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STRUCTURAL AND KINEMATIC ANALYSIS OF PLANETARY GEARINGS

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ABSTRACT

By bounding two or more gearings, using a role bear-axle element, we can obtain simple transmissions with caged wheels. A transmission with gear wheels generally has, an axle of fixed rotation, called main axle. The gear wheels whose rotation axles are different from the main axle and that are also mobile are called secondary wheels. The basic kinematical movements of planetary gearings can be determined if we know the movements of M external shafts (M = the mobility of planetary gearing).

KEYWORDS: planetary gearings, kinematics analysis

1. INTRODUCTION

The simplest transmission based on gear wheels is a device whose kinematic chain is made up of two gear wheels and one supporting part for axles H (Fig. 1).

By connecting two or more gearings using a single supporting part for axles, we can obtain simple transmissions based on gear wheels.

A gear wheels transmission generally has, one axle of fixed rotation, called central axle. The cinematic elements (gear wheels) that have the rotation axle the same as the central axle are called central elements (central wheels).

In figure 2 the central elements are the gear wheels 1 and 2 and the shaft H.

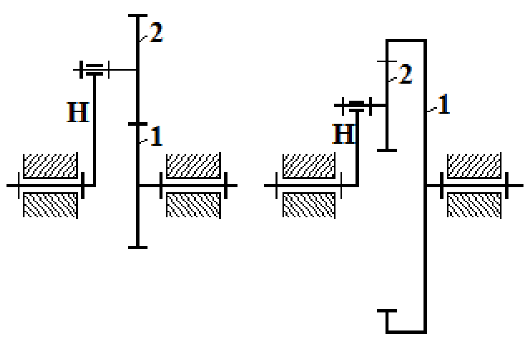

Fig. 1. Models of devices

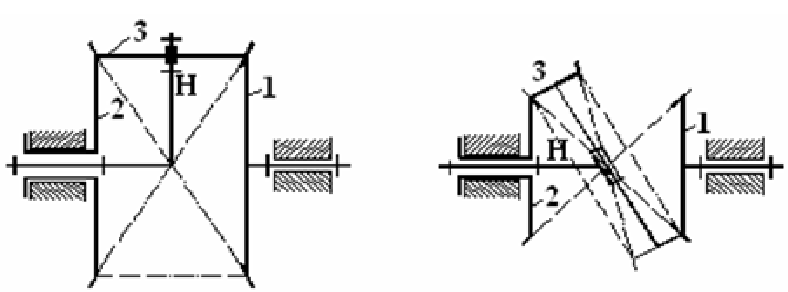

Fig. 2. Simple transmissions with gear wheels

The gear wheels that do not have their rotation axles the same as central axle and are also mobile are called planetary wheels and the gearing that is based on gear wheels with mobile axles are called planetary gearing.

Depending on the basic element chosen (the fixed element), the gearings shown in figure 3 can be:

a. gearings in which only the central axle is fixed (Fig. 3 a); this is an example of simple differential planetary gearing, with mobility M = 2;

b. gearings in which, beside the central axle, a central wheel is fixed (Fig. 3 b); this is an example of mono-mobile planetary gearing, with mobility M = 1;

c. gearings in which, beside the central axle, the kinematic element H, supporting the axles, is fixed (Fig. 3 c); this is an example of gearing based on fixed axles.

A simple planetary gearing with one or two gear wheels is called planetary unit and may function as a differential planetary gearing, as mono-mobile planetary gearing or as gearing based on fixed axles.

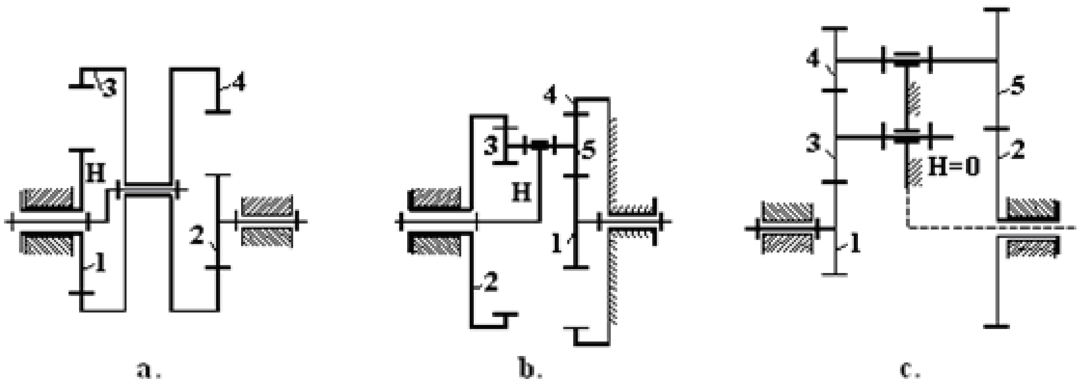

Fig. 3. Planetary gearings
a) simple differential planetary gearing; b) mono-mobile planetary gearing;
c) gearing based on fixed axles

By connecting two or more differential planetary units so as each unit has a couple of connections, we can obtain a complex differential planetary gearing, with mobility M = 2 (Fig. 4 a).

The same as for simple differential planetary gearing, by connecting a central element to the base, the complex differential planetary gearing becomes mono-mobile, M = 1 (Fig. 4 b).

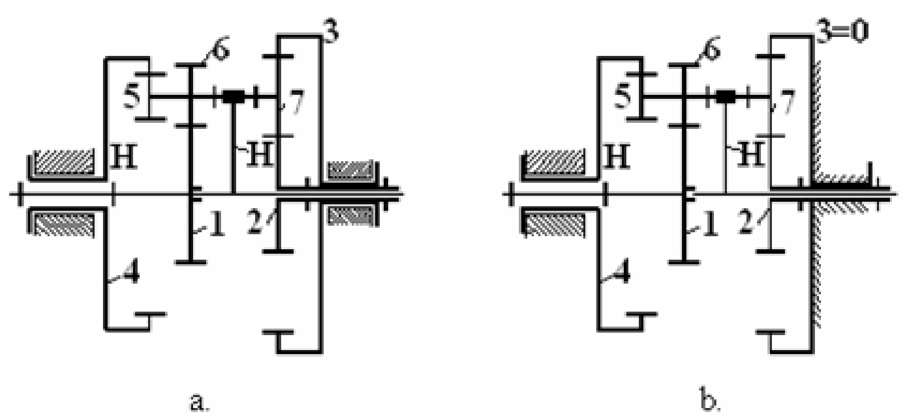

Fig. 4. Planetary gearings:
a) complex differential planetary gearing;
b) the complex differential planetary gearing becomes mono-mobile

2. THE KINEMATIC ANALYSIS

Performing a kinematic analysis, we obtain a block diagram related to the kinematic chart that shows the following information (Fig. 5) [1], [2], [3]:

- the supporting-axle element;
- the leading elements (that lead in);
- the follower elements (that lead out);
- the connections between the planetary units.

Taking the example of mono-mobile planetary unit with central wheels 1 and 2 and the secondary axle supporting shaft H, in which the second wheel is fixed, we can determine the kinematic transmission report $i_{1H}^{2\equiv 0}$.

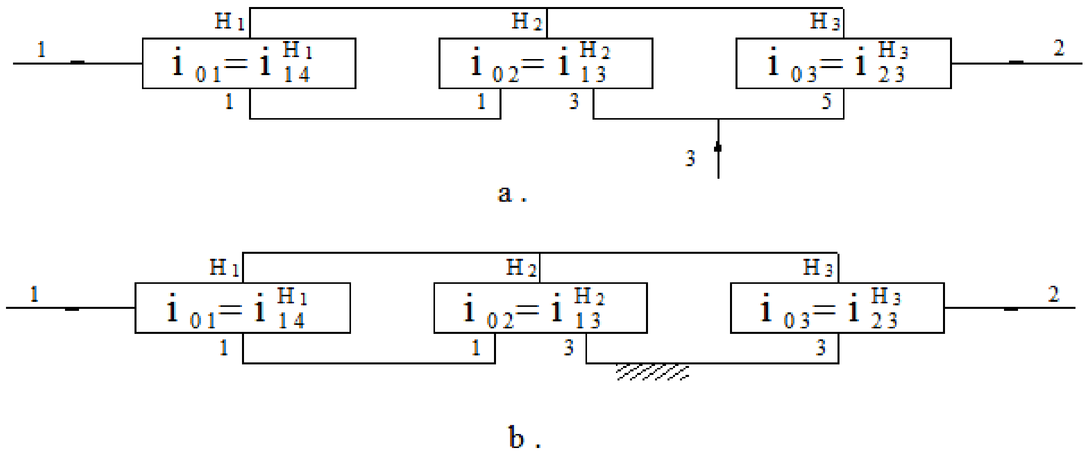

Fig. 5. The block diagram for:
a) complex differential planetary gearing (M=2);
b) mono-mobile complex planetary gearing.

We can write:

$$i_{1H}^{2\equiv 0} = i_{1H}^{2} = 1 - i_0 \qquad (1)$$

where $i_0 = i_{12}^{H\equiv 0}$ is the kinematic transmission report between the wheels 1 and 2.

In this case, the secondary axle supporting shaft H is fixed. The report may be called inner kinematic report.

Taking another example, of differential planetary units (M = 2) when the movements of two external shafts a and b are known, the movement of external shaft C is described by the equations [4], [5]

$$\varphi_C = f(\varphi_a, \varphi_b) \qquad (2)$$

where: φ_a, φ_b are the rotation angles of leading in shafts; φ_C is the rotation angle of the follower shaft.

By deriving the equation (2) using the time as variable, we can obtain the angular speed of follower shaft, depending on the angular speeds of leading shafts,

$$\omega_C = \frac{\partial f}{\partial \varphi_a}\omega_a + \frac{\partial f}{\partial \varphi_b}\omega_b = i_{ca}^{b}\omega_a + i_{cb}^{a}\omega_b \qquad (3)$$

where i_{ca}^{b}, i_{cb}^{a} are the kinematic transmission reports obtained by considering one after another that the leading wheels a and b are fixed.

For the complex planetary gearing from Fig. 4 a (M = 2), we can put down the following equations of movement:

$$\omega_1 = i_{01}\omega_4 + (1 - i_{01})\omega_{H1}\,; \qquad (4)$$

$$\omega_1 = i_{02}\omega_3 + (1 - i_{02})\omega_{H2}\,; \qquad (5)$$

$$\omega_2 = i_{03}\omega_3 + (1 - i_{03})\omega_{H3}\,; \qquad (6)$$

$$\omega_{H1} = \omega_{H2} = \omega_{H3} = \omega_H \qquad (7)$$

where:

$$i_{01} = -\frac{z_6 z_4}{z_1 z_5}\,; \quad i_{02} = -\frac{z_6 z_3}{z_1 z_7}\,; \quad i_{03} = -\frac{z_3}{z_2} \qquad (8)$$

3. CONCLUSIONS

In this work, the author presented a kinematic analysis for a transmission with gear wheels, with different degree of mobility (M=1, M=2).

Te following cases should be envisaged:

a) considering the shafts corresponding to wheels 1 and 3, as being leading kinematic elements, we can obtain the angular speeds of wheels 2 and 4:

$$\omega_2 = \frac{1-i_{03}}{i_{01}}\omega_1 + \frac{i_{03}-i_{02}}{1-i_{02}}\omega_3 \qquad (9)$$

$$\omega_4 = \frac{i_{01}-i_{02}}{i_{01}(1-i_{02})}\omega_1 + \frac{i_{02}(1-i_{01})}{i_{01}(1-i_{02})}\omega_3 \qquad (10)$$

b) if we consider fixed the wheel no 3, we can obtain:

$$\omega_2 = \frac{1-i_{03}}{1-i_{02}}\omega_1 \qquad (11)$$

$$\omega_4 = \frac{i_{01}-i_{02}}{i_{01}(1-i_{02})}\omega_1 \qquad (12)$$

In this paper, was determined the basic kinematical movements of planetary gearings according to the movements of M external shafts.

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