoperating and mechanical condition of equipment. Vibration analysis can identify developing problems before they become too serious and cause unscheduled downtime [4].This can be achieved by conducting regular monitoring of machine vibrations either on continuous basis or at scheduled intervals. Regular vibration monitoring can detect deteriorating or defective bearings, mechanical looseness and worn or broken gears. Vibration analysis can also detect misalignment and unbalance before these conditions result in bearing or shaft deterioration [5].

Suspension is the system of tires, tire air, springs, shock absorbers and linkages that connects a vehicle to its wheels and allows relative motion between the two. Suspension system is classified as passive suspension system, semi-active suspension system, active suspension system and adjustable suspension system.Out of which, adjustable suspension system is used in this study because it is moreprominently used in all vehicles. In adjustable suspension systems, the air or oil compression is used for the springs of the vehicle. When pressure is varied, the vehicle body rises or lowers [6].

II. EXPERIMENTAL SETUP

The vibration sensor is placed above the suspension system and the experiment is carried out. Initially, the normal spring suspension is fitted to the vehicle and experiment is conducted for two loads (1417 N, 1652 N) under MUD, PLAIN and ROUGH road conditions.

Fig.1 Vibration measurement set-up

Then, the normal suspension system is changed with the nitrox suspension which consists of nitrous oxide gas canister attached to the hydraulic damping system. All the experiments are carried out using DEWEsoft software.

2.1 Working principle

The transducer converts the mechanical oscillation into an electrical property. For example, acceleration might cause change in the electrical resistance of the accelerometer. Hand transmitted and whole body vibration requires tri-axial assessments. Therefore, a multichannel meter capable of measuring at least three axes simultaneously can substantially reduce the time required to test.

Data-acquisition systems are usually computer based system. The stored waveform can then be analyzed using any compatible software. Signal conditioning converts the output from an accelerometer into a voltage that can be measured by a data acquisition and analysis system.

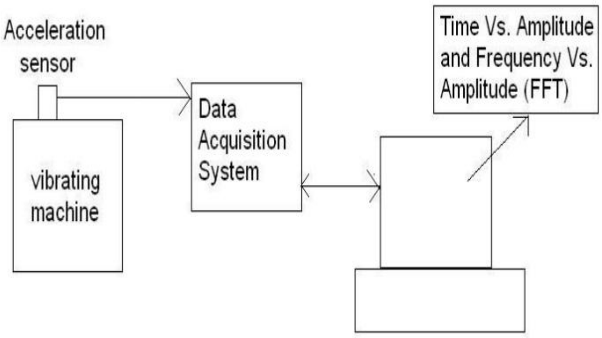


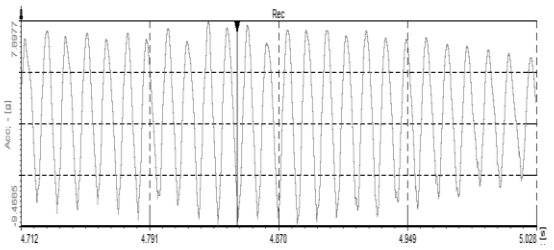
Fig.2 Block diagram of vibrational analysis in DEWEsoft software

The output of the signal conditioning must be compatible with the data-acquisition system. Once reliable and calibrated signals from the accelerometers have been acquired, they must be processed to generate numerical indicators suitable for the purpose of the assessment.

III. RESULT AND DICUSSION

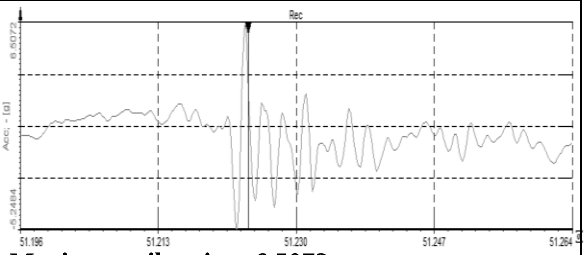
Experimentsare carried out in three road conditions (mud, plain, rough) with two load conditions(load 1=1417N, load 2=1652N) on two different suspension systems. The vibration changes and the maximum vibration of the suspension system which was measured using the vibration sensor under the driver seat are given below.

3.1 Vibration analysis for load 1417 N (Time vs Amplitude)



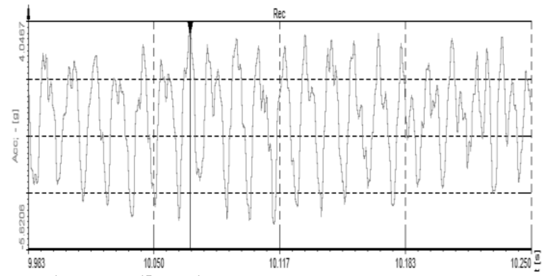
Maximum vibration: 7.8977 g

Fig. 3. Normal Suspension on Mud Road



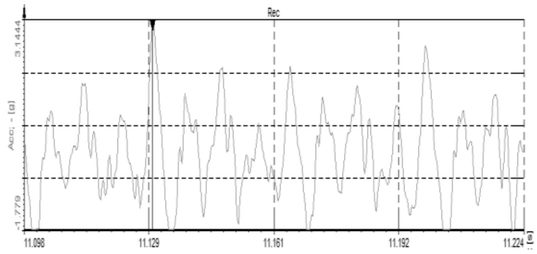
Maximum vibration: 6.5072g

Fig. 4. Nitrox Suspension on Mud Road



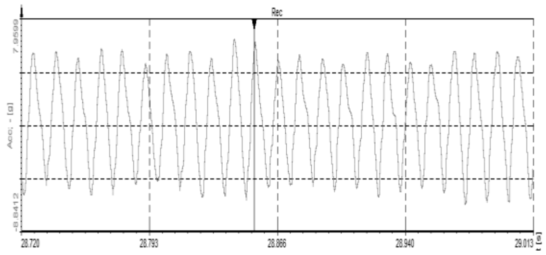
Maximum vibration: 4.0467 g

Fig. 5. Normal Suspension on Plain Road



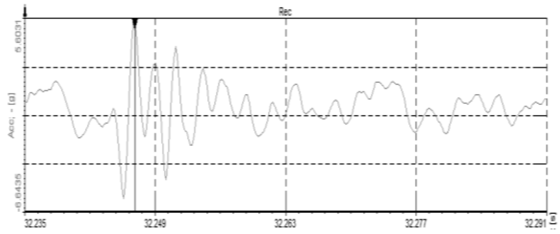
Maximum vibration: 3.1444g

Fig. 6. Nitrox Suspension on Plain Road



Maximum vibration: 7.9599 g

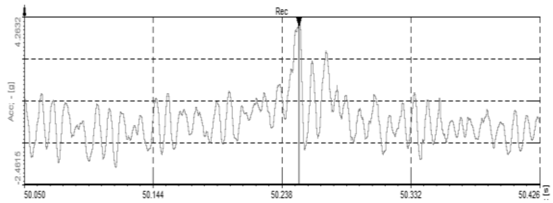
Fig. 7. Normal Suspension on Rough Road



Maximum vibration: 5.6031 g

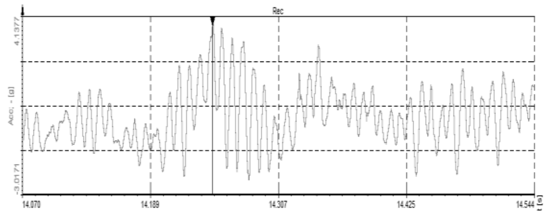
Fig. 8. Nitrox Suspension on Rough Road

3.2 Vibration analysis for load 1652 N (Time vs Amplitude)



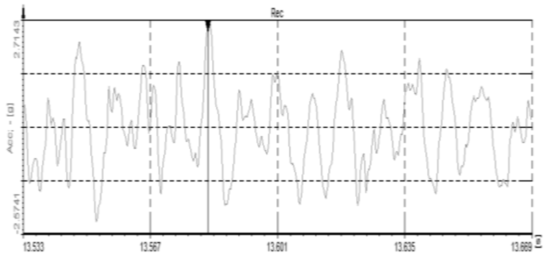
Maximum vibration: 4.2632 g

Fig. 9. Normal Suspension on Mud Road



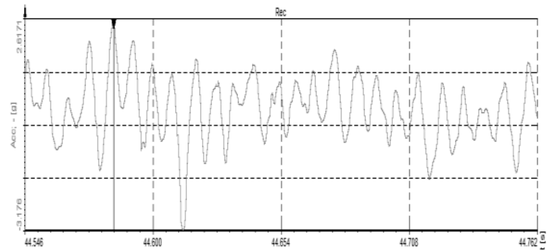
Maximum vibration: 4.1377 g

Fig. 10. Nitrox Suspension on Mud Road



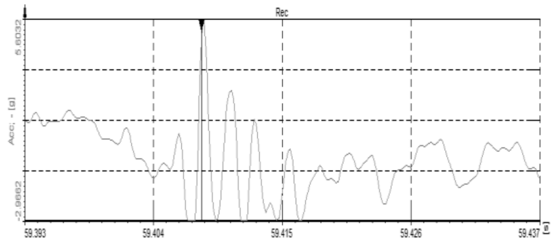
Maximum vibration: 2.7143 g

Fig. 11. Normal Suspension on Plain Road

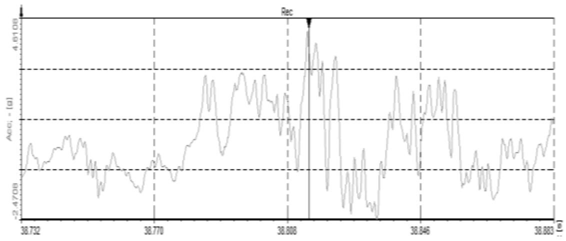


Maximum vibration: 2.6171 g

Fig. 12. Nitrox Suspension on Plain Road



Maximum vibration: 5.6032 g
Fig.13.Normal Suspension on Rough Road



Maximum vibration: 4.6108 g
Fig. 14.Nitrox Suspension on Rough Road

3.3 Observation of Vibrational Analysis

The maximum vibration values from the vibrational analysis using DEWEsoft Software for normal spring suspension (NORMAL) and nitrox suspension (NITROX) are listed in table 1.

Table.1 Observation of vibrations in normal and nitrox suspension

Sl. No.	LOAD	VIBRATION ON SUSPENSION SYSTEM (gravity)					
		MUD ROAD		PLAIN ROAD		ROUGH ROAD	
		NORMAL	NITROX	NORMAL	NITROX	NORMAL	NITROX
1.	1417N	7.8977	6.5072	4.0467	3.144	7.9599	5.6031
2.	1652N	4.2632	4.1377	2.7143	2.6171	5.6032	4.6108

From the observed values, the nitrox suspension has better comfort than normal suspension. This could be due to the presence of nitrox canister which reduces the bubble formation in the damper oil cylinder.

Table.2 Percentage differences between two suspension systems

Sl. No.	Road Condition	Decrease in vibration of NITROX compared with NORMAL (in %)	
		1417 N (Load 1)	**1652 N (**Load 2**)**
1	Mud	17.6%	9.99%
2	Plain	22.3%	9.34%
3	Rough	26.3%	13.20%

The difference in vibration between the suspension systems is higher at rough road conditions and it is lower for plain road conditions for nitrox suspension system (Table 2). Hence in all the road conditions usage of the nitrox suspension could be encouraged.

IV. CONCLUSION

Thus the vibration characteristics of the two wheeler suspension systems were found and the results are summarized as follows:

- At mud road conditions, vibration using the nitrox suspension system is decreased by 17.6% for 1417 N and 9.99% for 1652 N.
- At plain road conditions, vibration using the nitrox suspension system is decreased by 22% for 1417 N and 9.34% for 1652 N.
- Similarly, at rough road conditions, vibration using the nitrox suspension system is decreased by 26.3% for 1417 N and 13.20% for 1652 N.
- At different road conditions, when compared with normal suspension system the performance of nitrox suspension system is efficient, providing greater comfort to the rider at different conditions.

ACKNOWLEDGMENT

We would like to express our deep gratitude to our respected Secretary and Correspondent Dr. P. CHINNADURAI M.A., Ph.D., and our beloved Director Mr. C. SAKTHI KUMAR, M.E., for their enthusiastic motivation that inspired us in completing this project. We are highly indebted to our Principal Dr. K. Mani, M.E., Ph.D., for his kind words and continuous encouragement. Also, our sincere thanks to "Centre for Excellence & Research, Panimalar Engineering College" and "ATALON Product Center Private Limited", for providing the facilities.

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