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Changes in the dynamics of the output characteristics of mechatronic systems with planetary hydraulic motors

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Introduction

At present, gerotor, orbital and planetary hydraulic machines are widely used in hydraulic drives of mechatronic systems of self-propelled machinery. From the point of view of self-propelled equipment, planetary hydraulic machines deserve the greatest attention, having the ability to install directly into the drive mechanisms conveyors, winches, motor wheels, etc. The main components of planetary hydraulic machines are rotor systems and distribution of the working fluid. The design of the rotor system is based on the principle of operation of a gear pair (movable and fixed rotors) with internal hypocycloidal gearing. The distribution system of planetary hydraulic machines is formed by movable and fixed distributors, which allows the formation of a rotating hydraulic field, necessary to obtain the planetary motion of the rotors. One of the disadvantages of planetary hydraulic machines is the unevenness of the output characteristics due to the pulsation of the flow of the working fluid in the distribution systems.

The quality of the mechatronic system with a planetary hydraulic motor is largely determined by the stability of the output characteristics of the hydraulic motor. In order to improve the functioning of self-propelled equipment, by predicting the output characteristics of its mechatronic systems, it is necessary to study the influence of design features of the planetary hydromotor distribution system on changes the dynamics of transients occurring in these systems.

Research methodology

To study the dynamic processes occurring in mechatronic systems with planetary hydraulic motors, in order to predict changes in the stability of their output characteristics, it is necessary:

- to develop a structural-functional diagram of a dynamic model of a mechatronic system with a planetary hydraulic motor, taking into account the design features of its distribution system;
- substantiate the initial data and initial conditions for the simulation of transients occurring in a mechatronic system with a planetary hydraulic motor, as well as the design parameters of the distribution system of the planetary hydraulic motor, affecting the change in its output characteristics;
- to study the dynamics of changes in the output characteristics of the mechatronic system with serial and upgraded hydraulic motors, taking into account t
- he design features of their distribution systems.

Results

Previous theoretical and parametric studies made it possible to identify the design features of the distribution system that affect the change in the output characteristics of the planetary hydraulic motor, as well as to justify the most rational geometric parameters of the working fluid distribution system. It was found that the most rational is a distribution system with a 7/6 kinematic scheme.

Studies of the dynamics of changes in the output characteristics of a mechatronic system with a planetary hydraulic motor were carried out using the Vissim simulation package.

The influence of the design features of a serial (fig. 1, 2 a) and modernized (fig. 1, 2 b) hydraulic motors on the dynamic processes of the mechatronic system is investigated. It is established that fluctuations in the flow area of the distribution system of a serial hydraulic motor cause pulsations of pressure (fig. 1, a – curve 1) and torque (fig. 2, a – curve 1) on the hydraulic motor shaft in the discharge line of the mechatronic system. At the time of acceleration, significant pulsations of the flow of working fluid through the safety valve are observed (fig. 1, a – curve 3), and as a result, pulsations of the flow of working fluid through the hydraulic motor (fig. 1, a – curve 2). Elimination of fluctuations in the flow area of the distribution system of the modernized hydraulic motor allows you to stabilize the values of pressure, torque and flow rate of the working fluid throughout the study of the acceleration process (fig. 1, 2 b). Under steady-state operation, fluctuations in the area of the passage section of the distribution system do not affect the nature of the change in the shaft speed, either of the modernized or serial hydraulic motors.

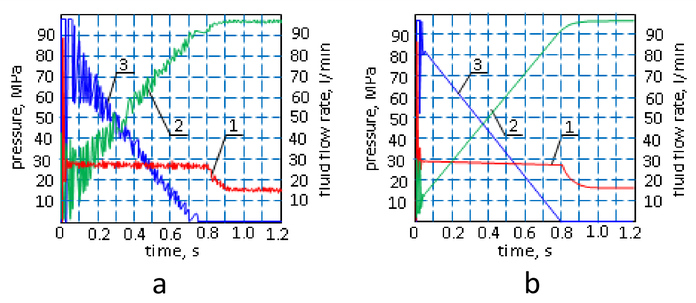

Figure 1. Dependences of pressure and flow rate in the acceleration mode of the mechatronic system: a – serial hydraulic motor; b – modernized hydraulic motor; 1 – pressure curve; 2 – curve of the flow of the working fluid through the hydraulic motor; 3 – curve of the flow of working fluid through the safety valve

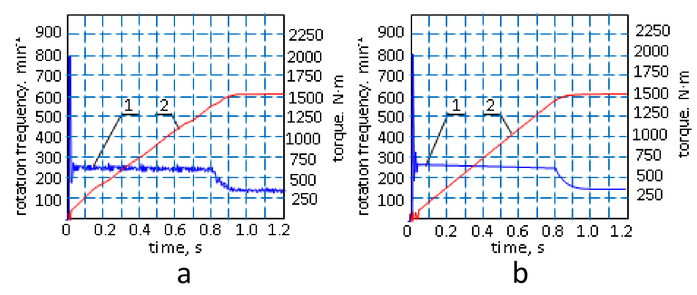

Figure 2. Dependences of changes in torque and frequency of rotation in the acceleration mode of the mechatronic system: a – serial hydraulic motor; b – modernized hydraulic motor; 1 – torque curve; 2 – curve of the frequency of rotation of the shaft of the hydraulic motor

Conclusions

As a result of the studies, a structural-functional diagram of a dynamic model of a mechatronic system with a planetary hydraulic motor was developed, taking into account the design features of its distribution system. The initial data and initial conditions for the simulation of transients occurring in a mechatronic system with a planetary hydraulic motor are substantiated. The design parameters of the distribution system of the upgraded planetary hydraulic motor, which affect the change in its output characteristics, are substantiated. The dynamics of changes in the output characteristics of the mechatronic system with serial and modernized hydraulic motors is studied, taking into account the design features of their distribution systems.

It has been established that insignificant fluctuations in the cross-sectional area of the serial distribution system (222...226 mm^2) of the planetary hydraulic motor cause significant pressure pulsations of up to 10%, flow rate of the working fluid up to 3% and torque up to 17%. Moreover, the elimination of fluctuations in the flow area of the modernized distribution system (226 mm^2) allows you to stabilize the values of pressure, torque and flow rate of the working fluid throughout the study of the acceleration process.

Under steady-state operation, fluctuations in the flow area of the distribution system do not affect the nature of the change in the shaft speed, either of the upgraded or serial motors.

The conducted studies of the dynamic processes occurring in the drives of mechatronic systems with planetary hydraulic motors make it possible to improve the functioning of self-propelled equipment by predicting the output characteristics of these systems at the stages of design, manufacture and operation.

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