Towards a predictive and comprehensive analysis of nonlinear vibrations in jointed gas-turbine structures

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Abstract

The gas-turbine engine and other critical machinery industries need high-fidelity predictive techniques to make the structures reliable and efficient while reducing expenses for their development. The problem of a replacement of the experimental investigation by 'virtual', numerical, experiments is already set as a challenge by the industries with an ultimate goal of massive reliance on numerical predictions, when making design decisions.

Gas-turbine engines and turbomachines for power are assembled structures, interacting at contact interfaces, which are nonlinear due to friction forces, variation of contact areas, closing and opening of clearances and interferences, etc. Yet, although high-accuracy finite element models are customarily used in analysis of linear structures, there have been no efficient predictive tools when nonlinear steady-state vibrations are involved.

To meet this challenge, a methodology is developed by the author for comprehensive and efficient analysis of steady-state forced response for structures with friction, gaps and other nonlinear contact interfaces. The methodology is generic and can be applied to a wide range of structures: bladed discs, rotors, casings, and other jointed machinery structures.

The major components of the methodology are discussed, including new friction contact modelling and methods for effective numerical analysis and optimization of strongly nonlinear models containing millions of degrees of freedom in presence of inevitable uncertainties of design parameter variations.

Examples of numerical studies are given to illustrate the accuracy and efficiency of the methods developed.