methods of the rock failure at the block of stone separation from the massif; for all this, while the splitting off the planes, in which the blast holes with the plastic substance and its material are practically used, that may be coincided with the planes of other blast holes methods of the breaking.

5. It has already been found, that for the transversal fracture formation at the bottom level of the blast hole at the shock injection of the plastic substance and its material into it, it is practically required the impact energy, than for the longitudinal fracture formation along the entire length of the blast hole, having begun from its mouth.

6. It has already been found, that for the efficiency increase of the directed shock injection of the plastic substance and its material into the blast holes, the drilled through the intended spalling blocks, it is quite necessary to be increased the impact energy and to be reduced their frequency; this is due to the fact, that the internal pressure, that can be bio-accumulated just in the plastic substance and its material, by applying it to the shock, does not have enough time to be relaxed during the time between them.

7. The method and the special technical facilities of the directed destruction and the disintegration of the natural and the artificial stone have already been introduced, by the shock injection of the plastic substance and its material into the fractures from the blast holes, having drilled through the intended spalling, in the mining, and as in the industrial, well as in the civil construction and their building.

8. The method and also the installation for the laboratory works carrying out by the directed destruction and the disintegration of the natural and the artificial stone in the Institutes of higher education of the building structure have already been developed and introduced.

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THE DYNAMICAL PROSESSES ADAPTIVE STABILIZATION IN THE ROBOT ELECTRIC DRIVES CONTROL SYSTEM

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The adaptive regulator application efficiency in the electric drives control system DC of the robot manipulation link has been carried out in the study. The control system dynamics adaptive stabilization has already been implemented, by means of the direct transfer coefficient modifying of the electric drive control regulator. In its turn, this is caused the whole system simplification with the adaptive control regulator with its technical implementation. This system simulation in the MATLAB (e.g. Simulink) medium has been carried out. The comparative evaluation of the electric drives simulation systems results with the adaptive control regulator with the traditionally used coordinate regulation method has been conducted. So, it has been shown, that the electric drives adaptive control regulator in the system application is provided the manipulator's desired dynamic characteristics . The similar approach to the robot manipulators electric drives system construction can be applied to the overwhelming majority types of the commercially industrial available robots.

The degrees' electric drives of the manipulation robots mobility are subjected the variable loads, which are caused by their configuration changes in the process of the motion, the weight and the dimensions of the cargoes transported, and also by the technological factors and the others. The electric drives load can be varied within the wide limits, and be caused the significant change in the dynamical properties of the electric drive control system [1, 2]. All these systems' peculiarities and the specific features should be considered at the manipulation robots designing.

The Control Dynamics Stabilization Method

So, for example, the degrees electric drives dynamic coupling of the mobility for the flat manipulator, having worked in the polar coordinate system, and having considered in the paper [3], is quite seen in the fact, that the moment of inertia of the angular displacement electric drive load of the manipulator is the variable quantity, and it is depended on the linear extension of the r hand:

$$I_n(r) = I_1 + I_{2c} + m_2\left(\frac{l}{2} - r\right)^2, \qquad (1)$$

where I_1 – the moment of inertia of the 1-st level of the manipulator, relative to the axis of rotation I_1 = const; I_{2c} – the moment of inertia of the 2-nd level of the manipulator, relative to the central axis, which is parallel to the axis of rotation. The inertial load variability of the angular position of the electric drive, due to the changes of the manipulator's linear position, is resulted in the quality worsening of the control process by it. This is the well – known challenge, which can be solved, for example, by a certain way, the manipulator's dynamics stabilization.

Here, in order to be improved the further quality improvement of the control process, in the result of the interaction reducing of the manipulator's electric drives, is proposed to be used together with the traditional coordinate control by the manipulator of the optimal adaptive regulator. So, the adaptive regulator implementation is carried out by means of the separate unit, which depending on the manipulator's configuration, automatically, according to the expressions for the values of the gain coefficients in the main chain of the electric drive feedback, it, moreover, is calculated the value of the correction adaptive signal. The adaptive signal is supported the optimal specified value of the gain coefficient, and, simultaneously, it is stabilized the gain coefficient of the electric drives system.

The Improvement of the Method

The present paper is dealt with the adaptive stabilization challenge solution, by the method further improving, having described in [3], the adaptive control method, and the study of its efficiency, by quality further improving the quality of the dynamical processes flow in the electric drives control system DC of the robot manipulation link. The adaptive control implementation is not in the chain of the feedback position (e.g. with the simultaneous stabilization of the system gain coefficient), is one from the further improvements, and by means of the direct transfer coefficient modifying of the electric drive control regulator, that is caused the system simplification with the adaptive regulator and its technical implementation.

Then, in accordance with the method [3] and with due regard for the expression (1), the optimal values of the variable gain coefficient in the direct chain of the electric drive angular movement of the hand, depending on its linear extension *r;* are defined by the following expression:

$$k_{\varphi_i}^{opt}(r)=\left[C\left(A+B\left(\frac{l}{2}-r\right)^2\right)^{3/2}+D\left(A+B\left(\frac{l}{2}-r\right)^2\right)^{-1/2}\right]^2, \qquad (2)$$

where: $A=I_{dv}+I_p+\dfrac{I_1+I_{2c}}{z^2\eta}$; $B=\dfrac{m2}{z^2\eta}$; $C=\dfrac{2\alpha_1}{c_e\alpha_2}\left(\dfrac{R_y^3 z}{c_m^3 k_{um}}\right)^{1/2}$; $D=\dfrac{c_e}{2}\left(\dfrac{c_m z}{R_y k_{um}}\right)^{1/2}$.

Here, I_{dv} – the moment of rotor inertia of the actuating motor (AM); I_p = (0,05....0,25)·I_{dv} – the moment of reduction gear inertia, has been given to the motor shaft; z – the reduction gear ratio; η – the reduction gear efficiency; R_y – the active line resistance of the AM armature winding; c_e – the cross – ratio counter EMF motor; c_m – the AM torque coefficient; k_{um} – the transfer coefficient of the power amplifier drive; α_1, α_2 – the normalizing factors.

For the technical implementation simplification of the work algorithm (WA), it is also advisable to be carried out the non – linear expression linearization (2), by the method of the least squares:

$$k_\varphi(r) = ar + b, \qquad (3)$$

and, in this expression, the a and b linearization constants are defined for the different i-th line positions of the r_i hand, by the following correlations:

$$a=a\left(r_i,k_{\varphi_i}^{opt}\right);\ b=b\left(r_i,k_{\varphi_i}^{opt}\right), \qquad (4)$$

where $k_{\varphi_i}^{opt}$ – the gain coefficient value for the r_i value, having defined by the non – linear expression (2).

The Control Dynamics Study

In the control process quality study by the manipulator, the mathematical models of the manipulator's electric drives have been considered, in the form of the block diagrams of the automatic control system (ACS), in which the simplified transfer functions of the AM electric drives are presented themselves the ACS aperiodic links, as the DC motors with the separate excitation (DCM SE) are used, as the AM ones. For all this, the DCM SE dynamics of the electric drive of the manipulator's angular moving with the variable load inertia moment can be presented by the transfer function of the aperiodic link with the variable time constant:

$$\frac{\Omega_{dv}(p)}{u_y(p)}=\frac{k_{dv}}{T_m(r)p+1}; \qquad (5)$$

where $u_y(p)$, – respectively, the stress on the AM operator pictures, and the AM armature winding, the AM shaft speed; – the AM gain coefficient; $T_m(r)$ – the DCM SE electromechanical time constant, the manipulator's angular moving electric drive. So, the latter one is depended on the AM given to the shaft $I_{np}(r)$ drive load inertia moment, which, in the considered case, is the function of the linear position r hand:

$$T_m(r)=\frac{I_{np}(r)R_y}{c_e c_m}=\left(I_{dv}+I_p+\frac{I_n(r)}{z^2\eta}\right)R_y\Big/c_e c_m. \qquad (6)$$

Having taken into account the expression (1), we will be obtained the expression in the general form, that is characterized the dynamical effect of the electric linear movement of the servo drive for the manipulator's angular movement:

$$T_m(r) = \alpha r^2 + \beta r + \gamma \ \ [c], \qquad (7)$$

where:

$$\alpha=\frac{m_2 R_y}{z^2\eta c_e c_m}\ \ c/m^2;$$

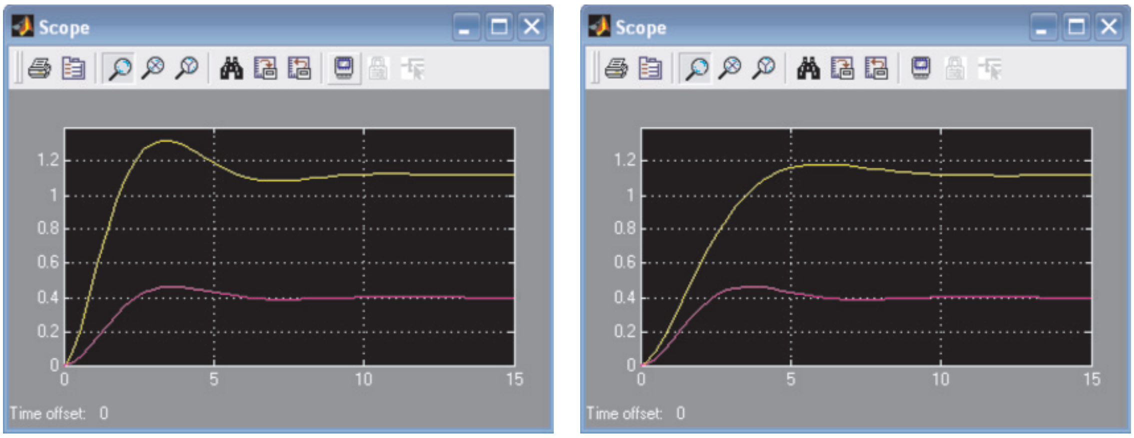
$$\beta=-\frac{2rm_2 R_y}{z^2\eta c_e c_m}\ c/m^2;$$

$$\gamma=\left(\frac{I_{dvp}+I\ \ +I_1+I_{2c}}{z^2\eta}\right)R_y\Big/c_e c_m,\ \ c.$$

The Simulation

The control process quality study by the manipulator has been made, with the help of the computer simulation in the MATLAB (e.g. Simulink) medium. In the study, the motor control systems model has been considered by the DC electric drives link robot manipulator with the adaptive regulator, in comparison with the traditional system model of the regulation to be coordinated by the manipulator with the degrees' mutual influence of the mobility.

The transient processes oscillograms have already been obtained at the electric drives systems developing with the adaptive regulator and the coordinate regulation of the stepped input influence signals, in the vicinity of the characteristic (e.g. from the point view of the drives interaction) points of the manipulator's working plane, corresponding to the maximum, average, and the minimum r hand extraction and its nomination. The value of the overshoot and the t_n transient response time have been accepted, as the criteria for the adaptive regulator impact assessing for the system's dynamic properties. So, the transient processes oscillograms for the cases with coordinate regulation and with the adaptive control regulator have already been given, for example, in the Figure.



a b

The transient processes oscillograms:
a – for the case with the coordinate regulation; *b* – for the case with the adaptive regulator

The Results Discussion and the Conclusions

With the manipulator's movements, in the vicinity of the characteristic points, corresponding to the maximum and the minimum $r_{\max}$ and $r_{\min}$ hand's extractions, in which the moment of inertia of the electric drive load manipulator's angular position has the maximum magnitude $I_{l\max}(r_{max}, r_{\min})$ value override processes in the electric drive of the angular motion without the adaptive regulator, which are the most: the average value $\sigma_{mn} = 30\,\%$. But, if you move the manipulator's gripper, in the vicinity of the characteristic point, corresponding to the average r_{mn} hand's extraction, hence, the minimum value of the load moment of inertia of the manipulator's angular position $I_{l\min}(r_{mn})$, the magnitude of the overshoot and the response time process in the electric drive of the angular motion without the adaptive regulator – $\sigma = 8\,\%$, $t_n = 3$ mkc, while in the system with the adaptive regulator – $t_n = 3$ mkc, and the overshoot is absent – at the constant transient processes characteristics of the electric drive line.

Thus, the linear adaptive regulator application to be maintained the optimal ones, the system's gain of coefficient values, depending on the manipulator's configuration, is provided the dynamical processes flow further improvement in the electric drive with the variable inertial load, and, hence, the qualitative indicators of the manipulation process. So, the similar approach to the electric drive system construction of the manipulation robots can be applied to the overwhelming majority types of the commercially available industrial robots.

References

1. Arpabekov M.E. The Research and Creation of the Mountain Robotized Technological Complexes with the Adaptively – Programmed Control. The Dissertation…of the Doctor of the Technical Sciences. – Almaty, 2010. – P. 342.

2. Medvedev V.E. The Regulators' Automated Synthesis of the Servo Drives Manipulators in Order to Stabilize Industrial Robots Dynamic Properties. The Dissertation…of the Candidate of the Technical Sciences. – M., 2006. – P. 169.

3. Tuleshov A.K., Ozhikenov K.A. The Dynamics Analysis of Manipulator Servo Drive. // The Proceedings of the National Academy of Sciences of the Republic of Kazakhstan (NAS RK). The Section of Mechanics and Machine Building. – 2010. – № 3 (271). – P. 91–95.

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