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Shaping the helical surface by the hobbing method

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Abstract

The shaping of a helical surface using a rotary tool with an arbitrary tool action surface axial profile has been discussed. Disc, ring, finger and cup-type tools were included in the computation program. The reverse task, where the arbitrary worm surface profile is given, was solved for the case of helical surface machining with a finger-type tool by the step-by-step method.

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Keywords: helical surface; hobbing method; step-by-step method;

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1. Introduction

Worm gears and worms are widely used in industry [1]. The development of modern multi-axial multi-purpose CNC machine tools contributes to the development of the design and technology of toothed gears [2, 3]. In the case of machining by the classic hobbing method [1, 4], the worm helical surface is shaped in the finishing pass over the entire profile height with a tool, whose geometry is dependent on the geometry of the surface being machined (the tool action surface and the machined surface are mutually enveloping) [5, 6]. In step-by-step machining, the machined surface is shaped with a tool, e.g. a ball-end finger mill, in multiple passes with the punctual contact between the tool and the machined surface. Therefore, the form of the machined surface is determined by the machining kinematics rather than tool geometry, and surfaces of different geometries can be cut with the same tool. This technology may be particularly advantageous in unit machining of large-module gears, where special tools will be very expensive, or in the case of forming surfaces with special profiles. The development of the construction and technology of worm gear machining is also facilitated by special CAD/CAM programs that enable the modelling of gears [7, 8], the analysis of the worm and gear mating [9, 10] or finally, the generation of the CNC machine tool

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control code [1]. The article presents a generalized mathematical model for forming a helical surface with an arbitrary profile by the hobbing and SbS methods, respectively, which has enabled the building of a universal computation program for the design of helical surface technologies.

2. The hobbing method of shaping a helical surface

It is accepted to preset an arbitrary tool axial profile in the tool's coordinate system $\{p\}$ with the coordinates of the points and the slopes of the tangents to the profile (Fig. 1).

$$\left\{ u \in \langle u_{\min}, u_{\max} \rangle : \underset{p}{\mathbf{x}}(u) = \left[\underset{p}{x}^{1}(u), \quad 0, \quad \underset{p}{x}^{3}(u) \right]^{T} \in \mathrm{E} \right\}, \qquad m_p = \frac{d\underset{p}{x}^{1}}{d\underset{p}{x}^{3}} = tg\alpha, \qquad \alpha \neq \frac{\pi}{2} \tag{1}$$

where: α - angle of direction of the tangent to the tool axial profile at the point under consideration; u - profile parameter; $\underset{\circ}{x}^{*}$ - the subscript $\circ$ identifies the coordinate system, while the superscript $*$ identifies the axis of the coordinate system.

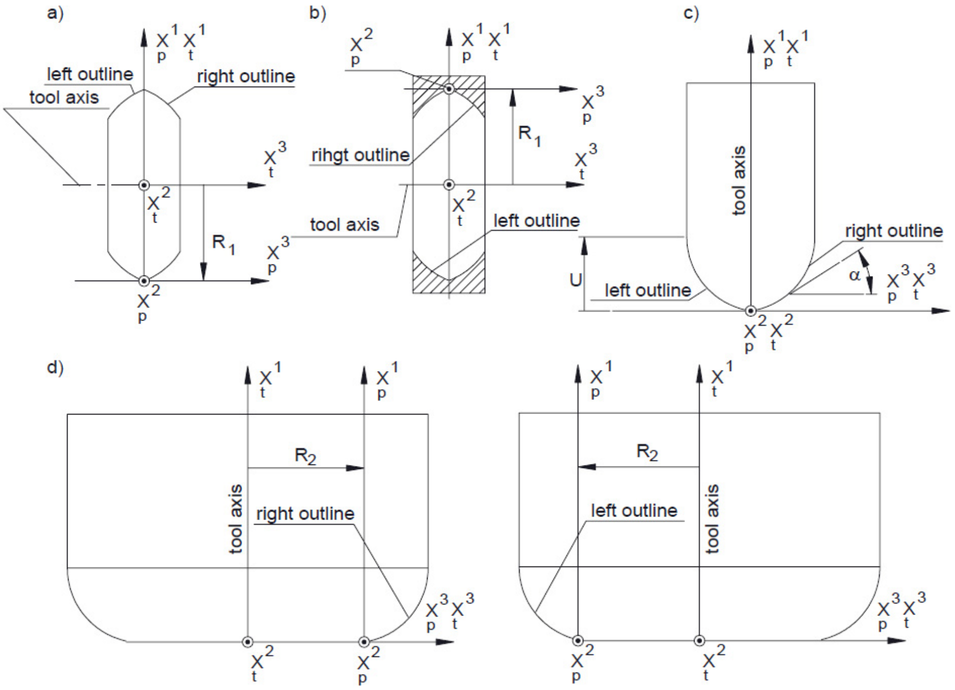

Fig. 1. Rotary tools of the: a) disc, b) ring, c) finger, and d) cup types.

The tool action surface can be generally described with the equation

$$\underset{t}{\mathbf{x}}(u, \quad \varphi) = [k_3, \quad \varphi]\left(\underset{p}{\mathbf{x}} + [k_1 R_1, \quad 0, \quad k_2 R_2]^{T} \right) \tag{2}$$

where: φ - tool action surface parameter (the angle of profile rotation around the tool's axis of rotation); R_1 - tool radius; R_2 - cup-type tool radius.