Global characteristics of solution domain structure and basins of attraction of gear systems

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1. Introduction

Gear transmission is widely used in the industrial equipments such as aviations, ships and automobiles. The vibration characteristic is an important element to ensure the performance of gear transmission. In this paper, the global characteristic analysis of the gear system is performed by using cell mapping technique. The discrete method is applied to comprehensively analyze the solution domain information and the state spaces, and the investigation will be helpful for the gear vibration control and dynamic load sharing design.

Scholars have paid close attention to the nonlinear global vibration behavior of gear systems in recent years. Chen Dailin et al investigated the influence of backlash on the global stability of gear system, especially considered the evolution of the basins of attraction near the saddle-node bifurcation and boundary crisis. Based on the Melnikov method, Farshidianfar and Saghafi studied the homoclinic bifurcation and chaotic migration paths of gear system, and determined the chaotic control parameters. The various dimensional parameter domains and initial conditions are explored based on global analysis, the solution domain structure is adopted to reveal the bifurcation structure and potential chaotic rotue. The basins of attraction reflect the sensitivity of the system vibration to the initial conditions.

2. Results

For examining the global dynamic characteristics of gear system, a nonlinear dynamical model of cylindrical gear system is formulated, numerical algorithm which can explore the discretization cell domain of parameter space and state space is deduced based on Cell mapping techniques. Two dimensional parametric solution domain structure constructed by damping ratio with general transmission error, mesh frequency and backlash are calculated, global evolution features of steady solution domain structure, period doubling bifurcation cascades as well as chaotic regions are analyzed. The bifurcation routes inside solution domain structure generated under damping ratio excitation are tracked by adopting bifurcation diagram and largest Lyapunov exponents, these of which demonstrate the validity of solution investigations. The boundary trajectory of cell domains is calculated, and global characteristics of basins of attraction are discussed for damping ratio at 0.02, 0.03 and 0.04 respectively, it reveals that basins of attraction performance with remarkable fractal characteristics and mainly concentrates in certain region; global expansion and convergence behaviors of basin of attraction of period 1, period 4 and chaotic attractors are explored, the results show that initial condition characteristics of basin of attraction is sensitively under damping excitation, multiple attractors coexisting happens significantly.

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