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NEW PROCEDURE TO ESTIMATE THE BRAKE WARPING IN A ROLLER TESTER

D. GARCÍA-POZUELO RAMOS*, A. GAUCHÍA, B. L. BOADA and V. DÍAZ

Mechanical Engineering Department, Research Institute of Vehicle Safety (ISVA), Carlos III University, Madrid 28911, Spain

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ABSTRACT–Vehicle systems such as the steering, brakes and suspension greatly influence vehicle safety. Therefore, these systems must be inspected to guarantee that they are functioning correctly and to certify that the vehicle is functioning at a satisfactory safety level. In disc brakes, warping is one of the principal reasons for vibrations and noise, and it contributes to diminished brake efficiency. Currently, the International Motor Vehicle Inspection Committee (CITA) demands disc brake warping inspections occur during periodic motor vehicle inspections (PMVIs); however, the procedure to carry out this inspection is not well defined. In this investigation, the warping phenomenon has been analyzed, and a new inspection procedure is proposed.

KEY WORDS : Brake system, Safety, Automobile vehicles, Warping, Periodic motor vehicle inspection

1. INTRODUCTION

One of the major concerns for vehicle companies, and for society in general, is increasing vehicle safety. Therefore, not only the vehicle design phase but also correct maintenance of the different vehicle components via a periodic motor vehicle inspection (PMVI) are important for guaranteeing a minimum level of vehicle safety (Reglamento de Obras Públicas y Transportes, 2002; Manual de Procedimiento de Inspección de las estaciones ITV, 2006; Directiva 2002/78/CE, 2002). Currently, brakes are inspected by a visual inspection and a roller brake test. Although the roller brake test checks the vehicle's braking efficiency, no procedure has been established to inspect disc brake warping. In this investigation, the disc brake warping phenomenon has been thoroughly studied; a new, objective inspection procedure is proposed.

Brake noise, squeal and thermal analysis have been investigated for the past few years (Song and Lee, 2009; Joe *et al.*, 2008). The finite element method has become one of the most-used techniques for these studies (Tirovic and Sarwar, 2004; Dufrénoy, 2004). Literature overviews covering the modeling of friction brakes (Jacobsson, 2003; Wallaschek *et al.*, 1999) have also been published. In Xiaojie *et al.* (2006), simulation of the brake judder phenomenon by means of ADAMS (Automatic Dynamic Analysis of Mechanical Systems) was proposed. Other researchers have proposed an integrated approach to reduce brake judder by using homogenous discs (Okamura, 2008). Vibrations in disc brakes have also been analyzed, and an experimental method has been proposed to reduce such vibrations (Berger *et al.*, 2003).

Disc brake warping is currently measured by means of a roller-type brake test in which the pedal brake is applied for a certain period. Knowledge of the brake oscillations allows the roller tester to calculate the disc warping as follows:

$$Disc\ warping_{wheel}\ (\%) = \frac{(F_{MAX} - F_{MIN})}{F_{MAX}} \times 100\,, \qquad (1)$$

where F_{max} and F_{min} are the maximum and minimum force registered during the time in which the pedal brake is pushed. However, this procedure is not very objective and is not standard because there are different roller tester types. For each of them, the applied braking force and the time during which it is pushed are different. There are also differences in the applied filters, and the way in which the roller testers analyze the signal data strongly influences the results.

To carry out this investigation, the same roller tester as those used at periodic motor vehicle inspections (PMVI) stations was employed. Several experimental tests were carried out to determine the most adequate filter to analyze the data and to indicate a rejection value.

2. THEORETICAL ANALYSIS

Disc warping is a permanent deformation of the disc, which generates an oscillating force during the braking process. This phenomenon can lead to vibrations during

**Corresponding author.* e-mail: dgramos@ing.uc3m.es