FINITE ELEMENT (FE) MODEL OF BRAKE INSULATOR IN REDUCING BRAKE SQUEAL NOISE FOR MOTORCYCLES

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"To my beloved family, especially my parents, brothers and sisters for supporting me all the way"

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ABSTRACT

In Malaysia, motorcycles are largely used for people to travel from one destination to another. Motorcycles can be said as a cheap and efficient transport in terms of fuel consumption and less in the traffic jam problem. With a large number of motorcycles on the road, it may create noise and air pollutions. One of the noise pollutions is produced by brakes system. Brake squeal noise produced by motorcycles is an annoying sound that can affect the comfort feeling of the rider and people surrounding it. Thus, this project aims to tackle such an issue by introducing brake insulator into the brake assembly. There are three stages have been followed to accomplish the objective, which are: i) generate the finite element model of the rear drum brake system, this model done based on the real system components, ii) perform modal analysis and modal testing and compare the results for validation (acceptable error < 5%) and iii) run the stability analysis with and without insulator to evaluate the effectiveness of the insulator in squeal suppression. The stability analysis performed using ABAQUS software through complex eigenvalue analysis (CEA), the positive real part of the (CEA) indicate unstable frequency (the propensity of squeal occurrence). Different insulator configurations such as thickness, arrangement and shape have been proposed and analysed against squeal generation and it was found that the insulator an efficient method to suppress the squeal but it does not totally eliminate the squeal.

ABSTRAK

Di Malaysia, motosikal banyak digunakan oleh orang awam untuk bergerak dari satu destinasi ke destinasi lain. Motosikal boleh dikatakan sebagai satu pengangkutan yang murah dan cekap daripada segi penggunaan bahan api dan kurangnya masalah kesesakan lalulintas. Dengan bilangan motosikal yang banyak di jalan raya, ia menyebabkan kebisingan dan pencemaran udara. Salah satu punca pencemaran bunyi dihasilkan daripada sistem brek. Kebisingan decitan brek yang dihasilkan oleh motorsikal boleh mengganggu keselesaan penunggang dan juga orang di sekelilingnya. Oleh itu, projek ini bertujuan untuk menangani isu tersebut dengan memperkenalkan penebat brek pada sistem brek. Terdapat tiga peringkat akan dilaksanakan untuk mencapai objektif tersebut, iaitu: i) menjana model unsur terhingga bagi sistem gelendong brek belakang berdasarkan komponen sistem sebenar, ii) melaksanakan Analisis Modal dan Ujian Modal dan membandingkan keputusan untuk pengesahan (ralat diterima <5%) dan iii) menjalankan analisis kestabilan dengan dan tanpa penebat untuk menilai keberkesanan penebat untuk pengurangan decitan brek. Analisis kestabilan dijalankan menggunakan perisian ABAQUS melalui analisis nilai eigen kompleks (CEA), bahagian sebenar positif bagi (CEA) menunjukkan frekuensi sistem yang tidak stabil.. Konfigurasi penebat yang berbeza seperti ketebalan, susunan dan bentuk telah dicadangkan dan dianalisis terhadap penghasilan decitan dan didapati bahawa penebat adalah satu kaedah yang berkesan untuk mengurangkan bunyi decitan walaupun tidak sepenuhnya menghapuskan bunyi decitan tersebut.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

During development of a vehicle, the common improvement of brakes has only focused on increasing braking power and reliability. In addition, the refinement of vehicle acoustics and comfort through improvement in other aspects of vehicle design has dramatically increased compared to brake noise problem. Brake noises is an irritant to customer who may believe that it is symptomatic of a defective brake and file a warranty claim, even though the brake is functioning exactly as designed in all other aspects. Thus, noise generation and suppression have become prominent considerations in brake part design and manufacture. It is noted by researchers (Abendroth, 2000), that many makers of materials for brake pads spend up to 50% of their engineering budgets on noise, vibration and harshness issues.

There are several terminologies for the brake noise in the literature, like: Squeal, groan, chatter, judder, moan, hum, and squeak. Squeal noted as the most disturbing for the passenger and environment and its cost the manufacturer a lot in term of warranty. There is no definition has fully acceptance among the researchers, as the squeal noise complex phenomenon, where the squeal occurs randomly under same operation conditions. But it is agreed that the squeal occurs at frequency above 1000 Hz (Kinkaid et al., 2003).

There are several methods have been proposed in order to predict the probability of the squeal occurrence which are: experimental approach, theoretical approach and finite element method (FEM). However, there are several methods also proposed to suppress the squeal noise which are: structural modifications, active control, adding damper. Kinkaid et al. (2003) Adding damper noted as an efficient method to suppress the squeal noise and it may apply by changing the material with high damping material or by adding an insulator to the pad or shoe (depends on the brake type). The insulators normally consist of sandwiched layers of viscoelastic material and steel attached together to the pad or the shoe.

The squeal is an interesting field for automotive industry because the noise an important factor in the product evaluation, therefore many researches study this problem and they could specify the range of frequency in which the squeal occurs in (4kHz – 15kHz) for motorcycle (Mahboob et al., 2010).

1.2 Problem Statement

Brake noise is annoying for customers and results in the perception of defective brakes, although brake noise has little or no effect on the performance of the brake system but it significantly affect the customer satisfaction and related warranty costs. With the frequent use of motorcycles in Malaysia the brake squeal noise will be an important factor that affects the people comfort and environment noise.

Furthermore, the development of methods to suppress the squeal occurrence has been the target of many researchers in recent years. However there is no fully solution for this problem.

Finite element method and experimental approaches are the methods used to identify the squeal noise. In this project a finite element method for the drum brake system of motorcycle used to predict the squeal occurrence and an insulator will be used to suppress the noise.

1.3 Objective of Study

- To develop a validated finite element model of a rear drum brake for motorcycles.
- To propose and evaluate effectiveness of brake insulator models against squeal noise.

1.4 Scope of Study

1. Perform modal testing and modal analysis on individual drum brake components to validate the FE models.
2. Perform stability analysis using complex eigenvalue analysis in order to predict unstable brake system.
3. Unstable frequency of interest is from 1 ~ 10 kHz.
4. Brake insulator is modelled based on different arrangement, shape and thickness.

1.5 Thesis Organization

This thesis consists of five chapters summarized as follows:

Chapter two presents the literature review about the brake squeal in term of the mechanism, suppression methods and the prediction methods.

Chapter three describes the methodology that has been used to predict the squeal generation using complex eigenvalue analysis.

Chapter four provides the results of the validation process for the dynamic properties (natural frequency and the mode shape) of the brake system components, and also the results of the stability analysis with and without the insulator, where the squeal predicted with different coefficients of friction then with different insulator configurations.

Chapter five summarizes the conclusion of the work and the recommendations for the future works.

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