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Single-Turn Worm Mills for Conical Round-Tooth Gears

A. G. Kondrashov*, D. T. Safarov, A. I. Faskhutdinov, and G. K. Davletshina

Naberezhnye Chelny Institute, Kazan Federal University, Naberezhnye Chelny, Russia

**e-mail: kondrashovag@mail.ru*

Abstract—Facets must be machined at the end of gear teeth. The shaping of facets by single-turn worm mills is considered in detail. Deficiencies are found in familiar design methods for such mills. Formulas are proposed for the calculation of single-turn worm mills used in machining conical round-tooth gears.

Keywords: single-turn worm mills, conical round-tooth gears, tooth facets

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Besides tooth shaping, gear production includes finishing operations such as sharpening, rounding, and the creation of facets at the ends of the teeth. Such faceting is required to ensure smooth engagement of the teeth with those of the paired gear.

Therefore, strict requirements are imposed on the shaping precision in such operations. At most enterprises, despite its utility, the faceting of gear teeth is regarded as of little value in lean manufacturing. The creation of facets at the ends of the teeth is regarded as necessary only to improve assembly or to eliminate flashing, which would affect gear performance.

However, analysis of the stages in the gear's life cycle indicates other functions. For example, the creation of tooth facets usually precedes heat treatment. Accordingly, modified structures may appear at the sharp edges, along with microcracks, which may be failure sites. Final tooth shaping by shaving is very sensitive to the presence of sharp edges at the ends of the teeth. In machining, such sharp edges may jam in the chip channel in the side of the shaver.

Zahnrad Fabrik (Germany) has given serious consideration to the creation of facets at the ends of gear teeth. Their internal standard includes recommendations regarding the shape and size of the facets and the preferred shaping method.

At present, in gear production, single-turn worm mills are widely used for end faceting [1, 2]. Cylindrical and conical gears are machined on VS-320, VS-500, and other systems produced at Vitebsk Machine Tool Plant. Those systems include a vertical spindle for the workpiece and two horizontal spindles for the tool.

A method of calculating the parameters of single-turn worm mills used in cutting facets on cylindrical gears was proposed in [3–6]. Its basic principles are as follows.

(1) The tooth profile of the workpiece is assumed to be trapezoidal.

(2) Each pair of machined end profiles is arranged symmetrically at the end of machining (in shaping by the last mill tooth).

(3) The angle of the mill profile is calculated for the end of machining, since the facet profile is formed by the last mill tooth.

Besides the parameters of the tool, the method permits calculation of the setup parameters. If the workpiece is machined by the specified tool in strict accordance with the specified setup, the required shape and dimensional precision of the facets on spiral and straight-cut gears may be ensured. However, this method does not permit calculation of the tool and setup for the faceting of teeth in conical gears.

In the present work, we improve the design method for single-turn worm mills used in the creation of facets at the ends of the teeth in conical round-tooth gears (Fig. 1a).

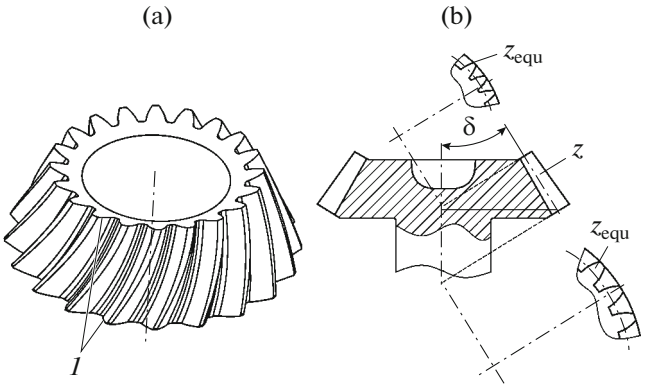

Fig. 1. Conical round-tooth gears (a); and determination of the parameters of the equivalent gear (b): (*1*) sharp edges.