Non-Axisymmetrical 3D Element for FEM Rotordynamics

Mario Silvagni
Giancarlo Genta
Andrea Tonoli

Mechanics Department and Interdisciplinary Mechatronics Laboratory
Politecnico di Torino
C.so Duca degli Abruzzi, 24 – 10129 Torino – Italy

ABSTRACT

The simplest way to model a rotor is to consider it as a beam-like structure even when using the Finite Element Method (FEM). The elements used are simple beam and concentrated mass elements, the latter with their moments of inertia accounted for to take into account gyroscopic effect. This approach leads to very compact models, useful when performing preliminary computations, but sometimes not detailed enough for a precise analysis of complex rotors. Standard FEM codes might also be used, but they usually do not take into account gyroscopic and centrifugal stiffening effects.

When the rotor is geometrically isotropic, it is possible to resort to axi-symmetrical elements with displacement field expressed by a Fourier series along the rotation angle, greatly simplifying the problem. The element described in the present paper is a fully three-dimensional element which takes into account all effects encountered in rotordynamics.

To validate the element a MATLAB code was developed and used for studying simple models. The aim of the code is not to write an optimised algorithm for computation but only to obtain a preliminary, easy to implement, tool for basic tests. A comparison with analytical solutions and with result typically obtained from commercial codes.(when possible) was performed computing the static response of simple three-dimensional solids (a cube and a beam), static centrifugal behaviour (centrifugal stiffening) for a solid beam and an annular ring, the dynamic response for non-rotating and then rotating solids (a beam and a ring). The results showed very good accordance with the closed form solutions and only small differences with the FEM results, manly due to a different formulation of the shape functions (commercial codes use *corrected* shape functions that are not implemented in the present code used for validation).

A further more complete series of validation tests on other typical application will be performed together with the implementation of more efficient numerical algorithms to deal with more complex models with a larger number of degrees of freedom.