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FINITE ELEMENT MODELING AND ANALYSIS OF BREAK SQUEAL

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ABSTRACT :

In this paper we had finite element modeling and analysis of break squeal.The 3D model is prepared in PRO-E or CATIA, and then analysis is performed in the ANSYS 11.0. For reducing the brake squeal and also determine squeal frequency and unstable squealing modes of disc-pad assembly. The results are verified by comparison of Analytical and Finite Element Method.

Brake squeal has been studied through experimental, analytical and numerical method for understand, to predict and to prevent squeal occurrence. The finite element method is used to predicting squeal at early stage in the design process.

Keywords

Squeal, disc brake, complex eigenvalue, temperature finite element method, stick slip

1. INTRODUCTION :

Luxuries cars have become one of the main transport for people travelling from one place to another place. smooth working of vehicle is major portion for vehicle manufacturer. Vehicle quietness and passenger comfort are also major issue. one of vehicle components that generate unwanted vibration and unpleasant noise is the brake system. As a result, brake and friction material suppliers face challenging tasks to reduce high warranty payouts Akay [1] stated that the warranty claims due to the noise, vibration and harshness (NVH) issues including brake squeal in North America alone were up to one billion US dollars a year. Similarly, Abendroth and Wernitz[2] noted that many friction material suppliers had to spend up to 50 percent of their engineering budgets on the NVH issues.

Masayuki and Mikio [3] used the beam on disc test with dry friction to study the brake noise. Their experimental apparatus used a beam on disc technique with accelerometers to measure the disc brake system vibration. The beam-on-disc consists of a cantilever beam which represents the pad while the rotation disc represents the disc brake rotor. The beam and the disc are pressed against each other by a weight. They classified the friction noise to rubbing and squeal. They found that the noise was caused by the lateral vibration of the rod only. They also found that when the friction coefficient is small the vibration is small for that the rubbing noise has low level. The results showed that the rubbing noise can be changed to squeal noise due to the wear during the sliding work to change the surface roughness. In a recent review, Kinkaid *et. al.* [4] listed a wide array of brakes noise andvibration phenomenon described by its own terminology. Squeal, creep-groan, moan, chatter, judder, hum, and squeak are among the names that can be found in the open literature. Of these noises, squeal is the most troublesome and irritant one to both car passengers and the environment, and is expensive to the brakes and car manufacturers in terms of warranty costs. [4]. It is well accepted that brakes squeal is due to friction -induced vibration or self-excited vibration via a rotating disc. Brake squeal frequently occurs at frequency above 1 kHz[5] and is described as sound pressure level above 78 dB [6].Brake squeal has been studied since 1930's by many investigators through experimental, analytical and numerical methods in an attempt to understand, to predict and to prevent squeal occurrence. In recent years, the finite element (FE)method, particularly using complex eigenvalue analysis, has become the preferred method in studying brake squeal. The popularity of finite element analysis (FEA)is due to the inadequacy of experimental methods in predicting squeal at early stage in the design process. Moreover, FEA can potentially simulate any changes made on the disc brake components much faster and easier than experimental methods. Kung *et. al.* [8] commented that although the complexeigenvalue analysis was successfully used in brake squeal problems, the shortcomings of this method were over-predictions and sometimes missing, unstable modes in the squeal frequency range. In a similar paper, they suggested that in order to improve the complex eigenvalue predictability, user experience and engineering judgement were essential to obtain reliable results. In addition to this, they also stated that realistic friction coupling between pad and disc interface,consideration of friction-induced (positive and/or negative) damping and lining wear could also play important role for improving the predictability. AbuBakar[9] in his thesis found that combination of realistic surface topography of brake pads with friction-induced negative damping could produce better prediction in the complex eigenvalue analysis.

2 . PROBLEM IDENTIFICATION

Squeal means the noise produce by brake, when disc and brake pad come into contact it produce friction and these friction produce the vibration in between disc and pad. while when frequency of both are different it produce squeal. Brake squeal is a phenomenon of dynamic instability that occurs at one or more of the natural frequencies of the brake system. The excitation comes from the friction couple. The disc rotor is acting like a "speaker" (sound wave radiated from the rotor surfaces). Pads and rotor coupling has major impact on mid to high frequency (4 ~16 kHz) squeal. Low frequency (1 ~ 3 kHz) squeal typically involves calliper, anchor bracket, knuckle and suspension, in addition to pads and rotor.

3. PROBLEM FORMULATION

During brake operation, the friction between the lining and the disc can induce a dynamic instability in the system. This instability can create noise, commonly known as brake squeal. One possible explanation for the brake squeal phenomenon is the coupling of two vibration modes. If two modes are close to each other in the frequency range and have similar characteristics, they may merge if the coefficient of friction between the pad and disc increases. When these modes merge at thesame frequency (become coupled), one of them becomes unstable. The unstable mode can be identified during complex eigenvalue extraction because the real part of the eigenvalue corresponding to an unstable mode is positive. The instability in the brake system design can be eliminated by changing the geometry or material properties of the brake components to decouple the modes. As vehicle quality improves, customers demand quieter brakes. Customer complaints result in significant warranty costs yearly, motivating the need to study brake squeal early in the design process. The complex modes approach is a common finite element modelling technique used to simulate this phenomenon.

4. Finite element model

Before a complicated model is used for predictions, it should be validated. The FE model of the whole disc brake will study in this paper. It validate through three stages for complex eigenvalue analysis (AbuBakar et al., 2005). Therefore the material properties of each disc brake component and of the connections between brake components are believed to be valid. However, there are important limitations to the transient analysis functionality in ABAQUS/Explicit. The first limitation is the unavailability of a specific spring element, which is used to connect one component to

another for contact interaction. Because of this limitation, the full disc brake model cannot be used. Instead, a reduced disc brake model that consists of two brake pads and a solid disc is used. The second limitation is that only the reduced-integration, eight-node solid element with hourglass control is available inexplicit version whilst full integration eight-nodes solid element is used in Standard version for complex eigenvalue analysis. Different approaches in rotating the disc are inevitable because the Explicit version does not have similar cards as Standard version to activate the boundary condition. MOTION card is used to rotate the disc in the complex eigenvalue analysis while a rigid body that ties to the disc boltholes is used instead in the transient analysis. These differences may slightly affect predicted results later in the analyses that follow.

5. CONCLUSION

This research is started with the Study of various types of disc brake. Study of mechanism used for brake system. From the preliminary study it is concluded that range of frequencies for brake system.effect of vibration in rotor disc and brake pad. Further it is decided to develop the CAD model of brake and to carry out Modeling by using Pro-E & analysis is carried out by using ANSYS Software by applying boundary conditions, & considering Stresses acting on each part & meshing on each component.

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