Sensitivity analysis of a large-order nonlinear dynamical rotor system with parametrical uncertainties

†Jin Huang[1,2] *Yuefang Wang[1,2]

[1]Department of Engineering Mechanics, Dalian University of Technology, China.
[2]State Key Laboratory of Structural Analysis for Industrial Equipment, Dalian, China

*Presenting author: yfwang@dlut.edu.cn
†Corresponding author: huangjinysf@163.com

Abstract

Current research on rotor dynamics is mainly focused on deterministic system with known mass and stiffness parameters. In reality, the parameters of a rotor are likely to be random due to uncertainties in terms of material, structural features and environmental effects. It is practically too costly to establish an exact probabilistic model of these uncertainties based on onsite data collection and assess the dynamics of the system via random vibration analyses. Alternatively, one can choose the interval analysis method to evaluate the system response using non-probabilistic analyses with limited prior knowledge of uncertain but bounded random parameters. This method resorts to the first-order Taylor series of interval parameters for the dynamical responses. However, in the case when parametric uncertainties are fairly large, the response region obtained with the first-order interval analysis method may fail to predict the real region of the dynamic response of the uncertain system.

To circumvent the drawback of the existent method we proposed an improved approach to predict the system response considering bounded parametric uncertainties. In this approach, the uncertainties in terms of intershaft stiffness and mass unbalance are considered. We solved the system response with sampled data generated in the parameter space, and then established an explicit response surface to express the key sensitivity information of the system behavior with respect to the parameters in the interval space. For full applications of the approach to a large-order nonlinear system, one may reduce the system into a lower dimensional one in the first place. In this study, the nonlinear Galerkin method was implemented to perform the model reduction to speed up the reanalysis process. A sensitivity analysis of parameter was carried out on the reduced system subsequently. Compared with the Taylor series-based method, it can be concluded that the proposed method can avoid overestimating of the dynamic response region of the uncertain systems, yet it does not introduce considerable computational expense to large-order nonlinear rotor systems.

Keywords: Parametric uncertainties, response surface, interval analysis, rotor system