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Methodology for Practical Selection of Force Compensating Manipulator Electric Drive

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Abstract

The article reviews the peculiarities of application of a methodology of multifactorial the electric motor selection for force compensating manipulator account for the fulfillment of the following conditions: coordination of freight and the engine transferring, minimization of maximum motor torque, freight transferring of maximum weight with the required maximum constant speed and maximum defined acceleration, providing standing mode of motor alive. According to the results of the performed review we selected a power part of electromechanical system of the manipulator and a practical test of high-speed and medium-speed synchronous electric motors driving from permanent magnets at application of gearboxes made by Sew Euro Drive and Russian-manufactured is carried out. The review showed that for the implementation of vertical movement system of freight it is reasonable to apply a DSM series electric motor of general industrial use that will allow reducing the cost of the perspective force compensating manipulator.

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Keywords: force compensating manipulator; gearbox; electric motor; multifactorial choice.

1. Introduction

During mechanical operations of productive processes connected with transferring of various goods and freights in various fields of the industry balanced manipulators are widely used. Peculiarity of these manipulators is compensation of links weight and lifting devices by means of couter weight or springs that allows to improve energy indicators of drive operation [1,2]. The review showed that for increase efficiency of loading and unloading works and level of their automation it is necessary to improve electromechanical systems of balanced manipulators [3-5].

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The review pointed out that the perspective direction of manipulators and special lifting devices improvement is application the force compensating control systems of efforts which allow performing required compensation of gravity force not only links, but also freight moved by means of the manipulator [6-8]. At the same time it is required to assign the solution of additional tasks of decreasing impact on manipulator operation of inertia forces of transferring masses to the electric drive (ED), dry and viscous friction of mechanisms [9-11]. For implementaion of such approach to manipulator control [12] it is necessary to select efficient parameters of ED which are simultaniuosly meeting contradictory requirements and operation conditions [13,14].

According to the review made in [15] at development of energy efficient electromechanical force compensating manipulators (EFCM) it is reasonable to apply the electric motors (EM) with higher nominal speeds of rotation from 4000 to 6000 rpm. At the same time the urgent problem with practical importance is determination of rate data of ED and efficient parameters of transmission mechanisms from a possible discrete number of their actual values which are able to provide the main requirements and operation modes corresponding to EFCM performance conditions.

2. Task description of mechanisms review

The results of review presented in [15] showed that for system of vertical freight transferring of long-term EFCM the effective solution is to apply synchronous EM driving from permanent magnets. To solve the problem of import substitution the choice of EM of Russian production is made taking into account: the required coordination of speeds of freight and motor movement; minimization of the maximum motor torque; freight movements of maximum weight with required maximum constant speed and the maximum nominal acceleration; providing standing mode of motor alive.

The objective of this work is development of practical approach to the choice of efficient EM and mechanical motion transformers meeting specified requirements of EFCM operation at minimization of the required motor torque providing nominal speed and acceleration of transferred freight. At the same time taking into account full production of EFCM we will forcus on application of EM and transfer mechanisms of Russian production.

3. Problem solving

At problem solving we will define accepted values of reduction radius ρ_R of mechanism taking into account main restrictive conditions given in table 1.

Table 1. Restrictive conditions.

№	Requirement	Condition	Restriction
1	Coordination of speeds of freight and motor movement	$\Omega_M \le V_M / \rho$	$\rho_R \ge \rho_\Omega$
2	Freight movement with constant speed and stated load	$M_M > M_S$	$\rho_R < \rho_S$
3	Freight movement with required values of maximum speed and acceleration	$M_{MM} > M_{DL} + M_{DM} + M_S$	$\rho_{D1} < \rho_R < \rho_{D2}$
4	Minimization of required maximum motor torque	$M_{\min} = M_{DL} + M_{DM} + M_S = \min$	$\rho_R = \rho_M$
5	Providing standing mode of motor alive	$M_{0M} \ge M_{ST}$	$\rho_R \le \rho_{ST}$

In table 1 the following symbols are given: Ω_M – permitted speed of EM in reviewed operation mode; V_M – maximum speed of freight movement; M_{MM}, M_M, M_{min}, M_{0M}, – permitted maximum, permitted EM torque, minimal motor torque at operation with maximum load and torque of standing motor alive; loading torques: M_S – static and $M_D = M_{DL} + M_{DM}$ – dynamic, torque M_{DL} conditional by freight weight и torque M_{DM} of dynamic motor load; M_{ST} –