SUPERVISOR DECLARATION

"I hereby declare that I have read this thesis and in my opinion this report is sufficient in term of scope and quality for the award of degree of Bachelor of Mechanical Engineering (Automotive)"

Signature :.....

Supervisor :.....

Date :.....

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EXPERIMENTAL STUDY OF STEERING WHEEL VIBRATION IN DYNAMIC CONDITION

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This report is provided to fulfill the requirement of the term and condition for the award of degree of Bachelor of Mechanical Engineering (Automotive)

Fakulti Kejuruteraan Mekanikal
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MAY 2011

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DECLARATION

"I hereby declare that the work in this report is my own except for summaries and quotations which have been duly acknowledged."

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Date : 16 MAY 2011

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ESPECIALLY FOR

MY LOVELY FATHER AND MOTHER

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ABSTRACT

Vibration of the steering wheel majorly cause by engine vibration. The vibration can cause lower customer satisfaction if the vibration level is uncomfortable. The steering wheel vibration level is different for every steering wheel model depending on its shape, design, weight, material and size. This experimental study will conduct 3 different experiments to investigate the nature of steering wheel vibration which are experimental study of modal analysis for a steering wheel in free-free boundary condition, experimental study of modal analysis for a steering wheel in constraint condition and experimental study on highest vibration for a steering wheel in dynamic condition. All the three experiments conduct to determine the natural frequency of the steering wheel. This study will investigate the best type of steering wheel for Perodua Kancil.

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ABSTRAK

Getaran pada stereng kereta kebiasaannya disebabkan oleh getaran pada enjin kereta. Getaran tersebut boleh menurunkan tahap kepuasan pelanggan sekiranya getaran itu ditahap tidak selesa. Getaran pada stereng adalah berbeza untuk setiap model bergantung pada bentuk, rekaan, bahan, berat, dan ukuran. Penyelidikan bereksperimentasi ini akan dibuat dalam 3 kajian yang berlainan untuk menyiasat sifat getaran pada stereng iaitu Kajian Analisis pada Stereng dalam Keadaan Bebas, Kajian Analisis pada Stereng dalam Keadaan Sekatan dan Kajian Analisis pada Stereng untuk Getarab Tertinggi dalam Keadaan Dinamik. Ketiga-tiga kajian akan di lakukan untuk menentukan frekuensi asli bagi stereng tersebut. Kajian ini di buat untuk menentukan steereng yang terbaik untuk kereta Perodua Kancil.

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LIST OF SYMBOL

BNC = Bayonet Neill-Concelman

BS = British Standard

DAQ = Data Acquisition System

HAV = Hand Arm Vibration

Hz = Frequency, Hertz

ICP = Integrated Circuit Piezoelectric

ISO = International Standard Organization

m/s^2 = Frequency, Metre/Second^2

NVH = Noise, Vibration and Harshness

WBV = Whole Body Vibration

FYP = Final Year Project

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CHAPTER 1

INTRODUCTION

1.0 BACKGROUND

Nowadays, world automobile industries have grown up until no one ever imagines what the next technologies would reveal after this. Big automotives manufacturer like Honda, Toyota, BMW and others always keep study and searching what customers need for their vehicle. For example, new fuel-cell car, hybrid technologies, navigation system and economy mode advance parking system. Customers are more demanding on fuel saving and ergonomic design because the rise of petrol prize and also environmental issues. Malaysian car's manufacturers, Proton also gives priority to produce a car that is more economical and ergonomic than the design of an attractive. The latest car review from Proton is Proton EMAS. Emas, an acronym for Eco Mobility Advance Solution, was designed in collaboration with acclaimed Italian design house Italy design Giugiaro. Proton EMAS is a hybrid vehicle that aiming to give customer satisfaction for economical vehicle due on high price of fuel at Malaysia. Even new car manufacturer like TESLA MOTORS that was founded in 2003 by a group of intrepid Silicon Valley engineers set out to prove that electric vehicles could be awesome to solve high price fuel problem. Technologies keep changing to a certain level that never imagine before.

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Each part of the car has been study to bring more customer satisfaction including the steering system. Steering system is very important subsystem in a vehicle. The steering system use to control the direction of the vehicle. The steering system is designed to control the direction of the front wheels over all types of the road conditions, through turns, and at different speeds. It is made of a linkage system that is attached to the front wheel, the steering wheel and the steering gear. As the drivers turn the steering wheel, the steering gear transfers this motion to a steering linkage and then the steering linkage turns the wheels to control the vehicle direction. There are 2 common types of steering system which is rack and pinion type and recirculating ball steering system. There also modern type of steering system which is very popular used is modern car which is power steering system that use hydraulic pump.

Comfort is the main demand from the customers. Each aspect of the car is important to be comfort and user friendly. The technologies apply are useless if there no comfort in the car. The comfort of the car is where the car in static and dynamic condition. Ergonomic study is the major comfort factor in a car. Besides that, the noise, vibration and harshness (NVH) is also the factor affecting the comfort of the car. In static and also dynamic condition, mostly the noise and the vibration came from the engine. Under idle conditions, the engine can be considered to represent the major source of vibration and sound which is transmitted to the driver within the vehicle cabin (M. Ajovalasit and J. Giacomin, 2008).

The vibration to human can divided into 2 categories which is whole body vibration (WBV) and hand arm vibration (HAV). At static condition which is due to engine only but in dynamic condition, suspension, road condition, surrounding effect like wind also effecting the vibration of the vehicle. Eliminating the vibration is impossible but car manufacture tries to reduce it to give comfort to the customer.

The most effected part cause of engine vibration is steering wheel. The fingertip and hand-arm are very sensitive to the vibration. So steering wheel had become most popular study about vibration part in the car that effected by the engine and suspension.

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1.1 PROBLEM STATEMENT

1. The steering wheel vibration in dynamic condition cause discomfort for driver. This study is to find the source of the vibration and reduce it to comfortable frequency.

   "Even slight fluctuations of engine idle can cause unpleasant vibration and sound emissions leading to lower customer satisfaction"
   Hoard and Rehagen, 1997)

   "Of these vibrating surfaces, the steering wheel is particularly important due to the great sensitivity of the skin tactile receptors of the hand. (J. Giacomin and S. Gnanasekaran, 2005)

   "The sensations produced by the vibration stimuli which reach the vehicle driver can provide important information regarding the dynamic state of the vehicle, but can also provide annoyance and discomfort"(M.S. Shayaa , J.A Giacomin, E. Dormegnie and L. Richard, 2001)

   "In Malaysian automotive engineering scenario, comfort or discomfort study is still in its infancy stage. It has been suggested in the literature that to develop a scientific framework model of automobile seat comfort, data from all parts of the world is crucial especially that Malaysia has its own automotive industry"(Dian Darina Indah Daruis, Baba Md Deros & Mohd Jailani Mohd Noor, 2008)

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1.2.1 OBJECTIVES

1. To conduct experimental modal analysis for a steering wheel

   The purpose of this research is to conduct an experimental modal analysis for a steering wheel to find the natural frequency of the steering wheel. For the experimental modal analysis, 2 experiments will be conducted which are a free-free boundary and constraint condition. In both experiment, resonance frequency and the mode shape of the steering wheel will be determine by using impact hammer and accelerometers fixed at the steering wheel.

2. To study the behaviour of steering wheel vibration

   In this research, sensors will be fixing at the steering wheel, and the rack to monitor the behaviour of the steering wheel vibration.

3. To analyze the highest vibration level for a car in dynamic condition

   To analyze in dynamic condition, the car will be in plain surface road with zero gradient. Accelerometers will be fixing at the steering wheel, rack, body of the vehicle and the engine. Finally the results will be compare and analyze to find the influence frequency from the engine to the steering wheel.

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1.2.2 SCOPES

1. National compact car with front wheel drive and non-power steering

   In this experiment, Perodua Kancil 660EZ automatic transmission type to fulfil the scope. Perodua Kancil is national compact car with front wheel drive and non power steering.

2. Experimental analysis for the steering wheel for free-free boundary condition and constraint condition.

   Free-free boundary condition is where the steering wheel will be hang and impact with impact hammer to find the natural frequency of the steering wheel. For constraint condition, the impact test for the steering wheel will be doing in the car with full assembly of the steering system.

3. Moving Passenger Car (Dynamic Condition)

   The last experiment is in dynamic condition which is the car will be drive on the road to find the highest vibration level of the steering wheel. This experiment is either using dyno test or drive in the real road.

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CHAPTER 2

LITERATURE REVIEW

2.0 INTRODUCTION

For this research, there are a lot of literature reviews about steering system, vibration which include whole body vibration (WBV) and hand-arm vibration (HAV). There are also some literature review for experimental methodologies which are Free-free Boundary Condition Impact Test and Constraint Condition Impact Test. For the equipment and software that had been use, there is some literature review to validate the results.

2.1 STEERING SYSTEM FUNDAMENTAL

The basic function of a steering system is to ensure that the wheels are pointing in the desired directions. This is typically achieved by a series of linkages, rods, pivots and gears. One of the fundamental concepts is that of caster angle each wheel is steered with a pivot point ahead of the wheel, this makes the steering tend to be self-centering toward the direction travel. The steering linkage connecting the steering box and the wheels usually conforms to a variation of Ackerman steering geometry, to account for the fact that in a turn, the inner wheel is actually travelling a path of smaller radius than

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the outer wheel, so that the degree of toe suitable for driving in a straight path is not suitable for turns. There are basically two types of vehicle steering systems, rack and pinion and recirculating ball bearing system.

2.1.1 Rack and Pinion System

The rack and pinion steering is one of the oldest types of steering systems which is still used today. Inside the rack body a flat rack gear moves in linear direction driven by a circular gear called a pinion. The steering wheel is connected to the pinion gear (shaft). The rack gear is connected to an inner tie rod end that is covered by a rubber below. The inner tie road end connected to the outer tie road end. These rod ends have the ability to move in any linear direction. Finally, the tie rod end is connected to the wheel spindle.

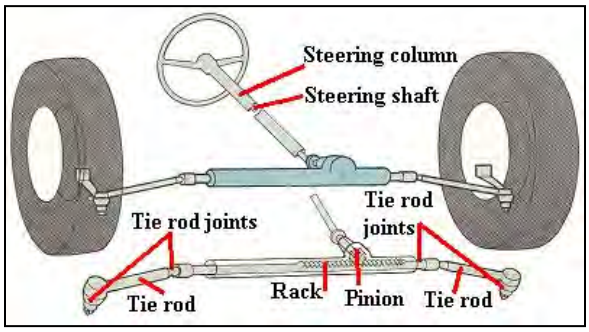

Figure 2.1 Rack and Pinion Steering System

Source: www.motorera.com/dictionary

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