The Adam technique produced generally fairly good results, as can be shown from the GLM building results for three cases. The Pareto distribution case was another one where the MCMC approach performed well. After using models in real-world situations to address the issue of foreseeing potential losses, the final parameter estimate approach is decided upon.

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THE POSSIBILITIES EVALUATION OF REPLACING ELECTRO-HYDRAULIC ACTUATORS WITH PLANETARY ROLLER SCREWS LINEAR ACTUATORS

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1. Introduction

For decades, electromechanical and electrohydraulic actuators have competed with each other. Despite the significant advantages of electromechanical actuators, firstly the absence of possible oil leaks, and the conversion of electrical energy directly into mechanical energy, in many industries they could not compete with electro-hydraulic actuators due to the high-power density of the latter. Also, the advantages of electro-hydraulic actuators include the possibility of damping shocks and vibrations that occur in equipment and heavy-duty machines.

2. Literature review and problem statement

The situation has changed with the advent of planetary roller screw linear servo actuators, which their manufacturers position as competitors to electro-hydraulic linear servo actuators [1-2]. The papers [3-6] present current trends in the development of electromechanical and electrohydraulic actuators, but comparative analysis has not been carried out. This research

paper [7] provides recommendations for selecting between self-contained electro-hydraulic and electro-mechanical cylinders. It examines the motion control of a single-boom crane as an illustrative example. The analysis focuses on the sizing process of various commercially available components, considering the design implications when replacing a traditional valve-controlled hydraulic cylinder. The self-contained electro-hydraulic solution is deemed the preferable choice in scenarios where there is a risk of high impact forces, a continuous power output requirement exceeding 2 kW, or when factors such as installation space, weight, and cost are critical design considerations. On the other hand, the electro-mechanical solution is expected to offer superior controllability due to its higher levels of drive stiffness and energy efficiency, as well as reduced system complexity. Moreover, the electro-mechanical solution requires less effort to achieve precise control of the actuator's linear motion. These factors collectively contribute to a more straightforward design approach. Shown that the mechanical transmission system includes the screw assembly (i.e. ball screw or roller screw). In the paper [7], it would be advisable to separate electromechanical drives with ball screw assembly or roller screw assembly. This is justified by the fact that they have significantly different characteristics. The papers present general trends in the development of mechanical engineering and mechatronics, which linear actuators must comply with [8]. Thus, articles that would justify the possibility of replacing electro-hydraulic actuators with electromechanical planetary roller screw actuators have not been identified.

3. The aim and objectives of the study

The study is designed to find out the limits of the possibilities of replacing electro-hydraulic linear actuators with electro-mechanical planetary roller screw actuators.

4. The study materials and methods

The research materials were the technical characteristics of electromechanical planetary roller screw actuators and electro-hydraulic linear actuators, presented by their manufacturers. Also, scientific publications in the field of actuators acted as research materials. The research method was a comparative analysis.

5. Results of studying

For a better understanding of the advantages and disadvantages, consider the design diagrams of an electromechanical planetary roller screw actuator (fig. 1) and an electro-hydraulic linear actuator (fig. 2). The manufacturer Ewellix characterizes its actuators as follows. The CEMC actuators incorporate hollow shaft motors directly around the planetary roller screw technology resulting in a very compact yet powerful solution. Besides dimensions, this design also minimizes inertia, thus allowing excellent control, responsive performance, significantly improved cycle time, and high productivity. This product range provides high power density in a small package, with approximately 50% shorter length than any typical electromechanical cylinder. They are an ideal solution when compactness

and power density are needed to replace fluid-powered cylinders. Moreover, there is the added advantage of reduced weight, an important feature for robot arms installations [1]. The actuator (fig. 1) [1] includes the following components: lubrication fitting (1), push tube (2), high-quality angular contact ball bearings (3), high-quality planetary roller screw for highest axial load rating, low axial play and high efficiency (4), integrated hollow shaft servo motor (5), motor connectors (6), fail-safe brake option (7), position feedback options for compatibility with main brands of robots/controllers (8), scraper seal to keep contamination out (9). Although EWELLIX claims that actuator 1 can replace hydraulic cylinders, their reliability characteristics under conditions of shock and vibration are not indicated.

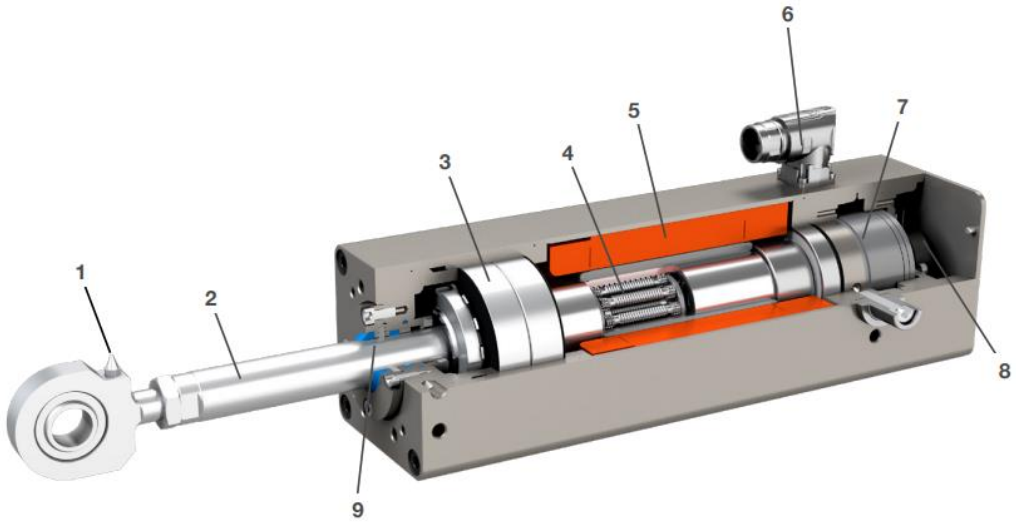

Figure 1 – Planetary roller screw actuator CEMC produced by EWELLIX [1]

Although for some types of actuators, the dynamic load capacity may be 8.67 times higher than the continuous force, it is nevertheless not clear how many cycles of such dynamic loads such an actuator can withstand. Although the above information could not be identified, nevertheless, recommended applications for electromechanical planetary roller screw actuators are indicated by the automotive industry and spot-welding solutions [1]. Another manufacturer of electromechanical planetary roller screw actuators, Tolomatic [2], gives a wider list of industries for the application of this type of actuator. However, he also avoids recommending the use of this type of actuator in applications that are subject to shock and vibration, such as construction equipment. A precision planetary roller screw assembly is much more sensitive to dynamic load changes than a hydraulic cylinder in which the fluid acts as a damping element.

Analysis of catalogues and websites of manufacturers of hydraulic and electro-hydraulic drive components showed that the basic design solution of electro-hydraulic linear actuators is the solution proposed by Parker Hannifin Gmbh [11]. The electro-hydraulic linear actuator [11] consists of the following elements: 1 sealing with a low coefficient of friction (ensures smooth separation and high productivity at low speeds and pressures); 2 high-

strength alloy carbon steel piston rods (for long service life and high impact resistance); 3 replaceable rod seals (for fast, simple maintenance and high performance); 4 pressure-operated body seals (prevention of leakage even in conditions of pressure surges); 5 one-piece steel pistons (mechanically fixed on the piston rod, ensures a long and reliable service life); 6 rods with external or internal threads (with two or four turnkey planes to choose from to facilitate access in limited space); 7 steel manifold with precision machining (optimizes valve/actuator operation); 8 strong steel pipes and fittings (for work in the most difficult conditions); 9. improved magnetostrictive converter (ensuring small error and repeatability over millions of cycles); 10 non-contact permanent magnets (for reliable signal generation in any conditions); 11 steel sleeves for severe operating conditions (protects both the electronic module of the converter and its connector). As we can see, the actuators [11] are specially designed to work under shock loads.

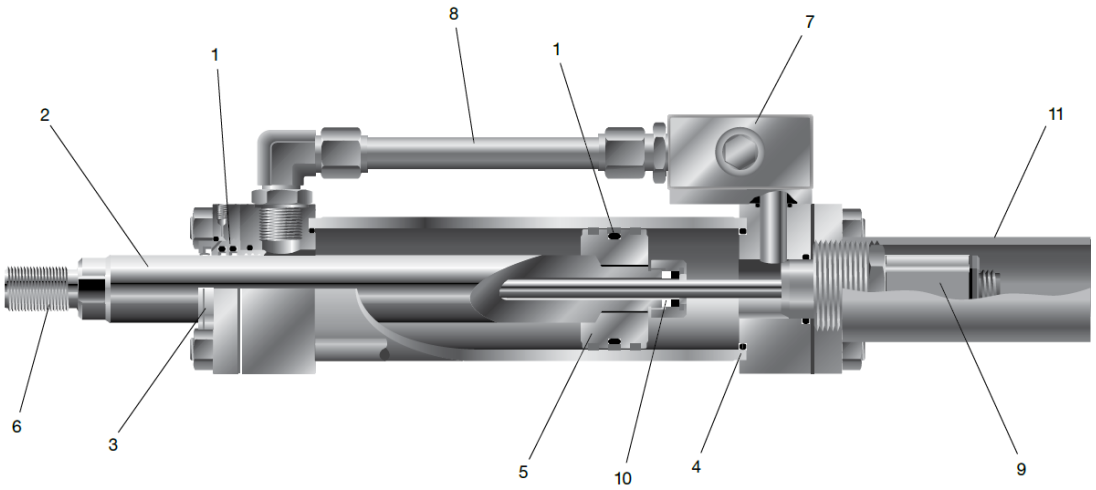

Figure 2 – The electrohydraulic linear actuator of Parker Hannifin Gmbh

6. Discussion of results

A precision planetary roller screw assembly is much more sensitive to dynamic load changes than a hydraulic cylinder in which the fluid acts as a damping element. The emergence of electromechanical planetary roller screw drives greatly eliminates one of the main advantages of electro-hydraulic drives - high power density. At the same time, electromechanical planetary roller screw actuators cannot dampen the dynamic loads which occur in many types of machines. Especially if the dynamic loads are stochastic in nature.

7. Conclusions

In cases where the loads are determined, for example, testing equipment, or industrial robotic complexes, it is recommended to use electromechanical planetary roller screws. If the dynamic loads and stochastic in nature, then it is recommended to use an electro-hydraulic linear actuator.

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