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REGARDING THE DETERMINATION OF ENERGETIC CHARACTERISTICS OF THE LINEAR ELECTROMECHANICAL ACTUATORS FOR THE MACHINE-TOOLS

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Abstract: *The paper presents the results of researches regarding determination of the functional parameters that characterize the energetic expression of the linear actuators. The optimization of the working conditions on the basis of the energetic characteristics of linear electromechanic actuator leads to the rational use of the operating system of the trained equipment and the electric power.*

Key words: *linear electromechanic actuator, virtual simulation, energetic characteristics.*

1. INTRODUCTION

The issue repressed in the paper of the research of some parameters which energetically label a linear electromechanic actuator correlated with the driving structure and the movement control of this actuator. The energy presents itself as a main direction of research activity and the technological design, of the choice of optimum structure from the point of view of energetic efficiency of any product. It is known that the efficiency of a product determined by the functioning in normal condition does not express entirely the energy consumption because in real conditions the actuators function with partial weights, with blank functioning periods which minimize to a high degree the real efficiency [2]. The optimum structure of the working actuators will be that for which for certain lapse the optimum value of the indicators of the efficiency is obtained, economy technique and the optimization of the functioning has as a criterion the minimization of energy consumption. As to the existent present stage there are great possibilities to increase the energetic efficiency of the electro mechanic actuators, possibilities that have to be valued especially in the industry of refining by sharpening, by assessing and by finding ways to reduce the bases. In the case of the actuators used in mechatronic where the consumption is lower, these have even a greater importance in the view of making it compatible with the numeric computer control [6].

The traditional solutions practiced in the field of the movement systems have to be abandoned in favor of some recipients and some new solution of utilization that should lead to the decrease of the losses. The exploitation of new actuator types especially mechatronic ones which are part of a cybernetic system can be appropriately achieved only if computers are used for the actuators and if the decisions of development and exploitation are prepared and enlarged. As the systems of electrical acting are developed, new structural changes of the actuators are imposed, so that on the whole, a maximum portent capacity showed can be achieved with minimum energy consumption. In the world there are famous achievements in saving and preserving the energy exceeding the study stage and some plans of practical application which enhance on the mentioned researches is that further on, one of the most economic solutions to solve the energy problem is to save it. The transition to a superior stage can be achieved by using some superior energy of movement of the actuators and by strict energy saving from the level of each actuator. For this it is imposed a conception that should have at its basis structural changes by obtaining an optimum construction where each component should absorb only the necessary energy by optimum functioning and with a maximum efficiency [1]. In this field there are famous achievements: such as kinetic energy saving mechanisms or energy generating system which re-uses the braking energy. The wide range of machine tools, as well as the requests imposed on the technological processes make necessary the new instruction of linear actuator with individual changing actions ever more compact to increase the quality and the flexibility of the products.

The technical and technological evolution towards the integration in mechatronic included the stages of development of the module of linear acting of the actuator type marked by the integration of the microprocessors. The development of the mechatronic technology within this context contributed to the development of the actuators as compatible elements of execution which have besides the cinematic chain, energetic and informational material. In the dynamic study of the actuators we have to consider the whole linear actuators in spite of the effects the transitory functional regime [8].

The electromechanic linear actuators, which are mechatronic products and part of the intelligent flexible systems of manufacture, have to fulfill special requirements which impose new concepts of design. All these can be best achieved only by using the methods of modern design by using the technique of numerical computations such as that of the virtual prototype.

Setting up the best solution by virtual modeling offers the idea of the overall technical conception of the actuator product, its possible composition by the appropriate structural solutions, such as the functions of its elements. 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.

The actuator has a complex structure, the mechanical part being composed of certain elements which ensure a high kinematic and dynamic precision, and the commanding part being represented by a computer-led system, based on appropriate software. In order to optimize the functioning of a tool, actions must be able to regulate the speed continuously by converting the reduced dissipation of electric energy into mechanic energy. The regulating electric actions consisted in an element of electronic execution, the electric machine, a mechanic transmission and the working machine.

The main component parts of an actuator are represented in figure 1, including the electric engine of acting, the transmission itself, the filling and the control devices.

2. THEORETICAL COMMENTS

Modern systems of movement have a high dynamics and a functioning with some transitory stages in critical conditions as well, in frequency. By analyzing the values of energetic characteristics it is certified that, as the soliciting force increases too and the velocity of the actuators stick, these have an increasing determining variation [2].

The functions that determined process of the representation function of the experimental data to characterize the process are of unknown expression:

$$y = f(x_1, x_2, x_2, \dots, x_n), \tag{1}$$

where y and x_n are dependent and independent variants of the process and f - the expression of the function.

An approximate function is chosen:

$$y = \gamma(x_1, x_2, x_2, \dots, x_n), \tag{2}$$

where the x_j, $j = 1, 2, \dots,$ k is the coefficient that is attributed to the independent variants x, it is determined on the basis of experimental data. For the energetic characteristics y – the absorbant power, the power factor cos φ and efficiency η of the actuators.

Function of polynomial expression and polytrophic expression in view of the determination of mathematical models. In mechanical transmission mechanisms with screw-nut with friction sliding or rolling of experimental research to extract the following relationship for efficiency (Fig. 1).

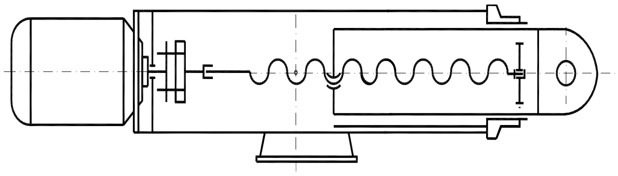

Fig. 1. The linear electro-mechanic actuator.

$$\eta = \frac{1}{1 + k \cdot d / p}, \tag{3}$$

here:

d is the average diameter of the screw;

p – the step of the propeller of the screw thread;

k– a coefficient that depends on the constructive type of the screw, namely: $k = 0.33$ for sliding and $k = 0.033$, for rolling.

The function of coordination and mechanic timing is replaced with the electronic alternative, using a new concept of dynamic regulation, which improves the performances of the system. The modern actions replace even more frequently the regulating mechanic transmission because these performances don't fit anymore the demands imposed by the user by increasing the power per unit of volume of the active materials.

Today, the electrical regulating actions are important parts of the machine tools with quick evolution. From the actions of continuous electric power to those with alternative power which are reunited as far as the high speed of regulation and precision of regulating. The couple are concerned as well as the good dynamic or other quality factors [2]. For the new criteria of the performances called errors of trajectories of machine tools with numeric control it is required the reconsideration of the main parameters of tracing servomechanisms which should correspond to the working transitorily and critical regimes.

The positioning systems with good dynamic and great possibilities of regulating the couple, which satisfy the mentioned requests, are the programming servomechanism with a regulating action. A control block diagram of the system is shown below in Fig. 2.

We can memorize different steps of number of rotations in both ways and also there can be assured the passing on over the frequencies of resonance memorized by the converter. The present day development in the software field allows the common development of some so-

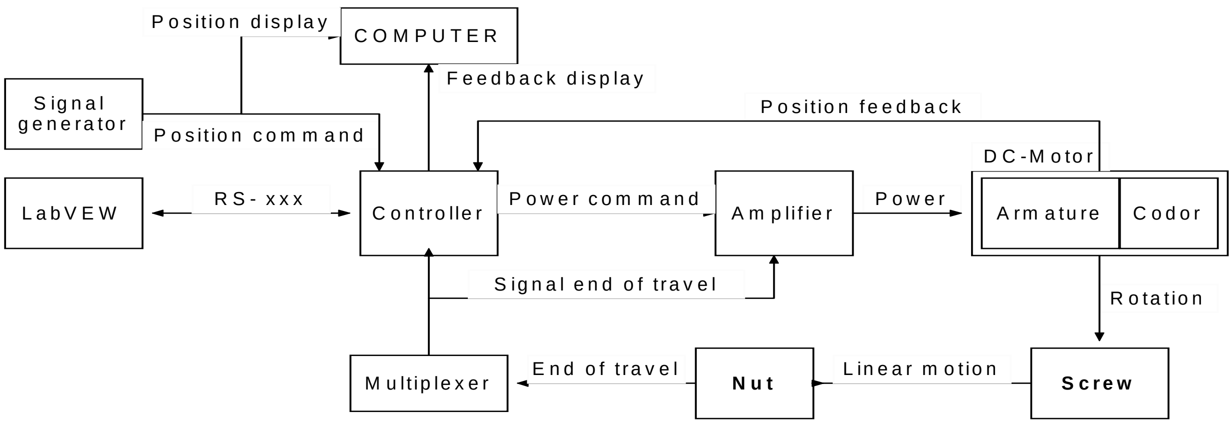

Fig. 2. Control block diagram of linear actuator.

lutions with multifunctional universal machines of the servo-converting type for the positioning and movement actions. The using of the digital technique allows such a bi-directional transfer of data without supplementary elements (just in time) through a parametric serial interface at a central leading system, which can interrogate the real values of the parameters at any hierarchic level.

The requirements of the mechanic construction of the actuator are more often dynamic, which give birth to the acceleration of the movement and to the inertia force which can cause vibrations in the end. If the system is put out of its state of stability due to an impulse and if this impulse is eliminated, then the system executes free oscillations, during which, there is a continuous exchange of kinetics and energy of distortion. In the case of continuous action of the disturbing force, the system executes forced oscillations.

According to these dynamic loading coefficients we can appreciate pretty well the endurance of the actuator and the degree of their loading. On the basis of the dynamic coefficient we can follow: the exact limitation of the work purpose, according to the maximum dynamic loading which appears within the flexible links in the mechanisms, the values of the maximum accelerations and of the minimum functioning time in the period of the start-up, of braking and the frequencies of oscillation of the supports. The scheme of the regulating action in the alternative electric power is presented in Fig. 3

The static converter of frequency achieves the electric drive engine feeding, of the asynchronous type of general use, with a variable frequency voltage, maintaining a certain voltage - frequency characteristic. Thus the variation of the engine rotations number is achieved and implicitly, that of the output rotations number of the reducer is a very large field (Fig. 4). The ratio between the maximum and minimum output speeds is the biggest.

The variation of the output number of rotations is achieved at a constant couple, up to the nominal number of rotations, and the number of rotation above the nominal one, at constant power (by couple decrease).It can be used at any planetary reducer drive where a continuous output number of rotations control is converter required. The correct definition of the economic functioning regime of an electromechanical linear actuator must take into account the clues that characterize the economic regime.

The basic elements, the most common electric motion control systems are: stepping motor-based and servo motor-based. Each has advantages over the other, some of which are highlighted in the diagram.

There are the training electric power and the efficiency of all the structural components. In the transitory dynamic regime, in order to maintain a constant of the efficiency at the nominal power of the power dissipations supposes the knowledge of a weight graphic as exact as possible (Fig. 4).

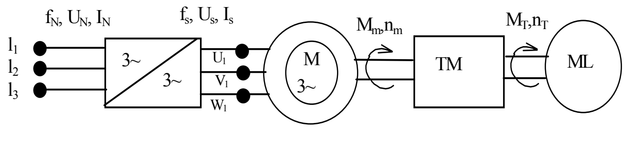

Fig. 3. The scheme of the regulating action.

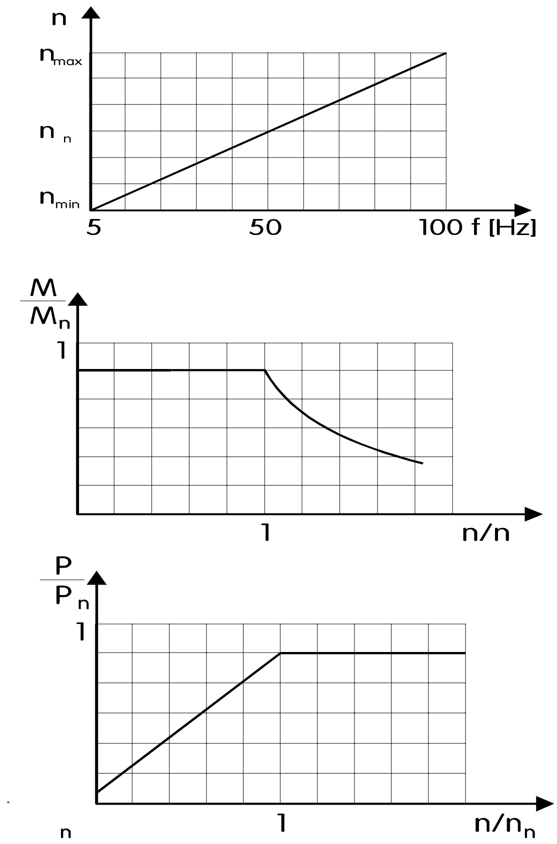

Fig. 4. The characteristics parameters regime.

The appreciation of the functioning economic regime should be done separately for each type of action engine as well as for every nominal parameter which changes, that is for each artificial characteristic. Saving the electric energy can be done by important measures in the whole chain of the actuator system starting from the filling point, passing to the control one or the regulating one and going on with the acting engine and the cinematic transmission.

At the majority of the electric engines, the efficiency has small variations about its nominal value in changes of power between the nominal value and approximate 50 % out of the nominal value. However [6], in the situation of the actuators, it is very important to establish the acting power owing to the conditions of transitory regime of work very good efficiency approaching 93 %, is able to get the value as close as possible to the values taken from the experimental stand.

The modern systems of movement have a high dynamics and a functioning with some transitory stages in critical conditions as well, frequency.

3. EXPERIMENTAL RESEARCH

These energetic tests was achieved by pushing the actuator at a braking force, using braking device by the type friction brake or electrical brake. The pattern of experimental stand used to determine some energetic characteristic of an electro mechanic actuator is presented in Fig. 5.

The fundamental component of the research stand is the electro mechanic actuator with a screw-screw drive mechanism in the laboratory of experimental researches.

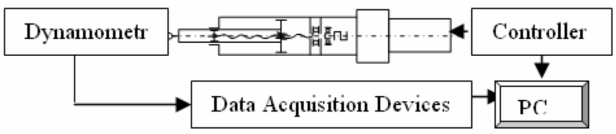

Fig. 5. The trial stand of industrial linear actuator.

Fig. 6. The trial stand of industrial linear actuator.

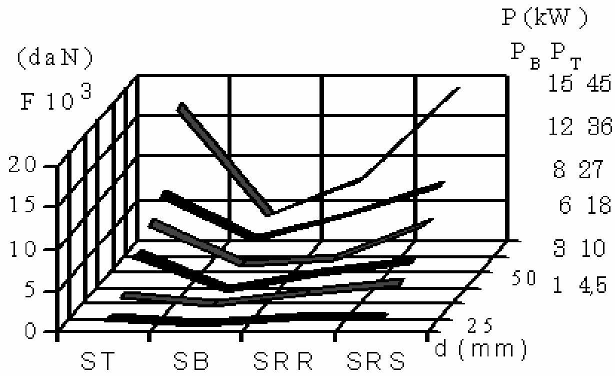

Fig. 7. Performance linear electro mechanic actuators: ST – trapezoidal screw; SB – ball lead screw; SRR – recirculation roller, and SRS – synchronized roller screw.

The dynamometric device used to push by braking force allows the application of an axial force hydraulic cylinder where the pressure uses a numerical data acquisition system. The trial stand of industrial linear actuator is presented in the Fig. 6.

The conditions under which the experimental research was done were the following are the shifting velocity and the course. The different working where the actuator was required was obtained by the increase within certain limits of the hydraulic cylinder by parameters of hydraulic oil and the shifting velocity by means of the mechanic variant on belt or the converter electronic ones.

The determination of energetic characteristics of the actuator supposes the measuring of effective turation the screw drives active electrical power within the *P* and *U* tension and the power intensity *I*.

The apparent power *P* was determined by applying the definition relation that is:

$$P_a = \sqrt{3} \cdot 10^{-3} U\ I \qquad (4)$$

and the power factor cos y according to the definition relation that is: $\cos y = P / P_a$

The energy resulting from the mathematical refining of the experimental data were formed under the expression of regressive function. The graphical representation of the surfaces of the there variants *F* and *P* is shown in Fig. 7.

The influence of the independent variants on the energetic characteristics is the following:

- the increase of the turation from *n* min at rotation/min leads to increase of the active power *p* and efficiency;
- the increase of the shifting force from determines the variation of the active power and of the efficiency with. It is noticed the great influence of the turation *n* on the efficiency. It is noted from the chart in Fig. 7 that optimum energy is at ball screws of small diameters.

4. CONCLUSIONS

This study makes possible solving some aspects specific to the dynamic of actuators, useful for the research and the general design of these transmissions, as well as for their exploitation under very safe conditions. The optimization of the working conditions on the basis of the energetic characteristics of the industrial linear actuator consists of the rational use of the operating system of the trained equipment and the electric power.

The researches results show that the efficiency and the stability of the dynamics are essential in order to characterize a certain type of actuator from the energetic efficiency point of view.

The researches follow in the future the optimization from the energetic point of view through the new structural phenomenological modeling.

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