STUDY ON CHASSIS VIBRATION INDUCE BY POWER TRAIN AND ENGINE OPERATION

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'Saya akui bahawa telah membaca karya ini dan pada pandangan saya karya ini telah memadai dari segi skop dan kualiti untuk tujuan penganugerahan Ijazah Sarjana Muda Kejuruteraan Mekanikal (Automotif)'

Tandatangan :.......................................

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Tarikh :13/05/2008

DECLARATION

I declared this report is my own writing except the paragraph that was declared the original source

Signature:…………………………..

Writer's Name:…………………………….

Date:……………………….

DEDICATION

Thank you for all Faculty of Mechanical Engineering staff including Dr. Khisbullah Hudha, En. Syakir, En Nasir, Cik Hidayah and all those involved direct or indirectly to this project.

ABSTRAK

Projek tahun akhir yang sedang dilakukan oleh saya adalah bertajuk " Study On Chassis Vibration Due To Power train and Engine Operation" ataupun di dalam Bahasa Melayu "Mengkaji Getaran Ke Atas Cesi Disebabkan Oleh Sistem Penghantaran Kuasa dan Operasi Enjin".

Kajian ini melibatkan eksperimen dan simulasi yang menggunakan komputer dan perisian komputer Matlab bagi mengkaji getaran yang dihasilkan oleh enjin dan kotak gear dalam operasi biasa dan membandingkan data yang diperolehi dari simulasi dan eksperimen.

Dalam menjalankan eksperimen, kajian menyeluruh telah dilakukan ke atas sistem gantungan enjin yang berfungsi menetapkan kedudukan enjin di atas cesi kenderaan. Dalam eksperimen ini, kerata Proton Gen. 2 telah digunakan sebagai subjek kajian. Terdapat 4 'mount' yang digunakan untuk menetapkan kedudukan enjin di atas cesi Proton Gen. 2. Bagi setiap 'mouting' 1 sensor akan diletakkan di atas cesi dan 1 sensor akan diletakkan pada unit enjin dan kotak gear. Jumlah keseluruhan sensor yang akan digunakan ialah 8.

Bagi tujuan simulasi, sistem gantungan enjin akan dimodelkan di dalam Matlab di dalam bentuk formula Matematik. Data akan dimasukkan dan hasil eksperimen direkodkan.

Data dari eksperimen dan simulasi akan dibandingkan. Kajian lanjut akan dilakukan sekiranya terdapat perbezaan yang ketara dalam nilai frekuensi. Hasil kajian ini akan digunakan sebagai data rujukan bagi menjalankan kajian bagi menggantikan sistem 'mounting' yang pasif kepada sistem 'mounting' aktif yang akan mengaplikasikan cecair hiraulik yang telah dimagnetkan dan aktuator.

ABSTRACT

My final year project entitled "Study on Chassis Vibration Induce by Power train and Engine Operation". This research including experiment and simulation by using computer software MATLAB 6.5 to study and find the vibration amplitude generate by engine and gear box unit under nominal condition. The vibration amplitude value gather from experiment activity will be compare with simulation generated by MATLAB 6.5 software.

For experiment purposed, full research will be done on the engine and gear box mounting system and Proton Gen.2 was selected to be the experiment subject. There were 4 point where attaching engine and gear box unit to the Proton Gen. 2. So, during the experiment held, 4 accelerometer sensors will be placed on the engine and gear box unit and another 4 unit of accelerometer sensor will be place on the Proton Gen. 2 chassis. In other words, 2 units of sensor will be placed for every mounting point.

For simulation purposed, Proton Gen. 2 suspension system and engine with gearbox unit will be review as a mathematical model. This mathematic model will be simulating in the MATLAB 6.5 software as full engine mounting system model.

Both data will be compared to understand the behavior of the engine and gear box unit including the advantages, disadvantages and limitation of the passive engine and gear box mounting unit.

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LIST OF SYMBOL

$-K$ = spring stiffness, N/m

$-C$ = damping coefficient, Nm/s

$P(t)$ = induction force, N

CHAPTER I

1.1 INTRODUCTION

This paper is focused on the finding the actual value of the engine mounting stiffness K_S and damping constant C_D of the Proto n Gen. 2. In this case Proton Gen. 2 is using in-line four cylinders engine coupled with 4 speeds automatic transmission engine.

For the analysis purposes, mathematical equation was developed which accurately describe the motion of the engine on selected condition, starting from idle condition, 1500 RPM condition and up until 4000 RPM condition. Mathematical equation is crucial for developing the model in MATLAB 6.5 computer programming. Mathematical model for engine mounting system is based on the full car model equation which describes the pitch, roll, and vertical acceleration of the engine on the chassis.

In experiment methods that have been done, accelerometer (KISTLER) with sensitivity 197 mV/g is used to collect vibration characteristic on certain condition. All the data collected with accelerometer is in analog signal, then this signal will be change to digital signal using Data Acquisition System (Smart Box) and later all output from Smart Box is become as input to the laptop or computer. All data was change to the digital format using Famos software to excel format.

1.2 OBJECTIVE OF STUDY

Main objective of this research is to gather vibration amplitude value by experiment and simulation in computer software, MATLAB 6.5. This vibration generates by engine and gearbox unit will be transfer to the Proton Gen. 2 chassis via engine and gearbox mounting system.

The goal of the research is to:

a. find rate of spring stiffness, K_S and damping constant C_D of Proton Gen. 2 by comparing data acquire from experiment and simulation.
b. find literature review of vibration from engine and gearbox unit to the vehicle chassis

1.3 PROBLEM STATEMENT

For over 100 years, comfort in road vehicles has been linked to the introduction of passive components that isolate passenger compartments from mechanical vibration. Near-optimal performance has been achieved by years of experimentation and testing, careful selection and shaping of individual component characteristics, and the development of ingenious mechanisms intended to minimize the effect of inherent design constraints associated with passive systems.

Lighter vehicles are typically more susceptible to noise and vibrations. Furthermore, as vehicle age, their vibration and noise level increase. Today, noise and vibration control have become a prime consideration in the general manufacturing industry, and more specifically the automotive industries. Increased attention to product quality has brought the issue of “psycho-acoustics” to the transportation industry. Thus within recent years, there has been a major increase of effort in the design of noise and vibration characteristics of vehicles that would better appeal to the occupants.

Usually passive mounting system made of rubber material that has been constrained to certain parameters. As an example, in order to limit the movement of the engine and gearbox unit, mounting system desired to have very stiff rubber. However to minimize transmission of engine and gearbox vibration into passenger compartment, a very soft mount is required. Both specifications contradict to each other making only one of the characteristic needs to be sacrifice.

These contradictory requirements have made engine mount manufacturers to design passive vibration absorbers that provide an optimal compromise. In case of mounting engine absorbers this compromise results in a very narrow-band of frequency. This frequency band may be selected in relation to the engine idle speed. However if the engine and or road excitations are at different frequencies than the design speed, or are broad-band, then typical passive vibration controllers would not be effective. This is a major shortcoming of the passive vibration control technique.

Current practice for reducing noise levels is to use such passive sound absorbing materials as fiber linings, acoustic foams and rubber material. Such a thick sound treatment may not provide more than 5dB noise reduction. Therefore, such passive noise treatments at low frequencies are physically unrealizable.

Too much exposure of human body to the source of vibration would lead to the vibration symptom diseases and human health would corrode. Drivers of vehicles such as automobiles, trucks, buses, tractors, taxis and locomotives, helicopter pilots and drivers of heavy construction vehicles are always in contact with the seat, the steering wheel and pedals.

1.4 SCOPE

For this research, it will be focused to study how vibration originated from engine and gearbox unit will be transmit to the vehicle chassis. As we noticed, the only physical connection between engine and gearbox unit to vehicle chassis is mounting system. Common practice in the automotive industry is to apply passive mounting system due to the low cost. Basic design of passive mounting system will be study to investigate the weakness of this unit.

The behavior of the passive engine mounting will be study by experimental method. Vibration sensor unit called accelerometer will be placed in a couple. One unit of sensor will be place on the engine and another one will be place on the chassis. Both of the sensors will be place near to the engine mounting point, labeled as point A, B, C, and D. Total of 8 unit of sensor will be place according to the specific point.

Specific mathematical model will be design exactly to the real vehicle model. It will consist of mathematical model of vehicle suspension unit and engine and gearbox mounting system. This mathematical derived from free body diagram of chassis, engine with gearbox unit and engine mounting system. Later, this mathematical equation will be simulated in computer software, MATLAB 6.5.

CHAPTER II

BACKGROUND

2.0 LITERATURE REVIEW

In automotive system, three dominant source of vibration is drive train, tire and wind. The engine produces broad band vibration resulting from combustion processes. The engine driven accessories and the transmission generate vibration as a result of their unbalances. The tires and suspension generate vibration as a result of tire tread interaction with the road surface. Wind noise results from viscous shearing in the boundary layer of air surrounding the vehicle. However, this research is more focused on chassis vibration induce by engine and power transmission component especially vibration that causes from unbalanced rotating mass.

Previous research held by other party including researcher from School of Automotive Engineering, University of Ulsan, Tokyo Institute of Technology, and Massachusetts Institute of Technology (MIT) are more focused on the designing new engine mounting system controlled by hydraulic and actuator. Some of them are focused on the automotive noise and vibration for the whole of the vehicle and not specifically on the engine mounting.

In research conducted by Kyong Kwan Ahn from School of Automotive Engineering, University of Ulsan, he and his team conducted a research on isolation of vibration related engine by hydraulic engine mount with controllable area of inertia track.

Itsuro Kajiwara and Akio Nagamatsu from Tokyo institute of Technology, Japan investigated the active and adaptive control of engine mounting as a way to overcoming the weakness of passive engine mounting. Their research covered mathematic formulation of active engine mounting and engine mount control design.

Lisa A. Sievers and Andreas H. Flotow from Department of Aeronautics and Astronautics study on active control of engine mount to enhance the quality of passenger compartment in the term of comfort. They also proposed three control schemes for actively controlling engine mounts.

For my research, it is more focused on the behavior of the passive engine mounting system under the specific condition. As example, there will be an experiment held to determine the vibration produce by engine and power transmission unit at idle speed and high speed. Accelerometer will be place at the engine and power transmission unit and at the chassis. These sensors detect the amplitude of vibration produce by engine and power transmission unit and the amplitude of vibration transmitted to the chassis of Proton Gen. 2 via passive mounting system.

Full car model in mathematical formulation with the formulation of the engine and power transmission mounting system have been developed by using computer software simulation, Matlab. The final goal of this research is to find the right value of spring stiffness K and damping constant D used by engine mounting system of Proton Gen. 2. Data obtained by this research will hand over to the researcher who interested to further the research in the active control of engine mounting system.

For this research, the main function of the engine and gearbox mounting system has been investigated thoroughly. The basic design, the main function of this mounting is to:

a. to attached engine and gearbox unit to the vehicle chassis
b. to absorb engine noise and vibration
c. to prevent vibration from reaching radiator, electronic control and any vital parts
d. isolating engine and transmission from the chassis

Engine mounts must be stiff enough to hold the engine and gearbox, and at the same time soft to absorb vibration. Also engine mounts must be flexible to permit frame to twist.

In practice, most of the manufacturer usually attached the engine and gearbox to the chassis according to the specific needs. Which axle would drive the vehicle will determine the layout of the engine and gearbox unit in the engine bay. If rear axle was selected to drive the vehicle, engine and gearbox unit will be arranged in longitudinal arrangement. But if front axle was selected, engine and gearbox unit will be arranged in transverse arrangement.

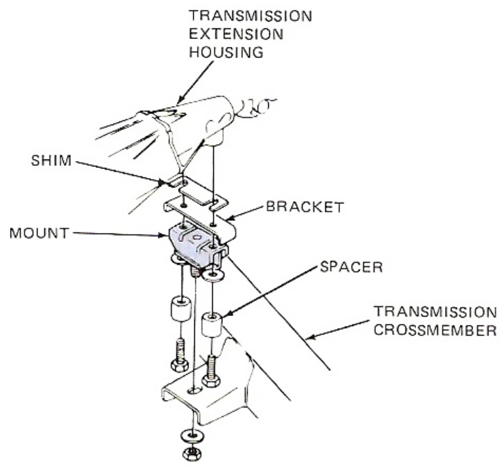


Figure 1. Gearbox mounting in longitudinal arrangement

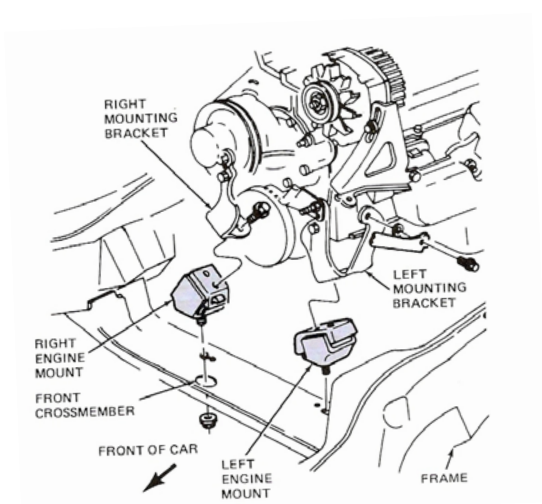


Figure 2. Engine mounting in longitudinal arrangement

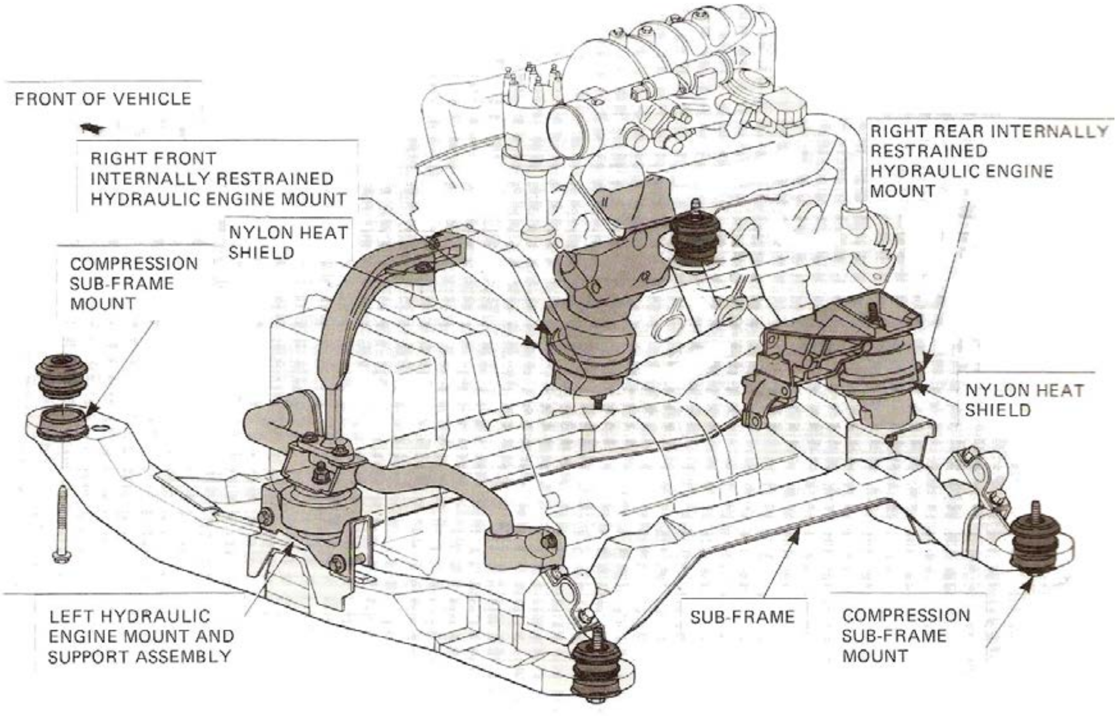
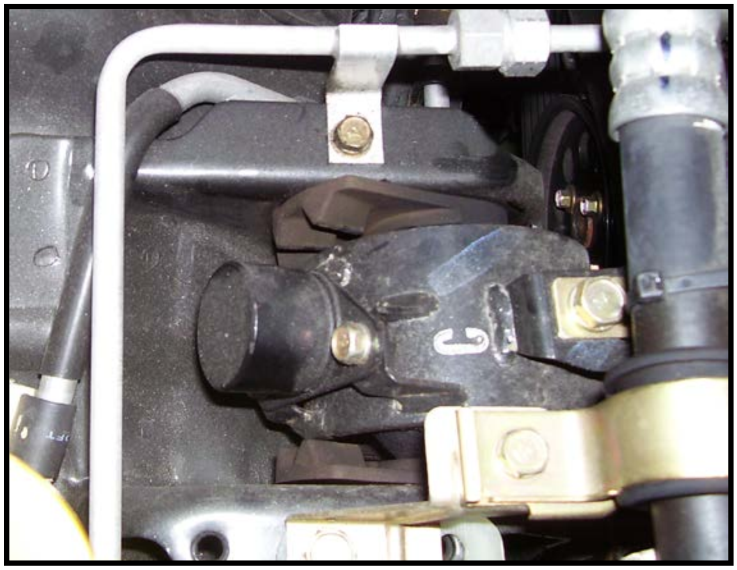


Figure 3. Engine mounting in transverse arrangement



Picture 1. Engine mounting at the left side of engine block

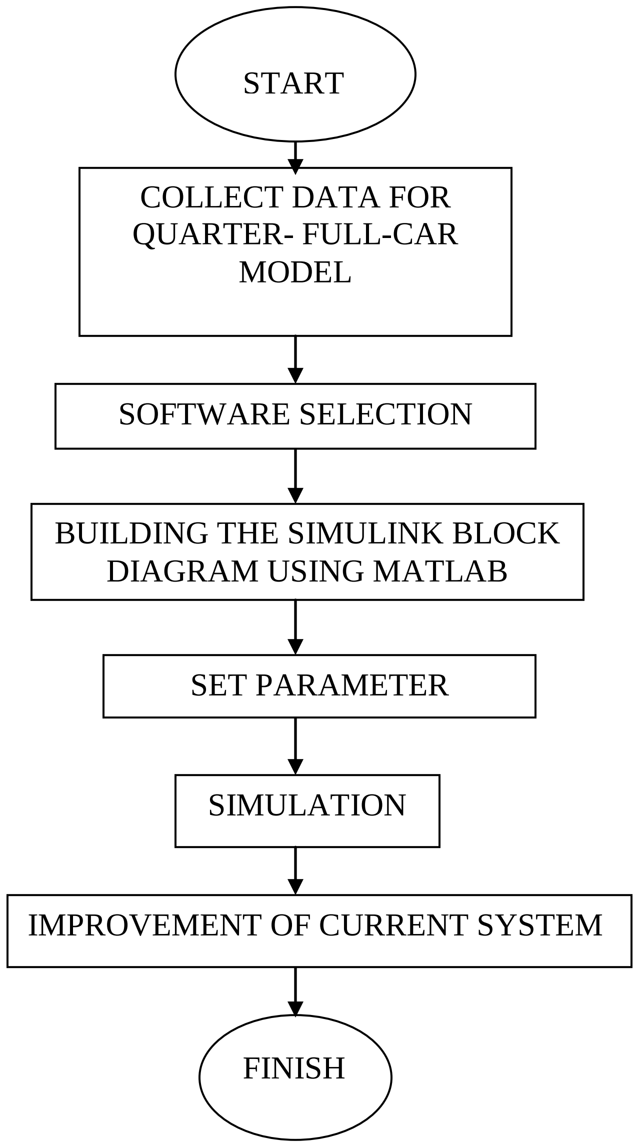
Picture 2. Engine mounting at the right side, on the top of gearbox

Picture 3.Engine mounting, located at the bottom of engine

Picture 4. Engine mounting, located at the bottom of engine

CHAPTER V

3.0 REASEARCH METHODOLOGY



3.1 Mathematical Formulation

Mathematical model was develop is based on the equation that have been developed is focused on the reaction movement of the engine itself on the axis and the reaction movement of the chassis imposed by vibration developed by engine. Both chassis and engine would pitch, roll and accelerate on the vertical axis.

For mathematical model, the idea is to assume the movement of the engine and chassis from the figure of the chassis and engine assembly. Chassis and engine were assumed to be rigid body of mass M_1 and M_2 respectively. The mass will be assume based on the real references.