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ANALYSIS OF DYNAMIC PARAMETERS FOR ELECTROMECHANICAL ACTUATORS USED IN AGRICULTURAL MACHINERY

Nasui Vasile, Banica Mihai, Butnar Lucian
Technical University of Cluj-Napoca, Faculty of Engineering
Correspondence author. E-mail: Vasile.Nasui@cunbm.utcluj.ro

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ABSTRACT

The research aims at the stability of optimal solutions depending on the destination of the actuator and environmental protection. In the current context, the technical optimum is the optimum of the consumption of substances and energy must be tracked specifically process. The proposed theme is of scientific importance because it addresses research in a field aimed at the energy efficiency of mechanical systems.The linear actuator is composed of a motor that rotates a screw where the nut on the screw is not allowed to rotate. One type is the electromechanical actuator, which converts the torque of a rotary electric motor into linear mechanical force (fig.1).

INTRODUCTION

The research is part of the modern concerns regarding the development of new systems of linear actuation as well as simulation using numerical calculation and virtual instrumentation programs. Electromechanical actuators are modern actuation systems used in industrial machinery, including agricultural machinery, as well as in numerous other automation and robotization applications (Chiver et al. 2021). Actuator-type roto-translational mechanical systems represent a new concept in mechanical transmissions of various types and destinations that effectively replace classical mechanically, hydraulically and pneumatically activated systems (Maties et al. 2000).

They offer the optimal solution for the construction of quantitative and qualitative mechanical transmissions due to a wide range of use, high efficiency, static, dynamic capabilities and high precision (Borangiu 2003). Electromechanical linear actuators that are mechatronic products must meet special requirements that require new design concepts (Şugar & Chiver 2020). All this can be achieved in an optimal way only using modern design methods using the numerical calculation technique such as that of the virtual prototype (Alexandrescu et al. 2019, Maties et al. 2000, Alexandrescu et al. 2021). Highlighting high-performance solutions through virtual modeling gives the idea of the overall technical concept of the actuator product, its possible composition through appropriate structural solutions, as well as the functions of its elements (Jurchiş et al., 2021, Medan et al., 2017). The technical system of the linear actuator perfected by these methods has extracted some basic characteristics expressed by specific indicators such as:

adjustable actuation, high precision, efficiency, bearing capacity, large speed range, numerical control.

The realization of the work took place in the modeling of a translation system based on Matlab-simulink and LabVIEW virtual simulation programs. Also, the research stand for these transmissions was physically created, on which the experimental researches were also carried out. In electro-mechanical linear actuators there are a great number of improvements and motion developments of new systems continue to appear.The screw-nut mechanism is mostly used because it allows high-speed movements and has high positional accuracy.

These transmissions are used in the linear electromechanical actuators shown in figure 1 (Nasui, 2006). Actuators of this type are equipped with servomotors that can ensure circular movement with a small angle or precision of linear movement over very small distances. Performance specifications include constant force, constant torque and very good resolutions. Actuator variants produced provide fine controlled motion in open closed loop systems when the force developed can be adjusted by power control (O'Neil 1990).

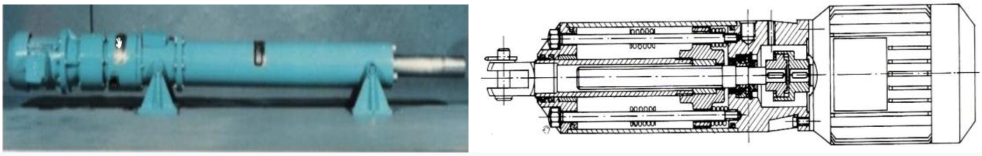

Figure. 1. Linear electro-mechanical actuator

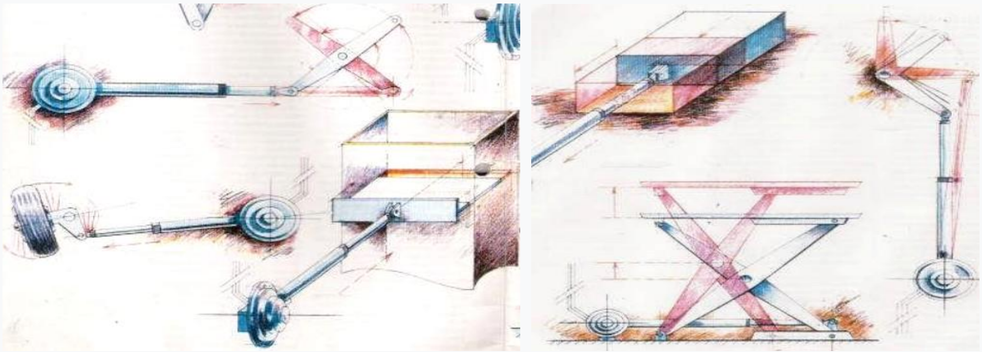

Figure. 2. Actuator applications to agricultural machinery mechanisms

The examples of applications shown in figure 2 are indicated for different mechanisms of some position equipment and in other applications for the automation of agricultural machines and installations, or silos. Thus, it would be at lifting tables, handling flaps, gripping, handling, lifting devices, window or door actuation, replacing hydraulic and pneumatic cylinders (Nasui 2010)

THE CONFIGURATION OF THE EXPERIMENTAL STAND

In order to establish and study possibilities for regulation and control of the actuation movement of the actuator, a new research direction was attempted using complex safety systems and data analysis through fuzzy logistics. The measuring stand on which the experiments were performed is shown in Figure 3.

As it can be seen from the hardware configuration model (Nasui 2010), the actuator interface and fuzzy logistic board (number of fuzzy calculation rules).

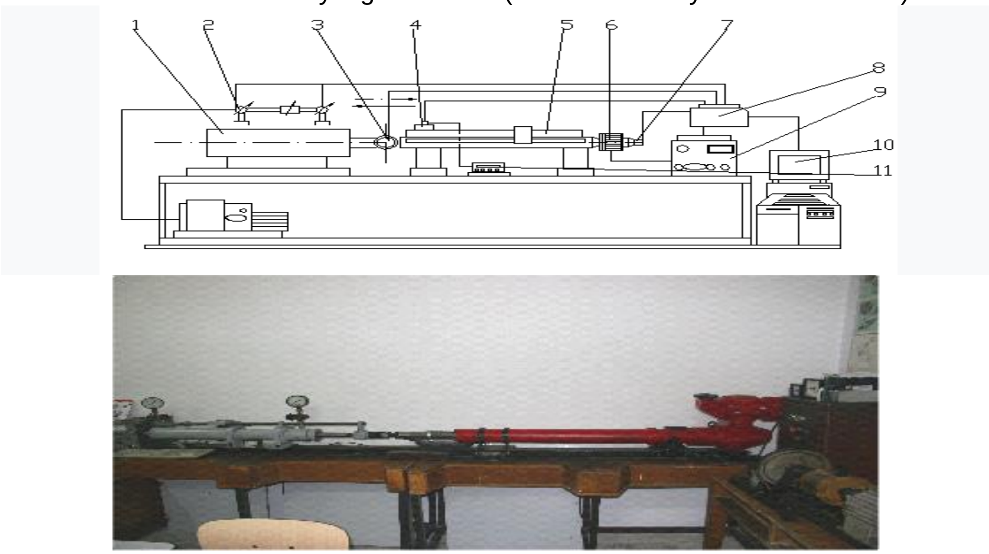

Figure 3. The research stand for linear electro-mechanical actuators:
1-hydraulic brake installation; 2- pressure tranduscer; 3-force tranduscer;
4-displacement transduscer; 5-optical ruler; 6-linear actuator;
7-speed transduscer; 8-data acquisition board; 9-power measuring kit;
10-computer; 11-display device; 12-support.

The stand allows empty and loaded tests, being equipped with a hydraulic braking system. In this way, experimental data can be obtained at different forces, working speeds, strokes and operating times of the actuator. These data will be used to establish the technical characteristics of the actuator, also using fuzi logic.

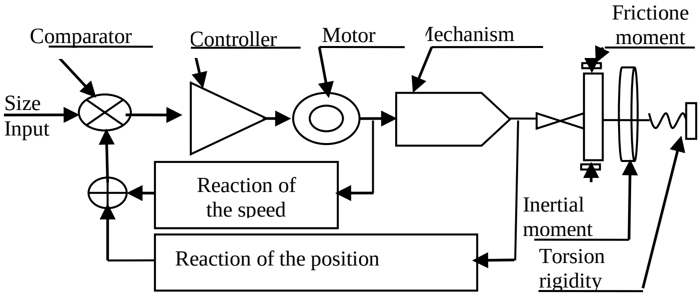

Figure 3. The dynamic control of the movements of an actuator

The system ensures the required performances with the help of reaction coils for speed and for position (Fig. 4). The reaction coil for speed command the acting servo engines and under the turation aspect comprises besides the engine and the amplifier, comparator and tahogenerator.The positioning coil is made up of comparators, the amplifier, and the moving translators (Nasui, 2006).

In order to control the process, a specialized module with data acquisition system takes over from the process of acceleration parameters and refines it by taking into account the shifts from a basis value and the dynamic of this shift.

EXPERIMENTAL RESEARCH

The experimental research on the test stand aimed at determining the functional dynamic parameters, such as absorbed power, load and working speed, dynamic performance of the type in order to label the energy of the product. To verify the theoretical considerations some experiments with servomotors equipped with screw-nut mechanism with trapezoidal spiral and ball screws (Tura, 2006). The measurement was carried out on a test stand under load recording the absorbed powers and then the efficiencies were calculated and plotted in Figure 5. Therefore, the actual efficiency can be determined from the experiment taking into account all these aspects, the geometry of the screw profile and the dependence of the friction angle on several factors. Increasing the performance of the actuator can be achieved, in general, by: reducing the complexity, by increasing the performance of the components, by reducing frictional losses, appropriate maintenance strategies. Two main directions have been developed in efficiency optimization – maximizing efficiency by reducing friction and minimizing cost by maximizing savings The radical solution is generally achievable by replacing the kinematic couple with a suitable kinematic polycouple and rolling elements As a consequence of the modeling, new kinematic solutions of the linear actuators were realized which, beyond the selection stage, were optimized and realized in a range of constructive typo-dimensions.

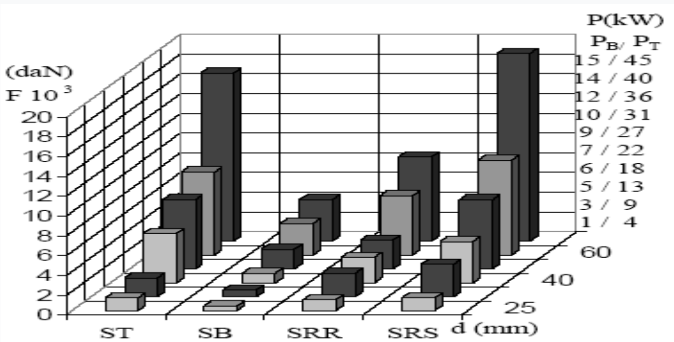

Figure 5. Characteristic parameters of the linear electromechanical actuator
Legend: ST - trapezoidal screw; SB - ball lead screw;
SRR-recirculation roller screw; SRS-synchronized roller screw

Finding the optimal technical solutions was the result of the optimization process for these models, recorded as draft kinematic schemes and computational models.

The results of the research phase contain a new approach to optimal design by developing the classical methodology together with dynamic modeling (Olaru 2000).

THE VIRTUAL DEVICE CONCEIVED

The chosen mathematical model confirms the possibility of its successful use in virtual simulation procedures through MatLab-Simulink support

The virtual device designed for the purpose of dynamic analysis of the actuator motion system as on the front panel plates of the activity can be entered the input data value for all the actuator components. The table also displays the values entered for the cycling data, the number of duty cycles and their deviation, i.e. the entire duty cycle. Output data, the virtual device returns the values of the characteristic dimensions of each component of the actuator and the shape of those characteristic types, such as: actuation moment, input moment, braking moment, working load, friction. efficiency coefficient etc. (Fig. 6) Individually for all components, the general characteristic parameters and their performances were determined by design and assisted research, by experiments and compared with values from the corresponding bibliography.

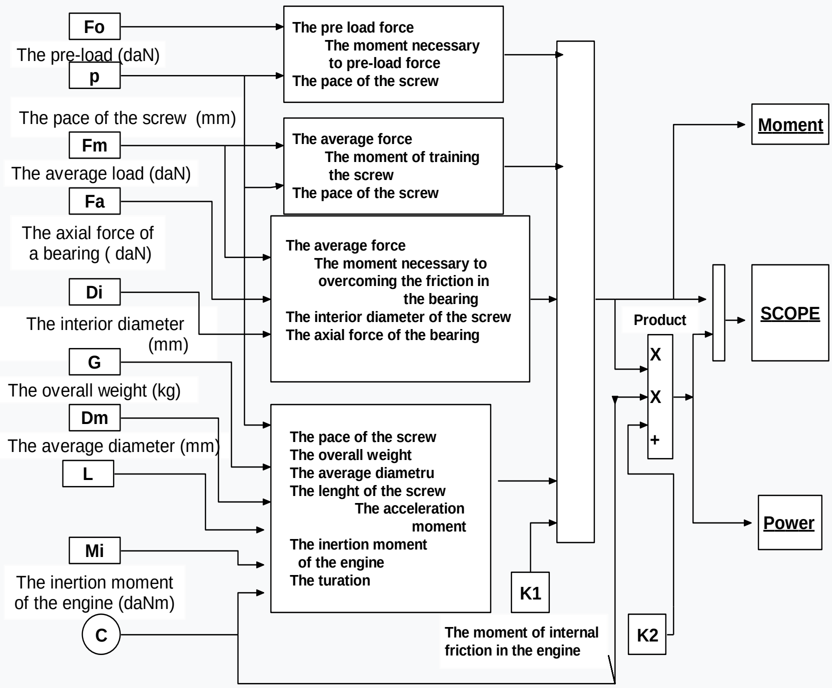

Figure 6. Dynamic simulation with virtual instrumentation through MatLab-Simulink

The sampling time must be chosen according to the operating regime to ensure a sufficient balance level. By performing those simulation cycles of the entire action system for a well-chosen time, a certain element reaches the steady state, but only after exceeding a certain transient time. These allowed the solution of some experimental problems that cannot be solved theoretically and for the validation or generalization of theoretical models (Nasui 2006).

CONCLUSIONS

The research was carried out by analyzing the characteristics of the speed acceleration index, the working course, the operating moment and the absorbed power, tracked and assisted for different values of the constructive and functional parameter. The chosen mathematical model is extremely sensitive to the modification of the alignment parameters, which confirms the possibility of its successful use in virtual simulation procedures by the MatLab-Simulink support

The solution to the described system of equations has been programmed for any given input. A computer-aided analysis software was used to study the kinematics and dynamic characteristics of the movement. Design software simulation allows testing design performance and simulating the in-service behavior of components before building a physical prototype.

This allowed the determination of the most critical situations and therefore the design of the necessary components and motion generators. On the other hand, industrial application is also an important target at this stage of scientific and industrial development. Their various types of industrial applications are expected to create a whole new market in the near future.

REFERENCES

Alexandrescu I.M., Cotețiu R.I., Haragâș S. 2019. Research on the load bearing force in narrow sliding radial bearings (L < 0,7 D) operating in shock conditions. Acta Technica Napocensis, Technical University of Cluj-Napoca, Series Applied Mathematics, Mechanics, and Engineering Vol. 62, Issue, 299-308.

Alexandrescu I.M., Cotețiu R.I., Cotețiu A. G. 2021. The Behavior of the Lubricant Film to Dynamic Stress at a Radial Bearing with HD Lubrication. Scientific Bulletin, Serie C, Fascicle: Mechanics, Tribology, Machine Manufacturing Technology, No.XXXV, 3 -6.

Borangiu Th. 2003. Advanced Robot Motion Control. Editura Academiei Romane.

Chiver O., Burnete N., Şugar I.R., Neamţ I., Pop E. 2021. Study on Gear Ratio of Battery Electric Vehicles. Ingineria Automobilului, No: 59, Bucureşti, 11-16.

Jurchiş B., Şugar I. R., Giurgiulescu L. 2021. Performance Analysis for an Experimental Diesel Engine Fueled by a Mixture of Rapesseed Oil and Diesel. Analele Universităţii din Craiova, seria Agricultură, Montanologie, Cadastru Vol. 51/2/2021, 326-331.

Maties V., Mandru D., Tatar O. 2000. Actuatori in mecatronica. Editura Mediamira Cluj-Napoca.

Medan N., Lobontiu M., Nagy S.R., Dezső G. 2017. Taguchi versus full factorial design to determine the equation of impact forces produced by water jets used in sewer cleaning. MATEC Web of Conferences, EDP Sciences, Paris, France, Volume 12, p. 3007-3011.

Nasui V. 2006. Actuatori liniari electromecanici. Editura Risoprint Cluj - Napoca.

Nasui V. 2010. Actuator mecanism liniar multiaxial. Brevet de invenţie RO122846.

Olaru A. 2000. Dinamica robotilor industriali. Editura Bren, Bucuresti.

O'Neil S. J. 1990. Motion Control Hanbook. Micro Mo Electronics, Inc,

Şugar I.R., Chiver O. 2020. Experimental Study on the Functioning of the Traction Batteries for Hybrid Vehicles. Ingineria Automobilului, Issue: 55, pp. 23-26, Bucureşti)

Tura L. 2006. Sistemul mecanic al masinilor-unelte. Editura Performantica, Iasi.