Master thesis : Nonlinear vibrations of a turbine blade undergoing structural contacts

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Nonlinear Dynamic Analysis Tool Development for Contact Interactions

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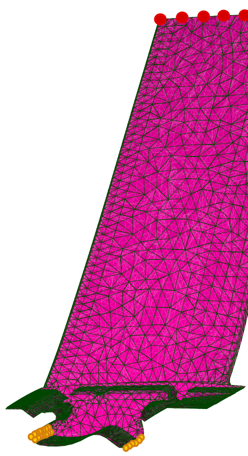
Abstract

Nonlinearity is a common issue when examining cause-effect relationships. Such instances require complex modelling and hypothesis to offer explanations to nonlinear events. Nonlinear properties are present in many fields in Science and Engineering (optics, mechanics, ...) Among them in aerospace engineering, the description of the contact interactions between aircraft engine blades and the associated casing is of prime importance. In this context, the study deals with the development of an original versatile open source tool based on the combination of the two computational languages (Python and C++) able to model and simulate interactions between multiple structures. On one hand, by using *code_aster*, the mechanical analysis allows the application of boundary conditions, creation of materials and computation of eigen-modes. On the other hand, on top of the open source aspect, the tool has been developed to be as flexible as possible to allow the addition of further modules more adapted to specific analysis. From a computational point of view, the mechanical contact has been described by using two recognized methods, namely the Lagrange Multipliers and the Penalty methods. The time integration process has been conducted by using the well known algorithm based on the Newmark schemes.

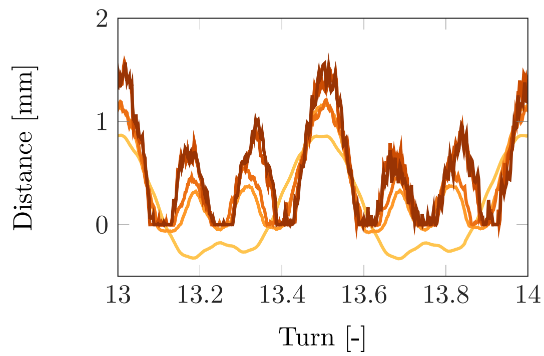
To validate the code, the first test case considered corresponds to the interactions between a falling cube between two rings. All the pertinent computational and physical parameters were systematically compared and

optimized. Depending on the initial conditions, different mechanical behaviours were observed.

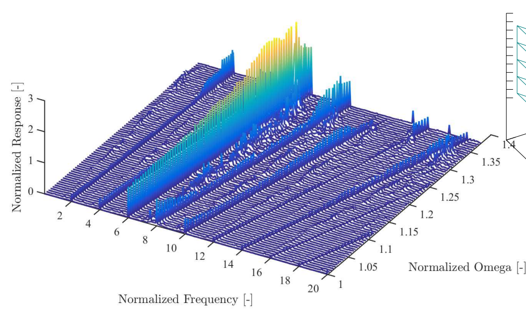
The major contribution of this work was the analysis of the contact interaction in a more complex case of a compressor blade entering in contact with its casing during rotation. The algorithm allows to compare how the dynamics of the engine is impacted. The influence of the reduction method on the obtained results clearly proved its advantages on large structures and complex finite element models. Interesting results have been observed when the response at the leading edge and at the trailing edge were compared (both in time and frequency domain). For instance, by increasing the rotation velocity, the interaction between the response and the harmonics amplified the frequency response up to a certain point where the harmonics and the response are fused together. After what the response suddenly dropped. This nonlinear behaviour retrieved thanks to the developed tool can be considered as a last validation proving its robustness.



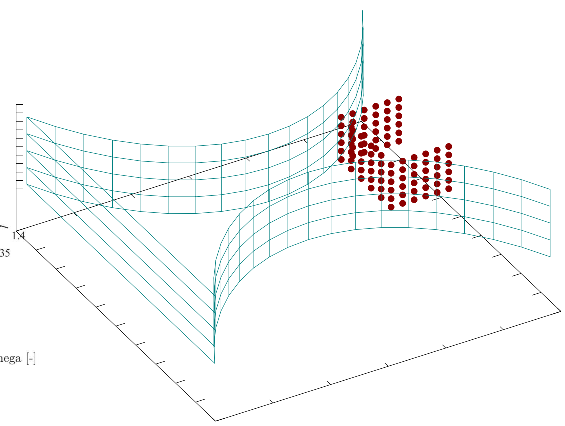
(a) Compressor blade.



(b) Displacement of the trailing edge of the blade.



(c) Response of the trailing edge of the blade for different rotation velocities.



(d) Graphical display of the first test case inside the tool.