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Validation of automotive passive engine mount system

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ABSTRACT – Engine mount has been designed to improve the engine vibration by providing unwanted vibration isolation from engine to the driver. There are three types of engine mount systems which consist of passive, semi-active and active engine mount system. This study emphasizes on the validation of mathematical equation derived from Newton Second Law of Motion with real time experiment. The engine mount characteristic generated using a 3-degree of freedom (DOF) mathematical modelling simulated in Matlab Simulink software. Finally, the mathematical model was verified by using experimental approach. The result from the experiment and simulation shows that the model is enables to generate the similar response as in the experimental result.

1. INTRODUCTION

In automotive industry, noise, vibration and harshness (NVH) have become the critical issues concerned. Unwanted vibration generated from several sources that cause uncomfortable situation to the driver while manoeuvres the vehicle. These unwanted vibrations are caused by the road condition and the engine itself. The engine vibrations generated from the unbalance mass in the engine components. Engine mounts system was discovered to minimize the vibration transfer to the driver. There are three types of engine mounting system that had been discovered, namely passive, semi-active and active engine mount [1].

Rubber engine mount is a passive engine mounting where it usually affects by the single frequency. The passive system depends on the damping coefficient of the rubber materials used. However, rubber mount are still being used for passenger cars due to the simplicity of the design and low maintenance cost. On the other hand, Hydraulic Engine Mount (HEM) has become the main focus for bigger engine such as diesel engine vehicle. However, modern cars and trucks have become lighter from time to time whereas the performance of engine increases, thus the vibration produced is much higher [2].

In order to study the characteristic of the engine mount, the mathematical equation of frame structure system has been derived by using Newton Second Law of Motion. The frame structure proposed in this work is considered as a small-scaled intermediate structure which has the dominant elastic modes in the frequency range of 20 Hz. The method used was referred from previous researcher in his publication [3].The main contribution of this work is to validate the mathematical model to be used before developing the control structure of semi active engine mount. In order to achieve this, the appropriate experiment on the frame structure was designed and fabricated. The vibration characteristic is filtered after the experiment to eliminate the noise and other disturbance. The passive system is used to the frame structure and subjected to vibration source which is up to 15 Hz. After establishing the sensors on the right position, the body acceleration and force transmitted was formulated. The control response such as acceleration and transmitted force at each mount are presented.

2. METHODOLOGY

The model validation experiment is illustrated in Figure 1 contains two parts where it represents the engine and passenger compartment of passenger car while the steel frame structure represents the vehicle chassis. The electrical motor is fixed on the test rig generates the engine motion where it provides the vibration source. The frequency setting on the electrical motor will be alternately changed to generate the unbalance motion. There are two types of sensors embedded with the data acquisition device which is accelerometer and gyro sensor. Gyro sensor used to obtain the pitch and roll moment data while the accelerometer is used to collect the vertical acceleration data. The data acquisition device used in this experiment was LEGO Mindstorm EV-3. It converts the data from analog to digital data before restore in the computer.

3. RESULTS AND DISCUSSION

This section discusses the comparison between simulation data and experimental data results. Both comparison data uses 9 Hz frequency input and the physical parameter for simulation and experiment such as length, mass and height. From the data, the trend of simulation and experimental were tremendously in correlation between each other for vertical acceleration as depicted in Figure 2.

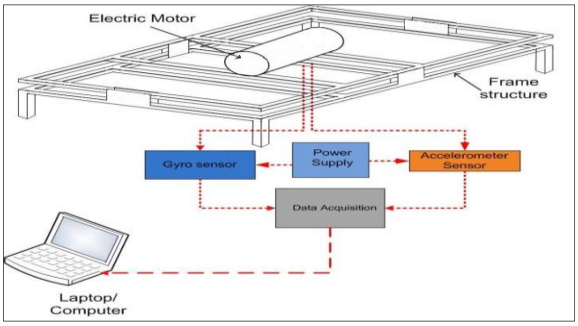

Figure 1 Experimental setup descriptions.

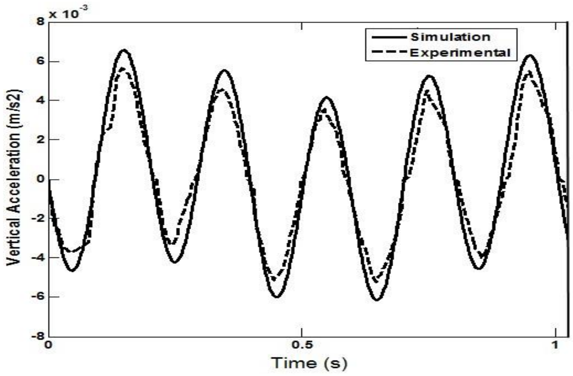

Figure 2 Comparison between the simulation results with the experiment results for the vertical acceleration with frequency input 9 Hz.

Meanwhile, Figure 3 shows the value of pitch moment acceleration for experiment is slightly higher compared to simulation results. Likewise, Figure 4 illustrates the value of roll moment acceleration for experiment is higher compared to simulation result. It is because the effect of mass and length of the frame structure. When the length of frame structure increases, the moment inertia of the structure also increases. Thus the pitch moment acceleration value also increases.

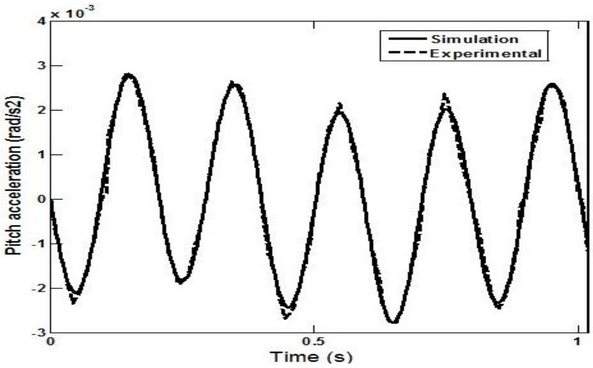

Figure 3 Comparison between the simulation results with the experimental results for the pitch moment acceleration with frequency input 9 Hz.

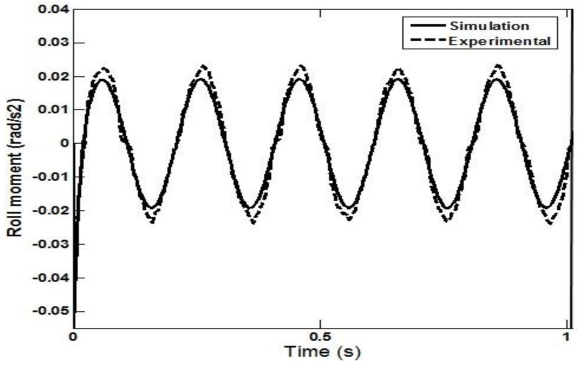

Figure 4 Comparison between the simulation results with the experimental results for the roll moment acceleration with frequency input 9 Hz.

4. CONCLUSION

As summary, the three engine mounts located on the designed test rig are able to represent the passenger vehicle engine's compartment. The engine was represented by the Direct Current (DC) motor while the chassis of the vehicle represent by the structural steel frame. The simulink model created from 3-DOF mathematical equation had been performed by using Newton Second Law of motion. The actual values of the engine mount such as damping (Cs) and the stiffness (Ks) have been used in the Simulink model. The 3-DOF passive engine mount was validated by experimental using a passive engine mount test rig and it shows that similarity trend in vertical acceleration, pitch moment acceleration and roll moment acceleration.

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