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RESONANCE PEAK VIBRATIONS OF NONLINEAR STRUCTURES WITH FRICTION INTERFACES: SENSITIVITY ANALYSIS AND OPTIMIZATION

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ABSTRACT

Machinery structures are mostly assembled structures which components interact through contact interfaces. Forces occurring at these interfaces are essentially nonlinear due to the friction, presence of clearances and interferences, variation of actual contact area during vibrations, etc.

Periodic loading excites in many industrial applications steady-state nonlinear vibrations. Forced response levels at resonance peaks and values of the resonance frequencies of these vibrations are of particular interest since the resonance peak vibrations are usually defining in a choice of parameters of a dynamic structure. For many structures, resonance vibrations are the major cause of failures and, therefore, they need to be avoided or damped. Besides, there are machinery structures which are required to operate at regimes close to the resonances and, therefore, for such structures, the resonance conditions need to be achieved and maintained.

In this paper effective method is proposed in order to calculate sensitivity of the resonance forced responses to variation of the design parameters of a structure. Special emphasis is made to determination of the resonance peak sensitivities to parameters of friction contact interfaces, such as, friction coefficients, clearance and interferences values, and stiffness coefficients due to roughness of contact surfaces.

The method allows calculation of the resonance peak frequency and response levels directly as function of one or several design parameters of interest for structures with friction contact interfaces. The sensitivities can be calculated simultaneously with calculation of the resonance peaks frequency and response level as a function of a parameter of interest within any parameter variation range required.

Steady-state resonance peak regimes are calculated in frequency domain using multiharmonic balance formulations for the equations of motion (see Refs.[1]-[4]). All expressions required for calculation of resonance peaks, tracing of the solutions with parameter variation and determination of resonance peak sensitivities are derived analytically which ensures exceptionally fast and accurate analysis.

High efficiency of the direct parametric analysis of the resonance peaks allows

development of efficient algorithms, which are aimed at search for the optimum values of contact interface parameters providing required resonance peak characteristics for structures with friction contact interfaces. The global optimization problem of is formulated and solved in this paper.

The methodology developed is demonstrated on a representative set of examples, which includes practical test cases using large-scale finite elements models with 10^5-10^6 degrees of freedom.

REFERENCES

[1] Petrov, E.P., "Direct parametric analysis of resonance regimes for nonlinear vibrations of bladed discs", *Trans. ASME: J. of Turbomachinery*, Vol.129, pp.495-502, (2007)

[2] Petrov, E.P., "Sensitivity analysis of nonlinear forced response for bladed discs with friction contact interfaces", *Proc. of ASME Turbo Expo 2005*, June 6–9, 2005, Reno-Tahoe, USA, GT2005-68935, 12pp

[3] Petrov, E.P. and Ewins, D.J., "State-of-the-art dynamic analysis for nonlinear gas turbine structures" *J. of Aerospace Engineering, Proc. of the IMechE*, Part G, vol.218, No G3, pp.199-211, (2004)

[4] Petrov, E.P., "A method for use of cyclic symmetry properties in analysis of nonlinear multiharmonic vibrations of bladed discs," *Trans. ASME: J. of Turbomachinery*, Vol.126, pp.175-183, (2004)