Modeling and Analysis of the Mechanical Behavior of Dry Contracts Slipping Between the Disc and the Brake Pads

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ABSTRACT

The complexity of the physical or technological systems to be developed or studied led to employing numerical methods based on the principle of an approach as possible nominal solution, but these require large computations requiring efficient computers. The computer code ANSYS also allows the determination and the visualization of the structural deformations due to the contact of slipping between the disc and the pads. The results of the calculations of contact described in this work relate to displacements, Von Mises stress on the disc, contact pressures of the inner and outer pad at various moments of simulation. One precedes then the influence of some parameters on the computation results such as rotation of the disc, the smoothness of the mesh, the material of the brake pads and the friction coefficient enter the disc and the pads, the number of revolutions and the material of the disc, the pads groove.

KEYWORDS

Finite Element Method (FEM), Gray Cast Iron, Pads, Shear Stress, Total Distortion, Ventilated Disc Brake

1. INTRODUCTION

With the development of new technologies in the automotive industry, vehicles have become more and more efficient. Braking systems should follow the same rhythm. The brake, as a major security organ, constantly arouses great interest to engineers. In addition, competition in the automotive field is increasingly harsh, putting pressure on efficiency, reliability, comfort, cost and production time of all automotive systems. For an engineer, the goal is to find the best compromise between the requirements of security, technology and economic constraints. To achieve an optimal design, it should implement all available economic technologies to solve the technical problems, thus complementing experimental studies. In the aerospace and automotive industry, many parts are subjected to simultaneous thermal and mechanical loads, constant of fluctuating. The thermo-mechanical stresses cause deformations and may even damage the systems. For example, in friction braking systems heat is generated in the disk and brake pads, causing high stresses, deformations and vibrations as cited in (Tajan and Mac-Lan, 2002).

Reibenschuh et al. (2009) studied the thermo-mechanical analysis of the brake disk, with an elaborate model to determine the effects of thermal and centrifugal loads on the brake disc and its associated system. Subramanian and Oza (2015) studied ventilated brake disc hub assembly subjected to braking torque and bolt pretension. The induced stresses due to the bolt pretension were found to be negligible compared to the braking torque. Shinde and Borkar (2015) carried out another...
analysis of brake disc system using ANSYS software to study the performance of two different pad materials – Ceramic & composite Fiber. This research provided useful design tools and improved brake performance of the disk brake system based on the strength and rigidity criteria. Jungwirth et al. (2014) carried out a thermo-mechanical coupled analysis of design brake discs and calipers. The simulation model was tested on a brake dynamometer to determine the deformations and its fatigue strength. The study was focused on the mechanical interactions between the calipers and brake disc, including the influence of heat power distribution on the brake disc. In the work carried out by Söderberg and Andersson (2009) a three-dimensional finite element model of the brake pad and the rotor were developed primarily for the calculations of the contact pressure distribution of the pad on to the rotor. Abdullah et al. (2013) used the finite element method to study the contact pressure and stresses during the full engagement period of clutches using different contact algorithms. In this study, the sensitivity of the results to the contact pressure was exposed to show the importance of the contact stiffness between contact surfaces. Dhiyaneswaran and Amirthagadeswaran (2014) guided a comparative study of disc brake with two different materials. The disc brake model was analyzed in dynamic load conditions and the contact stress pattern was modeled. The displacement and the elastic constraints of the existing material and the alternative materials of the disc brake were also compared. Sharath Kumar and Vinodh (2012) proposed a new automotive brake rotor design after they compared it with the ventilated disc rotor. The work used finite element analysis for both static structural and thermal transient analyses in order to evaluate and compare their performances. The analysis of the deformations of the rotor under extreme loads was carried out using a static structural analysis method.

Belhocine and Bouchetara (2012) used the finite element software ANSYS 11.0 to study the thermal behavior of full and ventilated disc brake rotor. A transitory analysis of the structural thermo-mechanical couple was employed in order to visualize the stress fields of the constraints and their deformations in the disc. The contact pressure distribution on the brake pad was also established. Belhocine et al. (2014) investigated the structural and contact behaviors of the brake disc and pads during the braking phase at the design case using FE approach, with and without thermal effects. The results of thermo-elastic coupling on Von Mises stress, contact pressures and total deformations of the disc and pads were presented. These are useful in the brake design process for the automobile industry. In another study by the same authors as, Belhocine et al. (2015) on structural and contact analysis of Disc Brake Assembly during a single stop braking event using the same commercial software, the stress concentrations, structural deformations and contact pressure of brake disc and pads were examined.

The principal objective of this paper is to study the contact mechanics and behavior of dry slip between the disc and brake pads during the braking process. The calculations were based on the rested static structural analysis in ANSYS 11.0. The main strategy of the analysis is to initially visualize the normal constraints and shear stresses thus the sensitivity of some of the computation results, which will then be approached in detail.

2. STUDY OF MECHANICAL CONTACT: BRAKE DISC-PAD

The disc and the pad was modeled by characterizing the mechanical properties of materials of each part. The type of analysis chosen was the static structural simulation. The total simulation time for braking was \( t = 45 \) s, and the following initial time steps were adopted:

- Increment of initial time = 0.25 s.
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