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Investigation of the dynamics of gear systems with consideration of a pinion support flexibility

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Abstract

The results of the study of gear systems dynamics with flexible pinion supports are shown in this paper. A periodic change of stiff meshed gears in elastic systems vibrates with all the natural frequencies and forms proportional differences in stiffness in the areas of the two pair and single-pair engagement. Parametric excitation in the elastic system with the gear wheels are made possible at resonance frequencies of excitation equal to an integer multiple of the number of times less than all frequencies of the system. It has been shown that the use of optimal multi-pith in the gear system reduces vibrations.

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Keywords: tooth, gear system, multi-pitch, shaft, flexibility, support, vibration

1. Introduction

The main cause of failure of gears in multipliers and gearboxes of different schemes is increased voltage variables due to resonance oscillations of complex mechanical systems [1-2].The experimental analysis of the mechanism and the ways to reduction stresses in the elements of gears was devoted to a series of works in our country and abroad [3-5]. The main reason for vibrations or oscillations of gears is the change of the stiffness of the teeth in the meshing process [6-8]. With one pair of engagement, periodic entering into engagement zone and out from it is - one and the two pairs of teeth, the stiffness of the engagement changes discontinuously and all the elastic systems with gears which belong to this elastic system, which lead to its excitation [9].

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A series of analytical studies to determine the cause of the dynamic processes of excitation of vibrations of gear wheels and the influence of manufacturing precision of the profile of the teeth on the vibration level has been done [10-13]. Recently, a large number of works devoted to the investigation of nonlinear processes in gear systems [14-19]. Influence of manufacturing errors of the dynamics of gear systems is discussed in the work [20].

The elastic model of gear systems with consideration of support flexibility was considered in work [21] and the influence of support flexibility on parametric dynamics of gears was also evaluated.

2. Problem definitions and assumptions

Consider the dynamics of a pair of gear wheels with a gear on the elastic support shown in Fig. 1. For simplicity, we will assume that the wheel gear is rotating freely in a uniform motion, inertly and does not react to dynamic excitation from the side of the teeth. Then we get a single-mass torsional system on a pliable support, i.e. one mass with two degrees of freedom. We will take the assumption that gaps are absent in the links, and damping is neglected.

When one-pair of meshed gears has the most powerful agent of dynamic processes in the meshing process – a periodic occurrence in and out of the zone of engagement of one or two pairs of teeth will have approximately two times the change in the stiffness of the gear.

We determine the characteristics of the excitation at intermitting teeth of elastic models proposed by one gear pair by taking into account the compliance of the pinion bearings (Figure 1).

For simplicity, we will take an example of the wheel gear pair which rotates uniformly and very inertly, it also does not respond to dynamic excitation from the teeth. Through this we obtain a single-mass torsional system compliant support, i.e., one mass with two degrees of freedom. We take the assumption that there are no gaps in the meshes, and damping is neglected.

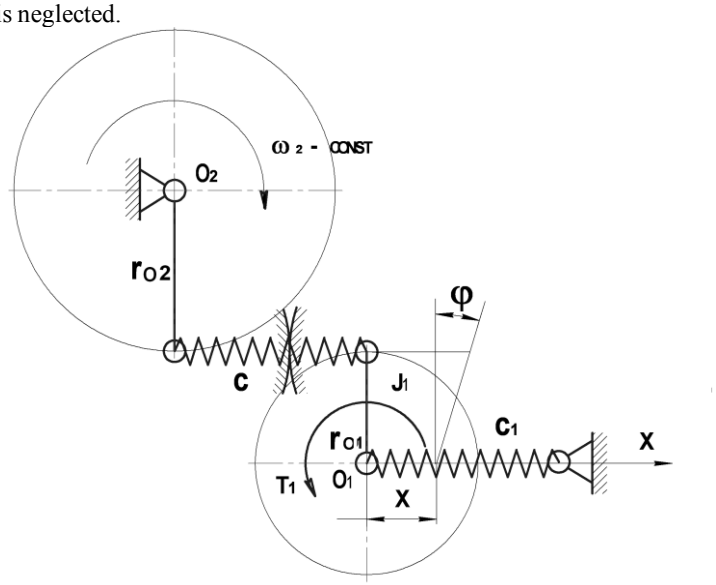

Fig. 1. Driving gears in a compliant support.

3. Calculations

The equations of motion of the elastic element systems are in the form of rotation and translation of the pinion

$$J_1 \cdot \ddot{\varphi}_1 = -\varphi_2 \cdot r_{O1}^2 \cdot C - x_1 \cdot C \cdot r_{O1}; \quad (1)$$

$$M \cdot \ddot{x}_1 = -x_1 \cdot C_1 - C \cdot x_1 - C \cdot \varphi_1 \cdot r_{O1}.$$