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OPTIMIZED METHOD FOR SYNTHESIS OF A MECHANISM FOR CONTROLLING A HYDRAULIC OPERATED MACHINE

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ABSTRACT

This paper presents how can be design a mechanism capable of self command. It is intended as a high uniformity of the way of action, so that external control is as safe and simple. Are taken into account the concrete conditions of work and restrictions imposed by the regulations. Developed mathematical model was associated with a computer program that allows exploration of design alternative.

KEYWORDS: hydraulic cylinders, mechanism, synthesis

1. INTRODUCTION

Self command mechanisms are used if is desired an automatic return to a neutral position in case of failure of hydraulic pump tilt control. In figure 1 it is shown such a mechanism. Main hydraulic cylinders, CH, agent are supplied with the variable flow reversible hydraulic pump, P2. The rotation of the pump control lever is made with a hydraulic cylinder control, HCC. The fluid for supplying the control hydraulic cylinder is made with constant flow by the pump P1. Its power control is achieved by an electrically controlled hydraulic divider D.

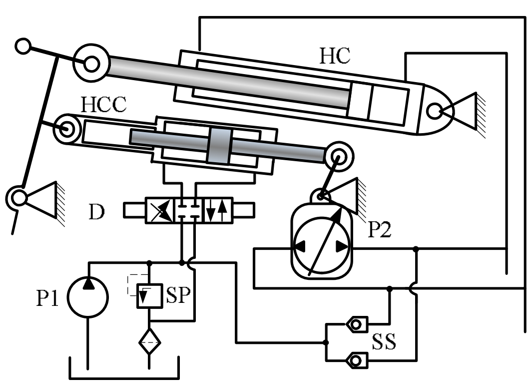

Fig. 1 Simplified hydraulic diagram of the machine

Also pump P1 provides compensation for the loss of main pump flow rate of P2. It takes into account the fact that the flows in and out of main hydraulic cylinders are not equal because of the differences of active and passive areas and different speeds of movement of the pistons. Compensation flow is performed using SS valves. SP pressure valve maintains a constant pressure command circuit and compensation.

Due to the constant pressure maintained by the SP, HCC command cylinder provides a force strong enough to rotate the flow control rod of hydraulic pump P2 and to maintain this position when rotating the tiller. To ensure equal reaction speed and equal strength in both directions of displacement CHH is made with the equal active areas.

When interrupting the flow of command by hydraulic distributor D, HCC command cylinder behaves like a rigid bar. Due to the continued movement of the tiller, HCC control the element acts on the hydraulic pump P2 flow, reducing the flow to zero. Angle that rotates the tiller angle in this period is called slow angle, α_s

Minimum and maximum lengths of the hydraulic cylinder controller are chosen such that the movement of the tiller angles limit α_h, to produce rotation of the pump P2 to zero flow, regardless of command electrically controlled distributor D

It is thus evident that a rotating tiller angle prescriptions imposed a challenging task because the size of α_s angle is variable, depending on the current angle and the sense of rotation. Furthermore, to be made and rotation of the tiller angles smaller than α_s.

A typical structure of a command cylinder is shown in Figure 2.

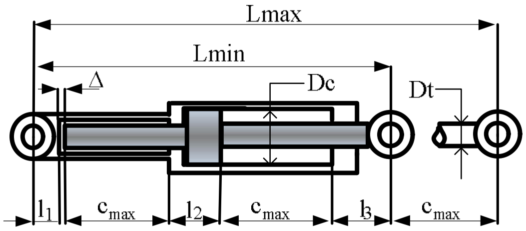

Fig. 2. Dimensional structure of a hydraulic cylinder command

The sum of the constant dimensions of the hydraulic cylinder sizes is

$$f_p = l_1 + l_2 + l_3 \tag{1}$$

The terms sum can be obtained from companies producing catalogs

Minimum and maximum lengths of the hydraulic cylinder controller are

$$\begin{aligned} L_{min} &= f_p + 2 \cdot c_{max} + \Delta \\ L_{max} &= f_p + 3 \cdot c_{max} + \Delta \end{aligned} \tag{2}$$

Δ parameter is taken according to constructive necessities. With its help can increase the size of minimum and maximum

If limits are too large, lengths can take the constructive solution presented in Figure 3. End joints are supersedes with a coaxial system with two bolts attached to the cylinder body.

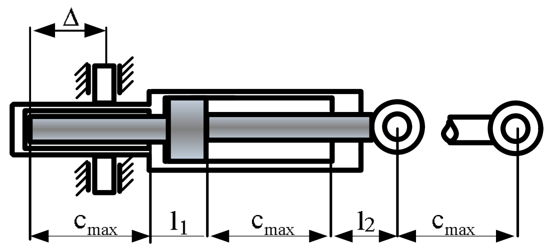

Fig. 3. Constructive version of command hydraulic cylinder

The constructive part in this case is given by the following equation

$$f_p = l_1 + l_2 + l_3 \tag{3}$$

and minimum and maximum lengths of command of the hydraulic cylinder are

$$\begin{aligned} L_{min} &= f_p + 2 \cdot c_{max} - \Delta \\ L_{max} &= f_p + 3 \cdot c_{max} - \Delta \end{aligned} \tag{4}$$

In this case dl parameter is used to reduce the dimensions limit.

2. DIMENSIONS CONTROL MECHANISM DETERMINATION

Determining the dimensions control mechanism is made using kinematical scheme shown in Figure 4. Tiller was represented in the two positions permitted by the limit control mechanism.

Minimum and maximum dimensions of the cylindrical hydraulic command were determined from the conditions:

- to calculate the minimum length, the tiller is positioned at the angle $-\alpha_h$ and the lever of the hydraulic pump is rotated to β = 0;

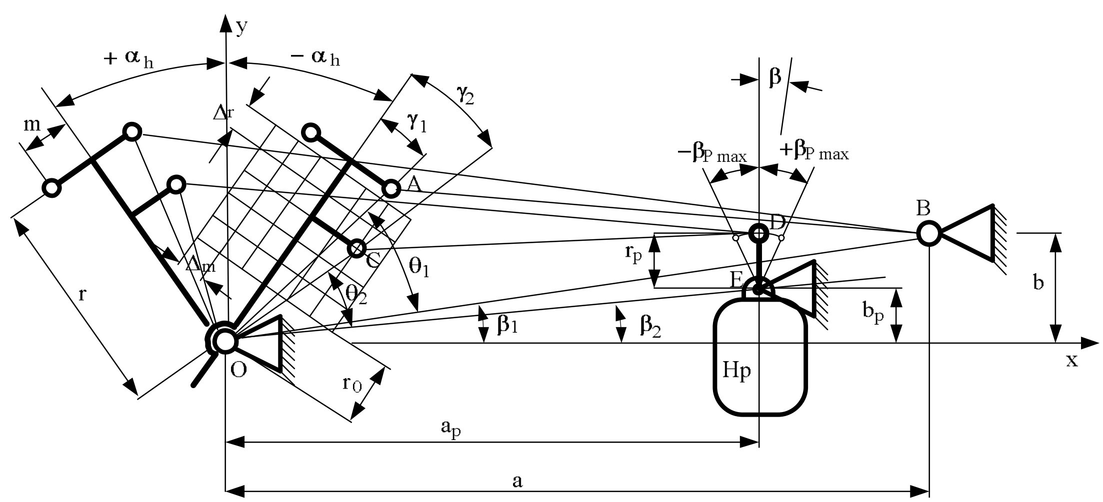

Fig. 4 Scheme of the mechanism kinematics

- to determine the maximum length of the hydraulic cylinder control, is considered tiller rotated at $+\alpha_h$ and hydraulic pump lever is positioned to $\beta = 0$.

The difference between maximum length and minimum length of the control hydraulic cylinder is just the maximum stroke

$$c_{max} = L_{max} - L_{min} \qquad (5)$$

Was developed a mathematical model to determine the law of variation of the tiller angle α_s with which are rotates when the hydraulic cylinder is rigid control. During this period, the lever of hydraulic pump P2 is pushed by the hydraulic cylinder and turn the control until $\beta = 0$. Hydraulic pump P2 produces a flow dropping until it becomes null.

It is necessary that the tiller can rotate in both directions and that the function of the angle AS is a portion of the range home use $+\alpha_h \ldots -\alpha_h$.

These areas (in each direction separately) were divided into equal parts. The results were calculated points α_s corresponding angles for each direction of rotation side.

Note that the areas mentioned are not equal and are partially overlapping.

Wen adopting the actuator dimensions the following aspects are taken into consideration:

- it is desirable that the position angle variation of α_s with α be as small as the domain of definition;

- maximum angle α_s function schould be very low to reduce the reaction times;

- α_s angles function values schould be as close together on the two directions of rotation of the tiller.

To achieve these goals was considered a variable position of the joint command hydraulic cylinder on the tiller. For analysis it was considered a rectangle divided into n rows and m columns. Different positions of point C on the tiller are considered and laws of variation α_s are determined.

3. NUMERICAL APPLICATION

Based on the principles of calculation shown was performed a numerical calculation program. This allows the synthesis of optimal control mechanism.

For example there are some results obtained from the following parameters:

- $\alpha_h = 35^0$;
- $\beta_{P\,max} = 21^0$;
- $r_0 = 0.4$m;
- $\Delta r = 0.2$ m;
- $\Delta m = 0.15$m;
- $a_p = 1.8$ m;
- $b_p = 0.5$ m;
- $r_{pir} = 0.15$ m.

For the node that has hooks on the tiller formal coordinates n = 0 and m = 1 are obtained tabular functions shown in Table 1.

Table 1

$\bar{\alpha}$	$\bar{\alpha}_s$	$\bar{\alpha}$	$\bar{\alpha}_s$
35.00	7.34	-35.00	14.28
28.94	7.33	-28.00	11.78
22.87	7.40	-21.01	10.10
16.83	7.58	-14.01	8.97
10.77	7.88	-7.01	8.19
4.71	8.35	-0.01	7.66
-1.34	9.06	6.89	7.31
-7.40	10.14	13.98	7.11
-13.46	11.93	20.98	7.02
-19.51	15.49	27.98	7.02

In this case, the parameters required for the hydraulic cylinder control mechanism are:

- $L_{min} = 1.504$ m;
- $L_{max} = 1.921$ m;
- $c_{max} = 0.417$ m.

Table 2 shows the situation in which the hydraulic cylinder actuator is articulated on the tiller at the point of symbolic coordinates n = 3 and m = 1.

Table 2

$\bar{\alpha}$	$\bar{\alpha}_l$	$\bar{\alpha}$	$\bar{\alpha}_l$
35.00	3.48	-35.00	3.82
27.63	3.26	-27.63	3.44
20.26	3.09	-20.25	3.23
12.89	2.97	-12.88	3.13
5.52	2.89	-5.50	3.10
-1.85	2.85	1.87	3.12
-9.21	2.88	9.25	3.18
-16.58	2.99	16.62	3.29
-23.95	3.22	24.00	3.44
-31.32	3.38	31.37	3.63

The parameters required by the hydraulic cylinder control mechanism are:

- $L_{min} = 1.107$ m;
- $L_{max} = 2.265$ m;
- $c_{max} = 1.158$ m.

4. CONCLUSIONS

Numerical simulations show the possibilities of the mathematical model and computer program.

Note that in the first case, the domain of definition of the α_s angle is reduced. α_s angle size significantly changes in the domain of definition. For the two-way rotational movement of the tiller there are laws that differ greatly.

In the second case above mentioned shortcomings are greatly diminished. This mechanism will make the machine more easily controlled and it will have the best reactions.

Less favorable aspects appear. Increases the maximum stroke and therefore limits the size of the hydraulic cylinder control. Shall be required to use the variant of Figure 3, more complicated and more difficult to enforce. Modifying position of flow control lever shaft, hydraulic pump P2 can change the limit and maximum stroke lengths.

By modifying the hydraulic pump P2 axis position or obtained for n = 1 and m = 3 values shown in Table 3.

There was a decrease of hydraulic cylinder size command:

- $L_{min} = 0.742$ m;
- $L_{max} = 1.258$ m;
- $c_{max} = 0.516$ m.

α_s average value of angle increases.

Must be considered that real slow angle is slightly smaller than the theoretical because of the way of stopping the hydraulic-mechanical system.

Designing such a mechanism may refine the solution adopted by making a new mesh around the area where the optimum is found.

Table 3

($a_p = 1\text{m}$, $b_p = 0.3\text{m}$, $r_{pir} = 0.1\text{m}$)

$\vec{\alpha}$	$\overleftarrow{\alpha}_l$	$\overleftarrow{\alpha}$	$\overleftarrow{\alpha}_l$
35.00	5.37	-35.00	5.45
27.83	5.05	-27.82	5.03
20.67	4.82	-20.63	4.78
13.50	4.65	-13.45	4.65
6.33	4.55	-5.26	4.60
-0.84	4.51	0.92	4.63
-8.00	4.55	8.10	4.71
-15.17	4.70	15.29	4.86
-22.34	4.98	22.47	5.07
-29.50	5.50	29.66	5.34

The program allows an easy modification of parameters so as to obtain constructive alternatives that seek the optimum value.

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