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«Review and analysis of the most common methods for shaping worm coils»

Akramova Komila Shuxrat qizi
Student, Namangan Engineering Technology Institute, Uzbekistan;
Gmail: akramovakamila06gmail.com;
tel: + 998930588636

Abstract: The operational qualities of a worm gear largely depend on the chemical composition, microstructure and properties of the materials used in the manufacture of the worm pair, as well as on the method of shaping the turns of the worms.

Key words: Worm, worm pair, cylindrical linear worm, non-linear worm, grinding, milling, CNC.

Widely known types of worm gears with cylindrical linear worms and non-linear worms. Despite the variety of theoretical profiles of the working surfaces of worms, all linear worms have almost the same load capacity. Preference should be given to the type that, under given production conditions, is the most technologically advanced and allows obtaining transmissions with stable parameters of the required degree of accuracy.

As indicated in the books, non-linear surfaces of worms are obtained by processing them with a conical or toroidal tool: in the first case, cylindrical, formed by a cone (2K), and in the second, cylindrical, formed by a torus.

ZK type transmissions can be received in the following ways (see Fig. 1):

ZK1 - when milling worms with disk cutters or when grinding them with disk conical circles;

ZK2 - when milling worms with conical finger cutters or grinding them with the so-called finger circle (conical shape);

ZK3 - when grinding worms with a cup wheel with a conical generatrix.

The most widespread of them are worms of the Z2K1 type, which require the most technologically advanced tool with a sufficiently high resistance. Gears with ZK2 worms are practically not used due to low productivity and low tool life.

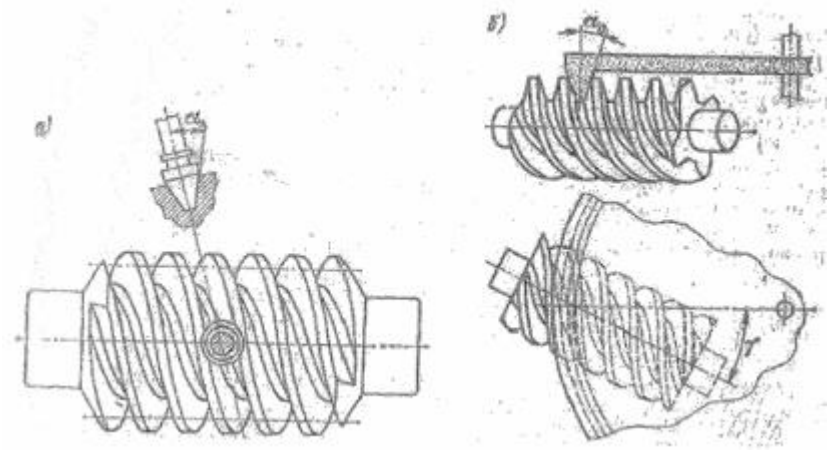

FIG.1.*A worm formed by a cone: a - ZK2 variant; b - ZK3 variant*

Gears with worms formed by a torus, sometimes called convex-concave in the literature, can have two varieties (see Fig. 2).

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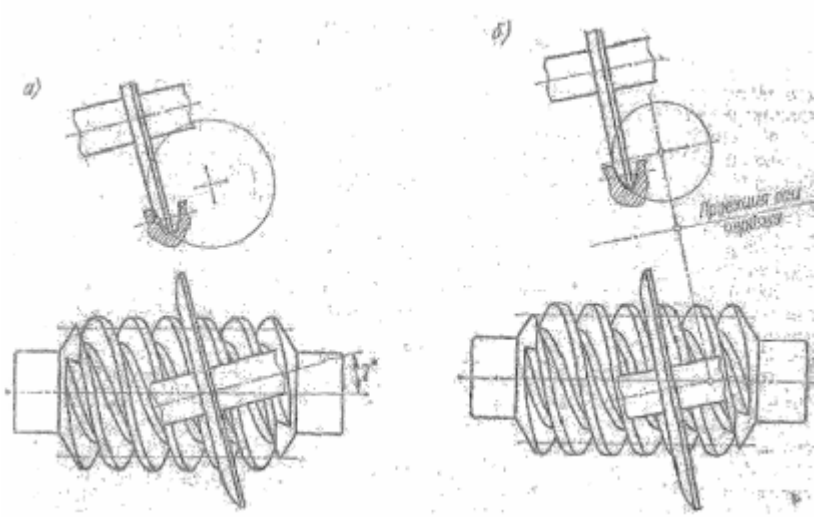

Fig.2. *Non-linear worm: a - variant ZT1; b - option ZT2*

A feature of the ZT1 transmission is that the angle of crossing of the axes of the tool and the worm during its grinding is equal to the angle of elevation of the helix on the dividing cylinder of the worm. They have some drawbacks; the main one is due to the fact that due to a change in the diameter of the circle after regrinding, the center distance changes during processing, and this can lead to a change in the surfaces of the worm turns. ZT2 gears do not have the above disadvantage, their main feature is due to the fact that the line of contact between the surfaces of the worm and the tool is flat, not a spatial curve, and that the geometry of their helical surface does not depend on the diameter of the disk tool.

The load capacity and durability of the transmission are determined not only by the type of worm, but also by the hardness of its working surfaces. Worms are divided into non-heat-treated, processed in the workpiece (improved) with a hardness of 32-42 HRC and heat-treated to hardness exceeding 50 HRC.

Non-heat-treated or improved in the workpiece worms in individual production are made on universal lathes, and in serial and mass production - by the vortex method or the plastic deformation method. At the same time, worms made by rolling without heating (cold rolling) have a roughness

surfaces $R_z < 0{,}63$ microns and slight deformations, in connection with which they can be used without further processing of the surfaces of the worm turns (mainly in low-speed gears). In large-scale production of worm gears, especially gears of power gearboxes, only heat-treated worms with a hardness of the working surfaces of the coils exceeding 50 HRC, and in many cases even 60 HRC, are used. The finishing operation of processing the working surfaces of such worms is grinding.

The most technologically advanced are worms of the ZA type, the processing of which on screw-cutting lathes does not differ much from the processing of threads. The helix angle of the worm must not exceed 10°. With large lead angles γ, it is impossible to provide cutting angles sufficient for the normal operation of the cutter. The method of multi-pass cutting with a cutter on lathes is the most common because it does not require a wide range of special equipment and, as a result, significant costs of both time and material resources in the preparation of production. The emergence and widespread use of CNC machines has significantly expanded the possibilities of this method and allows not only to ensure the stability of quality and work in automatic mode, but also to significantly increase the level of production flexibility. For large-scale and mass production, the most effective methods of processing worms are high-speed cutting with rotating cutters, often called whirl cutting and rolling. In whirl cutting, two processing schemes are used: with an internal touch and an external one.

Despite the fact that the scheme shown in Fig. 3-a allows you to work with increased circular feeds and gives a smaller cut on the surfaces to be machined, the scheme in Fig. 3-b. Devices for it are easy to manufacture and adjust, installation, alignment and fixing of cutters in the head, chip removal, installation and removal of the workpiece are greatly simplified.

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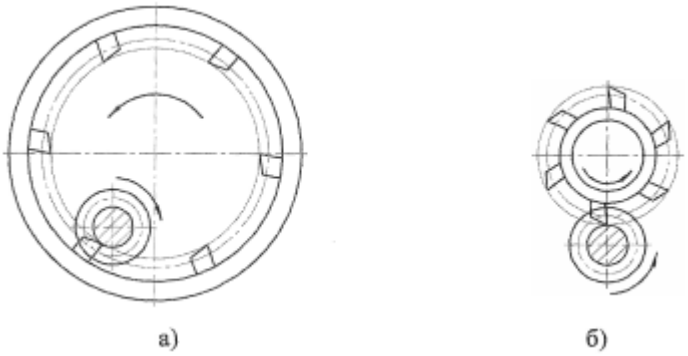

FIG.3.*Schemes for cutting coils by the "**vortex**" method; a - with internal touch; b - with external touch.*

For worms subjected to heat treatment, whirl cutting is a preliminary operation performed with an allowance for grinding.

The most productive and least material-intensive method of obtaining coils of worms is by rolling, which is carried out on roller rolling machines.

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