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A COMBINED METHOD FOR DIMENSIONING MECHANISMS OPERATED WITH HYDRAULIC CYLINDERS

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ABSTRACT

This paper presents a method of synthesis of a mechanism used in ship steering systems. The case examines the use of force as elements of hydraulic differential cylinders articulated at both ends. Sizing the difficulty comes from the existence of multiple conditionings, co-designed mechanism to ensure functionality, limitations that the nature of mathematics leads to complications. To overcome them an iterative method of synthesis is proposed. Hydraulic components are envisaged in the structure of the system. This paper refers only to the system that produces torque.

KEYWORDS: mechanism, hydraulic, hydraulic cylinders

1. INTRODUCTION

Some technical applications require simple and reliable mechanisms to produce high torques in a small space, without using expensive equipment. Figure 1 is an example of such a mechanism.

Fig. 1. Mechanism operated by hydraulic cylinders.

Depending on situation there may be a one, two, a four or even an eight-cylinder hydraulic drive. The system has the advantage of a good compactness, especially in height. Another advantage is the possibility of failure mode operation in a part of the total number of cylinders.

Constructive simplicity ensures a low price and good reliability.

Maintenance and repairs are relatively easy to achieve, with no need for special equipment or trained personnel.

2. MACHINE CONSTRUCTION AND OPERATION

Figure 2 shows the cinematic scheme of the principle of the whole mechanism. This mechanism contains of power mecanism and control mechanism.

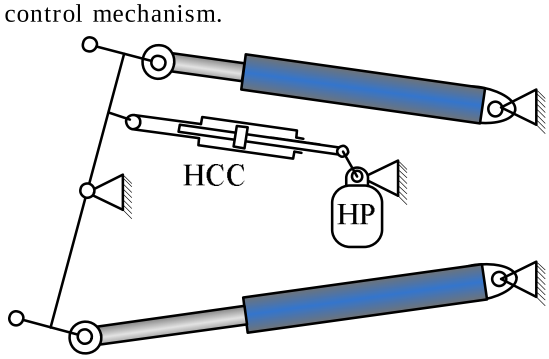

Fig. 2. General scheme of the cinematic mechanism

In terms of theory of mechanisms, the

system mobility is two.

Since between the mechanism of power and the control mechanism exist the hydraulic links, carrying volumes of hydraulic agent, real mobility is one.

The power hydraulic cylinders have different surfaces on the two active areas. Hydraulic cylinders for operating the control mechanisms have equal surfaces on both active surfaces (to achieve equal speeds in both directions).

Control hydraulic cylinders, HCC, and connect the tiller lever tilting hydraulic pump with variable flow HP. They are dimensioned and arranged to permit rotation equivalent to the maximum angle α_h

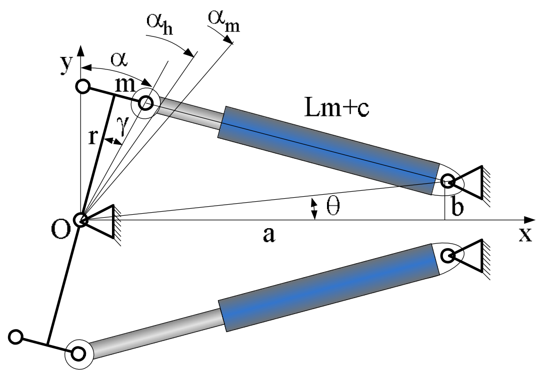

Fig. 2. Cinematic scheme with the angles made by the mechanism of force

Since the torsion moments are large, use of mechanical stops is objectionable. For emergency cases, when the angle is exceeded, the main hydraulic cylinders stops machine's steering mechanism. They reach the end of the race (minimum or maximum) position, which corresponds to α_m . Simultaneous reach this limit is important because otherwise it can be damaged first cylinder reaches the end of the race.

3. CALCULATION PARAMETERS

To determine the main dimensions of the machine we use two types of parameter:

- nominal, adjustable within the limits in which the system is functioning normally;

- maximum adjustable, depending on the maximum pressure safety valves are adjusted;

In Figure 3 are functions describing the variation of the torques at the nominal pressure p_n and maximum pressure p_{max} .

Nominal torque M_n is required for the maximum angle required, α_h, due to the control mechanism.

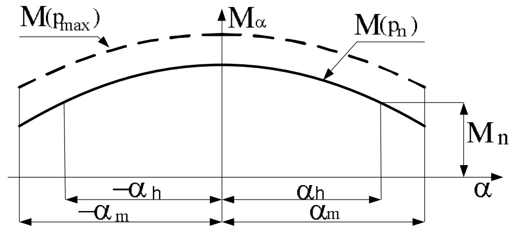

Fig. 3. Variation of torque to the axle tiller at nominal pressure and maximum pressure.

It is envisaged that the hydraulic cylinders and the rods have inner diameter series. It is required for sealing and guidance systems. Also minimum length, maximum length and stroke cylinder are dependent, as can be seen in Figure 4.

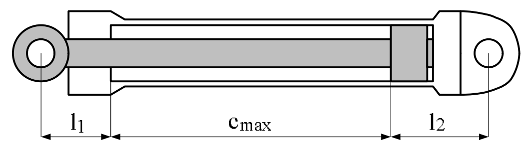

Fig. 4. Dimensional element of a hydraulic cylinder

Hydraulic cylinder manufacturers produce different versions by changing only the maximum stroke length, c_{max}, and keeping the elements at the ends unchanged.

Noting the constructive set

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

we can calculate the minimum length

$$l_{c\,min} = Lm = f_p + c_{max} \tag{2}$$

and maximum length

$$l_{c\,max} = f_p + 2 \cdot c_{max} \tag{3}$$

Establishing the dimensions of the mechanism is realized considering the dimensions of location (which determines the size b) and torque imposed, M_{min}, on the maximum angle α_h.

It is considered that this position cylinder axes are parallel to the x axis, as represented in Figure 5.

Since

$$M_{min} = \frac{b \cdot p_n \cdot \pi}{4} \cdot \frac{n}{2}\left(D_c^2 + \left(D_c^2 - D_t^2\right)\right) \tag{4}$$

n number of cylinders, D_c-cylinder diameter and the rod diameter- D_t. Manufacturers made hydraulic cylinders a report known between cylinder diameter and the rod diameter ($r = D_c / D_t$), minimum diameter can be calculated. In choosing from a catalog of and are obtained by default. In choosing from a catalog of D_c and D_t are obtained by default . In choosing from a catalog of D_c are obtained by default f_p .

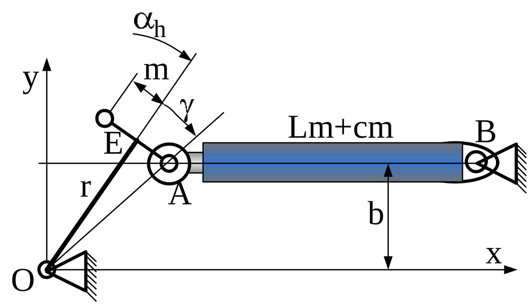

Fig. 5. Parallel to the axis of the hydraulic cylinder to angle α_h .

The parameter m depends on the size of the rod joint.

The coordinates of point E are

$$\begin{cases} x_E = r \cdot \sin(\alpha_h) \\ y_E = b + m \cdot \sin(\alpha_h) \end{cases} \tag{5}$$

With

$$r^2 = x_E^2 + y_E^2 \tag{6}$$

and raising (5) resulting squared

$$r = \sqrt{\frac{b^2 + 2 \cdot b \cdot m \cdot \sin(\alpha_h) + m^2 \cdot \sin^2(\alpha_h)}{1 - \sin^2(\alpha_h)}} \tag{7}$$

4. DETERMINATION OF MAXIMUM STROKE AND THE HYDRAULIC CYLINDER FIXED JOINT POSITION

To determine the position and the stroke of cylinder fixed joint consider we the diagram in Figure 6.

Refering to the extreme positions they will occupy the length of the cylinder A. The two positions are

$$l_{AB} = Lm = f_p + c_{max} = \\ = \sqrt{(x_B - x_A)^2 + (y_B - y_A)^2} \tag{8}$$

$$l_{A'B} = Lm + c_{max} = f_p + 2 \cdot c_{max} = \\ = \sqrt{(x_B - x_{A'})^2 + (y_B - y_{A'})^2}$$

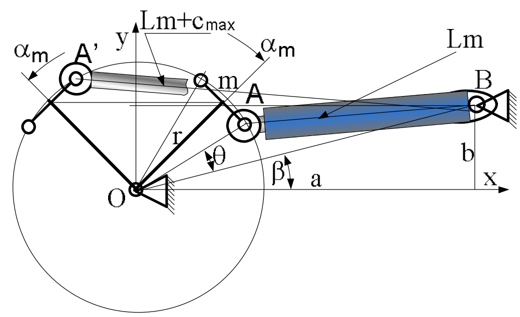

Fig. 6. Joint of hydraulic cylinder in two extreme positions

With

$$l = \sqrt{r^2 + m^2}; \quad \gamma = atg(m/r) \tag{9}$$

result

$$\begin{cases} x_A = l \cdot \sin(\alpha_m + \gamma) \\ y_A = l \cdot \cos(\alpha_m + \gamma) \end{cases} \begin{cases} x_{A'} = -l \cdot \sin(\alpha_m - \gamma) \\ y_{A'} = l \cdot \cos(\alpha_m - \gamma) \end{cases} \tag{10}$$

leading to

$$\begin{aligned} (f_p + c_{max})^2 &= (a - l \cdot \sin(\alpha_m + \gamma))^2 \\ &+ (b - l \cdot \cos(\alpha_m + \gamma))^2 \\ (f_p + 2 \cdot c_{max})^2 &= (a + l \cdot \sin(\alpha_m - \gamma))^2 \\ &+ (b - l \cdot \cos(\alpha_m - \gamma))^2 \end{aligned} \tag{11}$$

The unknowns of this quadratic system are a and c_{max}. The attempt to solve the equations leads to grade 4, which can not be solved exactly.

Therefore it is proposed an approximate method of solving. Calculation errors in determining the unknown parameters are controllable. To solve it numerically using a computer program that follows these logical steps:

1- approximates a minimum length Lm is 25% higher than f_p ;

2- stroke hydraulic cylinder is calculated by considering the tiller in the following way:

$$l_{OB} = \sqrt{a^2 + b^2} \tag{12}$$

$$\beta = \text{atn}\left(\frac{b}{a}\right)$$

$$\theta = \frac{\pi}{2} - \alpha_m - \beta$$

$$Lm = \sqrt{l_{AB}^2 + l^2 - 2 \cdot l_{AB} \cdot l \cdot \cos(\theta)}$$

$$c_{max} = Lm - f_p$$

3 – is calculated

$$l_{A'B} = f_p + 2 \cdot c_{max}$$

$$\theta = \arccos \frac{l_{OA}^2 + l^2 - l_{A'B}^2}{2 \cdot l_{OA} \cdot l} \tag{13}$$

$$\alpha = \beta + \theta + \gamma$$

and check if

$$\alpha \le \frac{\pi}{2} + \alpha_m \tag{14}$$

4 – the distance is increased with an especially convenient increment and the calculations of section 2 are repeated. The cycle continues until the condition is not met the 14

5- the search solution lies between the last two values of a. To refine the solution proceeds to halving the interval until the solution is relative positioning error is smaller than a permissible value.

3. CONCLUSIONS

The design of the machines mechanisms generates various situations related to the functional condition and constructive nature. To fulfill the requirements related to these conditionings are calculations necessary , exact or approximate.

This paper also present a combination of calculations that lead finally to the desired result. Such mathematical models have been used in the design of steering mechanisms. The current version represents an improvement in terms of elimination in a significant measure adopted parameters and their determination by calculation.

Numerical calculation method and software allow work done even when giving up the condition of parallelism of the cylinder axis at α_h.

This calculation method can be used with other mechanisms and structure similar conditionings, frequently encountered in technical applications today

REFERENCES

[1] **Deciu, E., Dragomirescu, C.**, *Maschinendynamik*, Ed. Printech, Bucureşti, 2001.

[2] **Frischer, U., Magdeburg, G., Stephan, W.**, *Mechanische Schwingungen*, VEB Fachbuchverlag Leipzig, 1984.

[3] **Hauger, W., Schnell, W., Gross, D.**, *Technische Mechanik 3, Kinetik*, Springer Verlag, Berlin Heidelberg, 2002.

[4] **Pascu, A.**, *Structura mecanică a aparatelor electronice*, OID-ICM, Bucureşti, 1992.

[5] **Voinea, R., Deciu, E., Dragomirescu, C.**, *Technische Mechanik*, Ed. ALMA Craiova, 2009.

[6] http://www.db-electronic.com/index.php?nav3&subnav=4&tipp=1&lang=de.