International Journal of Engineering & Scientific Research
Vol.10 Issue 12, Dec 2022
ISSN: 2347-6532 Impact Factor: 6.660
Journal Homepage: http://www.ijmra.us, Email: editorijmie@gmail.com
Double-Blind Peer Reviewed Refereed Open Access International Journal - Included in the International Serial Directories Indexed & Listed at: Ulrich's Periodicals Directory ©, U.S.A., Open J-Gage as well as in Cabell's Directories of Publishing Opportunities, U.S.A

Review On Advanced Vibration Processing Techniques for Condition Monitoring in IC engines

Anirudhda Shinde

Abstract

This paper deals with the strategies and techniques based on vibro-acoustic signals that can monitor and diagnose faults in Internal Combustion Engines (ICEs) under both test bench and vehicle operating conditions. This technique can also be used to measure the amount of vibration produced in the IC engine during its working conditions. The vibrations themselves can then be used to measure the other faults in the engine. The ways to reduce the vibration signals are also elaborated. In recent years, several authors have summarized critical reviews mainly focused on general reciprocating machines. This paper focuses on specific signal processing techniques to deal with IC engine condition monitoring. Given the recent needs of the industry to

•optimize component durability and ensure long-life cycles,
•verify the engine's final status at the end of the assembly line,
•reduce the maintenance costs by monitoring the ICE life during vehicle operations;

A detailed review of Advanced VibrationProcessing Techniques is much needed.

Keywords:

Artificial neural networks;
Conditioning monitoring;
ContinuousWavelet Transform
Elastomer;
Isolators;
Order Analysis;

Author correspondence:

First Author,
Master of Science, Department of Physics
Savitribai Phule Pune University, Pune -India
Email: anirudhdashinde1@gmail.com

1. Introduction

A remarkable amount of vibrations and shocks is produced in IC engines. If not handled properly, these vibrations may be harmful and decrease the engine's efficiency. The vibration condition monitoring deals with the effective reuse of vibrations. Based on the nature of vibration phenomena, the possibilities of usage of vibration become very wide. The vibration measurement procedure allows constant registration without invasion into the construction of the mechanism. These are non-destructive methods. Due to all these advantages and the challenging environment of the engine in transport, the application of vibration methods for engine monitoring systems has become very popular. If not managed properly, the vibrations in the engine may lead to hazardous accidents and, in turn, engine failure. It also reduces the engine's efficiency and increases the cost, including maintenance and repair. Thus management of vibrations plays a vital role in the IC engine. This paper contains some of the ways or techniques for condition monitoring of vibrations produced in IC engines. In some cases, there is also a need to reduce these vibrations by using cheap methods. These easy methods are also suggested here.

FIG. 1 -MULTI CYLINDER WATER COOLED ENGINE

2. Advanced Vibration Processing Techniques

2.1 Fault detection from vibration analysis:

Misalignment, unbalance, looseness, resonance, and other inaccuracies cause mechanical vibrations. Vibration signal involves signature information about the cause of vibration, and through its analysis using different methods developing faults are detected. When a fault develops, the signature of the collected vibration signal changes. Simple instruments to multichannel analysers are used to measure the vibrations. Various algorithms and methods are also used for the relationship between factors having the effect of vibration and a vibration signal.

2.2 Order Analysis:

Many other techniques are used to diagnose rolling elements and bearing faults, e.g. artificial neural networks (ANNs), fuzzy logic systems etc. According to the non-stationary characteristics of vibration signatures of roller bearing faults, a fault diagnosis method based on empirical mode decomposition (EMD) energy entropy has been presented by Yang et al.
Order analysis is a technique for analysing environmental and vibration signals in revolving or reciprocating machinery. Some examples of rotating or reciprocating machinery include aircraft and automotive engines, compressors, turbines, and pumps. Such machinery typically has various mechanical parts such as a shaft, bearing, gearbox, blade, coupling, and belt.
Order analysis is a type of analysis explicitly geared towards analysing rotating or reciprocating machinery and how frequencies change as the rotational speed of the machine changes.

FIGURE 2. VIBRATION ACCELERATOR TYPE 4368 LOCATION

2.3 Continuous Wavelet Transform

Continuous wavelet transform has some properties that make it better than other time-frequency techniques in analyzing impulsive signals, like diesel engine vibration signals. These properties are higher resolution and better localization characteristics.

The experiment was performed on the diesel engine to analyze by CWT, and results were noted.

The analysis considered vibration data collected under four loads in operating conditions of 0 Nm, 20 Nm, 40 Nm, and 60 Nm. The engine was operated at a constant speed of 1000 rpm, and the exhaust valve clearance was changed from 0.4mm (Healthy condition) to 0.0 mm (Faulty condition). Then the engine operated under the same conditions at a speed of 1500 rpm.

From the (CWT) representation in fig2, it can be seen four peaks representing the combustion events of the engine cylinders in the firing frequency from left to right (1, 2, 4, and 3).

It shows that a significant part of the energy is located in the lower frequencies (below 5 kHz), and the peak of the CWT extends to around 35 kHz.

Fig. 3 represents CWT of the engine vibration signals for different loads and 1000rpm engine speed, the frequency with a crank angle at a healthy case and vibration amplitude in meters; as the load increases, vibration amplitude increases.

By changing the operation loads from 0 Nm to 20 Nm to 40 Nm to 60 Nm at two different speeds, 1000 rpm and 1500 rpm, with 0.4 clearance (healthy condition), the heights of the combustion peaks are proportional to the engine load and speed confirming that the engine vibration signals are load and speed dependent.

The main target of this study is to acquire accurate data from the engine test rig operating under normal and abnormal conditions and apply signal processing techniques for condition monitoring. To collect these signals, accelerometers (sensors) of various types are used. Only exhaust valve clearance faults were investigated. The results are shown below in fig 3.

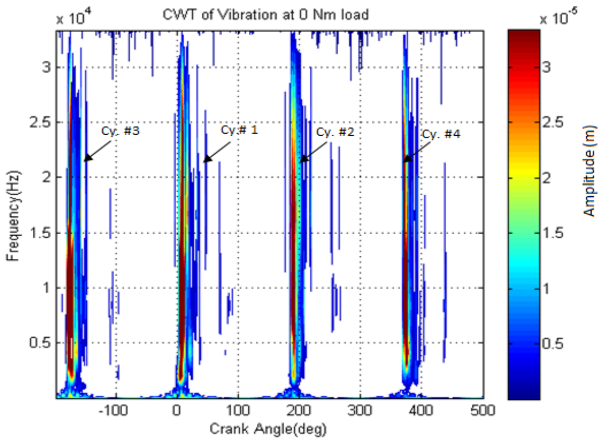

FIG 3- RELATION BETWEEN CRANK ANGLES, FREQUENCY, AMPLITUDE AND CWT OF VIBRATION

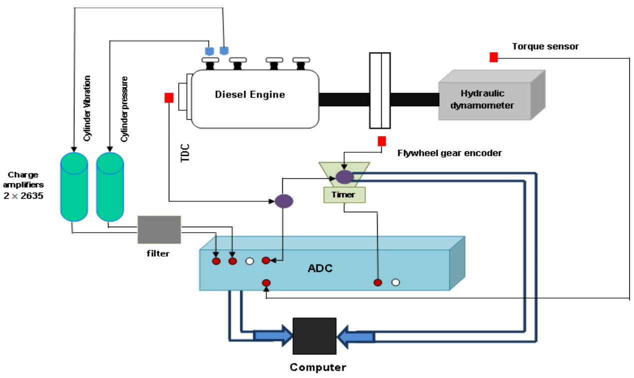

FIG.4 MONITORING SYSTEM AND WIRING DIAGRAM

3. Ways to Reduce Vibrations in IC Engine

Vibrations in an engine are never good, but they cannot be avoided. However, it can be reduced to a certain level. This can be done by analyzing three basic components-
o The equipment (any machine to be tested)
o The supporting member (floor, base plate, concrete foundation, etc.)
o The resilient member, like an isolator or mount (rubber pad, air column, spring, etc.), is placed between the equipment and the support structure.
If the equipment is the source of the vibration, the purpose of the isolator is to reduce the force transmitted from the equipment to the support structure. The direction of force transmission is from the equipment to the support structure. Vibration isolation is the process of separating an object, such as a piece of equipment, from the source of vibrations.
Active isolation: Active vibration isolation systems contain, along with the spring, a feedback circuit which consists of a sensor, a controller and an actuator.
Passive isolation: "Passive vibration isolation" refers to vibration isolation by passive techniques such as rubber pads or mechanical springs.
Common passive isolation systems:

A. Mechanical springs and spring dampers-
Helical coil springs are available in many different sizes and have load-carrying capabilities. These are heavy-duty isolators used for building systems and industry. Sometimes they serve as mounts for a concrete block, which provides further isolation.

B. Molded and bonded rubber and elastomeric isolators and mounts
These are often used as machinery mounts in vehicles. They absorb shock and reduce some vibration. Isolation mounts reduce energy transmission from one body to another by providing a resilient connection between them. Damping reduces vibration amplitude by converting a portion of the energy into low-grade heat. Anti-vibration Mounts (AVM) are the structures used to absorb the vibrations and dampen the harm-causing forces. Mount result in a system which is modelled as mass/spring/damper. AVM consists of the rubber or elastomeric sandwiched between the metal cover plates. The ability of an elastomer to convert the energy of motion allows it to absorb vibration. Anti-vibration mounts are designed to isolate undesirable vibration generated in engine, industrial, consumer and scientific equipment. An anti-vibration mount achieves these aims by balancing out the system frequency with the disturbing frequency. An anti-vibration mount can actually absorb over half of the energy produced by the vibration.

C. Tuned mass dampers-
Tuned mass dampers reduce the effects of harmonic vibration in buildings or other structures. A relatively small mass is attached in such a way that it can dampen out a very narrow band of vibration of the structure. The performance of an isolation system is determined by the transmissibility of the system, i.e. the ratio of the energy going into the system to the energy coming from the system.

D. Pads or sheets of flexible materials such as elastomers, rubber, cork, dense foam-
Elastomer pads and laminate materials are often used under heavy machinery, typical household and laminate materials items, vehicles, and even higher-performing audio systems.

4. Conclusion

The paper deals with the use of vibrations that are formed in the IC engine. The vibrations are processed, and signals are formed, which help diagnose or identify faults in the IC engine. The general methodology is that the reference vibration signals of known frequency, amplitude, wavelength and magnitude are imparted on the component, and due to faults, changed vibration signals are recorded.
The other way is - that engine body vibration signatures are rich in information about its operating parameters and physical condition and could be measured by attaching an accelerometer to the engine block. This helps to find faults in the engine- Continuous Wavelet transform method is widely used in industries to note the faults that are about to occur. This method also helps to plot the graphs and to study results graphically. This method gives accurate results as compared to any other method. It has recent advancements and is widely used for predictive maintenance.
From the above isolations methods, vibrations in the IC engine are controlled to some extent. This gives better performance of engines and increased life of all engine components due to reduced vibrations. The above suggestions are some easy methods used to reduce vibration and noise.

References

[1] Swapnil PralhadBarale, Dr. S. S. Gawade,
Internal Combustion Engine Vibrations and Vibration Isolation, International Journal of Scientific & Engineering Research, Volume 8, Issue 4, April-2017 ISSN 2229-5518

[2] 1ILHAN ASILTURK, 2HALIT ASLANCI, 3UGUR OZMEN, MACHINERY MONITORING USING VIBRATION SIGNAL ANALYSIS,Selçuk University, Faculty of Technology, Mechanical Engineering, Konya TURKEY, Feb-2017

[3] T. Ramachandran, K.P.Padmanaban, ―Review on internal combustion engine vibrations and mountings‖ International Journal of Engineering Sciences & Emerging Technologies, August 2012. Volume 3, Issue 1, Pages: 63-73

[4] Yousef Alhouli*, Abdullah Alkhaledi, AbdulazizAlzayedi, Mohsen Alardhi, Nawaf Alhaifi, "Continuous Wavelet Transform on Diesel Engine Vibration Condition Monitoring,"

[5] V.S.Chavan, R.Askhedkar, S.B.Sanap, ―Analysis Of Anti-Vibration Mounts For Vibration Isolation In Diesel Engine Generator Set‖, International Journal of Engineering Research and Applications (IJERA).Vol. 3, Issue 3, May-Jun 2013, pp.1423-1428.

[6] M. and M.A. Álvarez-López, Feature relevance estimation for vibration-based condition monitoring of an internal combustion engine, A *TecnoLógicas, vol. 39, no. 20, 2017*

[7] Dr.S.S.Gawade,―Experimental Analysis Of Single Cylinder Diesel Engine‖ International Journal of Engineering Research & Technology (IJERT) Vol. 2 Issue 7, July – 2013

[8] Łukasz Jedliński1, Jacek Caban2, Leszek Krzywonos3, Sławomir Wierzbicki4, František Brumerčík5- Application of vibration signal in the diagnosis of IC engine valve clearance, 1, 2, 3Faculty of Mechanical Engineering, Lublin University of Technology, Poland Faculty of Technical Sciences, University of Warmia and Mazuria in Olsztyn, Poland Faculty of Mechanical Engineering, University of Zilina, Slovakia

[9] Namdev A. Patil, Laukik P. Raut, ―Vibration Analysis of CI Engine Using FFT Analyzer‖ IJRET: International Journal of Research in Engineering and Technology.

[10] Google search