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Free vibrations of two-stage hydraulic cylinder.

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Abstract: The article presents the problem of free vibrations of a two-stage hydraulic cylinder subjected to a Euler compressive load. The cylinder is simply supported on both sides. The formulation of the linear vibration problem of the telescopic hydraulic cylinder was based on kinetic stability criterion using the Hamilton principle and the Bernoulli-Euler theory. The stiffness of the guiding elements and seals between its successive steps was taken into account. These stiffnesses were modelled with translational and rotational springs. The influence of cylinder thickness, piston rod diameter and thickness of guiding and sealing elements on free vibrations of the system was analyzed. The results in the form of characteristic curves on the plane: load – frequency of natural vibrations with various parameters characterizing the considered hydraulic cylinder are presented.

Keywords: hydraulic cylinder, free vibration, stability, slender system, Euler load.

1. Introduction

These Hydraulic cylinder are systems that are used in many industries. Due to obtaining very high longitudinal forces, they are systems exposed to destruction. Hydraulic cylinders are very responsible elements of mechanical structures, the destruction of which can have very serious consequences resulting from economic and loss of health and life. Lech Tomski developed two basic mathematical models of these structures. The first concerns free transverse vibrations and static stability of cylinder as slender system [3]. These model was used in [4]. The second model concerns the free and forced vibrations of the actuator (stocky system) in the longitudinal direction, which was presented among others, by at work [5]. So far, research on telescopic actuators with a number stages greater than one has been limited to fully extended systems [1, 2]. Telescopic cylinders with partial extension have not been tested. In this paper , the actuator is considered as a slender system. The boundary problem of the actuator is formulated on Hamilton's principle. The considered system is shown in Fig.1. It consists of three elements. Two of them are cylinders and one is the piston rod. The tested object was subjected to Euler load at various degrees of its extension. Figure 1 shows the successive stages of the cylinder extensions. In order to easiest presentation of the individual stages of the cylinder extension, a letter designation has been introduces. The letter A indicates the fully assembled cylinder. The letter B corresponds to the cylinder with the first cylinder fully extended. The designation AB was used to represent the extension between configurations A and B. The letter C marks the full extension of the entire hydraulic cylinder. Similarly to the previous situation, the designation BC was used to present the extension between configurations B and C. The letter D (fig. 1) represents the mathematical model used when formulating the linear problem of vibrations of a telescopic hydraulic cylinder.

The mathematical model takes into account the stiffness of the sealing and guiding elements between its individual members. In this study, considerations are limited to a linear system. The results of numerical calculations were presented in dimensionless form relating them to the stiffness of the piston rod of the considered hydraulic cylinder.

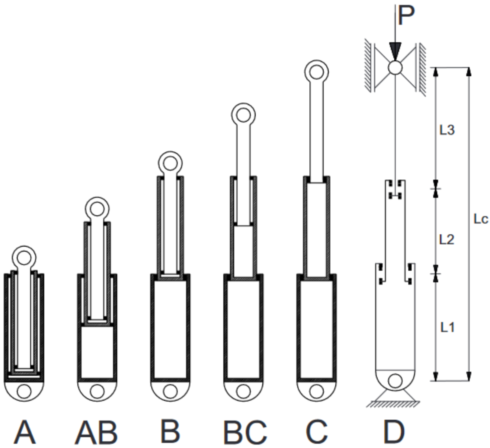

Fig. 1. Diagram of the considered hydraulic cylinder (A, AB, C, BC, C: next step of the cylinder extension, D: mathematical model)

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