THE FUNCTIONAL CONSTRUCTION PRINCIPLE OF THE MILLING CUTTERS WITH UNINTERRUPTED SHARPENING AND MECHANICALLY CLAMPED INSERTS

M. Severincu, C. Dumitraş,
Universitatea Tehnică „Gh. Asachi" Iaşi

In accordance with the aspects mentioned above, the romascon cutters with uninterrupted sharpening are made of a shank **1** on which the common elements are placed, that is the inserts **2** and the positioning elements **3** (figure 1**)**.

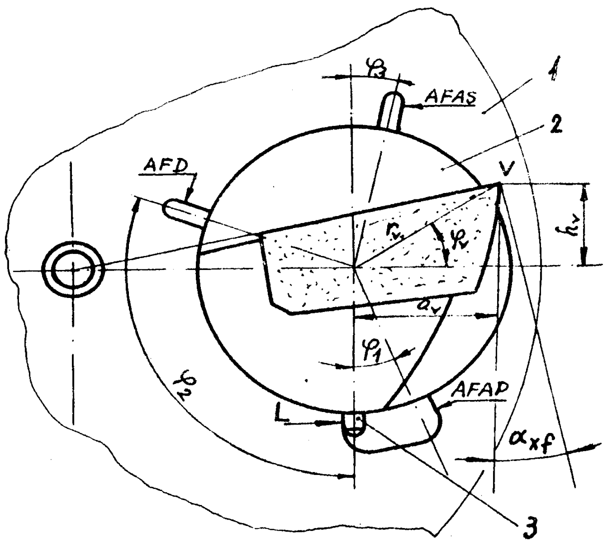

Figure 1

Irrespective of the tooth axis position, on the end surface of the shank of cutter, slots are made to serve both to positioning in sharpening and to the work as well, the symbols adopted being as follows:

L - work position;

AFAP – sharpening position of the flanks (the cleareance surface);

AFD – sharpening position for the rake surface;

AFAS – sharpening position of the secondary flanks.

In order to sharpen the flanks, the teeth are rotated from the work position **L** (figure 1) with the ϕ angle, to the sharpening position of the flanks, thus obtaining the cleareance surface (figure 2) and the pin **3** (positioning element) of each tooth touches the **AFAP.** The tool is subsequently transmitted a forward circular movement, spinning round its axis, in the direction „**A**" and the grinding wheel is transmitted the necessary speed to achieve an optimal cutting speed of 20...30 m/sec.

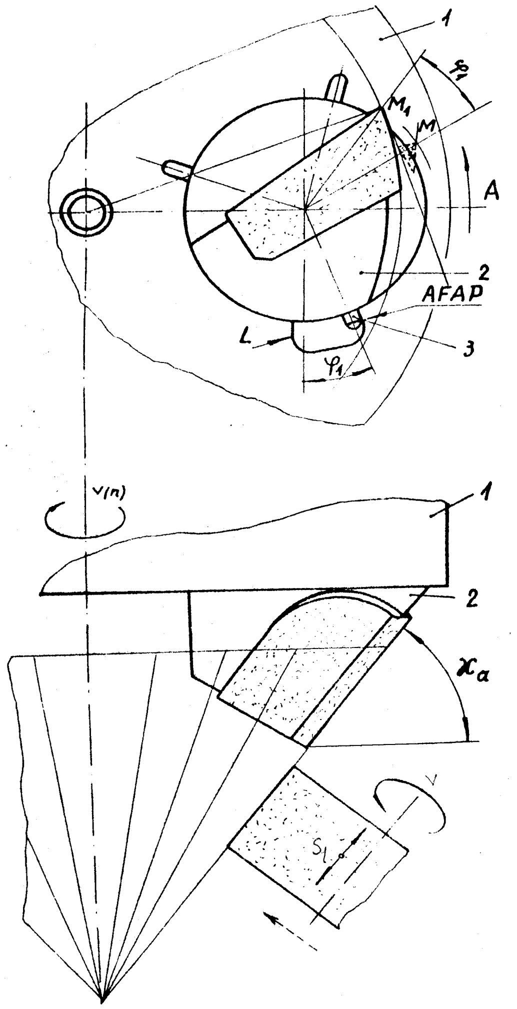

Figure 2

In order to sharpen rake surfaces, the tooth is set into **AFD** position (figure 1) and to sharpen the secondary flanks it is set into the **AFAS** by rotating with ϕ_2 angle, $180°-\phi_3$ respectively in reation with first position.

As compared to the classic cutters where sharpening is achieved tooth by tooth, this constructive solution has obvious advantages such as:

- simultaneous sharpening of all surfaces as well as rake surfaces, which contibutes greatly to the reduction of time allowed to sharpening thanks to the elimination of indexing moments;

- great simplification of the cutters grinder's kinematics;
- elimination of the grinding wheel wear on the radial and axial direction of the cutting edges depending on the manner in which the sharpening and work positioning are carried out and also, depending on the cutting edge position in relation to the geometric axis of the inserts.

In what follows a number of characteristics of the face milling cutters are presented which can be extrapolated to any type of uninterrupted sharpening tool with inserts.

From figure 2, 3 and 4 it can be seen that, however the tooth axis position in relation to the shank of tool axis may be, the surfaces to be sharpen are part of the convex revolved surfaces (cones, cylinders) coaxial to the shank of cutters axis. The shape of the respective surface is given by the geometric parameters which is to be obtained after sharpening.

The surface on which sharpening occurs may be even a plane, case which is to be considered a degenerate case of sharpening on a cone with the edge cone angle of 180°.

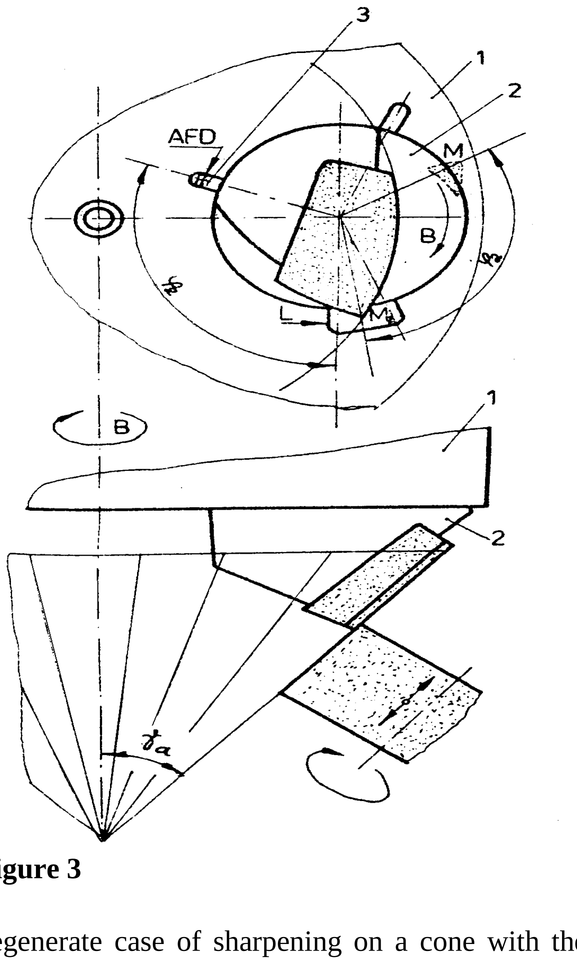

Figure 3

It can be seen from figure 2 that the ϕ_1 angle, formed by the positioning the **M** point which is on the work position edge and the $\mathbf{M_1}$ position of the same point in sharpening is equal to the ϕ_1 angle formed between the **L** and **AFAP** work position which is entirely natural, considering that all the points attached to the tooth are rotated at the same time with the tooth.

It must be remarked that the ϕ_1 angle differs from the α_{xf} angle, because the **M** point does not coincide in general with the tooth axis, but is found at the $\mathbf{a_V}$ distance and $\mathbf{h_V}$ height from the axis, or the polar coordinates $\mathbf{r_V}$ and φ_V. The ϕ_1 angle is equal to α_{xf} only when the edge point coincides with the tooth axis.

Following a similar resoning it can be deduced that the ϕ_2 angle is equal to 90°+γ_{xf} and ϕ_3 is equal to α'_{xf}.

In as much as the cutting edge of the tooth is made of rectilinear edges which are nevertheless positioned eccentrically in relation to the tooth axis, it results that, in rotating the edge from work position to any sharpening position, it actually describes a cross-section of an revolved hyperboloide. As the sharpening is practiced on a cylinder or cone surface and as straight line can be inscribed on one of these shanks only if it is a generating line, it comes out that the necessary angle to sharpen at differs from the imposed geometric parameters.

The case of profiled surfaces, by rotating the cutting edge from work position into sharpening position, it gets bent out of shape and so becomes different from the tool shape, which makes it necessary to determine the specific cutting edge shape that will ensure a correct shape.

Consequently, in sharpening the flanks of rectilinear edges (figure 2), in addition to the ϕ_1 angle of positioning the tooth arround its axis in rotation it is also necessary to position the shank of cutter in such a way so that the grinding wheel carry out the forward movement along the generating line of a cone, inclined with the ϕ angle, angle which is calculated at the cone base, in order to obtain the φ_g angle after sharpening. It must be mentioned that the φ_a angle differs from the φ_g angle only by few degrees.

In sharpening the rake surfaces (figure 3), in addition to the φ_2 angle it is also necessary to determine the φ_a to semi-angle of the cone edge, value which generally differs only by few degrees from the value of the γ_{yf} longitudinal rake angle. For the same reasons, in sharpening the secondary clearence surfaces (figure 4) it is necessary to determine, in addition to the value of the φ_3 angle which tends to α'_{xf}, the value of the φ angle from cone base following which the sharpening occurs.

Because of the fact that the edges in case are positioned eccentrically both in relation to the tooth axis and the cutter axis, there will appear on the edges in case after sharpening, hyperbolical errors and condition must be imposed that these are minimal as long as they affect the precision and the shape of the sharpened surface.

In conclusions, in order to attain the geometric parameters (φ_f, α_{xf}, α_{yf}, γ_{xf}, γ_{yf}) necessary to normally perform the cutting process, one must determine the φ_1, φ_2, φ_3 angles of positioning the inserts around their own axis in rotation, so as to sharpen the clearence surfaces, the rake surface and the secondary clearence surfaces respectively the φ_{af} , φ_{sa} angles of reciprocal position for the sharpening cutter – grinding wheel.

The active edges of the tool are the result of the intersection of the clearence surfaces and rake surfaces and so the influence of the grinding wheel wear on the reciprocal position of the edges is eliminated. This depends on the slots made in order to sharpen and work, which ensures a reapeted setting-up of the geometric parameters after each sharpening.

The construction characteristics of the face milling cutter with inserts with uninterrupted sharpening create a number of specific elements concerning their design.

The basic elements of a set of such cutters are in addition to the basic shank, the cutters with

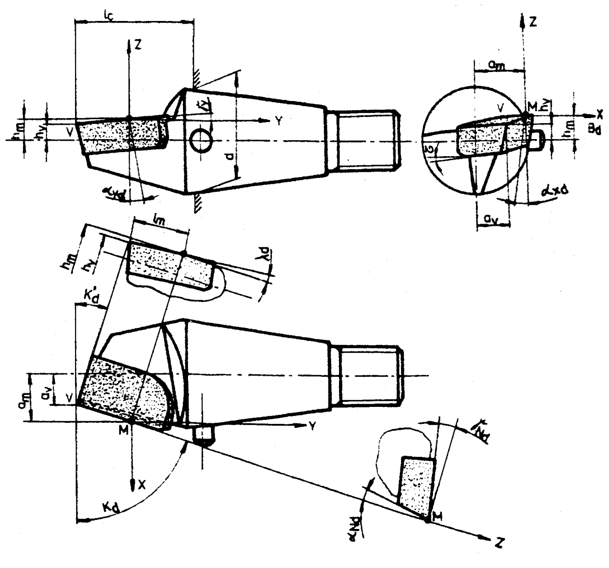

Figure 5

mechanically clamped inserts (figure 5).

These inserts are brazabile plates A_{12}, A_{16}, A_{20} or B type constitute the unique element of a set.

The inserts of metallic sinter carbide are

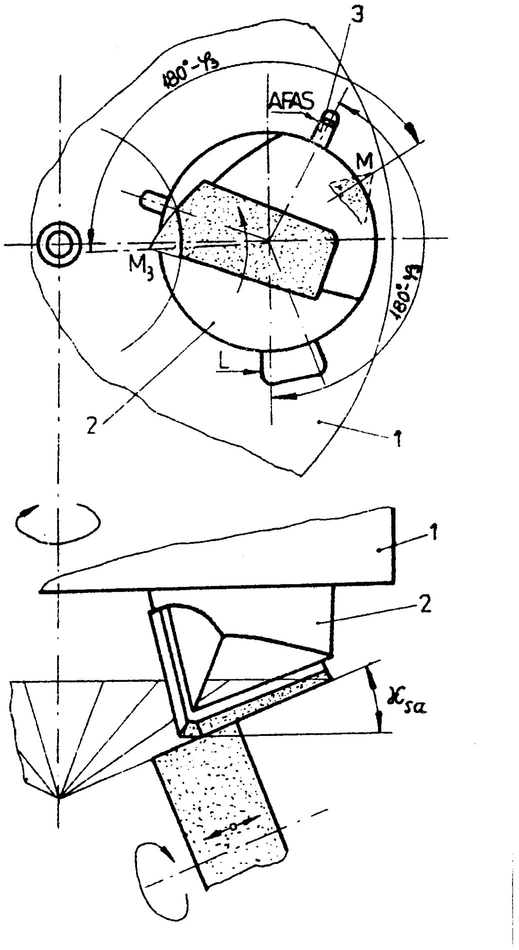

Figure 4

positioned on the shank of tooth in such a way to ensure both a strong mechanical resistance and a complete exploitation of their resharpening ability. The base surface for the tooth are of cone section, with the cone angle value of 7:24, value established in the workshop of Machine Tools Department, which ensures precise radial axial positioning.

The positioning element (the pin) can be placed at any point on the circumference (figure 6), but once established, the position remains fixed for a certain dimension. The positioning element may be a pressed pin, in the most technologically convenient position or obtained plastic deformation, as it is processed in the above mentioned workshop. Its position defines the work position of the tooth, including the position of the construction reference system attached to the tooth, in relation to which the basic constructive angles are defined (φ_d, α_{Nd}, γ_{Nd}, λ_{Nd}, φ'_d) .

These values are specially selected to be as close as possible to the geometric parameters values of tooth, due to their defining nature. The manner in which the connection between them is established will be examined separately within this chapter.

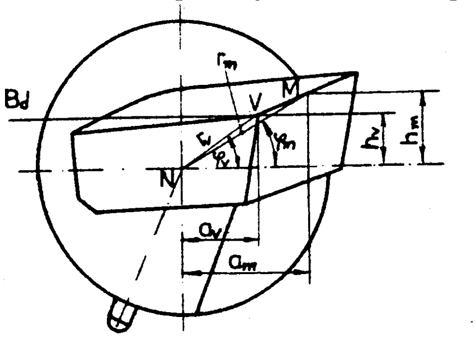

Figure 6

Reverting to the inserts, it can be seen that the position of the **V** edge is defined by the a_V and h_V distances in relation to the tooth axis and it is found at the l_c distance from the embedding section of the **d** diameter of the cutter's shank.

An **M** point, found at the l_m distance from the tool edge is defined in position by the a_m and h_m distances, given by the relations:

$$\begin{aligned} a_m &= a_V + l_m \cdot \cos\lambda_d \cdot \cos\varphi_d \\ h_m &= h_V - l_m \cdot \sin\lambda_d \end{aligned} \qquad (1)$$

In polar coordinates, defined in relation to the tooth axis and base plane of tooth, the **M** point position is determined by the r_m and φ_m (figure 6):

$$r_m = \sqrt{a_m^2 + h_m^2} \qquad (2)$$

φ_m is given by the equivalent relations**:**

$$tg\varphi_m = \frac{h_m}{a_m} \qquad (3)$$

The position of the base plane (B_f figure 7) is determined by the cutter axis and the considered **M** point, and the base plane of tooth (B_d) is a plane parallel to the one determined by the tooth axis and cutter axis.

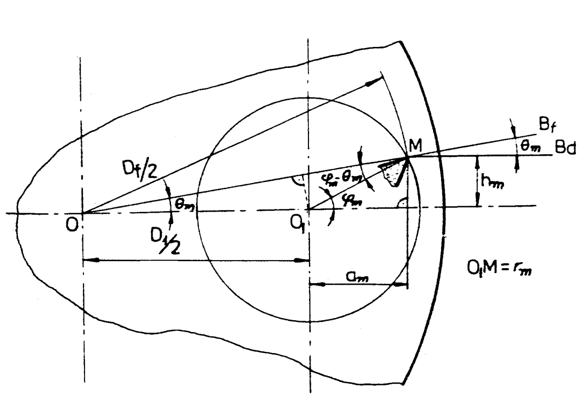

Figure 7

For the assembled cutter are defined:

D_f – milling diameter;

D_l – tooth disposal diameter;

θ_m – angle which defines **M** in the center of cutter, determined by the relation:

$$\sin\theta_m = \frac{2 \cdot h_m}{D_f} \qquad (4)$$

The connection relations between D_f and D_l are determined by means of figure 7, there resulting:

$$\frac{D_f}{2} = \frac{D_l}{2} \cdot \cos\theta_m + r_m \cdot \cos(\varphi_m - \theta_m) \qquad (5)$$

From these relations the expressions for D_l are deduced:

$$\frac{D_l}{2} = \frac{D_f}{2} \cdot \cos\theta_m - r_m \cdot \cos(\varphi_m) \qquad (6)$$

The number z of teeth which are apt to be inserted on the shank of cutter is determined by:

$$z \le \frac{\pi \cdot D_l}{d + a} \qquad (7)$$

where:

d - tooth diameter of embedding section (figure 5);

a – the minimal distance between 2 consecutive teeth recommended by the literature or by the specialist experience.

The Machine Tools Department makes use of the values presented in Table 1.

Table 1 Recommended values for **a** and **d** parameters

d [mm]	<16	≥16
a [mm]	2...3	3...5

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