The Calculation of the Tools Necessary for Slotting by Rolling of the Polyeccentric Profiles

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Abstract

The work presents the theoretical considerations for the establishment of the geometrical parameters used at the profiling of shaping-tool for polyeccentric hole working (type P2. P3 or P3G, PC3 or P3C, PC4 or P4C, conform DIN 32711 and DIN 32712). This method can be applied on every machine for slotting of the gear by rolling with slotting shaping-tool.
***Keywords**: slotting, shaping-tool, polyeccentric hole.*

1. Introduction

The necessity of products quality increase and the material consumption decrease imposed in the field of transmission in the machine construction, the use of slot-wedge and flute assemblage instead of profiled assembly of **PC** type (which will be called foreword "polyeccentic profiles".

Having in view the work [1], where the *polyeccentric profiles* (figure 1) are presented like the wrapping up of the positions of a line ***(Δ)*** which a rotation movement with a fixed centre ***O***, there was noticed that the ***M*** point of contact between generated profile and the generating line moves, in the ***xOy*** system of reference, on an ellipse with the equation:

$$\left(\frac{x-R}{e}\right)^2+\left(\frac{y}{eN}\right)^2=1$$

or in **X'O'Y'** system of reference:

$$\left(\frac{x'}{e}\right)^2+\left(\frac{y'}{eN}\right)^2=1$$

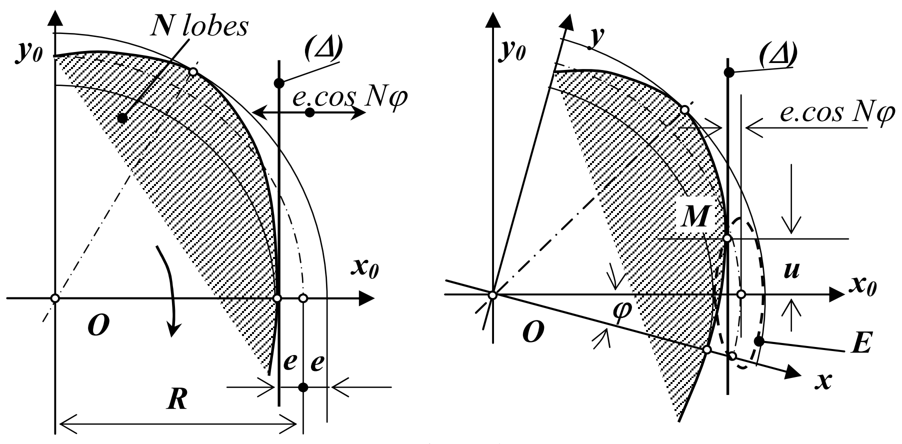

Figure 1

The last relation shows that ***M*** point moves on an **E** ellipse whose form is not dependent of ***R*** parameter (the profile main radius) and, so, it can characterizes the contact between ***(Δ)*** line and any other profile, with the same parameter ***e***, with the centre somewhere on the normal by ***O*** on the ***(Δ)*** line.

In this way, there results on gear limit situation of some profiles, witch is characterized by a unitary translation rate and same rotation sense, no matter if the gear if the gear is interior or exterior (only for ***N*** odd).

In figure 2, there is presented the situation of ***N=3*** lobes profiles. Like an application of these features, a new polyeccentric profiles working method more accurate, the shaping tool slotting by rolling has been based.

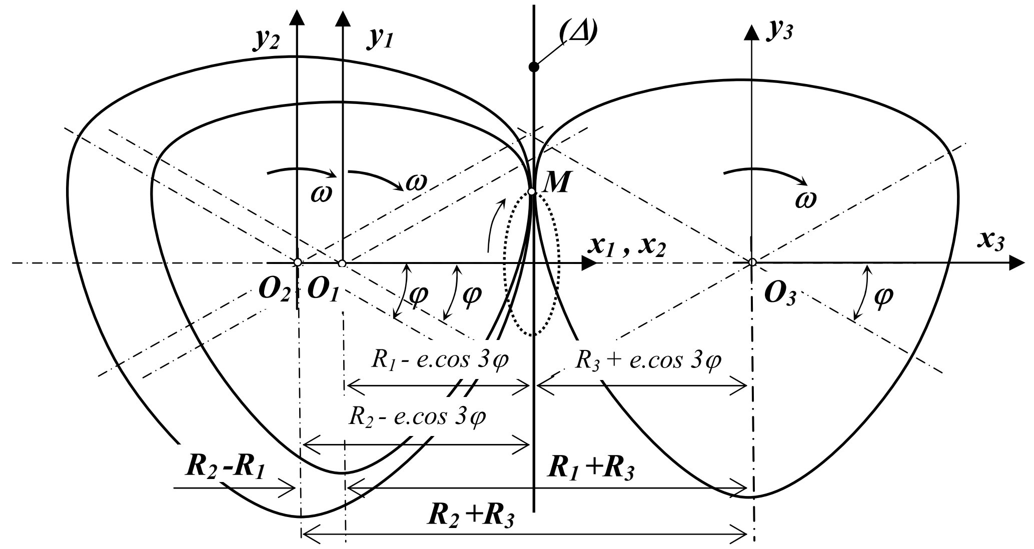

Figure 2

In this work, further more, there will be done the considerations necessary for the calculation of the slotting shaping tool for hole cutting. The scheme of the slotting shaping tool for hole cutting. The scheme of this procedure is presented in figure 3.

The considerations necessaries for calculating slotting shaping tool for holes working (figure 3.a).

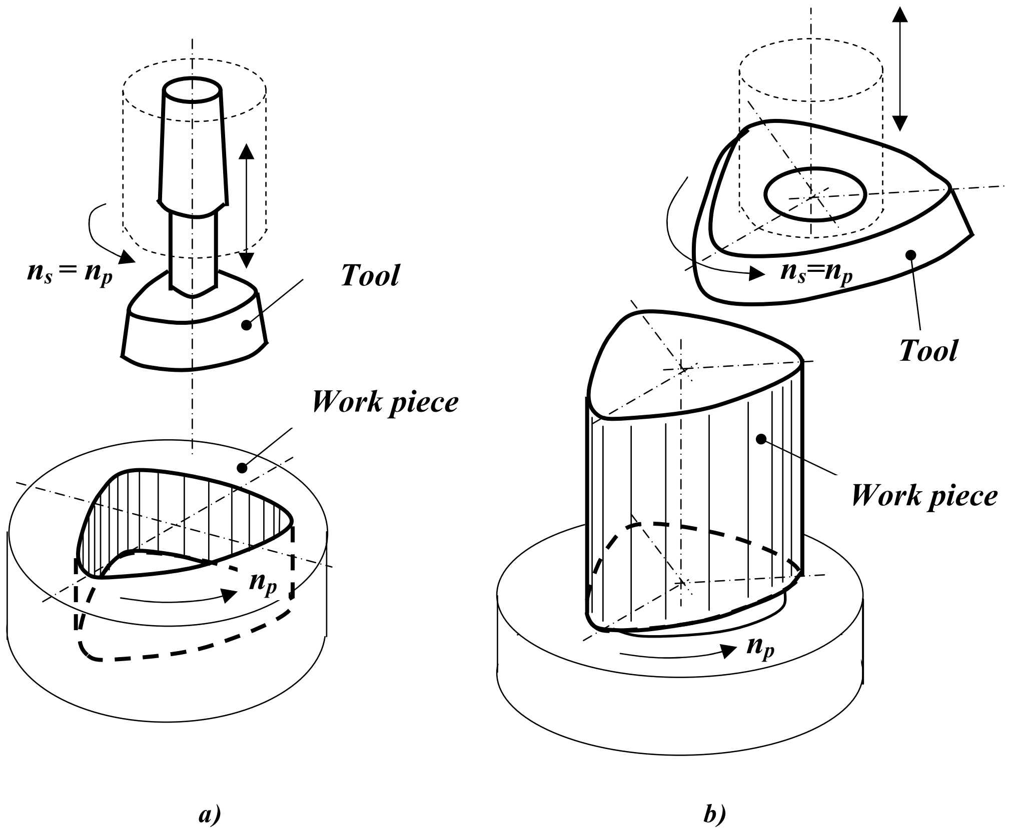

Figure 3

2. The Calculation of the Tools

The polyeccentric profile equation equations can be determined (figure 1) projecting ***M*** point in ***xOy*** system of reference associated with the profile.

After trigonometrically transformation:

$$x = R\cdot\cos\varphi + \frac{(N-1)\cdot e}{2}\cdot\cos(N+1)\varphi - \frac{(N+1)\cdot e}{2}\cdot\cos((N-1))\varphi$$

$$y = R\cdot\sin\varphi + \frac{(N-1)\cdot e}{2}\cdot\sin(N+1)\varphi + \frac{(N+1)\cdot e}{2}\cdot\sin((N-1))\varphi \qquad (1)$$

In the situation of continuous profiles called (***P2*** at ***P3***, figure 4) the tool calculation can be done simply, from the condition that the tool maximum radius to be smaller than the radius of the cylindrical hole from whom the profile working is started.

There result the conditions:

$$R_t \prec R - 2\cdot e + \frac{A_p}{2} \qquad (2)$$

where:

R_t is the main radius of the tool profiles;

e eccentricity of the tool and profile;

A_p supplement minimum to machining

The condition that the curved shape minimum radius of the tool profile to be positive is verified. His expression is:

$$\rho_{\min} = R_t - e\cdot(N^2-1)$$

and so the condition:

$R_t \succ e\cdot(N^2-1)$ is verified, (3)

The ***PC3*** and ***PC4*** profile are realised with polyeccentric curves and circle arcs (ad the 'corners') concentric with the profiles centre.

The profile definition is done with D_a diameter (the maximum diameter of the 'tape'), D_i (interior diameter) and ***e*** parameter which define the polyeccentric curve arc.

The parameter ***R*** can be established with:

$$R = e + \frac{D_i}{2}.$$

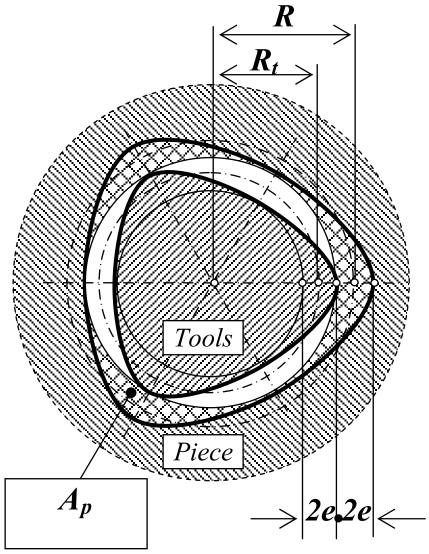

Figure 4

For ***PC3*** and ***PC4*** profile, the tool calculating is more complicated, firstly having to establish φ_1 angle (rolling angle for the working of the last point on a polyeccentric curve arc), figure 5.

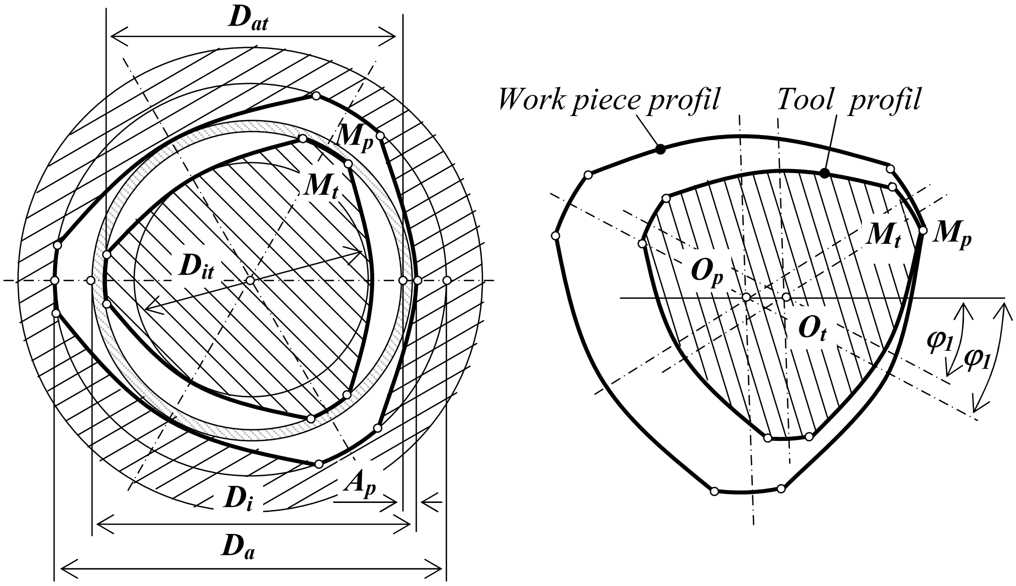

Figure 5

There will be imposed the condition that **M** point to be on the D_a diameter circle, so:

$$O_aM = \frac{D_a}{2}, \text{ or } \sqrt{x_M^2 + y_M^2} = \frac{D_a}{2},$$

where:

x_M , y_M are the **M** point co-ordinates in xO_Py system of reference associated with the profile.

Taking into account the relation (1) and raising it to the square the following equation will be obtained:

$$e^2 \cdot (1-N^2) \cdot \cos^2 N\varphi_1 - 2R \cdot e \cdot R \cdot \cos N\varphi_1 + \\ + R^2 + e^2 \cdot N^2 - R_a^2 = 0 \tag{4}$$

and the only solution compatible with the problem is:

$$\cos N\varphi_1 = \\ = \frac{R - \sqrt{N^2 \cdot (e^2N^2 + R^2 - e^2) + R_a^2 \cdot (1-N)^2}}{e \cdot (1-N^2)} = \\ = A,$$

We obtain:

$$\varphi_1 = \frac{\arccos A}{N}$$

Supposing that the hole is cylindrical with $D_{At} = D_i - A_P$ diameter (A_P is the minimum machining allowance), the condition that M_t point on the tool (M_t is the point which generates **M** point on the part, figure 5) to be on the diameter mentioned above is imposed.

We have:

$$(D_{A_S})_{\max} = 2 \cdot \sqrt{x_{M_S}^2 + y_{M_S}^2},$$

whare:

x_{Mt}, y_{Mt} represent the values determined by putting of φ_1 parameter, relation (5), on the relation (1).

This condition leads to the equation:

$$R_t^2 - 2 \cdot R_t \cdot e \cdot cos N\varphi_1 + e^2\left(1-N^2\right) \cdot cos^2 N\varphi_1 + \\ + e^2N^2 - R_{at}^2 = 0$$

(R_t parameter is the average radius associated with the tool).

Results the solution:

$$(R_t)_{max} = e \cdot cos N\varphi_1 + \sqrt{R_{at}^2 - e^2N^2 \cdot sin^2 N\varphi_1} \tag{7}$$

From the condition that the tool not have sharp tops, the condition:

$$arctan \frac{y_{Mt}}{x_{Mt}} \prec 60^o, \text{ for } N = 3,$$

and :

$$arctan \frac{y_{Mt}}{x_{M_{St}}} \prec 45^o, \text{ for } N = 4;$$

is imposed.

3. Conclusions

The relations established above permit the determination of the geometrical parameter of the profile of slotting shaping tool for the hole working.

The slotting method has the advantage that the tool profile can be realised very simply, with profiles grinding machines and, so, much more cheaper that the tools necessary for the broaching method (the main method used for hole cutting). So, the method is justified in the situation of some small and average sets, where the work performance is not very important.

Using the slotting method we can obtain blind hole, too, in this situation it’s the only method possibly to be used.

The results of these researches ware applied with good results for parts of automatic lather and for holes of some high speed turbines, figure 6)

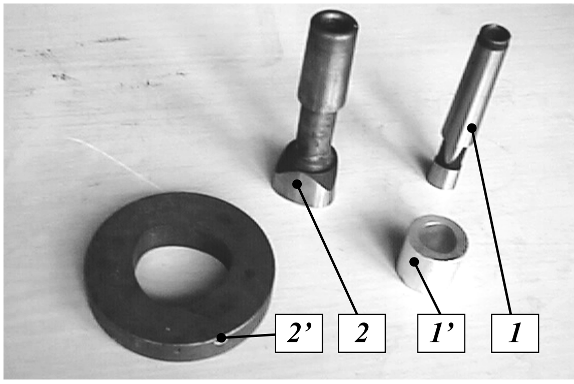

Figure 6

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Calculul sculelor necesare pentru mortezarea prin rulare a alezajelor cu profil poliexcentric

Lucrarea prezintă considerațiile teoretice pentru stabilirea parametrilor geometrici utilizați pentru profilarea sculelor de mortezare la prelucrarea alezajelor tip P2, P3 sau P3G, PC3 sau P3C, PC4 sau P4C, conform standardului german DIN 32 711 şi DIN 32712. Această metodă de prelucrare se poate aplica pe orice maşină de mortezat roți dințate prin rulare, utilizând cuțitele roată de mortezat.

Le calcul des outils nécessaire pour emboîter en roulant des profils polyeccentric

Le travail présente les considérations théoriques pour l'établissement des paramètres géométriques utilisé au profiler de façonnement outil pour trou du polyeccentric qui travaille (type P2. P3 ou P3G, PC3 ou P3C, PC4 ou P4C, conformez du DIN 32711 et du DIN 32712). Cette méthode peut être sollicitée emboîter de l'équipement en roulant avec emboîter le façonnement outil sur chaque machine.