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Dynamic Analysis of the Planetary Mechanism of the Horizontal Forging Machine

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ABSTRACT: Currently, many modern machines are automated. For the manufacture of such machines, it is necessary to perform accurate calculations, geometric, kinematic and dynamic parameters. This article provides a dynamic calculation of the planetary mechanism used in many machines.

KEY WORDS: planetary gear, gear, satellite, forging machine, cam mechanism, gear, linkage.

I. INTRODUCTION

The article provides an analysis of the planetary mechanisms used in many machine drives, for example, horizontally to an oval machine, a deep cold generator, a crank-slide press, a single-stage piston compressor, and many other machines. Currently, many machine drives are automated. For this, it is necessary to analyze and calculate the parameters with great accuracy.

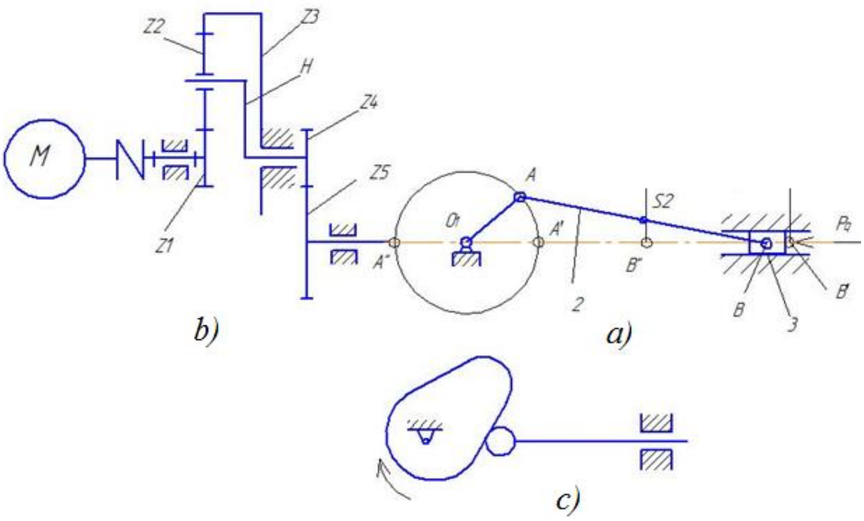

Figure 1. Kinematic diagram of the mechanisms of the horizontal-oval machine:
a) gearbox, b) crank-slider mechanism, c) cam mechanism

This paper provides a dynamic calculation of the parameters of planetary mechanisms, using the example of a horizontally forging machine.

Horizontal forging machine is designed for hot stamping products from bar material.

The landing slider 3 receives a reciprocating movement from the crank 1 through the connecting rod 2, (Fig 1, a).

The movement of all mechanisms is carried out from the electric motor by means of a planetary gear and a gear transmission Z_4 and Z_5, (Fig. 1).

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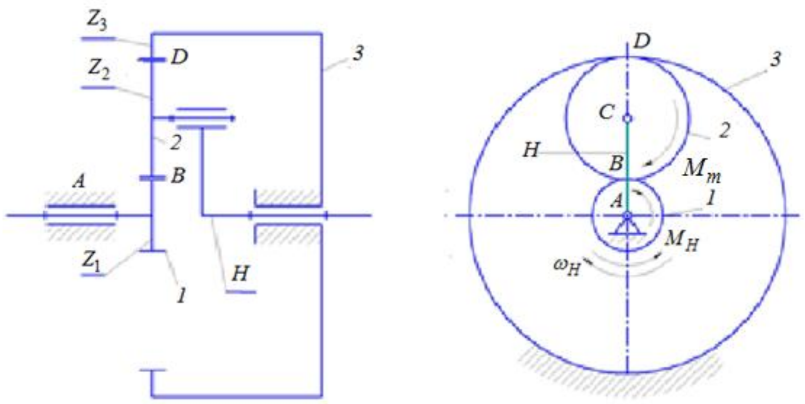
The cam mechanism, (Fig 1,c), is part of the clamping mechanism that clamps the workpiece. The gearbox (Fig 1,b), consists of a planetary gear and a gear.

II. RESEARCH METHODOLOGY

The gearbox receives movement from the electric motor and transfers to the crank-slide and cam mechanisms. When movement is received in the planetary mechanism (Fig2), force factors appear (Fig 3). This article analyzes and forces the calculation of this mechanism. The planetary mechanism consists of a driving gear wheel Z_1, a satellite Z_2 and a sun wheel Z_3 (Fig 3,b).



a) b)

Fig 2. Planetary mechanism diagram

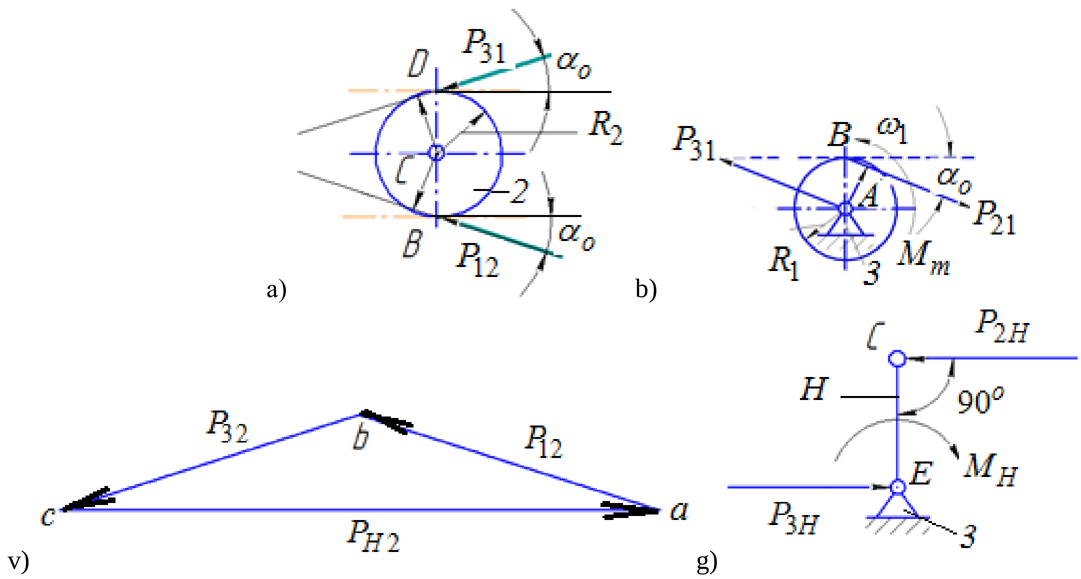


Fig 3. The forces acting on the wheels of the planetary gear.

In a horizontal forging machine, the drive is driven through a planetary gear. In the planetary mechanism, the number of shaft revolutions received from the electric motor is reduced to the required by the consumer and transmitted further. Therefore, it is necessary to comprehensively study the action of the planetary mechanism is the most important task. We make power calculation of the planetary mechanism. For this, the following paramatras are

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specified. The moment $M_H = 20\ нм$ is set on the carrier, the resultant moment M_m is set on the first wheel. The number of teeth $Z_1 = 24,\ Z_2 = 30,\quad Z_3 = 84$; tooth modulus of all wheels m=6 mm; the angle of engagement of the wheels $\alpha = 20^0$. In the force calculation of the planetary gearbox, in determining the reaction forces in kinematic pairs, the carrier H. is taken as the leading link.Suppose that if the moment of equilibrium $M_m$is set to the first wheel, and the acting moment of forces on the gearbox is set to the drive, then in this case it will be necessary to determine these moments.

The equilibrium moment M_m-is determined from the condition of equality i.e. the algebraic sum of these moments is zero

$$M_m \cdot \omega_1 + M_H \cdot \omega_H = 0 \tag{1}$$

here the load acting on the gearbox, we obtain the following equation

$$M_m = -M_H \frac{\cdot \omega_H}{\omega_1} = -M_H \cdot u_{H1} \tag{2}$$

Here, the gear ratio from carrier H of the planetary gear to the first wheel.

Here $u_{H1}$is the gear ratio from carrier H of the planetary gear to the first wheel.

1) The load-moment acting on the carrier is set, $M_H = 20$Nм, the moment of equilibrium based on formula (2) $M_m = -M_H \cdot u_{H1}$; from here

$$u_{H1} = \frac{1}{1+u_{13}^H} = \frac{1}{1+3,5} = 0,222,$$

Then $M_m = -M_H \cdot u_{H1} = -20 \cdot 0,222 = -4,44\ Nm$

2) H-he carrier will be considered leading.
3) First, wheel 1 is disconnected from the mechanism in order, after satellite 2, and at the end the last link of carrier H. remains.
4) For each link we draw up the equilibrium equations and solve.

III. RESEARCH RESULTS AND DISCUSSION

We compose the equilibrium equations for wheel 1 (Fig. 2, a). The wheel acts: balancing moment M_m = 4.44 Nm, the direction of which is directed in the opposite direction of the load moment M_H, the reaction force acting from the second wheel to the first wheel R_{21} and is directed along the tangent line drawn to the circumference of the first wheel, as well as the reaction force R_{31} pasted onto the axis of hinge A. Equilibrium equations of the first wheel $R_{21} + R_{31} = 0$, here $R_{31} = - R_{21}$. The following equilibrium equation is the algebraic sum of the moments of all the forces taken relative to point A is zero, i.e.

$$\sum M_A = P_{21} \cdot R_1 \cos\alpha_o - M_m = 0 \tag{3}$$

by (3) the formula $P_{21} = \dfrac{M_m}{R_1 cos\alpha_o} = \dfrac{4,44}{0,072 \cdot 0,94} = 63,43\ N$

i.e. $R_1 = \dfrac{mZ_1}{2} = \dfrac{6 \cdot 24}{2} = 72\ mm$

Now we proceed to the calculation of satellite 2 (Fig. 3. A). It is affected by: force $P_{12} = - P_{21}$; reaction force acting from the fixed wheel 3; the reaction force R_{H2} delivered from the carrier to the axis of the hinge S, to a line passing at an angle and directed tangentially to its initial circumference.

We write the equation of moment forces put on satellite 2 relative to the hinge S

$$\sum M_C = P_{12} \cdot R_2 \cdot \cos\alpha_o - P_{32} \cdot \cos\alpha_o = 0 \qquad (4)$$

from (4) $P_{32} = P_{12} = 63,43\ N$

satellite equilibrium equations 2 $P_{12} + P_{32} + P_{H2} = 0$ (5)

According to equation (5), on a scaleμ_p = 3Н/мм, we construct a force plan (Fig. 3, c).

hrough the point a, we insert the force R_{12}as a segment $(ab) = \frac{P_{12}}{\mu_P} = \frac{63,43}{3} = 21,14\ mm$

from this point we insert the force P_{32} in the form of a segment

$$(bc) = \frac{P_{32}}{\mu_P} = \frac{63,43}{3} = 21,14\ mm$$

The force $R_{H2}$is determined from the plan of forces (Fig. 3, v) through the segment av, its module

$$P_H = (ca) \cdot \mu_P = 100 \cdot 3 = 300\ N.$$

IV. CONCLUSION

Using the method of dynamic analysis and the obtained dynamic parameters, as well as determining the balancing moment, it is provided, in order to improve performance, it is provided to use these parameters when designing a horizontal forging machine.

The obtained results on the dynamic analysis of planetary machines make it possible to use them in the design of drives of automated machines, and can also be used in scientific research.

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