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THE GLOBOIDAL WORM GEAR WITH ROTARY TEETH AND AUTODENOUS BACKLASH SELF-ELIMINATING USED IN MOTORIZATION

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Abstract

The worm gears are useful where the transmission ratio and the self-locking are needed (for particular gears). In the automotive industry, the worm gears are used in worm-and-roller steering gears, drives of the windshield wipers, wind-down car windows, etc. These gears have various versions, as a helical worm-gear and a globoidal worm-gear. The globoidal worm-gear, with rotary teeth was presented. This is an innovative idea connected with this type of gears. In the gear, the globoidal worm gear was used, and the classical worm wheel was replaced by the wheel with rotary teeth in the shape of the frustum of cone. The frustum of cone shape is needed because of minimization of the slippage between the teeth and the surface of the worm gear. The gear teeth have the helical shape. Rotation of the teeth, having appropriate angle of the conical surface, helps to minimize the slippage. In addition, the teeth are able to displace axially. In use, the teeth are pressed against the worm surface by the push springs. It allows eliminating the backlash and improving the gear operation. This type of gear, compared to classic globoidal gear has much higher efficiency. This facility results from replacing the worm friction on the worm wheel into the journal friction in a rolling bearing, where the rotary tooth is bearded. The capacity of the globoidal worm gear, compared to the classic gear is lower, but the uniformity of the load distribution on all teeth is strong advantage of it. Above-mentioned gear can be used where the high transmission ratio is needed and the backlash caused during the gear exploitation is impermissible. For example, it can be used in steering system.

Keywords: *globoidal worm gear, backlash eliminating*

1. Introduction

Worm gears are used where the high transmission ratio is needed as well as the change of the axis position. Input shaft axis and output shaft axis are turbulent positioned, mostly at an angle of 90°. Hence, they are used in the steering gears where the gear is a bit simplified. Because of the determined range of rotation angle, the worm wheel is residual. The disadvantages of this gear are low efficiency and consequently overheating and the need of cooling. Contrary to appearances, it is hard to eliminate the backlash [1, 4, 5]. This problem also occurs when there is bilateral operation, for example in the steering mechanism. It is achieved mainly by increasing the making precision of the gear. Below the new solutions of the globoidal worm gear, without mentioned disadvantages, were shown [3].

2. The gear construction

To reduce the sliding friction, the new type of worm wheel was created. The worm wheel teeth are in shape of the frustum of cone and they are rotationally secured in rolling bears. Frustum of cone shape of the teeth allows minimizing the slip of cooperating teeth surfaces [2].
In the Fig. 1, the worm – and – roller globoidal gear was shown in the simplified way. The worm (1) drives worm wheel (2) whose teeth can rotate about their own axis.

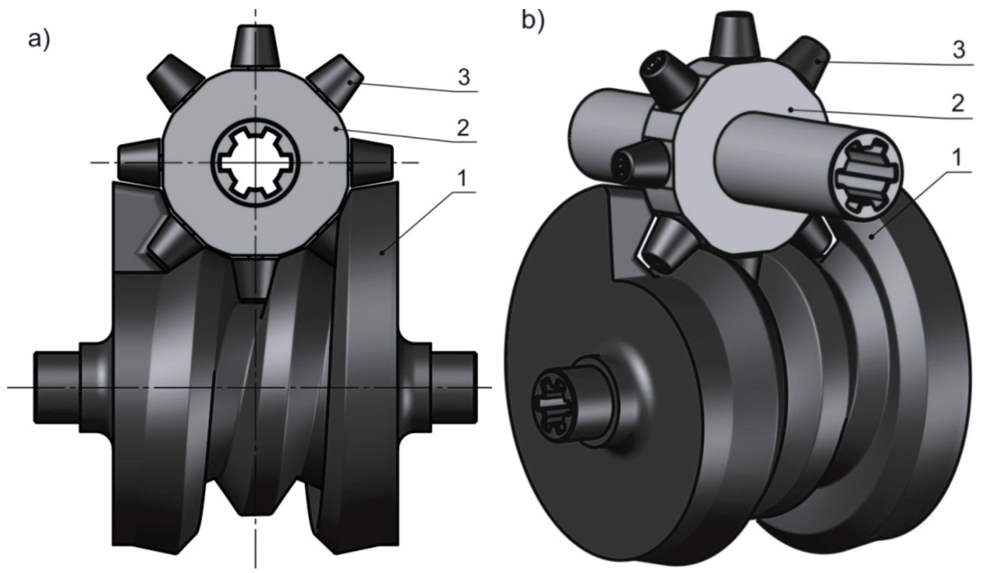

Fig. 1. The worm and worm wheel of the globoidal worm gear, with the rotary teeth; a –worm wheel forefront view, b – isometric view; 1 – worm, 2 – worm wheel body, 3 – rotary tooth

Several teeth, being in the teeth contact area, should operate equally (simultaneously). However, in view of manufacturing and montage accuracy, the situation where no contact would occur at all teeth, which should occur on, could be possible. To prevent mentioned situation, teeth are able to axial travel and they are pressed against the worm surface by the push spring. The new solutions were shown in the Fig. 2 (with rolling bearing) and Fig. 3 (with sliding bearing).

The mandrel, which the rolling bearing is mounted on, has the surface that cuts down the tooth displacement. The geometrical dimensions and the spring characteristic are calculated that the force between the tooth and the worm surface insure the contact on the particular number of teeth. Additionally the geometry has to be calculated so that the conical tooth surface will operate only on the one side with the worm surface, and on the other side of the surface the backlash c_o is needed (Fig. 4), because relative motions of the teeth surface and worm surface have another directions.

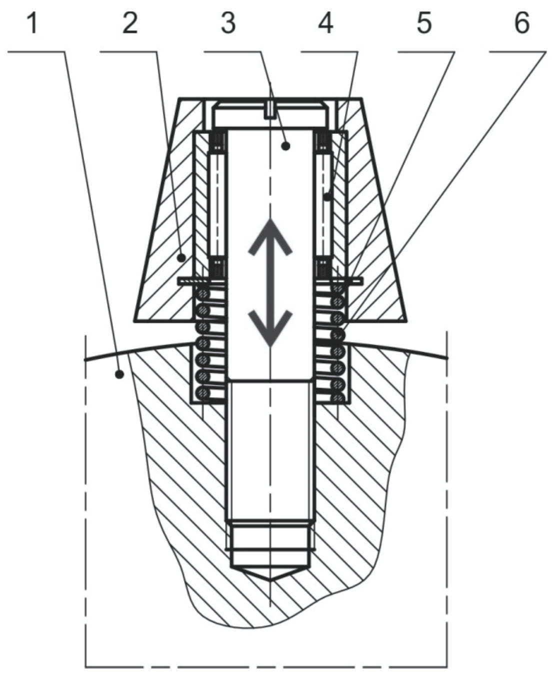

Fig. 2. Exemplary structural solution of the teeth clamp; 1 – worm body, 2 – the rotary teeth, 3 – mandrel, 4 – rolling bearing, 5 – washer, 6 – push spring

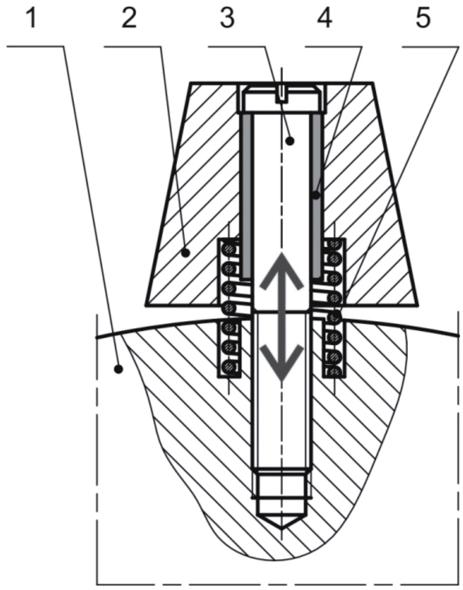

Fig. 3. Exemplary structural solution of the teeth clamp; 1 – worm body, 2 – the rotary teeth, 3 – mandrel, 4 – sliding bearing, 5 – push spring

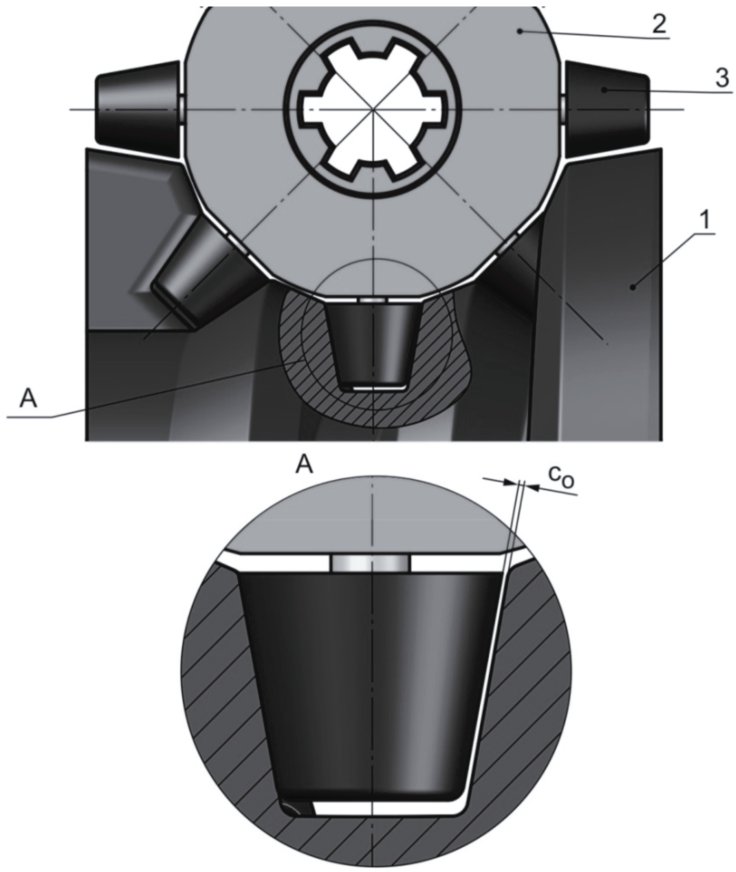

Fig. 4. Circumferential backlash at the nominal set of tooth; 1 – worm, 2 – worm wheel body, 3 – rotary tooth, c_o – backlash

The elements of the rotary tooth were shown in the Fig. 5. The gear demonstrator was designed in the CAD system (Fig. 6). To create the worm, the FDM (Fused Deposition Modelling) technology was used (Fig. 7) and other elements of demonstrator were also made by the Rapid Prototyping techniques (Fig. 8).

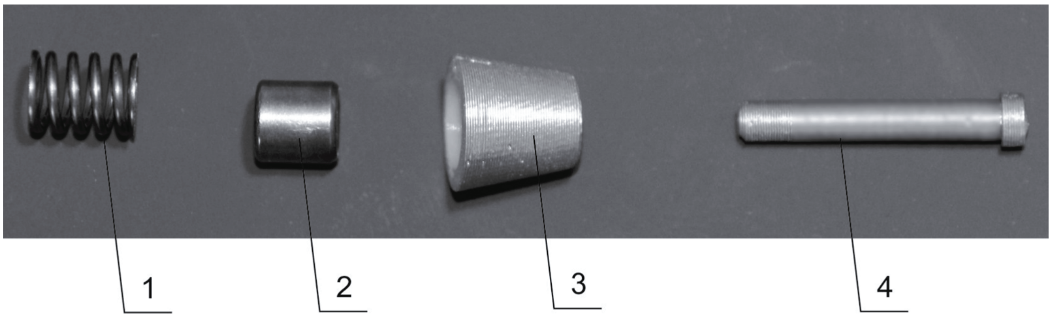

Fig. 5. The rotary tooth of demonstrator; 1 – spring, 2 – rolling bearing, 3 – body of tooth, 4 – mandrel

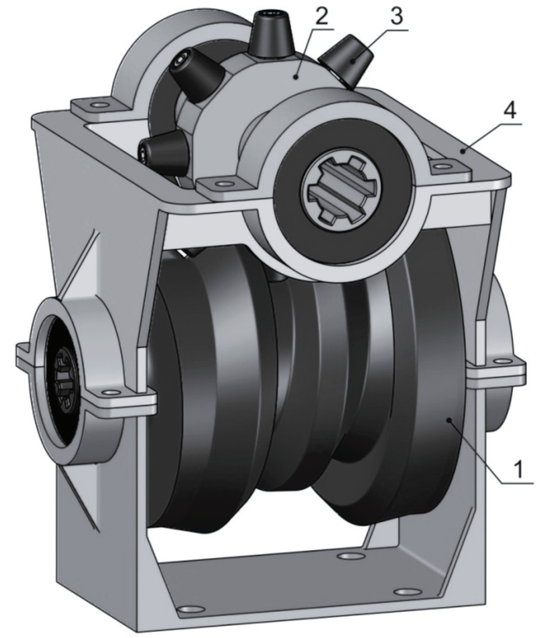

Fig. 6. The gear demonstrator – CAD model; 1– worm, 2 – body worm wheel, 3 – rotary tooth, 4 – frame

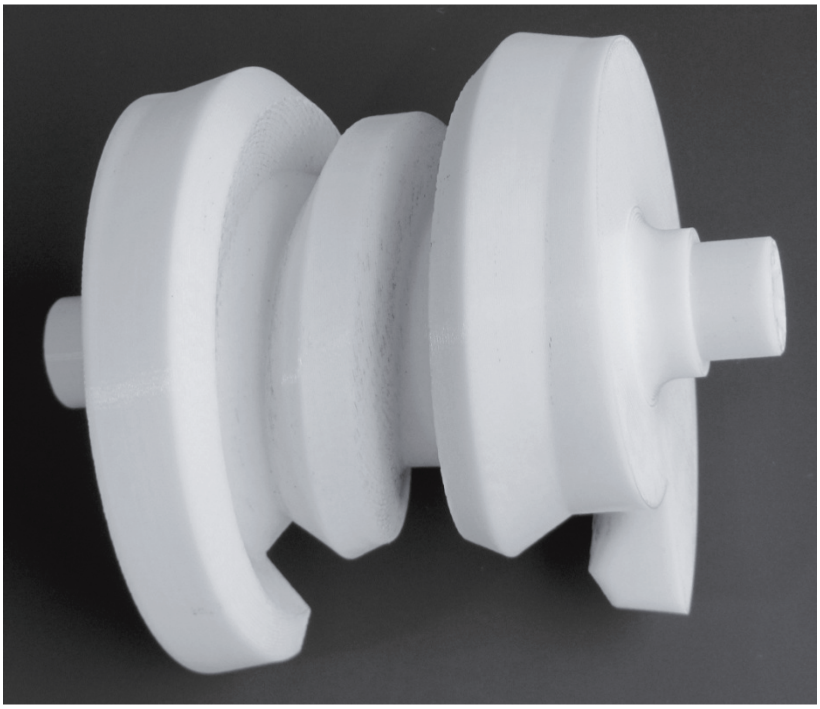

Fig. 7. The worm made by the FDM technology

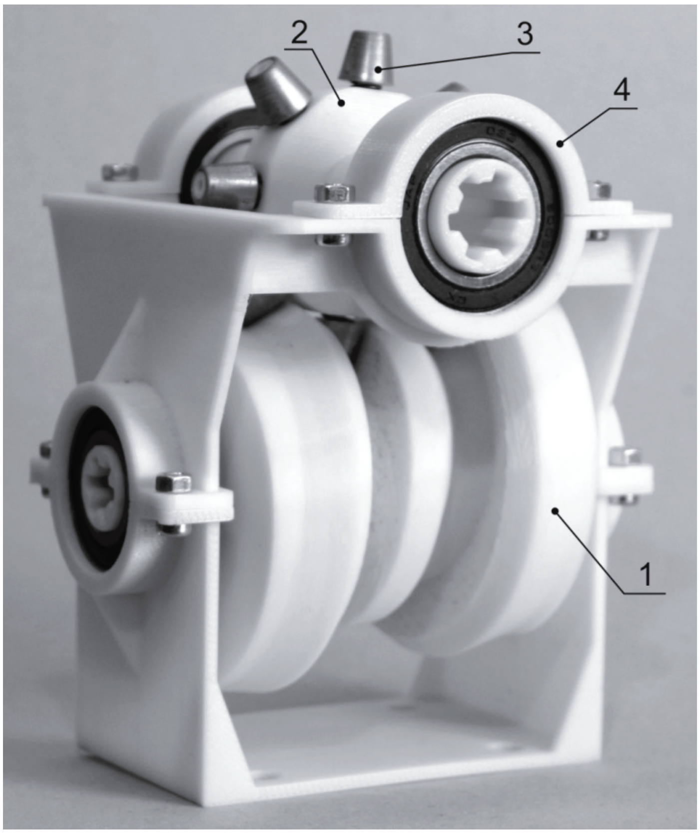

Fig. 8. The gear demonstrator – the prototype; 1– worm, 2 – body worm wheel, 3 – rotary tooth, 4 – frame

During the operation of the gear, consecutive teeth mesh in the tangential to the worm surface way, the pressing springs cave and the anti – backlash work occurs, assuming the conical surface of the rotary teeth presses against the operating worm surface.

3. Conclusions

The globoidal worm gear with rotary teeth enables for the self-eliminating intermonth backlash. In the classic gear, the backlash can be produced during the long-term work, as well. The presented solution allows eliminating mentioned backlash. Additionally, in view of the accuracy of manufacturing, the classic globoidal gear has less teeth in the meshing than the constructional structure assumed. In the presented solution all teeth operate in tooth contact area – the multipair contact occurs; hence, the operating teeth force distribution is more regular. The strong advantage is higher efficiency results from the replacement sliding friction by the rolling friction. Mentioned solution can be used to the machines and devices, which the gear with high transmission ratio is needed in (replacing the classic globoidal and helical worm gear).

The gear presented in this paper can be used to the automotive industry – steering system, and the dynamoelectric industry – mainly in the household products.

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