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APPLICATION OF A MODAL IDENTIFICATION PROCEDURE TO STUDY THE INFLUENCE OF OPERATING PARAMETERS ON FRICTION-INDUCED VIBRATIONS

*** P. Grange[1], D. Clair[1] and M. Fogli[1]**

[1] Laboratory of Research and Applications in Advanced Mechanics
French Institute of Advanced Mechanics and Blaise Pascal University, Clermont-Ferrand
Campus des Cézeaux - BP265 - 63175 Aubière cedex France
pierre.grange@ifma.fr, david.clair@univ-bpclermont.fr, michel.fogli@polytech.univ-bpclermont.fr

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ABSTRACT

Friction-induced vibrations affects numerous mechanisms and leads to complex dynamical behaviors, such as brake squeal, which are fundamentally nonlinear. Since the earlier 1900's, this phenomenon has been the topic of many research works [1]. Considering the recent literature, brake squeal is characterized by the coalescence of two modes of the brake system leading to increasing vibrations. Classically, two numerical methods are used to analyze the friction-induced vibrations: the complex eigenvalue analysis [2] and the temporal nonlinear dynamic analysis [3]. Nevertheless, these methods have drawbacks: the first one uses a basic modelling of the contact by assuming full contact and full sliding conditions at the pad/disc interface while the second one is not able to accede the modal parameters of the brake system.

This paper deals with a new approach to study friction-induced vibrations [4]. This approach is based on the sequential use of two methods: the Random Decrement Technique [5,6] and the Ibrahim Time Domain Method [7]. The first enables to calculate a matrix decrement function which is proportional to the free response of the system. This property allows to perform a modal identification with the Ibrahim Time Domain Method. Consequently, the proposed method enables to identify linear modal parameters (modal shapes, eigenfrequencies and damping ratios) of the system using data issued from the temporal nonlinear dynamic analysis of the contact. The proposed approach presents several advantages compared with the complex eigenvalue analysis and the temporal nonlinear dynamic analysis. First, this method complements the last one by performing a modal identification. Then, by using the nonlinear temporal analysis data, it is able to take into consideration the nonlinearities of the contact and particularly the existence of local stick, slip and/or separation. Furthermore, contrary to the complex eigenvalue analysis which lists the eigenfrequencies susceptible to be unstable and their associated modal shapes, the proposed approach identifies the characteristic frequency, damping ratio and modal shape associated to the friction-induced vibrations.

The modal identification procedure is applied to a pad/beam contact which represents a brake mechanism. The obtained results are compared with the complex eigenvalue analysis and temporal analysis

ones and show that the modal identification procedure is an improvement compared to classical methods. The analysis of the modal shapes identified by the proposed approach reveals the occurrence of a complex contact behavior mainly located in the rear part of the contact side of the pad. Furthermore, the proposed procedure depicts correctly the presence of harmonics which are associated, by nature, to the nonlinear behavior of the system. Then, in the second application, the influence of several operating parameters (friction coefficient, Young's modulus of the pad, roughness of the pad [8,9]) on the triggering of friction-induced vibrations is analyzed.

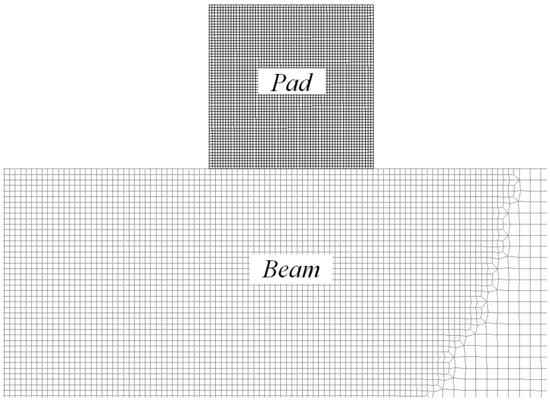

Figure 1: Zoom on the pad and beam meshings

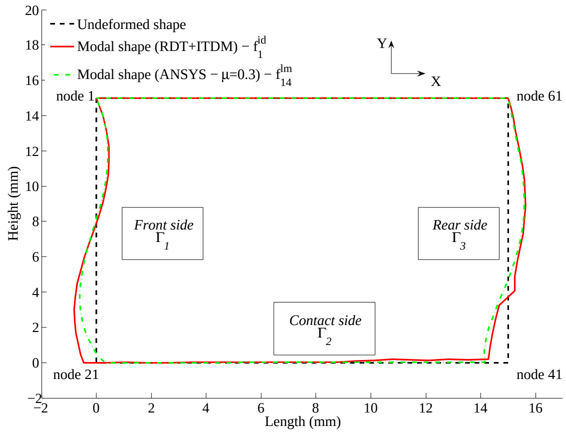

Figure 2: Modal shapes obtained by the complex eigenvalue analysis and the modal identification procedure

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