A METHOD OF ASSESSING THE STRESS IN SOME COMPONENTS OF HYDRAULIC CYLINDERS

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ABSTRACT

This paper proposes a method for evaluating the stress of the unit body of the hydraulic cylinder and the rod which was at work and the Hydraulic Brake at the end of the race. The paper analyzes the situation in which is acting hydraulic cylinder with a rigid axle set, being powered by a hydraulic installation whose source is a flow pump controlled by power regulator.

KEYWORDS: hidraulic cylinders, cushioning

1. Problem conditions

In many technical applications hydraulic cylinders are used to put in rotation rigids with fixed axis. In general, the calculations in a static conditions are accepted, with covering safety coefficients. The speeds and pressures of work are increasingly large and thus the danger of destruction of cylinder items appears due to the impact of the end of the race. To reduce the intensity of the impact hydraulic braking systems ware introduced. These systems do not eliminate the impact and may have contradictory effects.

The case analyzed in this paper is the one in which the race reaches the maximum value.

It is necessary to determine the unitary efforts that (stress) appear into the hydraulic cylinder tube in periods:

- Starting in place;
- Travel without braking;
- Travel with hydraulic braking.

2. Proposed evaluation mode

To determine the size of the unitary efforts from the tube of hydraulic cylinder are taken into account the following tems:

- Kinematical of the auctioned mechanism;
- The mass characteristics of the rigid with fix axle;

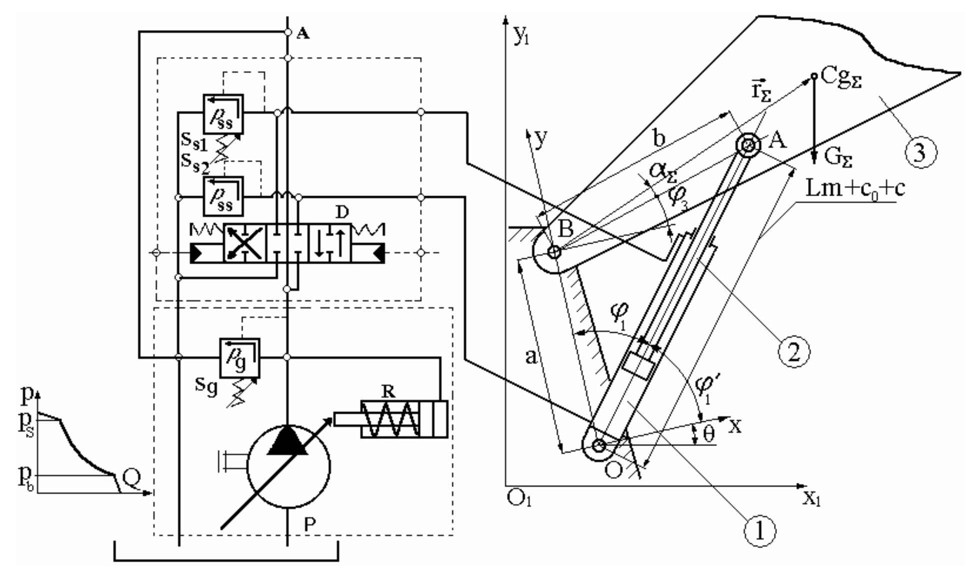

Figure 1 Elements of mechanical and hydraulic systems.

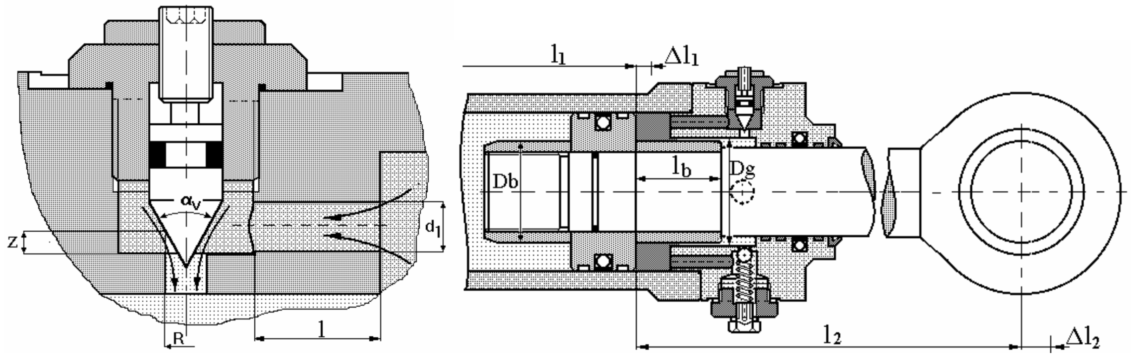

Figure 2 Hydraulic cylinder structure.

- The characteristics of hydraulic installation;
- The geometrical characteristics of the hydraulic cylinder (including the braking parts by cushioning system).

Kinematical mechanism results from the kinematical equipment which the system takes part. In this case, the mechanism is a quadrilateral one, with two coaxial elements, which formed a joint C4t, making a triangle with a variable side a-b-Lm+c0+c (fig. 1). It is considered that the movement of the entire assembly is made in a vertical plane.

Weight characteristics of the rigid with fix axle can be determined quite accurately using the facilities of a projecting program assisted by computer, starting from the drawing execution and the assembly stage.

At the hydraulic installation the interest is represented by the regulator characteristic pression - flow and the general valve characteristics S_g.

In fig. 2 are shown the hydraulic cylinder items that contribute to braking of the mobile assembly through cushioning system. The adjustable component, the cushion adjusting screw wit is presented in detail, with its geometrical elements which show interest.

The efforts appearing in tube cylinder occur in some areas, depending on the position of the piston, as it can be seen in Table 1.

The composing of these efforts was being made by the 4th theory of resistance, of total specific energy of deformation, theory which is closer to the conditions of this application. According to this theory, considering the 3 perpendicular directions (*li, ti*, and *ri*) on the interior front of the cylinder, the equivalent unitary effort is:

$$\sigma_{ech} = \sqrt{\sigma_{li}^2 + \sigma_{ti}^2 + \sigma_{ri}^2 - 2\cdot\nu\cdot\left(\sigma_{li}\cdot\sigma_{ti} + \sigma_{li}\cdot\sigma_{ri} + \sigma_{ri}\cdot\sigma_{ti}\right)}\,. \qquad (7)$$

Table 1.

Stress (unitary effort)	Unitary efforts on the area that corresponds to the linked pump room	Unitary efforts on the area corresponding to the room related to reservoir (tank)
Tangent	$\sigma_{tiA} = \frac{\left(D_i^2 + D_e^2\right)}{D_e^2 - D_i^2}\cdot p$ (1)	$\sigma_{tiB} = \frac{\left(D_i^2 + D_e^2\right)}{D_e^2 - D_i^2}\cdot p_d$ (4)
Radial	$\sigma_{riA} = -p$ (2)	$\sigma_{riB} = -p_d$ (5)
Axial	$\sigma_{li} = \frac{D_i^2 - D_t^2}{D_e^2 - D_i^2}\, p_d$ (3)	$\sigma_{li} = \frac{D_i^2 - D_t^2}{D_e^2 - D_i^2}\, p_d$ (6)

According to the way the problem has been formulated, the pressure from B chamber is the same as the evacuation pressure, no matter the path followed by the drop of hydraulically agent (by the cushion adjusting screw or through the distance between rod end cushion plunger from the piston and the hole where it enters). The equivalent effort is calculated on the two areas (table 1).

3. A numerical application

In order to show the operational way of the proposed working method, we should consider the case of the digging equipment of a hydraulic excavator. The analyzed hydraulic cylinder has the body articulated on a rotating platform of the excavator and the rod is articulated on the monoblock. Starting from the execution documentation have resulted the weight characteristics of the working equipment. It took into consideration the characteristics of the hydraulic installation, the working environment and of the hydraulic cylinder. With this data, the integration of the differential equations being numerically made by Runge-Kutta method of ordinal IV with a numeric calculation program especially realized. In fig. 3 it shows the way of variations of the basic parameters [6]. Their instant values influence the size of the unitary efforts which appear into the body of hydraulic cylinder.

Starting from the calculation program mentioned above and using the calculating relations of unitary efforts shown in table no.1, it was made a new numerical calculation program that allows unitary efforts of evaluation that appear into the body of the cylinder during its functioning, on each area considered.

In fig. 4 is presented the result of the numerical simulation, highlighting the components and the

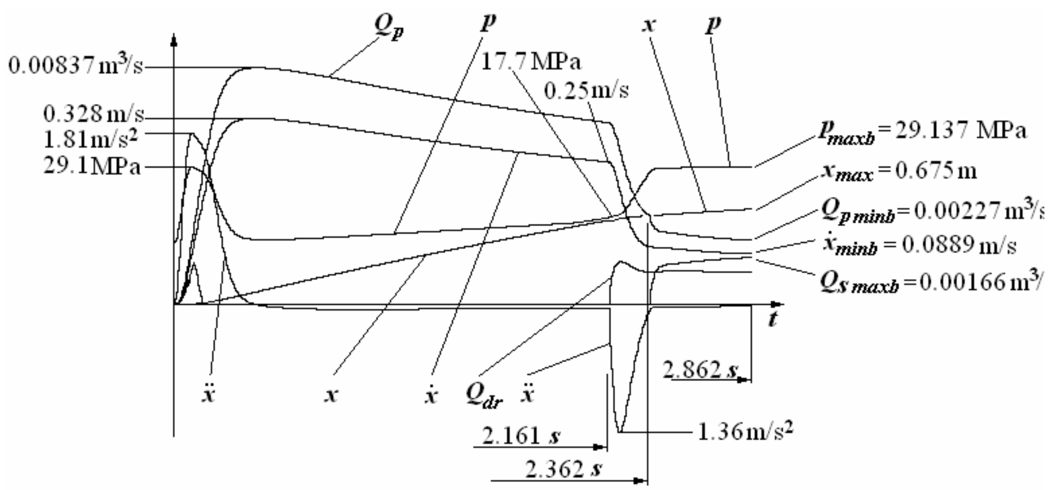

Figure 3 Variation functional parameters of numerical simulation.

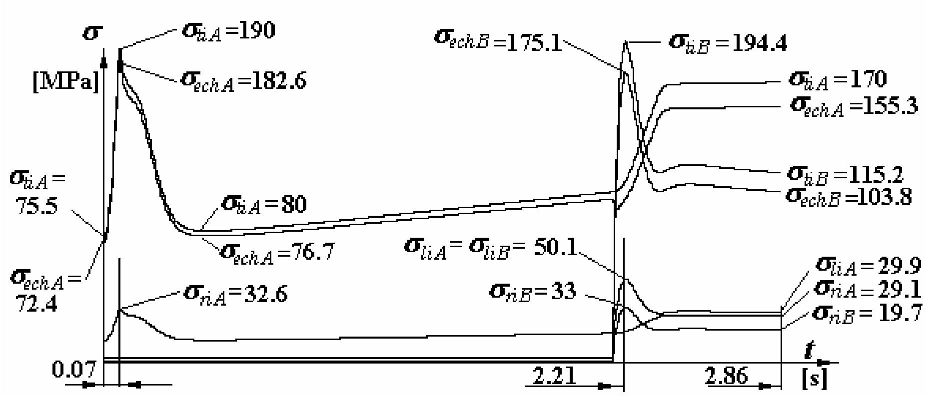

Figure 4 Variation of stress in body work unit of hydraulic cylinders during numerical simulation.

equivalent unitary efforts. The hydraulic braking process starts at about 2 seconds after beginning of the movement of the mechanism.

4. Conclusions

From the numerical simulations arise the following conclusions:

- The main component of the unitary efforts is the tangent one, recorded on the inside face;
- The highest values are registered at the beginning of the hydraulic braking by the cushion system;
- On starting, the maximum value is recorded in camera connected to the pump, maximum pressure being limited by valve Sg, which makes that the efforts to be placed within controllable limits;
- Braking by the cushion system gets to the strong increasing of the unitary efforts in the area related to the room connected to the evacuation, maximum pressure depending on many factors (the piston speed, the distance Db-Dg / 2, the opening of the cushion system, the viscosity of the hydraulic environment, the kinematical of the mechanism, weigh characteristics of the rigid, a.s.o).

A strong braking reduce the results of the impact on the end of the race but leads to a big increase of the unitary efforts into the cylinder body. It must be taken into account that this model does not take into calculation the influence of the tightness and of the guiding rings, factors that increase local unitary efforts.

It is noted that to reduce the maximum effort unit would be required a variation of the section of hydraulic flow of the agent. This requires a special form of bush on the piston rod.

In [7], it is described the theoretical and experimental study of an auto-adjustable stroke end cushioning device utilized in hydraulic cylinders, focusing the characterization of the bush geometry effect on the cushioning achieved.

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