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The Study of the Elastic Characteristics of the Coupling with Nonlinear Feedback When Starting the Motor

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Abstract. The most difficult moment in the work with an asynchronous motor is the launch. And the more powerful drive is the more difficult launch. This is due to certain features of the asynchronous motors: a limited starting torque and starting throws of the current of the stator motor chain. The mathematical modeling of oscillating process of actuation of the actuator with an asynchronous motor, which includes an elastic coupling with nonlinear mechanical feedback, is carried out. The influence of the type of elastic characteristics of the coupling on the magnitude of the amplitude and frequency of the oscillation process and its time was studied. A single-mass rotational system model was used for the studies. According to the Runge-Kutta method, the oscillation processes of starting the transmission of a machine unit with an induction motor were investigated. To determine the coefficient of vibration isolation, a system with an elastic coupling having a linear elastic characteristic was calculated. A study was also conducted in the case where the coupling determines the elastic characteristics of the Duffing type "soft" and "hard" type. The results of the calculations show that it is advisable to use a nonlinear coupling with a combined characteristic. On the basis of this, a synthesis of the target elastic characteristic and the study of the oscillatory process in the application of the proposed elastic coupling.

Keywords: Elastic coupling · Mechanical feedback · Oscillation process · Rotational mass · Starting torque

1 Introduction

In modern machine-building, elastic couplings with metal elastic elements have become widespread. This is facilitated by the ability of these devices not only to transmit torque, but also to prevent negative oscillations in the technical system. This is achieved by introducing into the design an elastic coupling of mechanical feedback, which provides a wide range of elastic characteristics, including also nonlinear. Studies in this direction have shown that the nonlinearity of the elastic characteristics of one of

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the components of the machine aggregate can significantly change the nature of the oscillating processes, which occur.

2 Scientific Research

Studies using mathematical model proved that elastic couplings with a nonlinear elastic characteristic show the most positive results [1]. However, already existing elastic couplings do not fully meet the stated requirements due to their narrow working range [2–4]. Up to now created potential designs of elastic couplings that implement a nonlinear elastic characteristic are not widely used due to the small number of their actual mechanical constructions.

2.1 Review of Modern Information Sources on the Subject of the Paper

At this stage, most of drives use asynchronous motors. The features of their operation, specifically the start-up of the engine, cause the considerable oscillatory load on the drive, this is due to the large and short-term starting torque. Because of this, there is a significant number of works devoted to oscillating processes in technical systems [5–9]. A mathematical modeling of the start of an asynchronous electric motor was carried out by using software packages [10, 11]. Developed the promising designs of nonlinear elastic couplings, which reduce the load on the drive and prevent negative oscillations [12–14]. The following studies show the feasibility of using elastic couplings with nonlinear mechanical feedback.

2.2 Objectives and Problems of Research

Mathematical modeling of oscillatory process of transmission starting of a machine assembly with an asynchronous electric motor, which consist of an elastic coupling with nonlinear mechanical feedback and studying the effect of elastic characteristics on the magnitude of the amplitude, frequency of the oscillatory process and its time.

2.3 Main Material Presentation

The chosen aim of the research is based on the fact that the results of the researches carried out in the field of nonlinear oscillation mechanics indicate that the nonlinearity of the elastic characteristics of one of the components of the machine assembly can significantly change the nature of oscillatory processes.

In the given research area it is believed that the starting torque M_{srart} of the asynchronous motor shaft is a torque that advances on the shaft of an asynchronous electric motor under the following conditions: the speed of rotation is equal to 0, the current has a constant value, the electric motor windings are connected to rated supply frequency and voltage, the winding connection corresponds to the rated operating mode of the electric motor.

In mathematical modeling of the oscillatory processes of the machine assembly, the starting torque $M_s(t)$ is modeled by a function of time characterized by two time

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