The Transitory Regime of the Electromechanical Actuators in the Modern Industrial Systems

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Abstract: In our present paper we are going to show a few aspects concerning the transitory regime of functioning of electro mechanic actuators which has a heavy impact in their usage within the modern systems of pre-working or different process industries, within this contest new acting solutions referring to components and working parameters in difficult conditions. This paper aims at revising the main constructive characteristics in order to improve the functionality under the energetic and the dynamic aspect.

Keywords: Electro-mechanical linear actuator, virtual simulation, transitory regime, energetic efficiency

1 INTRODUCTION

Lately almost in all the technological processes and in the industrial production based on machine construction the issue of a high economic efficiency has always been raised. By studying critically the evolution of the actuators mechanism we notice the evolution directions of the improvements.

The taking into account that this negative effect of the insertion forces is higher, being in direct relationship of the increased functioning speeds of the actuators. In this context, the introduction of the electro mechanic actuators can be achieved only in the case of superior performances which have been achieved lately due to new solutions of actuator mechanism [1].

The main problem for the conceiving optimal transmissions that should lead to well performing machines and equipment which have an essential contribution to the achievement of qualitative constructive and functional parameters, including also the energetic efficiency.

The period of functioning, the high efficiency, the large regulating range of the movement parameters, the functioning security, the compact constructive simplicity, the high accuracy of positioning are closely together etc.. An actuator's function is to provide thrust and positioning in machines used for production or testing. One type is the electromechanical actuator, which converts the torque of an electric rotary motor into linear mechanical thrust. The technical system of the linear actuator perfected through this method has a few basic characteristics expressed by particular indicators such as: adjustable acting, high precision and efficiency portent capacity, a rank of high speeds, numerical control etc. Although the actuators have a great functional and constructive variety, in general they must have the following characteristics: basic structure which consists of electric motor, drive mechanism for converting the rotary motion into a translation motion and its control system [3].

A new innovative and original structure of a type of linear actuator is presented in the Figure 1. In this structure the extension and the conversion of the energy are accompanied by the conversion of some informative signals. This offers the best solution to linear actions owing to the large flexibility, to the high efficiency, to the cinematic, dynamic and high precision capabilities [5] [7].

2. MATHEMATICAL MODELING OF THE LINEAR ACTUATOR DYNAMICS

The optimum for the actuators is done starting from the auctioning time analysis, the imposed technological requirements [4].

Fig. 1. Units with rotating variator with broad belts

Once these parameters are established, it will be set the priorities, after that follows the synthesis of the mechanism of movement transformation.

In this synthesis, the input data are the above mentioned parameters and the output data are: the dimension of the components, their dynamic behavior, the distribution of masses etc.

The main dynamic criteria for the optimization of the mechanism of movement transformations, which are useful in assessing of the quality of the functioning of the actuator mechanism in working regime, are: the mechanics average efficiency, the losses in kinematic couples, the multiplication coefficient of force, the non-uniformity of the working coefficient, the static and dynamic losses of balance [5].

- The losses in kinematics couples, which represents the report between the instantaneous power of the friction forces in the kinematic couples (\( P_r \)) and the appropriate power of engine forces (\( P_m \)): 
to loop systems, used especially for the electro mechanic actuators where the input signal is of alternative power.

The most used block scheme of a servo-system of control with the transfer functions of the composing elements for the electro mechanic actuator with position reaction and speed is presented in Figure 2.

![Fig. 2. The structural mathematical model for actuators](image)

For the transitory regimes of functioning, the efficiency can be calculated the two components of the moment of losses within the transmission according to the relation (6) including the dynamic moment. According to Newton’s when the load S is coupled to the engine which leads by means of a gear mechanism, by combining and grouping the equations results the equations which describe the system:

\[ J_{echiv} \frac{d^2 \theta}{dt^2} + B_{echiv} \frac{d \theta}{dt} + k_{echiv} \theta_i + M_i / i_r = M \]  

This equation shows the performances of the system as a function of a single variant, the input angle - \( \theta_i \).

An equivalent system is the one that has the inertia moment equivalent, damping and equivalent rigidity. The servo engine and gear is chosen in a way that creates the required pair \( M_i \) and the imposed acceleration \( \varepsilon_i \), which should take the load to the required speed. The mathematical pattern reflected the parameters of the engine \( J_m \) and \( K_m \) at the output axis. The choice of the optimum transmission raises a complex problem in the case when it is imposed a minimal angular velocity to trace \( \omega_\text{e} \) and \( \varepsilon_\text{e} \).

3. THE OPTIMUM WORKING REGIME

The parameters which characterize the economic regime are the training electric power and the efficiency of all the structural components. The basic problem in order to obtain a profitable regime is to correctly establish the nominal power according to the efficiency, the transmission report, the increase or decrease in the speed and the cinematic moment. In the situation of the actuators, to establish acting power is very important owing to the conditions of transitory regime of work.

When calculating the overall efficiency of the actuator’s transmission, we will approximate it taking into account only the losses that occur due the friction within the mechanism, neglecting among others like the degree of covering.
To take into account all the losses we can write the relation of the overall efficiency according to the total / overall moment $M_t$ with the constant $\Delta M_c$ and variable $\Delta M_a$ for mechanical losses as it follows:

$$\eta_t = \frac{M_t}{M_t + \Delta M_c + \Delta M_a}$$  \hspace{1cm} (7)

If we define: the loading coefficient, $K_l = M_t / M_c$ and the loss coefficient, $K_p = \Delta M_t / M_t$ using the relation (7) results:

$$\eta_t = \frac{\eta_n}{1 - \eta_n K_p (1 - \frac{1}{K_l})}$$  \hspace{1cm} (8)

For this, we make real assessment of the value of the efficiency of the actuator transmission considering the overall of the power losses within the actuator and for partial loading.

For the transitory regimes of functioning, the efficiency can be calculated by the two components of the moment of losses within the transmission according to the relation (6) including the dynamic moment.

Establishing the loading coefficient is necessary in view of the choice of the acting engine and of the calculation of the overall efficiency of the mechanical transmission of the actuator.

4. SUMMARY AND CONCLUSIONS

The research is of great importance for the present calculation algorithms regarding the main dynamic parameters, the power and the mechanical efficiency. The applicative and experimental researches and the industrial validation of these were tested on the theoretical patterns implemented in practice showing the convergence of the ways of approaching to the problems to reality.

It results the great importance of the correct establishing of the functioning in this regime by mathematical modeling of these influences.

The kinematic and dynamic analysis on synthetic pattern of the servo-analog rapid control actuator type system has direct implications by deducted practical recommendations to design the transmissions of mechatronic systems.

For the actuators included in machine tools with digital control or in the manufacturing centers, the dynamic stability is of utmost importance, fact that makes the study of the loading coefficient variation in a transitory regime when starting under loading welcome and trends.

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REFERENCES


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