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Determination of Maximum Damping Efficiency based on Electric Drive Vibrations of Elastic Mechanisms

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Abstract

The main factors that determine maximum values of elastic mechanical vibrations of operating machines with an electric drive were detected. The efficiency of different ways of vibrations passive damping of elastic mechanisms was reviewed. The conditions were determined and recommendations about the choice of parameters of electric drives ensuring minimum dynamic efforts in springy elements of mechanical gears were given. It was found that damping of vibrations in the elastic mechanisms caused by changing of disturbing effort by the electric drive is the most effective if the resonant frequency of mechanical vibrations is in the range of frequencies of electric drive dropping. The estimation of marginal efficiency by the electric drive of vibrations in elastic mechanical gears has been performed, the areas of reasonable application of damping devices and the electric drive for the reduction of dynamic efforts in springy elements of mechanical gears were defined. The practical implementation of the proposed recommendations has been carried out for the MP100 type balanced manipulator.

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Keywords: electric drive; efforts control; speed restriction.

1. Introduction

An increase of operating machines productivity is provided due to stimulation of their electric drives (ED) operation that with elasticity of expended mechanical gears and designs reduces reliability and durability of their operation [1]. Studies have shown that dynamic loads of elastic mechanisms considerably exceed their values in a steady operating mode [2]. Elastic mechanical gears provide the increase in the vibrations amplitude of controlled coordinates of ED, help to increase dynamic loads of mechanisms, lead to accumulation of fatigue voltages that

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causes progressive wear of operating machines, unplanned equipment downtimes and also increases maintenance expenses [3,4].

In world practice, studies of ED taking into account elastic mechanical links were performed which are designed to improve the operation of rolling mills [5], papermaking machines [3,6], machine mechanisms [4,7], mine elevators [8], belt conveyors [9], crane mechanisms [10], industrial robots [11,12].

The analysis has revealed that in the industry to decrease negative impact of springy elements (SE) on working of operating machines shock-absorbers, anti-vibrators, dampers are applied which are included into mechanisms design for the reduction of elastic vibrations [13]. However, in practice, implementation of this approach leads to a rise in equipment cost, a complexity of mechanisms, an increase of their weight and dimensions. Due to it, engineers are not often able to resolve conflicting requirements to metal consumption and durability, complexity and reliability of mechanisms designs, mass-dimensional and other important indicators of the projected production machines. The studies performed in [13] have found that despite considerable additional costs of damping devices implementation they often can't provide required amplitude reduction of elastic mechanical vibrations.

Dynamic processes in electromechanical systems with elastic links (EMS with EL) are followed by power interactions during which the kinetic energy of inertial masses is converted into the potential energy of springy elements (SE) deformation of mechanical gears and constructions. Therefore, performing studies of power interactions in EMS with EL in order to define conditions and ways of ED implementation that increase efficiency of effort vibrations damping in SE of mechanisms is an actual task. [14,15].

2. Task description

The objective of studies is to detect main factors implementing on coordinate vibrations EMS with EL, to define implementation conditions of ways improving efficiency of ED application for vibration damping in SE of mechanical gears.

To solve the task with the use of the system approach, it is necessary to study electromagnetic and power elastic interactions in EMS with EL, to define the major influencing factors, to find the conditions and rational combinations of parameters of mechanisms and ED ensuring to minimize vibration of elastic mechanisms. In paper [16], it is revealed that to solve the problem of parametrical synthesis of EMS with EL, it is reasonable to use frequency methods.

3. Mathematical description

Nowadays, to review elastic-dissipative properties of mechanisms with expended mechanical gears mathematical models are widely used in the form of two-mass rated schemes which enable us to consider the main systems features of the reviewed class. The analysis of different approaches to the description of ED has revealed that at the initial study stages of EMS with EL, it is reasonable to use the simplified linearized mathematical models [16]. In the modern control theory, structural-topological methods of analysis and synthesis problem-solving of multiloop systems with use of the directed graphs are widely used. Application of Mason directed graphs [17] allows directly by the graph form EMS with EL to receive the analytical formulas establishing interrelations between any system coordinates and, therefore, to build effective algorithms of the study.

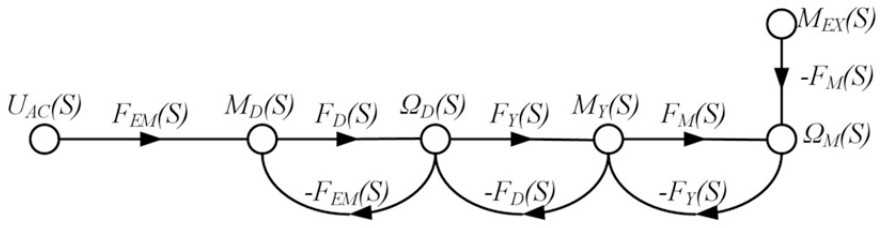

Fig. 1. Mason graph of studied EMS with SE.