Node-dependent kinematics elements for the analysis of FGM rotating structures

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The analysis of rotating structures is still a challenging topic for the computational mechanics. Rotors are composed of different structural components. They may have two main components: the shaft and one or more discs. The analysis of such structures requires models able to describe the behavior of both these components properly. The increasing complexity of advanced materials, such as composite or functionally graded materials, the complex geometries and the complex boundary conditions have pointed out that classical structural models could lead to inaccurate results. The use of three-dimensional models, in many cases, is the only approach able to deal with realistic configurations but it requires a huge computational cost.

The introduction of refined structural models allows the limitations introduced by the fundamental assumptions of the classical models to be overcome. Refined one-dimensional models have been used in the rotor-dynamic analysis [1], and the results showed that a quasi three-dimensional solution could be obtained. A unified approach for the derivation of advanced models has been proposed by Carrera and exhaustively presented in [2]. The use of refined models over the whole rotor requires more computational costs than those necessary. While the shaft geometry fulfills the classical beam models assumptions, the disks may have large out- and in-plane deformations that can be detected only using refined one-dimensional models. The best solution would be to use refined models only in the region in which they are required and classical models elsewhere, as shown in [3].

The node-dependent kinematics models used in this work permits to consider a Finite Element with a different kinematics at each node of the structure. If a two-nodes one-dimensional finite element is considered, the kinematic assumptions used at node 1 can be different from those used at node 2. These models have been extended to the rotor-dynamics analysis of composite structures with the following advantages: an increase of the accuracy of the model only in the part of the structure where it is required, the connection of elements with different kinematics, the accurate modeling of composite and functionally graded materials. The outcomes show how, the use of node-dependent kinematic models, can lead to a reduction of the computational costs of the model if compared with those with a uniform kinematic. At the same time the accuracy of the results can be preserved locally just in those areas of the models where an accurate description of the displacement fields is required.

References

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