Optimization of Linear Electromechanical Actuators

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Abstract: *This paper includes a part of expression and fundaments of a new concept regarding the improvement of the parameters of linear actuators, experimental research on the dynamic behavior of these systems within all the assemblies where they are used. Optimization of characteristic parameters of linear electromechanical actuators, aimed at raising the parameters characteristic of the actuators, high yields, reliability, tribological optimization, cost reduction, they must be miniaturized, non-polluting, silent, with a low number of moving parts. The main purpose of this research is the development of a modularized family of linear actuators, intended for the operation of high-performance systems specifics to fine mechanics and mechatronics.*

Keywords: *actuator, electromechanical, efficiency.*

1 INTRODUCTION

The use of electromechanical actuation is becoming increasingly popular in the industry, robotics, processing factory and aerospace industry as more importance is placed on maintainability. Electromechanical actuators are being used in the actuation of flight critical control surfaces and in thrust vector control.

Electrical motor servo systems are indispensable in modern industries. Servo motors are used in a variety of applications in industrial electronics and robotics that includes precision positioning as well as speed control.

Advanced automation and miniaturization, meeting today in all fields of engineering, require the continuous development of a variety of safe and compact actions in the composition on modern systems. The speed and accuracy with which a process or a mechanical system can be controlled, parameters of particular importance.

Actuators have become fast key elements for improving the overall performance of existing products, adding additional features, or even for the appearance of some new products that could not be made before.

In order to improve the transmission efficiency, two kinds of precision line transmission parts of ball screw and planetary roller screw are used as the chief components of actuator.

The fork structure actuator, which is compact power transmission route and high efficiency, however, it only directly drives rudder and the installation position is not adjustable. To reduce volume and improve accuracy, the motor and linear transmission parts of electromechanical actuator, are integrated as a whole.

The design and dimensioning of an electromechanical actuator call into play a great number of parameters which are subject to the laws which describe physical phenomena on the one hand, and to the specifications of the schedule of conditions on the other hand. By admitting that, these phenomena can be represented analytically, the translation of the coupling inside the system considered makes it possible to obtain the set of relations which, when associated with the drawing up to the schedule of conditions, makes up the structure dimensioning relations.

Optimization theories seem well suited, as long as the design approach can be directly interpreted as being the search for a solution which optimizes a certain number of criteria under a set of constrains which correspond to the structural relations and the specifications of the design.

In this paper, I want to describe the optimization methods for the characteristics of linear electromechanical actuators. This theme represent one objective to research, for a study-work and finally give optimized solutions to growth the performances of electromechanical actuators.

2. ELECTROMECHANICAL ACTUATOR

Electromechanical linear actuators, (Fig.1), are mechatronic products and are part of the intelligent manufacturing systems that must meet special requirements which requires new design concepts. All this can only be done optimally using modern design methods, using numerical computing techniques such as virtual prototyping.

Increasing the efficiency of a system in general can be achieved by reducing the complexity of systems, adding a constant amount to the content of component efficiencies, reducing friction losses, proper maintenance strategies.

Fig.1 Electromechanical linear actuator [9]

Actuators as modules in the structure of mechanical systems use power to drive rotating and translational moving elements. Actuators used in mechatronics applications as components of actioning systems, and they have several particularities in that the propagation and conversion of energy is accompanied by the propagation and conversion of information-carrying signals. [4]

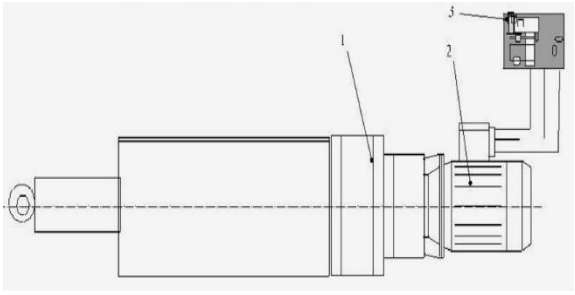

Fig.2 Simplified diagram of an actuator with frequency converter [4]

In figure 2 we can see an simplified diagram of an actuator with frequency converter, like a method of operation. To describe the diagram, we have 3 pointers, notated with 1- The corp of electromechanical actuator, with 2- Electrical engine, and with 3-Unity command.

The actuation is done in many variants of speed regulation: constant, adjustable, with programming, and the modular translation system, replacing the hydraulic and pneumatic cylinders, does not require hydraulic or pneumatic actuators, achieving a high efficiency and a high precision of travel offering a precise positioning of the drive mechanism.

3.OPTIMIZATION OF ACTUATORS

The optimization represents the totality of the constraints that are considered, in order to satisfy certain needs, and thus the offered solution to be accepted.

The main optimization methods involve mathematical analysis so as to perform efficiently high systems in conditions of maximum safety.

The global optimization refers, from the studies, that the optimization is not done at a general level, but an optimization is made at the level of a parameter, and it is optimal only in terms of the function adopted. The solution is the set of parameters that meet the optimization criteria.

The optimization criteria refer to the materialization of the mobility or the degree of mobility or dynamic stability, the load-bearing capacity or the degree of load and the lifespan, the maximum efficiency that refers to the coefficient of friction, the use index or the specific power loss. The minimum size refers to the reduction of the dimensions, the economic efficiency refers to the specific price, and the energetic-phenomenological criterion refers to phenomenon and optimization.

Mathematical programming is a branch of operational research that deals with the general problems of optimization, using various techniques and methods to determine the optimal solution. It is considered a solution, the best calculation option that respects the multitude of requirements, both operation and needs.

We know 4 methods for mathematics optimization. One is the simplex method, or the linear programming method is generally solved with the simplex algorithm. Starting from a basic admissible solution, the algorithm provides a process of successive improvement, until the optimal solution is reached.

The Lagrange multiplier method is a method specific to dynamical systems. This refers to an end of the purpose function, which involves compliance with functional restrictions. By introducing multipliers, some of those constraints are removed and the size of the problem is reduced to provide an optimal solution.

The dynamic programming method involves a simple solution, if there are no restrictions in providing an optimal solution, if the function is decomposed into a sum of nonlinear functions that depend only on 2 variables [5].

The stochastic programming method involves solving the optimization problem from several points of view. A representation will be made on as many probability levels as possible, then all possible combinations of values will be established, linear programs will be solved and the function of the optimal value sets will be obtained.

4. THE RANDAMENT OF ACTUATORS

The efficiency is the production capacity of a worker, a machine, an ensemble, in a unit of time in relation to consumption or the ratio between the effect obtained and the effort made in an activity, action.

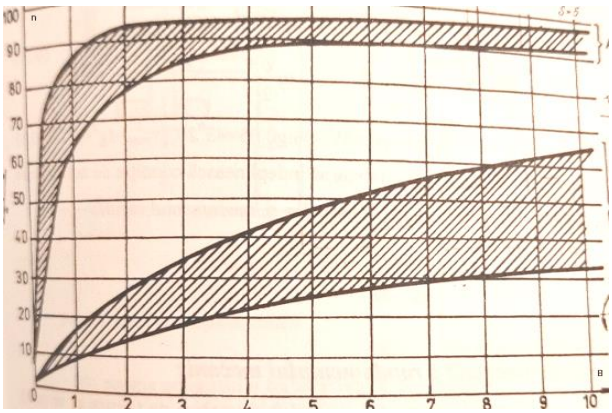

Fig.3 The variation of efficiency of friction screw [4]

The total efficiency is the indicator that considers the multitude of factors that influence the

transmission losses, speed, construction types, lubricant, processing quality or assembly accuracy.

The efficiency of the screw-nut transmissions, figure 3, with rolling elements, at these, the sliding friction (figure 3 down) compared to the rolling one (figure 3 up) is much higher than at the bearings [4].

The main causes for this phenomenon are due to the precision of execution, roughness, and the impossibility of achieving identical treads for the two nuts, which leads to a riding effect.

The riding effect under the action of the loading load and the shape deviations of the rolling bodies, make appear variations of the friction moment, felt on the whole body of the mechanism.

Fig.4 Actuator with screw and nut Mechanism [8]

Determining the maximum values of the mechanical efficiency of a mechanism with screw and nut, figure 4, starts from the theoretical relationship of the efficiency. If the friction angle between the screw and the nut is constant, then we will have a continuous and positive function, and its maximum values are obtained by canceling the yield derivative [8].

5. CONCLUSIONS

In this paper, I want to describe the optimization methods for the characteristics of linear electromechanical actuators.

This theme represents one objective to research, for a study-work and finally give optimized solutions to growth the performances of electromechanical actuators.

This work wants to show the advantage of a deterministic optimization methods in the optimal design of electromechanical actuators.

The numerical methods classically used are founded either on programming techniques or on stochastic approaches which are more satisfactorily adapted to global optimum research, and these methods only guarantee reaching this global optimum with some probability.

The future results, and unexpected results obtained in this research, they are comparisons with previous works.

The mathematical optimization of electromechanical actuators is one part of this research, but from another side we most use one stand from measurements, studies, research, ideas implementations, a hard work, and after,

I hope to develop and growth the characteristics, optimization of parameters from linear electromechanical actuators.

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(Nasui V. Sisteme avansate de miscare rectilinie cu actuatorii liniari electromecanici)

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