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Dynamic stiffness and loss factor measurement of engine rubber mount by impact test

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ABSTRACT

Dynamic stiffness and loss factor for engine rubber mount are important dynamic behaviours to represent the performance of an engine mount system. The investigation of the dynamic behaviour of engine mount system using impact technique, particularly in the simultaneous measurement of the dynamic transfer stiffness and driving point stiffness where the impact hammer replaces the shaker as the source of excitation is presented in this paper. The results showed that the dynamic driving point stiffness can only be used to represent the dynamic transfer stiffness for the lower range of frequency. The curve fitted functions of the loss factor obtained from the dynamic driving point stiffness measurement showed linear dependency on the frequency and the loss factor obtained from the transfer stiffness measurement showed non-linear dependency on the frequency. Both of the stiffnesses are accurately reproduced by using these functions. The values of both dynamic stiffnesses obtained from impact technique are validated with the values obtained from shaker.

1. Introduction

Engine mounts are commonly used to provide vibration attenuation to isolate the vibration source. Accurate dynamic measurement is important to predict the dynamic behaviour of the engine rubber mount such as stiffness and damping. The existing damping measurement techniques are generally divided into resonance and non-resonance based methods. Theoretical studies and definitions exist for each measurement methods. Different location of the sensors will represent different measured parameters; i.e. input force and output force. Proper identification of these captured signals is important because they determine the dynamic parameters being measurement. The identification of each must matched the standard definition of the measurement method so that the correct mathematical model can be selected.

There have been several important work carried out in the past to improve the understanding and the measurement techniques of the dynamic behaviour of engine rubber mounts. The concept of complex stiffness with viscous and hysteresis damping was exquisitely explained by Neumark [1] for a single degree of freedom (SDOF) system where different cases for damping i.e. harmonic oscillations and decaying oscillations are re-examined and compared. The measurement of dynamic stiffness of an isolator by using shaker was presented by Gade et al. [2] by using resonant and non-resonant methods. The input force and acceleration are measured to obtain the dynamic stiffness of an isolator. The stiffness measurement at discrete frequencies using shaker was investigated to model the non-linear elastomeric vibration isolators [3]. The input force from the shaker and the deformation of specimen is used to generate hysteresis loops so that the stiffness of engine mount is obtained. Dynamic testing to account for non-linear effects of rubber compounds was conducted by Ramorino et al. [4] using shaker. The tested frequency range was set up to 1000 Hz. Dynamic modulus was studied instead of dynamic stiffness through the analysis of transmissibility of specimen. Nader and Ken [5] developed a high frequency testing machine for measuring rubber mount dynamic stiffness up to 5 kHz and the associated mathematical model. Foumani et al. [6] developed a technique to optimize the properties of the engine mount in order to minimize the steering wheel and chassis vibrations. Mundo et al. [7] had measured and modelled the dynamic stiffness of automotive rubber connections. Ladislav et al. [8] studied the rubber element for reduction of vibration from railway wheels by determining the stiffness and phase angle for different preload conditions and force amplitudes using wattmetric method and discrete Fourier transformation for increase reliability of the data. More recently, Kulik et al. [9] conducted experimental measurement of dynamic properties of viscoelastic materials with loaded inertial mass. Hofer and Lion [10] modelled the frequency and amplitude dependent properties of carbon black filled rubber. The dynamic properties are indentified by the storage modulus and loss modulus. A non-linear viscoelastic constitutive model of rubber was

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