Nonlinear dynamic characteristics and four contact states of a spur gear pair considered tooth profile error and extended tooth contact

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Abstract. The actual tooth profile of a spur gear will inevitably deviate from involute tooth profile due to the machining error, and so on. The nonlinear characteristics and contact state of the gear transmission system will be changed by tooth profile error, and the system stability will be affected accordingly. A dynamic model of spur gear pair is established by considering tooth profile error, extended tooth contact, and some time-varying parameters. Tooth profile error and extended tooth contact are directly involved in the calculation of the dynamic meshing force. Besides, the five Poincaré mapping sections Γi and corresponding triggers are established to capture the information on motion type, extended teeth contact, tooth disengagement, and tooth back contact of the system. Finally, the bifurcation characteristics and four contact states of the system are studied by using the established Poincaré mapping sections, bifurcation diagrams with multi-mapping sections and phase portraits.

Introduction

The system bifurcation, chaotic motion, and other nonlinear behavior in the gear transmission system will be induced due to tooth profile error [1, 2], and the system will also occur tooth disengagement and tooth back contact [3]. Meanwhile, the extended tooth contact caused by tooth profile error and tooth contact deformation will further complicate the nonlinear characteristics and contact state of the system [4, 5]. In the published literature, most scholars focused on the meshing excitations and nonlinear dynamics characteristics of the system considered tooth profile error [1-3], or the meshing excitations considered extended tooth contact [4, 5]. Tooth profile error and extended tooth contact are rarely considered simultaneously in the studies of nonlinear dynamic characteristics. The four contact states of the system, including tooth disengagement, back tooth contact, approaching tooth contact, and recessing tooth contact, were also not revealed. However, both the nonlinear characteristics and contact state of the system are critical to the transmission quality of the system.

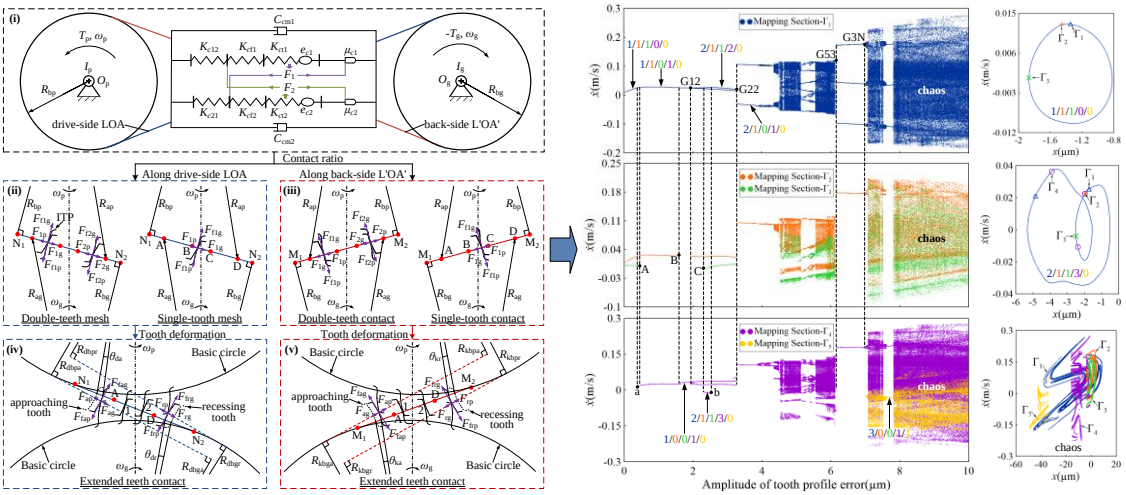

Figure 1: The dynamics model and calculation results.

Results and discussion

The established dynamics model and representative calculation results are shown in Fig. 1. The calculation results show that with the increase of the amplitude of tooth profile error, the system will go through the stable periodic motion, the alternation between periodic motion and chaotic motion, and unstable chaotic motion, as well as tooth disengagement and tooth back contact will also occur in turn. The contact of extended teeth is also changed because of system bifurcation, tooth disengagement, and tooth back contact.

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