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Influences of carrier assembly errors on the dynamic characteristics for wind turbine gearbox

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ABSTRACT

Due to the existence of assembly errors, the dynamic characteristics of planetary gear system could be changed compared with the original ideal design. Considering the assembly errors of component, a bending-torsional-pendular coupled vibration model of the 1st helical planetary gear system in wind turbine gearbox was built using lumped parameter method. Then the variable step Runge–Kutta algorithm was applied to solve the dynamic model of helical planetary gear system. The effects of carrier horizontal assembly error, carrier axis assembly error and carrier spatial assembly error on the dynamic characteristics were investigated. Results show that the influence of carrier assembly error along the z-axis on the variations for DTE response of the system is worse than other axis error cases. The carrier assembly errors along the different directions tend to make the dynamic responses for dynamic mesh forces (DMFs) larger. The frequency responses for DMFs of helical planetary gear system are influenced comprehensively by carrier assembly errors along the different directions. The frequency positions of DMFs are reduced under carrier spatial assembly errors (<2000 Hz).

1. Introduction

As the major economic cost part of the wind turbine, the gear transmission system has a major influence on the stability and reliability of the whole wind turbine system. Due to the existence of different types for assembly errors in wind turbine gearbox, the reliability and operating life of wind turbine are affected a lot. However, very limited previous research work was performed on the effects of assembly errors on the dynamics for helical planetary gear system used in wind turbine gearbox. Therefore, the influence of different assembly errors on dynamic characteristic of helical planetary gear system is essential in the design of wind turbine gearbox.

Currently, numerous studies have been conducted on the dynamic characteristics for planetary gear system. Bahk et al. studied the response characteristics of planetary gear system considered the tooth separation [1]. The nonlinear characteristics of the 2D planetary gear system were researched by Ambarisha et al. [2]. The modal characteristics of three-dimensional planetary gear system were studied by Parker et al. [3]. The modal characteristics of a three-dimensional double helical planetary system were researched by Kahraman et al. Then based on a lumped parameter dynamic model, the spectrum characteristics of planetary gear system were analyzed [4,5]. Gu and Velex studied the load ratios and component trajectories of planetary gear system under the position errors and eccentric errors [6,7]. Zhang investigated the influence of eccentric error on the load of spur planetary gear system [8]. Considering time-varying gear mesh stiffness, synthetic mesh error, the influences of random transmission errors on the vibration responses and gear dynamic mesh force were analyzed by Qin et al. [9]. Li et al. studied the influences of

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gear backlashes and damping on the nonlinear bifurcation characteristics of planetary gear system [10]. Zhu et al. studied the influences of assembly errors on the gear contacts and dynamic responses of beveloid geared rotor system. And the dynamical characteristics of the flex-pin wind turbine gearbox were investigated [11,12]. Based on the multi-body dynamic model of helical planetary gear transmission system, Zhang et al. studied the influences of circumferential assembly errors on the dynamic characteristics of helical planetary gear train [13]. Qiu et al. reviewed the dynamic researches for planetary gear transmission system of wind turbine gearbox [14]. Xu et al. analyzed the influences of pin stiffness and pins error on the load sharing of planetary gear transmission system with flexible pins in wind turbine gearbox [15]. However, little discussed the effects of carrier assembly errors (CAEs) on the dynamic characteristics for helical planetary gear system.

In this paper, a bending-torsional-pendular coupled vibration model of the 1st helical planetary gear system in wind turbine gearbox was built using lumped parameter method. And the typical assembly errors were defined based on the structure analysis and actual assembling process. Then, the influences of CAEs on the dynamic characteristics for helical planetary gear system were analyzed.

2. Transmission principle and the definition of assembly error

2.1. Transmission principle of wind turbine gearbox

The high-power wind turbine gearbox is composed of two planetary gear transmission stages and one parallel transmission stage. The diagram of transmission system is shown in Fig. 1. In Fig. 1(b), 1, 2, 3, 4 characterize the ring gear, planet gear, sun gear, carrier of the 1st stage, respectively. 5, 6, 7, 8 denote the ring gear, planet gear, sun gear, carrier of the 2nd stage, respectively. 9 and 10 are the wheel and pinion of the 3rd stage, respectively.

The 1st planetary gear stage consists of five uniform helical planet gears. The input torque was applied on the carrier of the 1st transmission stage and the 2nd transmission stage was driven by the sun gear of the 1st stage. Finally, the power was transmitted to the generator by the pinion of the 3rd parallel transmission stage.

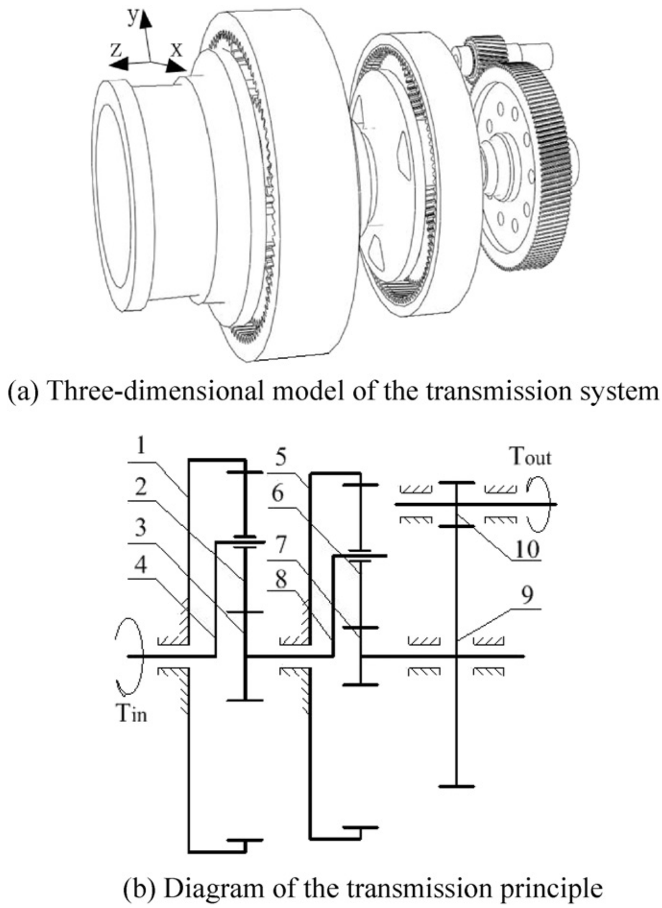

Fig. 1. Structure of the wind turbine gearbox transmission system.