International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2013): 4.438

A Review Paper on Vibration Analysis of DI Engine

Satish V. Dawange[1], V. L. Kadlag[2]

[1]PG Student, Mechanical Engineering Department, SVIT Chincholi, Nashik, India

[2]Associate Professor, Mechanical Engineering Department, SVIT Chincholi, Nashik., India

Abstract: ***As we see in our day-to-day life the engines with the less vibration & noise are developing. This can be done only if we measure vibration & try to reduce it. In this topic we will review how the vibration of engine will be affected by different parameters like fuel, acoustic pressure, mountings of engines, fuel injection system and gearbox.***

Keywords: vibration, engine, gearbox, noise, acoustic pressure, fuel injection

1. Introduction

The internal combustion (IC) engine is the concentrated mass in vehicle and if not properly designed it will cause vibrations and transfer to the supporting structures ride comfort, driving stability and drivability are important factors for the performance of a vehicle and are affected by the engine vibrations. Because of the environmental considerations, as well as changes in consumer preferences regarding vibration induced must be reduced. Vibration behavior of an IC engine depends on unbalanced reciprocating and rotating parts, cyclic variation in gas pressure, shaking forces due to the reciprocating parts and structural characteristics of the mounts. Engine vibrations are caused due to the reciprocating and rotating masses of the engine. The variations of inertial forces are due to the combustion and the compression differences of the piston cylinder arrangement during their operation. The engine inertial forces leads to the unbalanced forces of the engine and they are quiet varying with respect to speed, fuel supply and combustion characteristics of the fuel. To predict the vibration output of an engine and to minimize the possible durability and consumer perceived quality problems associated with engine vibration, a robust and accurate design and simulation model is needed. To reduce the engine vibration proper mounting must be provided as dampers at the interface of the engine and chassis. The vibrations caused at the engine are two types they are torsional and longitudinal vibrations. Engines always have some degree of torsional vibration during operation due to their reciprocating nature. The rotation of crankshaft of an engine increases the cylinder pressure as the piston approaches top dead centre (TDC) on the compression stroke. Ignition and combustion increases the pressure just after TDC and the pressure starts to decrease when the piston moves down to bottom dead centre (BDC). The pressure on the piston generates the tangential force that does useful work and increases the rotational speed of the crankshaft during this combustion stroke, whereas the compression stroke decreases the engine's angular velocity. The changing rotational speed results in the speed fluctuations of the crankshaft and the torsional vibrations at the crankshaft. The reciprocating and rotating components of engine have subjected to variation in inertial motion and the combustion pressure during the operation and the variation in the inertial motion of the parts during the upward motion and variation in the combustion pressure during the downward motion produce the unbalanced forces at the engine block and the unbalanced forces at the block are measured as longitudinal vibrations in the three orthogonal direction. Both the vibrations can be reduced by minimizing the unbalanced forces and by supporting the engine at proper mounts.

Engine produces the vibratory forces due to the unbalanced forces from the engine parts during the operation. The vibration caused by the engine at the supports is torsional vibration and the longitudinal vibration. The torsional vibration is caused at the crankshaft due to the fluctuating engine combustion pressures and engine loads. The longitudinal vibrations are caused at the block and the mounts by the reciprocating and rotating parts of the engine.

2. Literature Review

Lech Sitnik, Monika Magdziak–Toklowicz, RadoslawWróbel in 2011 [1] carried out tests on two spark-ignition engines: 1.4BZ 90CV CD and 1.4BZ120CV CD installed in new Fiat Bravo (model 198, version 54A) motor cars. The latter engine model (120CV) was equipped with a supercharging system. The research consisted in comparing engine vibrations measured in specific and representative points. In order to determine the vertical component vibrations, the measurements were performed via a mirror. A PSV-400 laser Doppler vibrometer made by Polytec was used to measure vibration velocities. The vibrometric system directly measures two quantities: displacement and velocity. In the investigated case, vibration velocity is the variable which supplies better diagnostic information. Vibrations were measured for the car standing on its wheels and for the car jacked up to reduce the influence of the car vibration damping systems on the measurement results. The latter are presented in the form of comparative diagrams. Moreover, the fast Fourier transform was used to determine the frequency distribution. It is shown that the way in which the engine is mounted affects the vibrations of the car. They found that the vibrations generated by the engine have a stationary character, the maximum vibration velocities are higher in case of the engine equipped with a supercharger. Exactly the opposite was found for the average velocities, it is very difficult to maintain crankshaft rotational speed forcing and in order to obtain reliable results several measurements need to be performed, particularly in case of the engine without a supercharger the engine mounting system is highly effective in dam

L. Barelli and et al, in 2009[2], has given the detail of vibration acoustic pressure non-intrusive measurement techniques for diesel engine. The aim of the paper is to develop diagnosis methodology internal combustion engines (ICE) quality, by evaluating microscopic working parameters measured with non invasive instruments. The diagnosis methodology is based on the craterisation of working conditions by means of acoustic and vibration measurements and relating the data to the pressure inside the cylinder.

S.Vulli, J.F.Dunne, and et al, in 2008[3] have identified sources of IC engine block vibrationusing Short Term Fourier Transform (STFT) from single point acceleration measurement taken with commercial knock sensor. A series of experimentation is discussed to create the data to isolate this different event on a 3 cylinder gasoline engine. The paper shows that a single time frequency analysis method applied to sensor data in the form of an appropriately tuned STFT, can effectively identify the occurrences of these events in the time domain if response are adequately separated and strong enough

Arthur Lee, in January 2007[4], has focused on the vibration of generator. The vibration of generator was measured and analyzed to determine the frequency and amplitude level of vibration that generator may experience during the operation and transport of portable generator. In a portable generator engine vibrates when running. This vibration is transferred to the generator's metal frame. To measure this vibration two accelerometers are mounted perpendicular to the engine shaft's rotation in the horizontal and vertical axis. Two different sized (5250 and 2250 watt) generator were tested. The transportation test showed small acceleration and displacement peaks compared to operating the generator

Joe Deery, in 2006[5] has given the methods to analyze the vibration data.Real-time spectrum analysis is used to predict and analyze mechanical faults and failures in rotating machinery to analyze vibratory motions of components, systems and structures; to analyze the noise constituents in these systems; and for many other purposes. Real-time spectrum Analyzer (RTA) development has a 50-year history that involves overcoming numerous technical barriers, challenging measurement techniques and physical obstacles. This article travels down memory lane from the earliest days in the development of these instruments at the Applied Research Laboratories of Columbia University to some of the latest product offerings. The many individuals that have contributed to this history and their accomplishments are chronicled.

Hannu Tienhara, in 2004,[6] has given the details of how vibration is created and measured for the engine. The pressure on engine manufacturers to improve vibration behaviour has increased, which has also driven the development and use of advanced vibration analysis and simulation methods. The challenge is to keep vibrations on an acceptable level while output power increases and structures become lighter. A piston engine is, by its nature, a vibrating machine. To keep vibrations under control it is essential to understand the basics and the main sources of engine vibrations.

Brian C. Howes, in 2001[7] has given the detail of gear box vibration. In this work A case study of a gearbox. Late last fall, routine monitoring of a gearbox showed an increase in overall vibration levels, which was not apparent in the spectra. If the gearbox failed during the winter, the process plant would not have been able to start up again until spring. Plant engineers called us in to determine whether the gearbox would run through the winter. The investigation uncovered problems with the way the routine monitoring was done. As well, vibration was present in the spectra that seemed to be unrelated to gear mesh frequency. Was there a problem or not?

Renard Klubnik, in 1998 [8]has given the details of how to measure the vibration parameters using accelerometers.There is a common misconception that measuring displacement using an accelerometer is not possible or can lead to erroneous information. In reality, accelerometers have long been used to measure displacement. However, it is important to understand that displacement measured with an accelerometer is not the same displacement measured with shaft riders or eddy current style vibration transducers. Eddy current probes are precisely thru-hole mounted into a mechanical casing and measure two very important shaft parameters. First, eddy current probes indicate the location of the shaft relative to the casing. This is very important in sleeve bearing applications because it tells the operator where the centreline of the shaft is relative to the casing. Second, eddy current displacement measurements indicate the amount of 1x rotational vibration. From this measurement, it can be determined if the shaft vibration is within acceptable limits. If an operator looks at the vibration spectral content measured with a displacement probe, it is possible to see higher order harmonics of the shaft. However, these levels are typically very small in amplitude due to the natural inclination of rotating machinery to dampen and attenuate vibration displacement levels at higher frequencies.

3. Observations Obtained From Reviewed Papers

The maximum vibration velocities are higher in case of the engine equipped with a supercharger. Exactly the opposite was found for the average velocities.

Table 1: Maximum and average vibration velocities in different states.

No.	Description	1,4BZ 90CV CD		1,4BZ 120CV CD	
		V_{max} [m/s]	V_{av} [m/s]	V_{max} [m/s]	V_{av} [m/s]
1.	Idle running engine without forcing, car not jacked up	15.5	0.017	17.2	0.017
2.	Idle running car with forced 2000 min.$^{-1}$, car not jacked up	26.6	-0.041	27.6	-0.017
3.	Idle running engine without forcing, car jacked up	19.6	0.011	12.9	-0.018
4.	Idle running engine with forced 2000 min.$^{-1}$, car jacked up	23.5	-0.024	28.3	-0.010

4. Concluding Remarks

In all above research papers discussed, vibration of engines, gear box and generator are measured. But, the direct correlation of DI engine vibration for three speed and four speed gear box is not available. Comparative analysis of Generator vibration is done for two different kinds of generator which formulated the platform for comparative analysis of engine vibration which is coupled with different gear boxes. Also the engine vibrations in above literatures are measured for different cylinder pressures, different fuel used and different injection systems. Future scope is available for measures of the engine vibration by using the same techniques which are followed by above researchers but, here the impact on vibration of engine because of changing the gearbox will be measured which is not done up till now. Only sensitive knowledge of vibration of engine was available. So, with in that work the comparative data of engine vibration with three speed and four speed gear box in terms frequency domain graphs obtained by Fast Fourier Transform (FFT) Analyzer will be available.

5. Objectives of the Reviews

To develop the comparative study of changing gear box on
1) Engine vibration
2) Fuel economy
3) Engine Temperature

References

[1] Lech Sitnik, Monika Magdziak et. Al. 'Comparative analysis of the vibration of different kind of engine mounted in the same new motor vehicle', Journal of KONESP power train & transport Vol.18,No.4 2011.
[2] L. Barelli , G. Bidini, C.Burati, R.Marioni in their paper entitled 'Diagnosis of internal combustion engine through vibration acoustic pressure non-instructive measurement'; Applied Engineering 29 (2009):1707-1713
[3] S.Vulli, J.F.Dunne, R.Potenza, D.richardson 'Time frequency analysis of single point engine block vibration measurement for multiple excitation-event identification', Journal of sound and vibration; Oct.2008:1129-1139
[4] Arthur Lee, Directorate of engineering science, 'Portable generator vibration measurement', January 2007: 5-19
[5] Joe Deery, AIM and C, Newfoundland, New Jersey 'The real history of real time spectrum Analyzer';2006:54-58
[6] Brian C. Howes entitled 'A Gearbox vibration –Fact OR Friction';2001:2-6
[7] John S. Mitchell, San Juan Capistrano, California, "From Vibration Measurements to Condition Based Maintenance";1999:2-9
[8] Renard Klubnik, Applications Engineer, Wilcoxon Research 'Measuring displacement using accelerometers';1998:2-5