Effect of IGA formulation on the simulation of friction instabilities of disc-pad systems

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ABSTRACT

As a first approximation, brake systems can be considered as disc-pad systems, enabling interesting research work on squeal noise generation [1]. We investigated the use of isogeometric formulation to represent such systems. We investigated the use of different order basis and continuity to generate different formulations for a given geometrical disc-pad system. Often a linearized dynamical model of the brake system is considered to asses the stability around a steady-state condition through complex eigenvalue analysis (CEA), where the instabilities are considered to induce squeal noise. While the advantages of the NURBS discretisation in a typical modal analysis of linear systems are shown in [2], the main aim of this study is to investigate the advantages of such discretisations in assessing the friction induced instabilities like squeal noise phenomenon, while also considering the contact formulations involved in such systems. This also results in other well known advantages of the IGA which can be be exploited in applications like shape optimisation of brake systems w.r.t. squeal noise criteria.

In a typical finite element model for squeal noise prediction with CEA, the contact constraints are typically enforced with penalty method and through which the friction characteristics are defined with coulomb's law. The C_0 discretization of a typical finite element model leads to nodes directly on the geometry and hence defining the contact is fairly straightforward. While in IGA, the control points acting as nodes are rather a scaffold representing the geometry and hence a different approach should be considered for NURBS discretization, for which the resulting contact definition should also be suitable for complex eigenvalue analysis [3]. This is achieved by collocating the contact stiffness—enforcing the penalty constraints—at the Gauss quadrature points on the contact face of one of the bodies, which is also projected surface normal on to the other face in contact. The NURBS function used for discretization is then used to weigh the contact stiffness considered at the quadrature points on to the control points. This makes it also efficient to describe the friction characteristics through coulomb's law, resulting in a linear model which can be used for CEA. Results have been then compared to the published finite element model behaviour of similar disc-pad systems.

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