Development of efficient flexible multibody techniques for rotordynamic systems including rotors and supporting structures

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Abstract

A correct prediction of the rotor-supporting structures interaction is very important in turbomachinery to identify safe operative conditions [1] and to avoid unstable operating range. For this reason, the understanding and the accurate modeling of the complicated dynamic phenomena characterizing the complete rotor machines-support structure system represent a critical issue in the rotordynamic field and involves always increasing investments to better investigate the physical phenomena behind this interaction.

The whole rotating machine comprises three main components [2]: rotors, bearings and supporting structure. However many research activities have been focused in this years on the study of single components without taking into account the whole system assembly. The spreading of turbomachinery plants in very different fields, like off-shore installation, where the baseplates have enhanced flexible characteristics, leads to the necessity of a more complete point of view on the whole rotordynamic plant.

The aim of this study is to develop a flexible multibody approach based on suitable finite element method techniques, able to efficiently and accurately describe the whole rotordynamic assembly. To achieve an effective description of the rotordynamic phenomena, the research activity focuses on the use of innovative modal reduction techniques starting from the classical baseplate FEM matrices (mass, stiffness and damping matrices). Due to the growth of the complexity of the analyzed system the new approach aims also at reducing the calculation times and, at the same time, guarantee the minimum lack of accuracy.

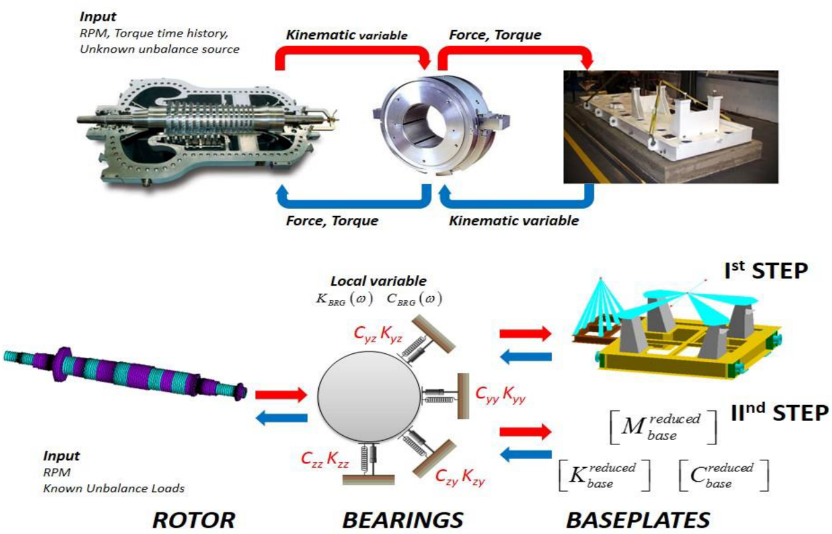

Figure 1: General architecture.

The general architecture of this paper (Figure 1) comprises two main steps:

1. an accurate model of the rotor-bearing-foundation system, described as flexible multibody assembly and characterized by good accuracy and low efficiency;
2. the introduction of the innovative reduced formulation of the supporting structure [3] [4] [5], instead of a full FEM representation of the component, in order to reduce time of calculation.

In particular, in the second step, the rotor and the bearing model do not change with respect to the first model (the supporting structure is the real focus of the study). The new modelling strategy (the second step) has been validated through a comparison with the full representation obtained with the finite element method and with experimental data.
The new approach aims at highlighting the mutual interaction between the three main components of this model: rotor, bearings and elastic support [6]. The rotor, under different unbalanced configurations during the frequency sweep in the operative field of the real plant, exchanges with its bearings all the relative kinematic variables (translations and rotations) and, consequently, the bearings react with forces and torques. Through the bearings, the elastic supporting structure (see Figure 1) influences the dynamic response of the whole system, amplifying the displacements near its proper resonances and modifying the dynamics of the rotating element.
The new approach showed a good level of accuracy and a good compromise in terms of numerical efficiency. The good numerical performances will allow the new strategy to be applied to more complex plants including several rotating machines.

The presented approach has been developed and validated in cooperation with General Electric (GE Oil&Gas) plant. The industrial partner supplies the description of the centrifugal compressor (multistage, horizontally split, centrifugal compressor, MCL) to be modelled, the technichal support during the pre and post processing phase [7] and experimental data to validate the approach.

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