Monitoring Face-Mill Geometry

N. V. Kolesov and N. N. Petrosyan

Stankin Moscow State Technical University, Moscow

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It is difficult to monitor the geometry of face mills and other axial tools with small external diameter ($d < 8$ mm), because the known measuring instruments are incompatible with the tools' small tooth size. For example, the measuring tip of the Babchinitser instrument does not fit in the tooth channel. In addition, this instrument is intended to monitor axial tools with at least three teeth. Laser scanning microscopes may be employed, but they are very expensive, and measurements (for example, of the front angle of helical teeth in axial tools) are very difficult on such microscopes.

The monitoring method that we propose is based on the attachment (by means of a glue pencil) of thin wire or strip (thickness around 0.1 mm) to the tool surface, over a length of 1–3 mm, in the plane of front-angle measurement (for example, the face plane). The strip extending beyond the external diameter (over a length of 10–15 mm) serves as a continuation of the intersection of the cross-sectional plane with the tool's tooth surface.

On a standard tool microscope (State Standard GOST 8074–82), the front angle in the end cross section of a face mill is monitored as follows.

The mill is placed on a microscope table so that its axis is parallel to the vertical axis of the main objective lens, toward which the end of the mill is turned. The vertical guide line on the objective lens passes through the mill axis and the tip of the tooth at which the angle is measured. For mills with a cylindrical shaft, we use a prism to which the shaft is attached.

At a distance $L = 5$ –10 mm from the end of the mill, the strip is attached to the tooth's front surface, in the end cross section. The objective lens moves downward a length L on the microscope column, so as to obtain a sharp image of the line of the strip. The microscope table is rotated around its vertical axis by an angle θ , so that the strip aligns with the vertical guide line on the objective lens.

We calculate the front angle (deg) as $\gamma = (360/P)L - \theta - \delta$, where P is the axial increment in the helical teeth, mm; θ is the measured angle of mill rotation, deg; and

$$\sin \delta = 2[f_2 \cos \lambda (\tan \omega - \tan \lambda)]/d.$$

Here f_2 is the length of the recessed section of the tooth's helical front surface near the end of the mill, mm (according to State Standard GOST 18372–79, $f_2 = 1$ –1.5 mm is best for hard-alloy face mills with diameter $d = 3$ –12 mm); ω is the inclination of the mill's helical tooth with respect to its axis ($\tan \omega = \pi d/P$), deg; and λ is the inclination of the mill tooth with respect to its axis near the end of the mill in the recessed section. In this section, λ is assumed to be less than ω . (The recommendation in State Standard GOST 18372–79 is $\lambda = 6^\circ$.)

As an example, we consider the monitoring of the front angle for a mill with $d = 6$ mm, $P = 27$ mm, $\omega = 34.92^\circ$, $f_2 = 0.5$ mm, and $\lambda = 10^\circ$. We assume that $L = 5$ mm. According to microscope measurements, $\theta = 49.7$. For those values

$$\sin \delta = 2[0.5 \cos 10(\tan 34.92 - \tan 10)]/6;$$

$$\delta = 4.913^\circ;$$

$$\gamma = (360/27) \cdot 5 = 49.7 - 4.913 = 12.05^\circ.$$

Microscope measurement of the front angle directly at the end of the mill is impossible on account of the recess (length f_2).

The accuracy of the proposed method is verified for hard-alloy mills (diameter $d = 6$ –8 mm) that are electrochemically cut by means of a wire. At the cut end section, the front angle γ is measured by means of a microscope. The discrepancy in the front angle for these measurements is no more than 1° – 1.5° (about 10–12%).

Translated by B. Gilbert