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Software for Blank’s Minimum Rolling Radius Determination

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ABSTRACT

Is well known the fact that the possibility to generate by rolling a certain profile depend in big measure by the form and the dimensions of the profile for generate and by the position of the tool’s cutting edges regards the rolling plane (in case of the generation with rack-gear tool) or the rolling cylinder (in case of generation with gear shaped tool).
For the determination of the minimum rolling radius it was proposed an analytical algorithm based on fact that in profile’s points the normal at profile must intersect or to be tangent at the rolling circle.
***Keywords**: minimum rolling radius, generation by*

1. Introduction

Is well known the fact that the possibility to generate by rolling a certain profile depend in big measure by the form and the dimensions of the profile for generate and by the position of the tool’s cutting edges regards the rolling plane (in case of the generation with rack-gear tool) or the rolling cylinder (in case of generation with gear shaped tool).
In accordance with WILLIS theorem, in the contact point of the two rolling surfaces, those admit a common normal, which cross by the gearing pole.

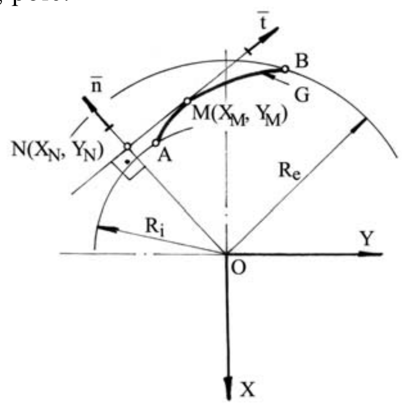

Fig. 1. Minimum rolling radius

If, due of the small width of the emptiness between the flanks of the piece, the tool teeth’s flanks intersect, the height of tool’s teeth become insufficient for assure the piece’s profile cutting on the entire height. The intersection point of the tool’s cutting edge will generate on the piece a curve different to the piece’s profile, called “transiting curve”.

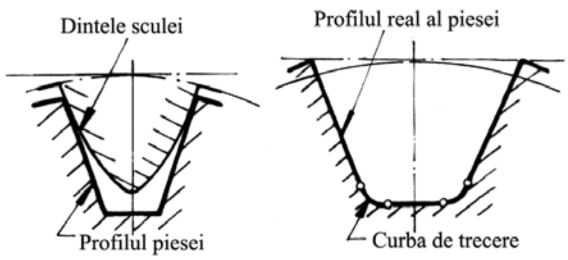

Fig. 2. The transiting curves

In order to establish the minimum-rolling radius of the piece, we have to consider the simultaneous completion of four conditions:

-the normal, in any point of the piece’s profile must intersect or to be tangent at the rolling circle;

-the tool must have in any point of the cutting edge positive back angle;

-the piece profile’s points must be generate successive, in accordance with the value of these radius on piece;

-the transiting curves must be finite as extension.

For the completion of first three conditions is profitable the enlargement of the rolling radius and for the fourth condition is profitable as the rolling radius to be smaller is possible. Theoretically, exist a single value for the rolling radius which simultaneous completion this four conditions. This radius may be defined as minimum rolling radius.

For the determination of the minimum rolling radius it was proposed an analytical algorithm based on fact that in profile's points the normal at profile must intersect or to be tangent at the rolling circle.

If we accept the profile for generation in

$$G:\left|\begin{array}{l}X = X(u);\\ Y = Y(u),\end{array}\right. \tag{1}$$

then the tangent equation at this profile will have the form

$$\frac{X - X(u)}{X'_u} = \frac{Y - Y(u)}{Y'_u}, \tag{2}$$

and the normal which cross the reference system origin will be

$$X \cdot X'_u + Y \cdot Y'_u = 0. \tag{3}$$

If we mark with N the intersection point of these two straight segments, so from equations (2) and (3) we can determine the N point's coordinates on type

$$N:\left|\begin{array}{l}X_N = X(u);\\ Y_N = Y(u).\end{array}\right. \tag{4}$$

For each M point which belongs to G curve, is determined the N corresponding point and is calculate the $\overline{MN} = \Delta$ segment's length, in form

$$\Delta = \sqrt{(X_M - X_N)^2 + (Y_M - Y_N)^2}. \tag{5}$$

Is accepted as minimum rolling radius the biggest $\overline{MN}$ segment determinate in this way for profile's points between A and B.

2. The determination of the minimum-rolling radius for a profile on type straight-line segment

Based on the above showed algorithm it was realized a software for minimum rolling radius calculus in case of a profile on type straight line segment, known by its start and end point's coordinates (see fig. 3)

The parametrical equations of this segment are

$$\Sigma:\left|\begin{array}{l}X = X_A - u \cdot \cos\varepsilon;\\ Y = Y_A + u \cdot \sin\varepsilon,\end{array}\right. \tag{6}$$

where $\varepsilon = \arctan\left(\dfrac{Y_A - Y_B}{X_A - X_B}\right)$.

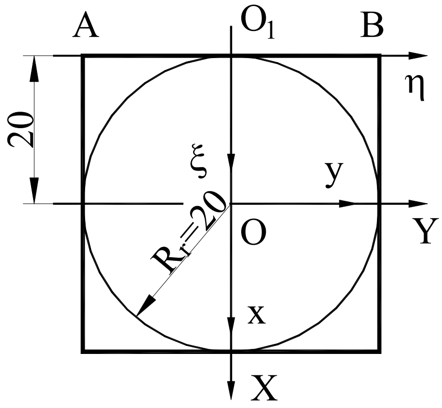

Fig. 3. Minimum rolling radius for straight line segment

From (2) and (6) equations it's obtained the specifically form of the tangent at this profile

$$\frac{X - X_A + u \cdot \cos\varepsilon}{-\cos\varepsilon} = \frac{Y - Y_A - u \cdot \sin\varepsilon}{\sin\varepsilon}, \tag{7}$$

equivalent with

$$X \cdot \sin\varepsilon + Y \cdot \cos\varepsilon = X_A \cdot \sin\varepsilon + Y_A \cdot \cos\varepsilon. \tag{8}$$

The (3) and (6) equations permits the determination of the normal in specifically form for this profile

$$-X \cdot \cos\varepsilon + Y \cdot \sin\varepsilon = 0, \tag{9}$$

equivalent with

$$Y = X\,\frac{\cos\varepsilon}{\sin\varepsilon}. \tag{10}$$

The equations system formed by (8) and (10) permit the determination of the intersection point's coordinates between tangent and normal, which in this case is

$$N\left|\begin{array}{l}X_N = (X_A \cdot \sin\varepsilon + Y_A \cdot \cos\varepsilon) \cdot \sin\varepsilon;\\ Y_N = (X_A \cdot \sin\varepsilon + Y_A \cdot \cos\varepsilon) \cdot \cos\varepsilon.\end{array}\right. \tag{11}$$

The Σ straight line segment is discreetly consider, giving to u parameter values between umin and umax (with $u_{max} = \sqrt{(X_A - X_B)^2 + (Y_A - Y_B)^2}$) and for each u value is calculate the value of segment

$$\Delta = \left[\,(X_A - u\cos\varepsilon - X_A\sin^2\varepsilon - Y_A\sin\varepsilon\cos\varepsilon)^2 + (Y_A + u\sin\varepsilon - X_A\sin\varepsilon\cos\varepsilon - Y_A\cos^2\varepsilon)^2\,\right]^{1/2}. \tag{12}$$

Is considered as minimum rolling radius the maximum value calculated for Δ.

In fig. 3 is represented the minimum rolling radius calculate for a segment with start point *A(-20;-20)* and end point *B(-20;20)*. Running this program it was obtained the value *Rr=20* mm for minimum rolling radius.

3. The determination of minimum rolling radius for a profile on type arc of circle

Similarly with above presented algorithm was realized the software for minimum rolling radius for an arc of circle known by it's center *C(X0;Y0)*, it's radius, r and start and end angles (v_{min}) and (v_{max}) (see fig. 4).

In this case the profile's equations will be

$$\Sigma : \begin{vmatrix} X = X_0 - r \cdot sin v; \\ Y = Y_0 + r \cdot sin v. \end{vmatrix} \quad (13)$$

For this profile the tangent's equation in a point determined by v parameter will be

$$\frac{X - X_0 + r \cdot sin v}{-r \cdot cos v} = \frac{Y - Y_0 - r \cdot cos v}{-r \cdot sin \varepsilon}, \quad (14)$$

equivalent with

$$X \cdot sin v - Y \cdot cos v = X_0 \cdot sin v - Y_0 \cdot cos v - r. \quad (15)$$

The normal at this segment, crossing the reference system origin will have the equation

$$X \cdot cos v + Y \cdot sin v = 0, \quad (16)$$

equivalent with

$$Y = -X \frac{cos v}{sin v}. \quad (17)$$

The equations (15) and (17) formed an equation system which permit the determination of the intersection point's coordinates between tangent and normal.

$$N \begin{vmatrix} X_N = X_0 \cdot sin^2 v - Y_0 \cdot sin v \cdot cos v; - r \cdot sin v; \\ Y_N = -X_0 \cdot sin v \cdot cos v + Y_0 cos^2 v + r \cdot cos v. \end{vmatrix} \quad (18)$$

Giving values at v parameter in domain $[v_{min}, v_{max}]$, it is possible to calculate the value of Δ segment, in form

$$\Delta = \left[\left(X_0 sin^2 v - Y_0 sin v \cdot cos v - X_0 \right)^2 + \right. \left. + \left(- X_0 sin v \cdot cos v + Y_0 cos^2 v - Y_0 \right)^2 \right]^{1/2}. \quad (19)$$

It is considered am minimum rolling radius the maximum value calculated for Δ.

In fig. 4 is represented the minimum rolling radius for a profile having *C(-60;10)*, *r=20* mm, $v_{min}=10°$ and $v_{max}=90°$. Running this program it result a minimum rolling radius *Rr=57.35198* mm.

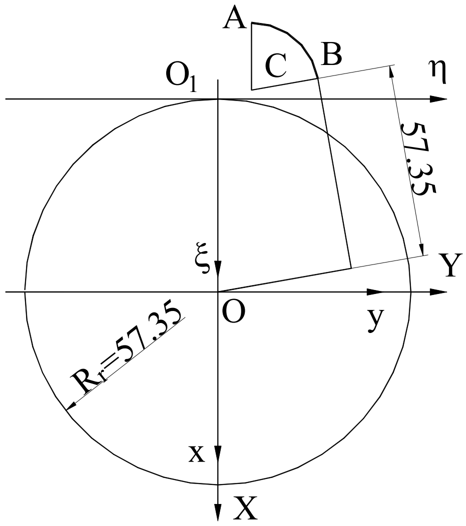

Fig. 4. Minimum rolling radius for arc of circle

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Program pentru determinarea razei minime de rulare a semifabricatului

Rezumat

Este cunoscut faptul ca posibilitatea de a genera prin rulare un anumit profil depinde în mare măsură de forma şi dimensiunile profilului de generat şi de poziția muchiilor aşchietoare ale sculei față de planul de rulare (în cazul generării cu scula cremalieră) sau față de cilindrul de rulare (în cazul generării cu cuțit-roată).
Pentru determinarea razei minime de rulare este propus un algoritm analitic bazat pe faptul că în toate punctele profilului normala la profil trebuie să intersecteze sau să fie tangentă la cercul de rulare

Logiciel pour la Détermination de Rayon Roulante Minimale de Semi-Produit

Résumé

Est bien connu le fait que la possibilité de produire en roulant un certain profil dépende dans la grande mesure par la forme et les dimensions du profil pour produisent et par la position des tranchants de l'outil considère le projet roulant (en cas de la génération avec l'outil crémaillère) ou le cylindre roulant (en cas de la génération avec le coteau roue).
Pour la détermination du minimum roulant le rayon il a été proposé un algorithme analytique basé sur le fait que dans les points de profil le normal au profil doit se croiser ou être la tangente au cercle roulant.