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Realization of Servo-Constraints by Electromechanical Servosystems

M. Kh. Teshaev[1*]

[1] *Bukhara Technological Institute of Food and Light Industry, ul. K. Murtazaeva 15, Bukhara, 705017 Republic of Uzbekistan*

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Abstract—In this paper we consider a problem of realization of geometric servo-constraints. To this end we construct a digital servosystem whose executive element is a direct current motor of independent excitation. We present the full system of equations for a digital servo-system and discuss the questions of stable realization of servo-constraints.

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In the analytical mechanics the concept of servo-constraints has been introduced by H. Beghin [1]. The methods used in [1] have been further developed in the works of P. Appel [2], A. Przeborski [3], V. S. Novosyolov [4], M. F. Shul'gin [5], V. V. Rumyantsev [6, 7], V. I. Kirgetov [8], A. G. Azizov [9, 10], and others. In these papers considerable attention has been paid to generalizing the basic principles of dynamics for systems with servo-constraints, to writing equations of motion, and to defining reactions of servo-constraints. The development of methods of analytical mechanics for systems with servo-constraints was mainly based on using the peculiarities connected with the non-ideality of servo-constraints. These peculiarities manifest in the fact that for such systems the elementary work of servo-constraint reaction forces on virtual displacements allowed by constraints differs from zero [1, 2, 9, 10].

The mentioned works are of importance, but in order to apply methods of analytical dynamics to solving a wide range of actual problems, one has to take into account other peculiarities connected with stable realization of servo-constraints. Sh. S. Nugmanova [11] was the first to call attention to this fact. Based on the theory of parametric release [12] and the theory of forced motions [13], A. G. Azizov constructed a theory that allows one to apply methods of analytical mechanics to systems with servo-constraints including the issues of their stable realization [9, 10].

In this paper we study the realization of servo-constraint and develop one of possible approaches.

Consider the following problem of realizing servo-constraints [1]:

$$\Phi_\alpha(t, q_1, \dots, q_n) = 0 \quad (\alpha = 1, \dots, a), \tag{1}$$

where $q_1, \dots, q_n$ are generalized coordinates and t is the time variable.

For the parametric release of the system from servo-constraints [9, 10] we introduce additional independent variables η_p which reduce system (1) to the form

$$\Phi^*_\alpha(t, q_1, \dots, q_n, \eta_1, \dots, \eta_a) = 0 \quad (\alpha = 1, \dots, a),$$

where parameters $\eta_1, \dots, \eta_a$ characterize the release of the system from servo-constraints (1). Zero values of parameters η_p and their derivatives $\dot\eta_p$ correspond to constraints (1) and their differentiated forms. We can take for these values, for instance, the left-hand sides of Eqs. (1) computed for the real motion of the system [9, 10].

According to papers [6, 7] and [9, 10], servo-systems represent a typical example of systems with servo-constraints. Because of this the stated problem can be solved with the help of an electromechanical digital servo-system (DSS) [14].

*E-mail: muhsin_5@mail.ru.