SQUEAL SUPPRESSION APPROACHES OF A DISC BRAKE ASSEMBLY

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ABSTRACT

Brake squeal is an annoying noise emanating from a car disc brake and is typically a single-tone, high-pitch noise. In general, brake noise can be divided into three groups: low frequency noise (below 1 kHz), low frequency squeal (1 kHz to 3 kHz), and high frequency squeal (4 to 15 kHz). To date, there are a number of approaches have been proposed and implemented to suppress disc brake squeal but very few are effective to suppress and eliminate it. This thesis proposes an approach to suppress disc brake squeal noise, ranging from 1 to 10 kHz, through structural modification using the finite element method. First, a three dimensional finite element (FE) model of a real disc brake assembly is developed and validated. Then, complex eigenvalue analysis made available in commercial FE software package is performed to determine stability of the brake system where positive real parts of the complex eigenvalue indicate unstable system and in turn exhibit squeal generation in the brake assembly. Then, various structural modifications on the disc, brake pad, caliper and carrier are proposed to reduce the brake squeal. A good modification should be able to reduce and eliminate squeal at various brake operating conditions.

ABSTRAK

Brek *squeal* merupakan kebisingan yang disebarkan daripada cakera brek adalah dalam satu nada and nyaring. Secara amnya, kebisingan brek boleh dibahagikan kepada 3 kumpulan: *squeal* frekuensi rendah (bawah 1 kHz), *squeal* frekuensi rendah (1 kHz ke 3 kHz) dan *squeal* frekuensi tinggi (4 – 15 kHz). Sehingga kini, banyak pendekatan telah dicadangkan dan dilaksanakan untuk mengurangkan cakera brek *squeal* tetapi hanya beberapa sahaja yang dapat mengurangkan dan melenyapkannya. Tesis ini mencadangkan pendekatan mengurangkan cakera brek *squeal* dalam julat dari 1 kHz ke 10 kHz secara modifikasi struktur menggunakan kaedah unsur terhingga. Pertama, model unsur terhingga tiga dimensi telah dibangunkan dan disahihkan. Selepas itu, analisa nilai eigen komplek yang terdapat dalam pakej perisian FE komersial telah dilaksanakan bagi menentukan keadaan stabil sistem brek dimana bahagian nyata positif daripada nilai eigen komplex menunjukkan ketidakstabilan sistem dan menghasilkan *squeal* dalam brek sistem. Maka, pelbagai modifikasi struktur pada cakera, *brake pad, caliper* dan *carrier* telah dicadangkan untuk mengurangkan brek *squeal*. Modifikasi yang baik akan mengurangkan atau melenyapkan *squeal* pada keadaan operasi yang berbeza.

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CHAPTER 1

INTRODUCTION

The functions of an automobile disc brake system are to slow down a moving vehicle, to maintain the vehicle speed during downhill operation and to hold vehicle stationary while parking. When pressing brake pads against the rotating wheel disc, the friction between the pad linings and the disc dissipates the energy of the moving vehicle, resulting in deceleration. During braking operation, the friction between lining and disc can induce a dynamic instability in the system. This instability can create noise and vibration, particularly brake squeal as it is the most annoying sound to the people. Squeal is associated with noise generated by friction-induced vibration and is also known as frictional noise. It occurs at a certain level of vibration which frequency ranges from 1-15 kHz [1]. The squeal noise in the frequency region of 2 kHz to 5 kHz is the most annoying to human ear [2].

1.1 Problem Statement

Noise of squeal is the engineering problem that still cannot be solved until this moment. Squeal will create annoying sound to car passengers and likely to cause faulty to other components of car by induced vibration. Automotive engineers are still doing the research to suppress squeal in order to prevent faulty happen to cars and eliminate annoying sound to passengers.

Finite element method and experimental approaches are the methods used to identify the squeal frequency. Researchers have proposed a lot of suppression approaches but only few are successful.

Simulation by finite element method is the cost effective method to predicted squeal frequency. In this project, several modifications on disc brake components are modified to be analyzed by simulation.

1.2 Objective of Study

1) To predict disc brake squeal using finite element method through complex eigenvalue analysis.
2) To propose various structural modifications into disc brake components in order to reduce squeal.

1.3 Scope of Study

a) Based on passenger cars
b) Brand new disc brake assembly and hence any materials degradation is not considered.
c) Current study does not take into account thermal and wear effect.
d) Pad and disc interface is assumed flat and perfect surface and hence surface roughness is not considered.
e) Squeal frequency is limited from 1 kHz to 10 kHz.

1.4 Thesis Organization

In this section, chapters of project are briefed. Beginning of this chapter tells about the noise problems that need to be solved by modification of disc brake components. Chapter 2 describes about the modification of disc, brake pad, caliper and carrier that have been made. Experimental approaches to solve the problem are included in this chapter.

Methodology to complete this project stated in chapter 3. Finite element method is used in complex eigenvalue analysis to find the unstable noise frequency. Validation process of the finite element model is described in this chapter also.

Models of modification listed in chapter 4. Modifications are made on disc, brake pad, caliper and carrier. Results of analysis are discussed in chapter 5. Graphs of squeal frequency versus models of modification are plotted and discussed.

Lastly is the conclusion about the project where good models of modification are proposed. Suggestions are added for further work consideration by other researcher.

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