

Research on Vibration Isolation of Semi-Active Controlled Hydraulic Engine Mount with Air Spring

Wei Yang and Wenku Shi
Jilin University

Chunxue Chen
Jianxin Zhao's Group

ABSTRACT

Aiming at the abnormal vibration of driver seat of a passenger car in idle condition, vibration acceleration of engine, frame and seat rail was tested to identify vibration sources. Order tracking and spectrogram analysis indicated that the second order self-excitation of engine was the main cause. To solve the problem, semi-active controlled hydraulic engine mount with air spring of which characteristics could shift between a high dynamic stiffness and a low one was applied. Then the structure and principle of the mount with variable characteristics was introduced and control mode was analyzed. Dynamic characteristics were obtained by bench test. With sample mount applied, vibration of seat rail was tested again in multiple vehicle and engine working conditions. Dates showed that abnormal vibration in idle condition was extremely reduced and the mount could also meet the requirement of engine to dynamic stiffness in driving conditions.

CITATION: Yang, W., Shi, W., and Chen, C., "Research on Vibration Isolation of Semi-Active Controlled Hydraulic Engine Mount with Air Spring," *SAE Int. J. Passeng. Cars - Mech. Syst.* 7(1):2014, doi:10.4271/2014-01-0008.

INTRODUCTION

Automotive engine is one of the most important exciting sources of vibration and noise. Reciprocating motion of piston-connecting rod and unbalanced rotational motion of cranktrain could cause multi-freedom vibration of power train. The vibration is transferred to frame through mount, even to driver seat and passenger seats, making ride comfort worse.

In driving conditions with various speed and engine start/shut conditions, rotational speed, output power and torque of engine vary greatly, causing various vibration frequency and amplitude of power train. In order to reduce and isolate vibration from engine to frame, demand for best dynamic characteristics of engine mount varies according to automotive working conditions. For passenger car, idle condition works for most frequency, so vibration of driver seat caused by engine working in idle speed is one of the most important evaluation indexes of automotive NVH performances.

In this paper, abnormal vibration on driver seat of a passenger car on idle condition reduced comfortableness. Significant vibration energy of engine caused by its second order excitation was discovered according to test data. To isolate the vibration, semi-controlled hydraulic mount with air spring of

which dynamic characteristics alternated between high damping/stiffness and low damping/stiffness was applied for power train fixing.

Hydraulic mount was developed based on rubber mount in the 1980's. Resistance caused by hydraulic liquid flowing rapidly crossing inertia track provides significant damping and stiffness. The hydraulic characteristics could overcome the limitations of flexible damping in low frequency and dynamic hardening in high frequency, and meet requirements for vibration reduction and isolation from engine to frame in a wider frequency band [1, 2, 3].

VIBRATION TEST AND ANALYSIS

Power train was fixed longitudinally on the passenger car by three mounts, shown in [figure 1](#). Left mount and right mount under engine were hydraulic mount, while rear mount under gearbox was rubber mount.

Vibration acceleration in multiple working conditions was tested by LMS data acquisition system, shown in [figure 2](#) and [3](#). Test point monitoring point covered engine and frame adjacent to each mount, shown in [figure 4, 5](#).

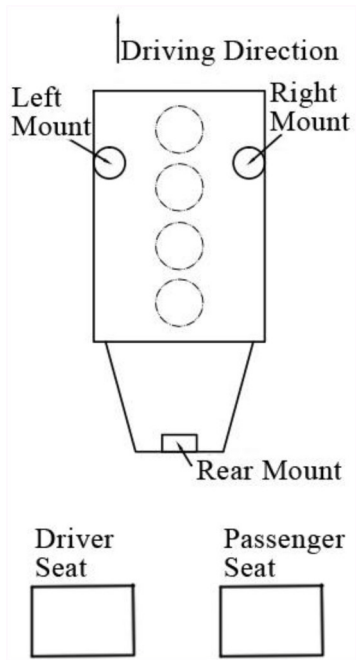


Figure 1. Disposal of mounts on power train



Figure 2. LMS Data acquisition equipment



Figure 3. Data test GUI



Figure 4. Sensors location on left mount

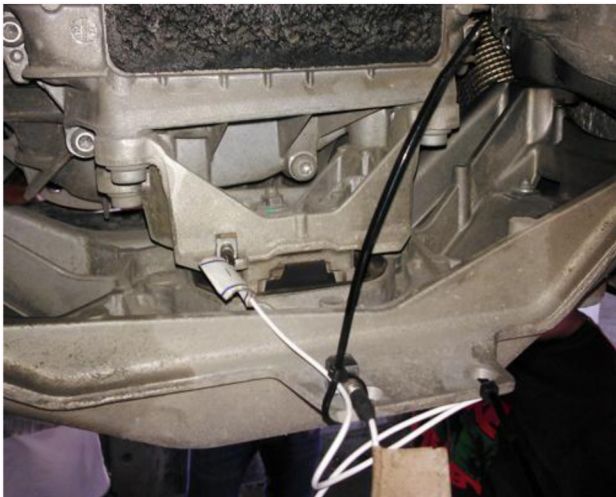


Figure 5. Sensors location on rear mount

With parking car and neutral gear, vertical vibration acceleration of test point adjacent to left mount on engine was test in rotational speed up condition (700-3300rpm). As shown in [figure 6](#), it could be inferred from the order tracking analysis that the second order excitation in frequency of 23.3Hz (corresponding engine speed of 700rpm, idle speed) got severe vibration energy. In addition, it could also be inferred from the spectrum analysis (shown in [figure 7](#)) that the peak vibration acceleration appeared in frequency of 23.3Hz, idle speed for engine. Thus when engine worked on idle condition, vibration on left side of engine would get worse and transferred through frame to driver seat, causing severe riding comfortableness. By contrast, from order tracking and spectrum of engine point adjacent to right mount (shown in [figure 8, 9](#)) it could inferred that vibration on engine of right side was not that severe when compared with that of left side. Right mount control was not sensitive for NVH performance improvement.