8th. World Congress on Computational Mechanics (WCCM8)
5th. European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMAS 2008)
June 30 – July 5, 2008
Venice, Italy

A numerical method to take into account the damping induced by viscoelastic materials in brake squeal.

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Key Words: *Damping, friction, viscoelasticity, brake squeal, complex eigenvalues, stability.*

ABSTRACT

The squeal is one of the major issues for the engineers who design the brake systems. One of the most efficient ways in order to reduce the number of noise occurrences is to apply some viscoelastic insulators as the so-called shims. Nowadays they are well known in an experimental point of view [1], but only a few numerical works [3] have tried to take them into account. It is rather important to do it in order to give some indications to the designers on the optimal location and size of these insulators. Moreover there are other viscoelastic parts in a brake system, like the friction pads; all those parts are to be modelled with a realistic behaviour in order to increase the reliability of the model. Most of the previous works have shown that the models using the fractional derivatives models or the Maxwell's generalized model are powerful to describe this kind of materials [2]. We have performed experimental tests and found the datas to describe those materials with the Maxwell's generalized model. Therefore, the objective of the work presented here is to calculate the damping generated by the viscoelastic materials in the case of stability analysis. The complex eigenvalues are a good indicator of the stability of a system. The finite element codes like Abaqus or Nastran are able to calculate some dynamic response using viscoelastic materials but it is not possible to calculate the complex eigenvalues. The main issue is the fact that the problem is of a higher order than the classical second order. Therefore it is needed to transform the problem into a state model of the first order. Transforming and solving the problem cannot be done in a classical finite element code. Thus we have done it in a Matlab routine which although use Python to transfer the data from the first step of calculus, from Abaqus to Matlab, [4]. The paper is organized in three sections. Firstly, we present the tools that we have developed. Secondly we discuss the results we have obtained on some part and on the all brake system. Finally, we present the results obtained from the stability analysis.

In the first section, we first explain how we can transform an eigenvalue problem from a high order one to first order one. The main issue is the increasing of the size of the model. Choosing the same poles and the same order to describe all the viscoelastic materials, allows reducing the size of the model. This technique is theoretically described and some comparaisons with the work of Daya are presented. We although

show, from experimental data and their identification, that this technique does not affect the performances of the Maxwell's model. Finally we present the all process of simulation that we have developed.

In the second part, we detail the analysis that we have performed on some brake pads. The results are compared to experimental ones. The modal damping coefficient can be rather different from a mode to another. Some explanations are given looking at the modal strain energy stored in the viscoelastic part of the pads. It is shown that the biggest is this energy, the biggest is the modal damping. The same kind of analysis are performed on a complete system with more than 500.000 degrees of freedom. It is shown that the CPU time does not increase so much from the old process of calculus to the new one.

In a third part, we have compared the results obtained from the old analysis, which did not take into account the viscoelasticity, and the results obtained from the new analysis. It is interesting to show that

- For some unstable modes, the positive real part is decreasing to a value which corresponds to the old value minus the added damping.
- For others, the coupling between modes disappears and therefore these modes become stable.
- And finally there are some modes which were stable and become unstable because of the viscoelasticity.

To conclude, we present some outlooks which lead to take into account some other kind of damping like friction induced one. Moreover We present the possible ways in order to increase the efficiency of our algorithms.

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