Numerical Modelling and Simulation in Rotordynamics

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ABSTRACT

After more than a century, rotordynamics is still a field in which research is very active. The basic phenomena are well understood, but there are many aspects still needing theoretical work, while the theory is applied to build models of ever increasing complexity. The deviations from 'classical' rotordynamics are mainly in the introduction of nonlinearities, the detailed study of the simultaneous presence of deviation from isotropy of rotating and nonrotating elements and the consideration of nonstationary working conditions. These studies are usually performed by numerically simulating the behavior of the system in the time domain, and hence require very powerful computers.

The need for advances in rotordynamics is felt in various fields of technology, owing to a trend towards lighter, more powerful and more efficient machines and to the need of containing construction and operating costs. A more efficient use of high strength material, for example, results in machines which are more compliant and more prone to vibrate, while the tendency to increase the operating speed of many machines increases the productivity and contains costs, but aggravates rotordynamic problems.

Rotating machinery increasingly incorporate transducers, actuators and control systems, moving towards what goes under the general name of 'intelligent' machines. One of the aspects of this trend is the use of active bearings, as magnetic bearings. The dynamics of machines running on active bearings is a field in which rotordynamics and control science must deeply interact and this is a field in which a strong research work is under way and will keep busy many research groups for a long time.

In all these applications of rotordynamics simple models which allow to obtain closed form solutions are replaced by much more complex numerical models. The growing power of computers allows to build models with thousands of degrees of freedom, and to use them to obtain both frequency domain and time domain solutions. These complex models are needed to obtain precise prediction of the dynamic behavior of rotors and to perform numerical experiments even before the machine has been built. However, the analyst must always remember that any model is only an approximation of real world and that its validity can be assessed only in that the results obtained apply to the physical system under study. A model which is too complicated to be effectively used may be a very interesting (and costly) exercise, but is just waste of time and money. Models must not only be built, but also validated, used and updated.

Keeping this in mind, the possibility of experimenting on a machine which has not yet been built, introducing design changes before actually having the prototypes in the lab and performing virtual experiments is a great tool in the hands of designers. Numerical modeling and simulation of rotors is a powerful tool but the end results are, as always, in the hands of its user.