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# Studies Regarding of the Real Geometry of the Polyeccentrical Surface Milling-Tool

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## ABSTRACT

*The milling of polyeccentric surfaces is, according to the procedure described in this paper, different in that the cutting tool operates under considerable variation of its real geometry*

*In order to ensure normal operating conditions it is necessary to use certain values according to the initial relief and clearance angles of the tool.*

*In the paper the real tool geometry is determined and the variation limits of the initial angles are calculated. Finally, some recommendations are made as to how to choose the tool initial angle values.*

**Keywords***: miling, tools, polyeccentrical surfaces*

## 1. Introduction

In previous papers [1], [2] some theoretical contributions have been presented regarding the properties of the polyeccentric surfaces as well as a number of original variants of milling such surfaces and the practical achievement by new procedures employing the existing machine tools.

**- The milling speeds**

The analysis of the polyeccentric surface milling with cylindrical mills eccentrically fitted to the cutter arbour shows [1] that the effective cutting speed vector $v_e$, figure 1, permanently changes its direction. This is due to the permanent variation of the peripheral speed modules $v_w$ and $v_t$.

When the piece speed $v_w$ is maximum, the milling-tool speed $v_t$ is minimum and vice versa. The relations give the values of then speeds:

$$(v_w)_{max} = (R+e)n_w ; (v_w)_{min} = (R-e)n_w ;$$
$$(v_t)_{max} = (R-e)n_t ; (v_t)_{min} = (R+e)n_s . \quad (1)$$

**- The angle of the effective milling speed**

From the analysis of *figure 1* according to a given direction *A*, parallel to a common normal of the rotation axes of both piece and tool (*Figure 2*), it can be seen that the real cutting speed $v_e$ makes an angle $\theta$ with the tool axis.

Applying the sinus theorem to the speed triangle, and taking into account that:

$\frac{n_t}{n_w} = N$, and:

$\cos\theta = \frac{1}{N}$ it follows:

$$\frac{v_w}{\sin\psi} = \frac{v_t}{\sin(\theta-\psi)}$$

$$ctg\psi = \frac{v_t}{v_w \sin\theta} + ctg\theta \quad (2)$$

Considering the relation (1), we'll have:

$$(ctg\psi)_{max} = \frac{(R_t+e).N}{(R-e).\sin\theta} + ctg\theta;$$
$$(ctg\psi)_{min} = \frac{(R_t-e).N}{(R+e).\sin\theta} + ctg\theta \quad (3)$$

Applying the relation (3) and using the data in ***table 1***, the extreme values of the angle $\psi$ are obtained.

## 2. The edge inclination angle

In is known [3] that the leading edge of a cutting tool will cause chips to detach from the piece material in better conditions if then is an as large as possible angle *l* between the normal to the edge $d_0$ and the cutting direction $d_1$ (*Figure 3*).

This is due to the fact that in the cross section with plane $P_1$ these are operating angles $a$ and $g$ of higher values than the initial angles $a$ and $g$.

At the same time the sharpening angle $\beta_e$ decreases.

In the case concerned, the inclination angle of the tool edge $l$ (*Figure 2*) takes the values:

- $l = w - q$ for right-helix cylindrical mills;
- $l = w + q$ for left-helix mills.

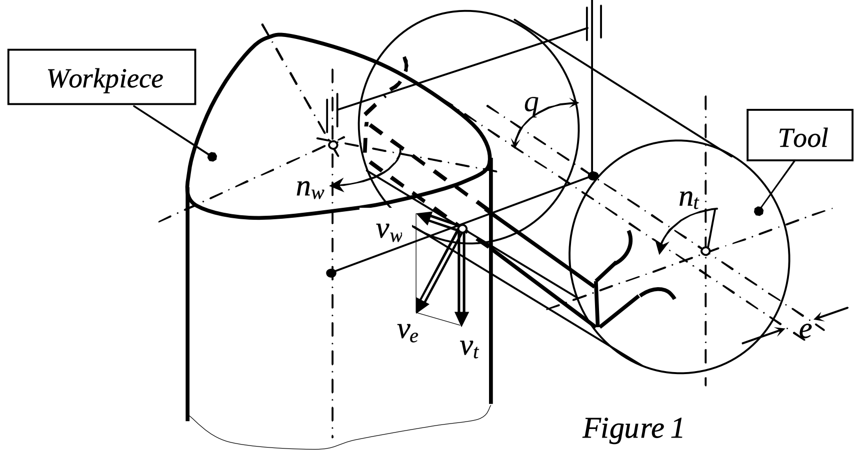


*Figure 1*

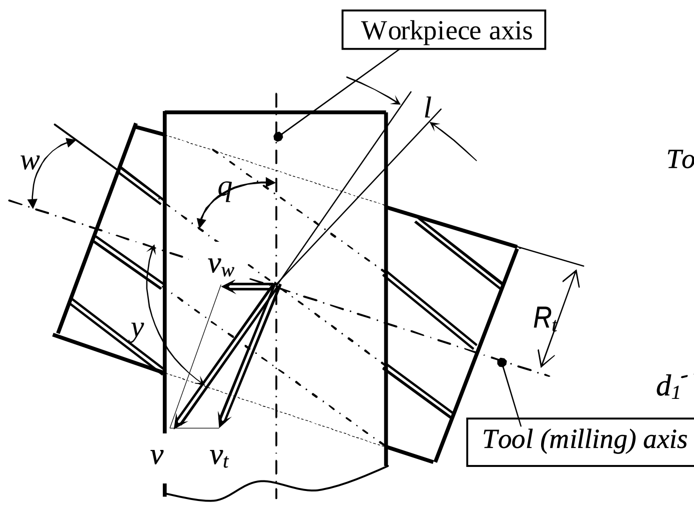


*Figure 2*

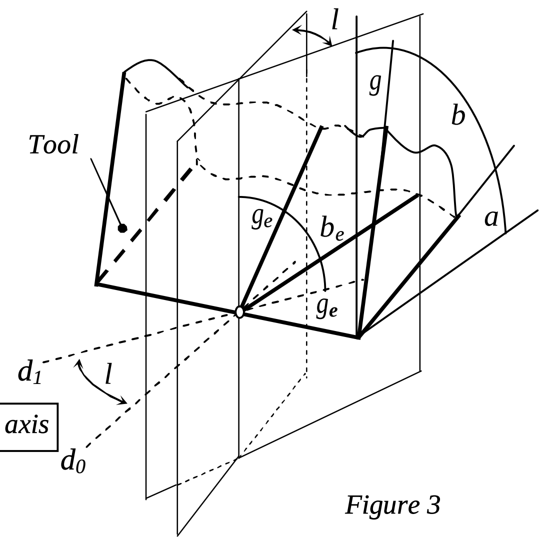


*Figure 3*

*Table 1*

| No. | The type of profil | e [mm] | N | The characteristics of tools | y [grad] | | |
|---|---|---|---|---|---|---|---|
| | | | | $D_t$ [mm] | $z_t$ | Max. | Min. |
| **1** | P3 - 50/2 | 2 | 3 | 80 | 16 | 12 | 9 |
| **2** | P3 – 50/2 | 2 | 3 | 100 | 20 | 10 | 7°30’ |
| **3** | P3 – 100/4.5 | 4.5 | 3 | 80 | 16 | 23 | 16 |
| **4** | P3 – 100/4.5 | 4.5 | 3 | 100 | 20 | 20°40’ | 13°30’ |

## 3. Real cutting teeth angles

If *figure 1* is analyzed, to a common direction perpendicular to the rotating axes of both piece and tool, it can be noticed (*Figure 4*) that the speed planes $v_w$ and $v_t$ do not remain parallel to the piece axis.

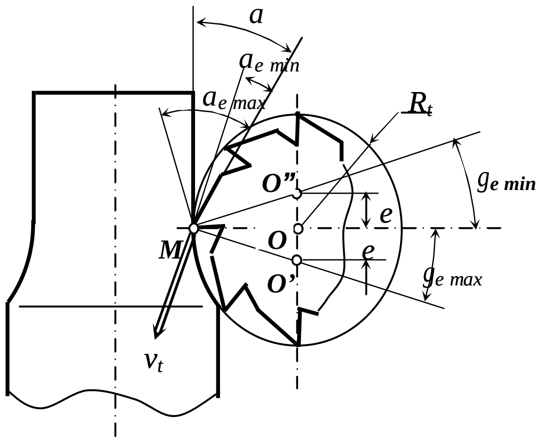


*Figure 4*

When the rotation centre of the tool gets to the positions *O'* and *O"*, the direction of the tool peripheral speed gets the maximum inclination to the piece axis causing the cutting under a real geometry different from the initial one.

Thus, in position *O'* it follows $a_{e\ min}$ and $g_{e\max}$ while in position *O"* we have $a_{e\ max}$ and $\gamma_{e\min}$.

From the triangles $O'MO_s$ and $O"MO_s$ we can write:

$$a_{e\min} = a - h; g_{e\max} = g + h$$
$$a_{e\max} = a + h; g_{e\min} = g - h \quad (4)$$

Where $h$ is given by:

$$\mathrm{tg}\eta = \frac{\mathrm{e}}{\mathrm{R_t}} \quad (5)$$

## 4. The initial tool angles

Upon teeth sharpening initial angles α and $g$ should be achieved to ensure optimum values during cutting.

Thus $a_{min} = a_{opt}$ and $g_{min}=g_{opt}$.

The optimum values can be estimated by using experimental relations of the form [4]:

$$\sin a \cong \frac{A}{a_{0\max}^{0.3}} \quad (6)$$

$$g_{opt} \cong 7.k_l^{1.15} \quad (7)$$

valid for high speeds steel teeth and steel pieces.

Under these assumptions, *A=0.13* and $k_l$ is the coefficient of plastic contraction in the chip detached which can be experimentally determined.

The initial sharpening is made under the angles:

$$\alpha = \alpha_{\mathrm{opt}} + \eta$$
$$\gamma = \gamma_{\mathrm{opt}} + \eta \quad (9)$$

The standard *STAS R 1685-75* provides the optimum values of these angles depending on the material machined (*Table 2*).

## Conclusions

When milling the polyeccentric surfaces, by the method advanced in the paper the tool real geometry changes much during the tool rotation.

The paper provides the calculation relations as well as the practical data necessary to establish the real angles and the initial ones in order to provide optimum milling conditions.

The experiments with the milling tool fastened to an arbour by means of an eccentric sleeve [1] show a dynamic behaviour favourable to the technologic systems, the cutting parameters being the usual ones upon the classical milling with cylindrical tools.

***Table 2***

| Workpiece material | Streigh $R_m$ [N.mm$^{-2}$] | Hardness HB [N.mm$^{-2}$] | Angles $a_{opt}$ [ $^0$] | $g_{opt}$ [ $^0$] |
|---|---|---|---|---|
| **Rolled Steel** | < 500 | - | 10 | 15 |
| | 500 - 800 | - | 8 | 12 |
| | 800 - 1000 | - | 6 | 8 |
| | 1000 - 1300 | - | 4 | 6 |
| **Castings Steel** | - | - | 8 | 12 |
| **Grey cast Iron** | - | ≤ 180 | 8 | 8 |
| | - | > 180 | 6 | 6 |
| **Malleable cast iron** | - | - | 6 | 6 |
| **Copper** | - | - | 8 | 12 |
| **Brass Bronze** | - | - | 8 | 8-15 |
| **Copper alloys** | - | - | 6 | 0-5 |
| **Aluminium Alloys** | With low and medium hardness | | 12 | 20-35 |
| | With high hardness | | 10 | 15 |
| **Magnesium Alloys** | - | - | 10 | 12-20 |

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## Studiu asupra geometriei reale a sculelor de frezat suprafețe poliexcentrice

**Rezumat**

Lucrarea face parte dintr-o serie de lucrări, apărute în numerele anterioare ale acestei publicații, legate de problematica aplicării unei noi tehnologii de prelucrare a suprafeţelor poliexcentrice exterioare. Noua tehnologie se referă la un procedeu de degroşare prin aşchiere a acestor suprafețe. Aplicarea frezării se poate face pe maşinile universale de danturat cu freze-melc sau, şi mai bine, pe maşinile de frezat caneluri cu freze-melc.

Concluzia lucrării este că, pentru aplicarea frezării suprafeţelor poliexcentrice cu freze cilindrice, aceste scule trebuiesc construite cu unghiurile de aşezare şi de degajare majorate, cu unghiul η, față de unghiurile optime recomandate de literatura de specialitate.

## L'étude sur la géométrie réelle de l'outil pour le fraisage des surfaces polyexcentriques

**Résumé**

Le fraisage des surfaces polyexcentriques "polygonales" conformément au procédé décrit dans cet ouvrage, est caractérisé par la particularité que l'outil fait l'usinage dans des conditions spéciales. Dans ce cas, la géométrie fonctionnelle est essentiallement différente de la géométrie constructive.

Dans cet ouvrage on présente ces conditions spéciales et on détermine les variations des angles fonctionnels. En final, on donne les recommandations pour choisir les valeurs des angles constructives de l'outil.