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Accuracy forecasting disks manufacturing of axial power machines considering the forces at the industrial process system

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Abstract

The paper provides information on the axial displacement calculation of the hydraulic pump non-rigid disk when their dimensional processing. The radial forces accounting actions method by means of equivalent axial force has been offered. The ability of the proposed replacement was proved with experimental studies. The boundary conditions for the calculations for various disc fixing schemes during processing are presented.

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Keywords: disk, engineering process, processing accuracy, the form error.

1. Introduction

While manufacturing disks of axial power machines which are used in the chemical and oil industry, the central issue is the ability to forecast and control the errors originated in the course of their processing. The clearest and the most frequent example is the example of processing error resulting from the axial displacement of the processed disc body relative to the rim. As a result of considering the mechanism of this error the conclusion has been made that it is necessary to consider a set of factors that affect the disk body ω deflection. Some of these factors are the forces in the industrial process system.

2. Study subject

The study subject was to establish the dimensional errors forming patterns of axial power machines non-rigid disks considering the simultaneous action of all the forces in the industrial process system.

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Turning to the consideration of these forces it should be noted that the deflection value is inextricably linked with the stability of the disk body. We understand stability as the disk body ability to counteract the forces aiming to bend it in the axial direction.

As it is known, the deflection of the disk body is the most strongly influenced with force of cutting P, namely its component P_y applied axially to the disk body. The action of this force component can be measured both qualitatively and quantitatively using approaches and methods of the theory of elasticity. When assessing the action of the cutting force it is also necessary to consider that its value is a variable depending on the mode used for processing (cutting speed *v*, cutting depth *t*, supply *s*), the value of the tool wear h_3 for its back surface.

As the permissible errors for the manufacture of the disc body in the axial direction are of 0.01 - 0.05 mm to evaluate the effect of cutting forces on the processed disc a mathematical model based on the equations of the initial parameters method (IPM) was developed. The IPM equation for calculating will be the following:

$$\omega = (D\omega_0 - r^2 M_{r0}\psi_{\omega r} - r^2 M_{\theta 0}\psi_{\omega q} - P_y r^2 \psi_{\omega p})/D \qquad (1)$$

where ω_0 is deflection at the inner radius of the disk body (determined from the boundary conditions); M_{r0}, $M_{\theta 0}$ are moments acting on the inner radius in the radial and tangential directions, respectively, they are determined from the boundary conditions; *r* is the current radius, the deflection is calculated using it; $\psi_{\omega r}$, $\psi_{\omega \theta}$, $\psi_{\omega P}$ are maintainig functions [1]; P_y is a component of the cutting force; *D* is cylindrical rigidity:

$$D = \frac{Eh^3}{12(1-\mu^2)}, \qquad (2)$$

E is modulus of elasticity; μ is Poisson's ratio; *h* is the thickness of the disk body.

To determine ω_0, M_{r0}, $M_{\theta 0}$ is necessary to determine them with boundary conditions. Depending on the cross-section of the disc body different schemes may be regarded. Such schemes and boundary conditions are shown in Table 1.

In addition to cutting force the deflection is affected with the values of fastening force. Fastening forces P_{fo}, acting in the axial direction, can be assessed with increment of the argument to the power factor function in equation (1), whereupon it takes the form:

$$\omega = (D\omega_0 - r^2 M_{r0}\psi_{\omega r} - r^2 M_{\theta 0}\psi_{\omega q} - (P_y r^2 \psi_{\omega p} + P_{fo} r^2 \psi_{\omega p}))/D, \qquad (3)$$

Fastening forces P_{fp}, acting in the radial direction effect disk body resistance to deflection during processing. The influence of such forces may be different: they both reduce resistance and increase it. We consider the worst of these cases, when stability decreases (Fig. 1). This condition arises from the effects of compressing of fastening forces applied to the rim of the disc or to the outer radius of the disk body, and the tensile forces applied to the hub or to the inner radius of the disk.

As long as the fastening forces value does not exceed the critical values (till the stability loss), their action is possible and must only be regarded together with the cutting force (Fig. 2).

The action of radial fastening forces with simultaneous cutting forces component action is proposed to be considered as the action of the axial force P_E, which is determined from expression [2]:

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