1051. Detailed analysis of drum brake squeal using complex eigenvalue analysis

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(Received 2 June 2013; accepted 4 September 2013)

Abstract. Nowadays one of the major topics in the brake development community is the NVH (noise, vibration and harshness) problem. Although reasonably well researched in the disc brake systems, the squeal prediction in the drum brakes is often neglected, manly due to its complexity. The newly developed methodology presented in this work gives the directions on how to develop a squeal free drum brake design using some novel approaches to closely correlate the numerical results with the experimental brake tests. The goal is to make a robust drum brake design that is stable under the different noise factors and under broad operational conditions. In order to predict if a brake system will generate the squeal noise during the operation, the finite element method was used to simulate the system. By solving the complex eigenvalues of the FEM (finite element method) matrices, the presence of unstable modes was predicted. A good correlation with the SAE J2521 noise matrix dynamometer test procedure was established.

Keywords: brake squeal, drum brake, eigen frequency, complex eigenvalue analysis, finite element methods (FEM).

1. Introduction

The braking process in an automobile involves a contact of metallic solids sliding against each other, which sometimes generates undesirable noise, vibration, and harshness (NVH). Brake squeal is known as an annoying high-pitched single-tone noise [1].

Brake squeal is becoming an increasing concern to the automotive industry because of the warranty costs and the requirement for the reduction of the interior vehicle noise. The majority of the research has been directed to either analytical and experimental studies of the brake squeal mechanisms or the prediction of the brake squeal propensity using finite the element methods. By comparison, there is a lack of systematic analysis of brake squeal data obtained from a noise dynamometer [2].

As Oberst and Lai [2] have pointed out, the majority of the research undertaken over the last two decades has focused primarily on exploring the mechanism of brake squeal using simplified analytical models or applying the finite element method (FEM) complemented by experiments to determine unstable vibration modes in a brake system. The general conclusion was that in the foreseeable future no complete and practical solution is most likely in sight.

More specifically, the finite element (FE) method is the preferred method in studying brake squeal. Finite element analysis (FEA) is popular due to the inadequacy of experimental methods in predicting squeal at the early stage in the design process. Moreover, FEA can potentially simulate any changes made on the drum brake components much faster and easier than experimental methods [3].

Drum brakes operate by pressing a set of brake linings against a rotating drum. The friction between the linings and the drum causes deceleration, but it may also induce a dynamic instability of the system, known as brake squeal. One possible explanation for the brake squeal phenomenon is the coupling of the two neighbouring modes. Two modes, which are close to each other in the frequency range and have similar characteristics, may merge as the friction contribution increases. When these modes merge at the same frequency (become coupled), one of them becomes unstable.