Dynamics Analysis of Flexible Beam Systems with Stochastic Uncertainty and Thermal Coupling Effect

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Abstract. A polynomial chaos transfer matrix method of multibody systems is proposed to study the dynamics of flexible beam system with stochastic uncertainty and thermal coupling effect. Based on the floating reference frame and nonlinear elasticity theory, the transfer equations and transfer matrices of flexible beams and the corresponding hinges with thermal effect are derived firstly, and then according to the topological structure of system, the overall transfer equation of system can be assembled easily by using these transfer equations of elements. These transfer equations and coupled transient heat conduction equations, are all uncertainty equations when considering the stochastic parameters. The nonintrusive polynomial chaos method is used to solve above uncertain model. The numerical simulation is also presented to validate the correctness, feasibility and computational efficiency of the proposed method.

Introduction

The dynamic analysis of modern mechanical systems usually involves in coupled multidisciplinary, such as heat, fluid, electromagnetics and multibody dynamics. The mathematical modelling of multibody system and involved physical fields is a prerequisite to obtain the system dynamics. When considering the uncertainties existing in geometric/material parameters, boundary/initial conditions, loads and so on, these mathematical equations are uncertain equations, whose numerical solution is more difficult and time-consuming compared with the deterministic model. How to deduce a feasible uncertain mathematical model of multibody systems with multifield coupling effect, and then carry out an efficient and accurate uncertain evaluation on the dynamics of system is one of the key problems and research hotspots in the field of multibody dynamics. In this paper, taking a flexible beam system with stochastic parameters and thermal effect as an example, a novel efficient method for dynamics analysis and uncertain quantification will be studied.

Simulation and Conclusions

The dynamics simulation of a hub-beam system with parameter uncertainties and thermal effect shown in Fig.1 is given by the proposed method. The hub 1 rotates with a specified angular velocity about the *oz* axis. The upper surface of beam 3 is affected by the heat flux. The density, Young's modulus, specific heat, thermal conductivity coefficient, and thermal expansion coefficient of beam 3 are regarded as stochastic parameters with uniform distribution. The dynamics model of flexible beam system with thermal effect and stochastic parameters is deduced by the transfer matrix method of multibody systems, and the involved matrix order is low, which is independent of the DOFs of system. The transient heat conduction equation with stochastic parameters is obtained by the finite element method. The nonintrusive polynomial chaos method [2] is used to solve above uncertain model. Due to the existence of parameter uncertainty, the tip transverse deformation of the beam 3 is also not deterministic. The characteristics of low matrix order and high computational efficiency of the transfer matrix method of multibody systems is significant for improving the calculation efficiency of uncertain analysis.

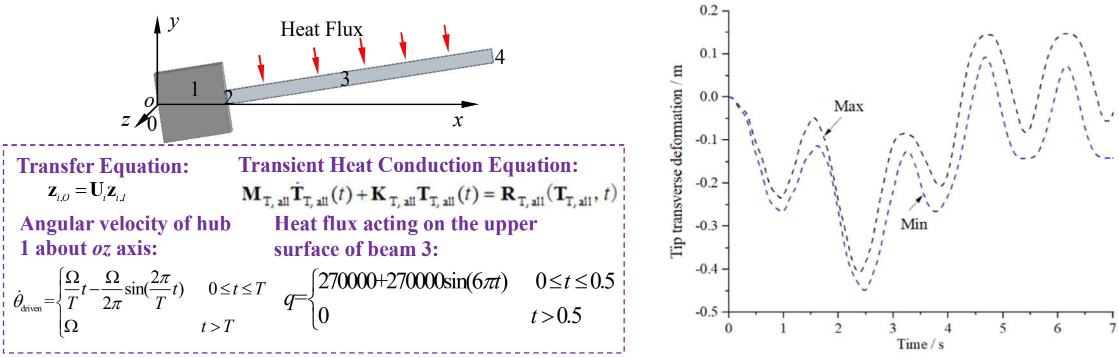

Figure 1: Hub-beam system with stochastic parameters and thermal effect.

The research received the support of the Natural Science Foundation of China (Grant No: 11702292).

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