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Development of Structures and Structural Analysis of Gear-Lever Belt Transmission

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ABSTRACT: At present, the achievement of energy and resource efficiency in every sector of industry, the improvement of existing designs of machines and mechanisms, as well as the creation of new generations are urgent tasks. This paper presents the results of research related to the development of a constructive scheme of gear transmission and its structural analysis. As a result of the research, a constructive scheme of gear-to-belt drive transmission was developed, which allows to automatically control the rotational movement of the driven joints in the same direction and the tension of the belt. However, the developed gear-lever extension was structurally analyzed.

I. INTRODUCTION

There are various transmission mechanisms in mechanical engineering, which are gear, gear, chain, belt and other transmissions. These transmissions differ from each other in the type of motion transmission, the constant number of transmissions, and the ability to operate at large loads. However, it is not recommended to use some extensions when the bullet distances are large. Mainly chain and belt extensions are used, which have large arrow distances. In these cases, chain transmissions are more commonly used because the asterisks with the chain transmit motion at the expense of coupling. But at the same time, chain transmissions have the following disadvantages, i.e., if the load is increased, additional shocks are generated at the chain coupling with the asterisk and they cannot operate at high speeds. Also, in chain work, in chain transmissions, two rigid elements stick together, while in belt transmissions, one of the coupling elements, i.e. the belt, is elastic (soft). If two solid elements are in contact, their dimensions must match exactly. Otherwise, the coupling process will be disrupted, leading to the formation of noise and additional shock forces. However, if one of the two elements in the joint is elastic (soft), in the process of work, the tick element deforms due to the compression of the elastic element, ensuring that the bonding process is uniform.

The first stages of the study of mechanisms are the structural analysis and synthesis of mechanisms. First of all, we will answer the questions of what is the structural analysis and synthesis of mechanisms.

Structural analysis is the drawing of schemes of mechanisms on the basis of the specified conditions, without taking into account the dimensions of the joints and kinematic pairs, and the determination of their levels of excitability. Design of the structural scheme of the mechanism providing the required level of excitability on the basis of the given structural spheres is a structural synthesis [1, 2, 3].

II. SYSTEM ANALYSIS

At present, the achievement of energy and resource efficiency in every sector of industry, the improvement of existing designs of machines and mechanisms, as well as the creation of new generations are urgent tasks.
Based on the analysis, an extension structure consisting of a toothed belt and a lever was developed. This belt extension allows the guide joints to rotate in the same direction and automatically control the tension of the belt.

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III. DIAGRAMMATIC REPRESENTATION

The essence of the proposed design is that the gear belt is transmitted from the leading and driven gear pulleys mounted on the housing, the gear belt surrounding them, the tensioning device in the form of tension rollers and the drive pulley to the third shaft by means of a lever (Fig. 1).

The toothed belt drive consists of the following. The lead 1 and the driven gear pulleys 2, the gear belt 3, the tension rollers 4 and 5 are fastened to the two-shoulder lever 6. The double-shoulder lever 6 is hinged to the housing and pulled to one side using a spring 7 to automatically provide the tension of the gear belt. The lever 9 is mounted on the drive gear pulley 2 and the disc 10 mounted on the third shaft to transmit the torque from the drive gear pulley 2 to the third shaft 8. In this case, one end of the lever 9 is fastened by a bolt 11 in the form of a fifth-class rotary kinematic pair at a distance l from the center of rotation of the driven gear pulley 2 and the other end by a bolt 12 in the form of a fifth-class rotary kinematic pair l at a distance l from the center of rotation.

The construction works in the following order. The rotational motion is transmitted from the leading gear pulley 1 to the driven gear pulley 2 via the gear belt 3. The third shaft 8 is transmitted through a disc 10 from a lever 9 fastened by means of a bolt 11 to a gear driven pulley 2. Therefore, the driven gear pulley 2 and the third shaft 8 rotate in the same direction. In order to automatically provide the required tension of the gear belt, the tension rollers 4 and 5 are mounted so that the two-shoulder lever 6 moves in a free rotation. To ensure constant tension of the gear belt 3, the two-shoulder lever 6 is tightened to the corrugation by means of a spring 7. It is recommended to use this gear in cases where the distance between the driven gear pulley shaft and the third shaft is small and the direction of movement is the same. The design slightly extends the life of the transmission.

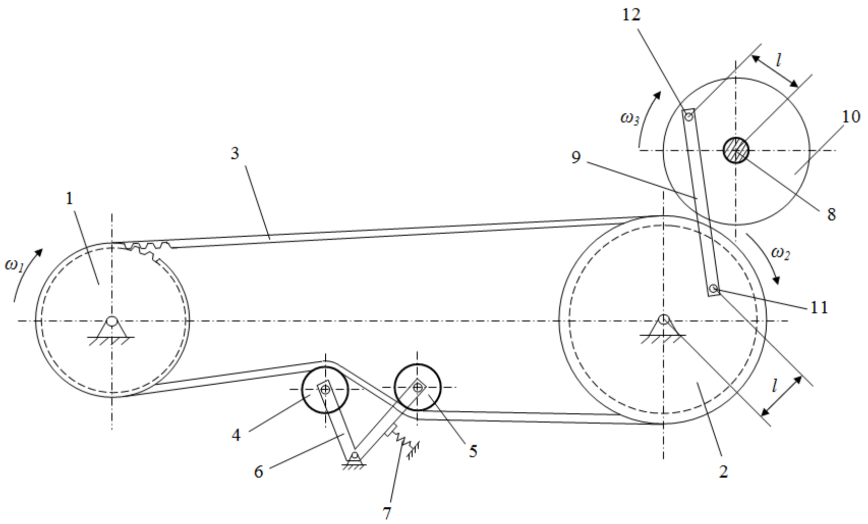

Fig.1. General view of the gear drive

IV. RESULTS

According to AM Malishev, if the flexible joint does not stretch and the distance between points A and B does not change, then the flexible joint can be considered as a connecting rod, and the pulleys as a crank (Fig. 2) [4]. Considering this mechanism as a flat mechanism, we determine the degree of its excitability using the formula P.L.Chebishev [5]

$$W = 3n - 2P_5 - P_4 \tag{1}$$

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where the number of moving joints in the n-mechanism; P_5 is the number of fifth-grade kinematic pairs; P_4 is the number of fourth-class kinematic pairs.

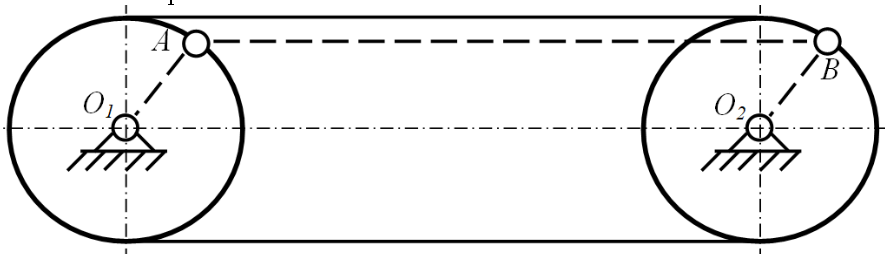

Fig. 2. Scheme for the replacement of a flexible joint mechanism with a tensioned mechanism

If we consider the mechanism shown in Fig. 2 as a tension mechanism, then the joints are connected to each other by means of fifth-class rotational kinematic pairs at points O_1, O_2, A and B. Therefore, in this mechanism, $n = 3$, $P_5 = 4$, and $P_4 = 0$, and the degree of excitability is equal to

$$W = 3 \cdot 3 - 2 \cdot 4 - 0 = 1.$$

In view of the above, we construct a schematic diagram of the proposed gear-belt drive replacement mechanism as follows. In this case, the flexible joint (toothed stone) without the tension rollersma) are considered to be crankshafts and pulleys (Fig. 3).

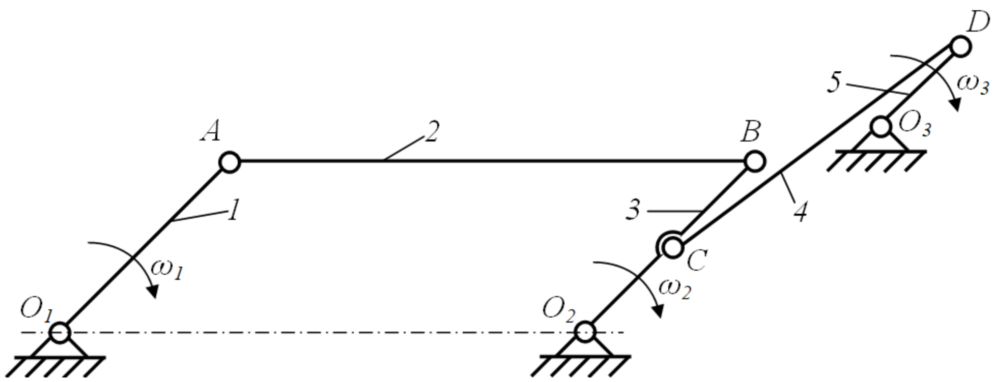

Fig. 3. Six-link lever mechanism

We determine the degree of excitability of the six-joint tension mechanism shown in Figure 3 using the P.L.Chebishev formula. In this case, the number of moving joints is $n = 5$, the number of kinematic pairs of the fifth class is $P_5 = 7$ and $P_4 = 0$, the degree of excitability of which is equal to

$$W = 3 \cdot 5 - 2 \cdot 7 - 0 = 1.$$

We divide the mechanism shown in Figure 3 into Assyrian groups. According to the teachings of L.V. Assur, any mechanism is formed by sequentially connecting kinematic chains with zero degree of excitability to a fixed joint with a leading joint [6]. For this reason we start with a kinematic pair consisting of 4 and 5 joints farthest from the leading joint (Fig. 4). This kinematic pair is considered a 2nd class 1st order group according to Assyrian doctrine.

We determine the degree of excitability of the kinematic pair shown in Figure 4. In this case, the number of moving joints is $n = 2$, the number of kinematic pairs of the fifth class is $P_5 = 3$ and $P_4 = 0$, the degree of excitability of which is equal to

$$W = 3 \cdot 2 - 2 \cdot 3 - 0 = 0.$$

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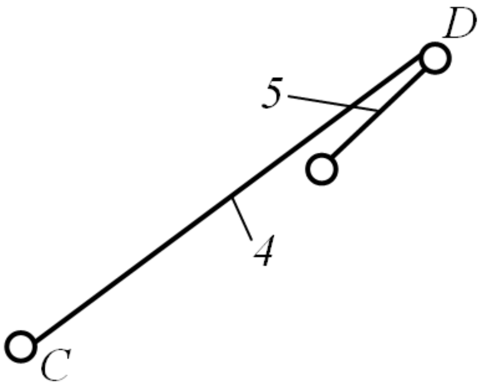

Fig. 4. A kinematic pair consisting of 4 and 5 joints

In a wide space we distinguish a kinematic pair consisting of 2 and 3 joints (Fig. 5). This kinematic pair is also considered a 2nd grade 1st order group according to Assyrian teachings. We determine the degree of excitability of the kinematic pair shown in Figure 5. Here, too, the number of moving joints is $n = 2$, the number of kinematic pairs of the fifth class is $P_5 = 3$ and $P_4 = 0$, and the degree of excitability is equal to

$$W = 3 \cdot 2 - 2 \cdot 3 - 0 = 0.$$

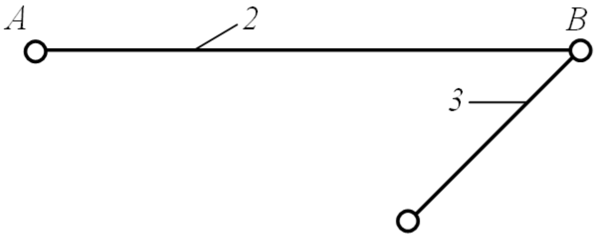

Fig. 5. A kinematic pair consisting of 2 and 3 joints

Both of the Assyrian groups separated above have zero levels of excitability. By definition, the degree of excitability of the remaining kinematic pair in the mechanism should be equal together (Fig. 6). This is because the degree of excitability of the six-link lever mechanism shown in Figure 3 is the same. The kinematic pair, consisting of the remaining fixed and movable joints, is considered a Class 1 1st-order mechanism according to Assyrian teachings. We determine the degree of excitability of the kinematic pair shown in Figure 6. Here, too, the number of moving joints is n = 1, the number of kinematic pairs of the fifth class is P5 = 1 and R4 = 0, and the degree of excitation is equal to

$$W = 3 \cdot 1 - 2 \cdot 1 - 0 = 1.$$

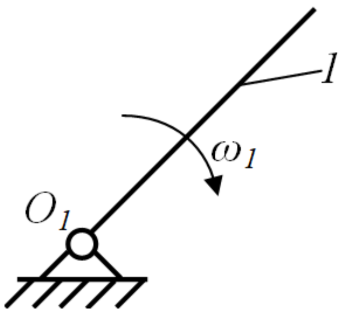

Fig. 5. A kinematic pair consisting of fixed and guide joints

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V. CONCLUSION

As a result of the research, a structural analysis of the gear-to-belt drive was carried out, which allows to automatically control the rotational movement of the drive joints in the same direction and the tension of the belt. The analyzes were performed using existing methods and it was determined that the mechanism was structurally correct. This is because when the gear-belt drive was analyzed by replacing it with a gear mechanism, it was theoretically justified that it had a single drive link.

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