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Optimization of hydraulic drive parameters of caterpillar forest loader

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Abstract. The document discusses the methodology for calculating the optimal parameters of a tracked forest loader. Based on the data obtained, a mathematical model of the kinematics of machine drives was compiled when the cargo was released "through itself." As a result of the work, changes in the demand for force on the boom lifting hydraulic cylinder and graphs of the dependence of the forces of the hydraulic cylinders on the angles of rotation of the boom and rocker were built. Based on the results of the work, conclusions were made about the change in the moments changed by the cargo.

1 Introduction

Different influence of several factors on selection of optimal parameters of machine in pre-calculated range indicates expediency of solution in such cases of multi-criteria problem of designing optimal parameters of mechanism connecting output drive link with controlled device. For example, in the construction and road and logging engineering, hydraulic and pneumatic drives with reciprocating movement of output links connected by lever mechanisms with controlled devices are widely used [1].

The multi-criteria task of designing optimal mechanism parameters becomes relevant in such cases due to the influence of several factors on the choice of these parameters. Consider, for example, the case of the use of hydraulic and pneumatic drives in construction and road and logging machinery.

These industries often use linkage mechanisms that allow reciprocating movement of the output link from the drive to the controlled device. The parameters of such a mechanism, such as the length of the lever, the drive force, the speed of movement, can have a significant effect on its operation and efficiency.

Various factors must be taken into account when choosing the optimal parameters of the mechanism. For example, the requirements for the speed and accuracy of movement of the output link, drive power and power consumption, the reliability and durability of the mechanism, as well as restrictions on available resources [2].

The multi-criteria approach allows you to take into account all these factors at the same time and find the optimal mechanism parameters that meet the specified requirements and

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restrictions. To do this, it is necessary to analyze and optimize the mechanism based on various criteria, such as performance, efficiency, reliability and durability.

Thus, the multi-criteria task of designing optimal parameters of the mechanism, taking into account the influence of several factors, is an appropriate solution when designing machines in such industries. This allows you to improve the operation and efficiency of the mechanism, as well as achieve the satisfaction of all requirements and restrictions.

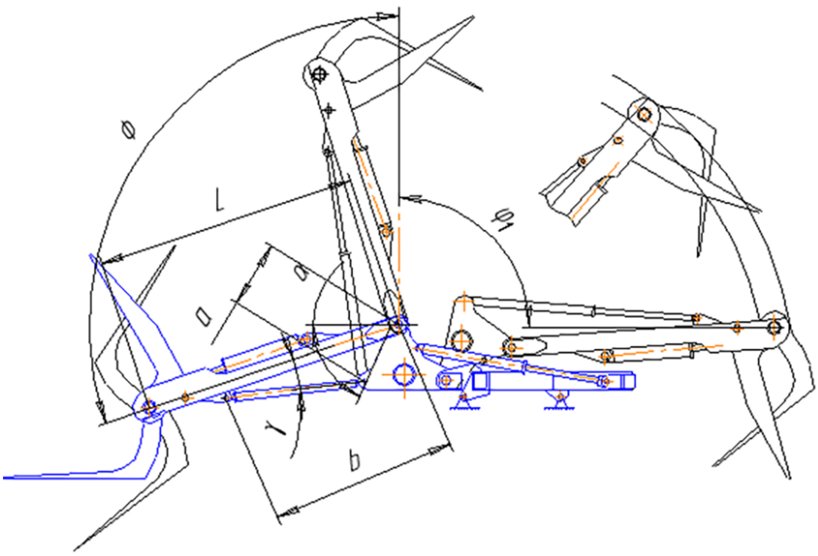

Fig. 1. Lever mechanisms with controlled devices.

2 Results and discussion

Minimizing the maximum force, Pmax generated by the drive at different positions of the output link reduces the drive cost, which can be a significant part of the cost of the entire machine. The problem of selecting the optimal parameters of the mechanism is formulated to find the values a, b, β = α + γ which the objective function (criterion):

$$P_{\max} = P(\varphi)\ at\ \varphi_{\min} \le \varphi \le \varphi_{\max} \tag{1}$$

The objective function must be supplemented with restrictions that follow from the relationship defined by the cosine theorem between linear dimensions and angles. These limitations can be represented by equalities [3]

$$2ab \cdot \cos(\beta + \varphi_{\min}) - (a^2 + b^2) = -z_{\min}^2 \tag{2}$$

$$2ab \cdot \cos(\beta + \varphi_{\min}) - (a^2 + b^2) = -z_{\max}^2 \tag{3}$$

Where z_{min} and z_{max} are displacements of actuator rod end (drive output link) relative to cylinder support at z_{min} and z_{max}, respectively.

Function $P(\varphi)$ can be found based on the load equilibrium condition with weight m at different positions of the drive output link [4]:

$$P(\varphi, b) = \frac{L \cdot m \cdot g \cdot \sqrt{(a^2 + b^2) - 2 \cdot a \cdot b \cdot \cos(\beta + \varphi)} \cdot \cos(\varphi)}{a \cdot b \cdot \sin(\beta + \varphi)} \tag{4}$$

Substituting the known data into the above expression, we will plot the dependence of the need for the boom lifting hydraulic cylinder force, on the angle of rotation φ, at different values "b"

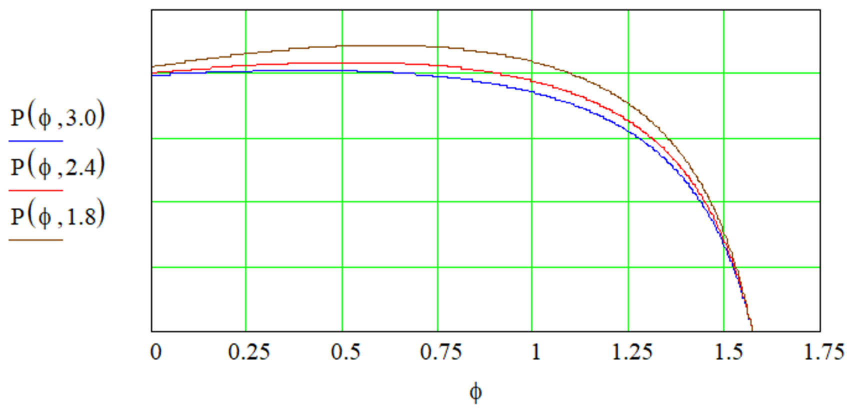

Fig. 2. Graph of geometric parameters change.

It can be seen from the graph (Figure 2) that with the change in the geometric parameter "b" the required force on the boom lifting hydraulic cylinder changes.

The equation of changing the moment of the load, from changing the angle of rotation (φ) can be written as follows:

$$M_{c_1}(\varphi) = m \cdot g \cdot (0.5 + L \cdot \cos(\varphi)) \quad (5)$$

Where L is the length of the entire boom, m is the weight of the load, g is the acceleration of gravity

And the moment developed by the load after movement through the vertical axis is recorded in the form of [5]:

$$M_{o_1}(\varphi_1) = m \cdot g \cdot L_3 \cdot \cos(\alpha(\varphi_1)) \quad (6)$$

Where L_3 is the distance from the center of gravity of the cargo, to the point O_3, m is the weight of the cargo, g is the acceleration of gravity, α(φ1) is the change in the angle of lowering of the cargo.[6]

The obtained diagram (Figure 3) shows that the moment of rocker lifting hydraulic cylinder is insufficient to raise the rocker until the moment of load is small enough.

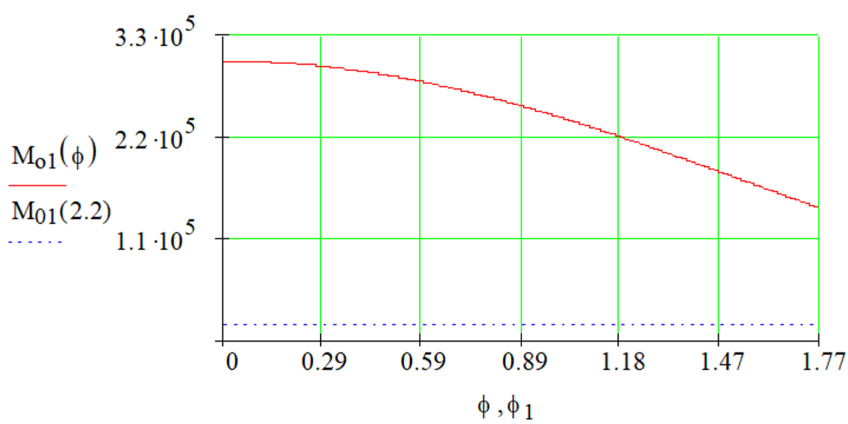

Fig. 3. Hydraulic cylinder lifting schedule.

Record the moment developed by rocker lifting hydraulic cylinder in the form of:

$$M_p(\varphi_1) = (p \cdot S_2 - p_n \cdot S_{2n}) \cdot 2 \cdot h_2(\varphi_1 - 5) \quad (7)$$

Where p is the pressure in the drain line, p_n is the operating pressure in the system, S_2 is the piston area in the rod cavity, S_{2n} is the diameter of the hydraulic cylinder, h_2 is equal to [7]:

$$h_2(\varphi_1) = \frac{\sin(\varphi_1)}{\sqrt{\frac{1}{a_1} - \cos(\varphi_1) \cdot \frac{1}{b_1} + \frac{1}{b_1^2}}} \quad (8)$$

The resulting moment shall be recorded as the sum of moments by the developed load and rocker lifting hydraulic cylinder [8]:

$$M_\Sigma(\varphi_1) = M_{0_1}(\varphi_1) - M_p(\varphi_1) \quad (9)$$

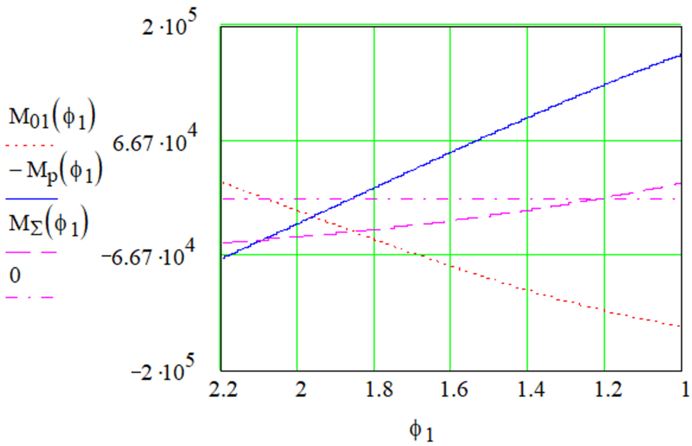

Fig. 4. Schedule of moments.

3 Conclusion

From this article, we can conclude that when the load passes through the vertical Y axis, the direction changes and the moment developed by the load and the rocker lifting hydraulic cylinder increases.

The moment developed by the load becomes negative, and the moment developed by the hydraulic cylinder begins to increase. This may indicate an increase in the load on the hydraulic cylinder and its active operation when lifting the load through this axis.

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