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ScienceDirect

Procedia Manufacturing 20 (2018) 434–439

Procedia MANUFACTURING

www.elsevier.com/locate/procedia

2nd International Conference on Materials Manufacturing and Design Engineering

Dynamics and Vibration Measurements in Engines

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Abstract

Vibrations lead to fatigue failure or damage which is harmful to engine supporting structures. The impact introduces large forces and thus large stresses, which can cause both vibrations and early failure of the mechanisms. Our objective in this work was to show the effectiveness of engine support and effect of looseness on the structural vibrations. To minimize the possible problems associated with engine vibration, a robust and accurate design of support is needed which includes bolted joints. To reduce the engine vibrations proper mounting must be provided. Sometimes dampers at the interface of the engine and foundation are required. The internal combustion engine is the concentrated mass and if not properly supported, it will cause vibrations and will be transferring to the supporting structures. Damping is difficult to model out, so our focus was on to the stiffness as a parameter for this research by direct measurement of vibration values near the resonance conditions. Results of this paper will enable the designer an easy way to adjust the stiffness parameter by tightening of bolts to the supports, which helps in reducing the overall vibration and noise level.

Peer-review under responsibility of the scientific committee of the 2nd International Conference on Materials Manufacturing and Design Engineering.

Keywords: *vibrations; engine support; stiffness; bolts*

1. Introduction

Noise and vibrations which generates in the interior of vehicle reduces the user's ride comfort .As the quality and competitiveness are the key features in today's automobile industry, it is necessary to measure, analyze and diagnose the root cause for the major source of noise and vibrations. It is found that engine is the main source of structural vibrations due to loosening of mounts. It also causes excessive wear and loosening of mountings. It is

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2351-9789
Peer-review under responsibility of the scientific committee of the 2nd International Conference on Materials Manufacturing and Design Engineering.
10.1016/j.promfg.2018.02.063

important to remember that stiffness is a difficult phenomenon to model in vibrating systems. Stiffness can be approximated by using direct experimentations. [1-6].

Mounting technology and in particular the bolted joints are widely used to control vibration and interior cabin noise levels, for which engine noise and vibration levels are key elements to measure .The vibrations caused at the engine are two types, torsional and longitudinal vibrations. The rotation of crankshaft of an engine increases the cylinder pressure as the piston approaches top dead center on the compression stroke. Ignition and combustion increases the pressure just after and the pressure starts to decrease when the piston moves down to bottom dead center [7-10].

Jump phenomenon, vibration control and natural frequencies of engine systems are all integrated. In an engine system, the follower is kept pressed against the cam surface by means of a retaining spring. Due to inertia of the follower, beyond a particular speed, during a part of cam rotation, the follower may loose contact with the cam, which is a type of vibration. This is a transient condition that occurs only with high speed engine. With jump, the cam and the follower separate owing to excessively unbalanced forces exceeding the spring force during the period of negative acceleration. It increases the unbalanced components of forces on engine mountings [11, 12].

2. Vibration Theory for Bolted Joints on Structure

Bolts are made from elastic materials such as steel. When a bolt is tightened, it is stretched like a spring. Bolted joints are also elastic in nature. As the bolt is tightened the joint is compressed and acts as a compressive spring. The stiffness of the joint is typically five times or more than that stiffness of the bolt. The effect of axial loading is to primarily reduce the compression in the joint rather than extending the bolt. This is why the bolts are tightened than left loose.

The vast majority of machine failures caused by vibration problems are fatigue failures. The time required to achieve fatigue failure is determined by how far an object is deflected (displacement) and the rate of deflection (frequency). Of course, displacement is simply a measure of the distance travelled and frequency is a measure of the number of times the "trip" is taken in a given period of time such as a minute or second. If it is known how far one must travel in a given period of time, it is a simple matter to calculate the speed or velocity required. Thus, a measure of vibration velocity is a direct measure of fatigue [13-15].

Hence, fatigue = displacement x frequency, velocity = displacement x frequency, thus, velocity = fatigue.

The fact that vibration velocity is a direct indicator of fatigue and vibration severity is clearly indicated by the general machinery vibration severity charts. The benefits and advantages of measuring vibration velocity instead of vibration displacement include:

- Vibration velocity is a direct indicator of fatigue since it takes into accounts both displacement and frequency.
- It is not necessary to know the frequency of vibration in order to evaluate the severity of vibration velocity since frequency is already a part of velocity.
- A measurement of overall vibration velocity is a valid indicator of the overall condition of a machine whether the vibration is simple (one frequency) or complex (more than one frequency).

3. Vibration Measurement on Diesel Engine Support Structure

The internal combustion (IC) engine is the concentrated mass in the vehicle and if not properly supported, 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, vibrations induced, must be reduced. Vibration behaviour 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 model is needed. To reduce the engine vibration proper mountings must be