Analysing algorithm for the cinematic unevennesses at the gear processing

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ABSTRACT: The aim of the present paper is to analyze the cinematic unevennesses. Tooth generation by envelope curve inserts profile errors that are independent on tooth charging. It is proposed a mathematic calculus model in order to get the profile error inserted by envelope curve tooth generation. The calculations based on the proposed model demonstrate profile errors with maxim values 53 um.
KEYWORDS: Cinematic unevennesses, involute, tooth generation

Introduction

It is well known that the most precise method of operation in gear processing is the worm cutter splinting. The process has also some disadvantages; the most important of them might be called unevennesses.

These unevennesses are:
- dynamic unevennesses - regarding on the cutting edges charging during the splinting;
- cinematic unevennesses - regarding on the tooth's generation principle.

Because of the edge charging, which for the same tooth has very different values and also very different values for the whole cutting worm, the dynamic unevennessses generate shocks and vibrations.

These unevennesses usually settled the splinting parameters high values.

Cinematic unevennesses generates profile deviation, error values indicates that the worm cutter will be use for low or high precision.

In this situation it is important the working principle because the splinting cinematic and precision are affected.

1 The elaboration of the calculus model

It is presented in figure 1 the diagram that helps in the calculus from now on. In the diagram it can by seen 2 (two) successive position of the cutting edge, *k-1* and *k* teeth.

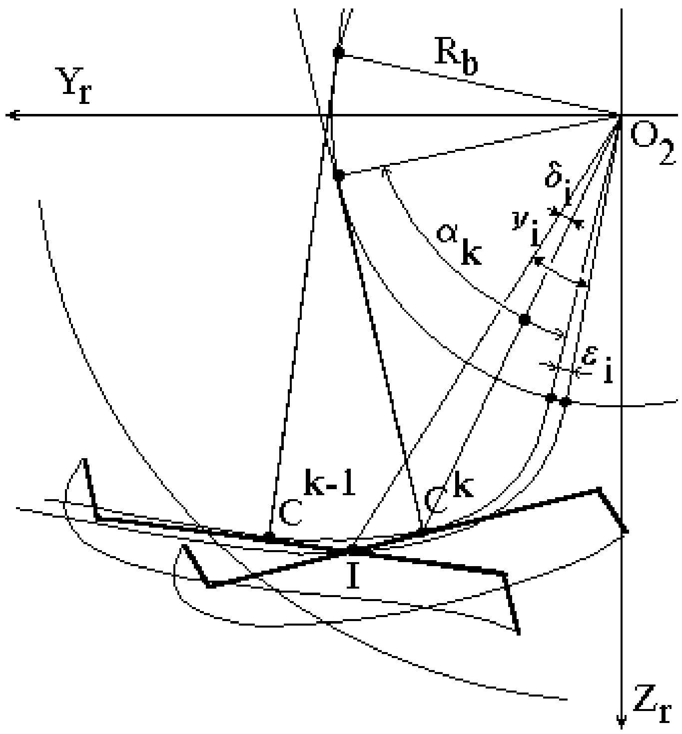

Figure 1. Two successive position of one tooth during the splinting

These teeth' cutting edges are tangent with the involute profile in C^{k-1} and C^{k} points and the intersection of the splinted surfaces is in *I* point.

The profile error is the distance from the involute flank to the *I* point, or the distance on the basic circle, between the profile involute and a involute parallel with the first one that goes through *I* point. The equation for the *k* tooth edge is:

$$\frac{Y - Y_V^k}{Y_M^k - Y_V^k} = \frac{Z - Z_V^K}{Z_M^K - Z_V^k} \qquad (1)$$

The expression (1) may be also wrote:

$$Y\frac{Z_M^k - Z_V^k}{Y_m^k - Y_v^K} - Y_k^k\frac{Z_M^k - Z_V^k}{Y_M^k - Y_V^k} + Z_V^k = Z \tag{2}$$

From C^k point it is considered the perpendicular on the edge *k*. The perpendiculars family is described by the equation:

$$Z = Y(-\frac{Z_M^k - Z_V^k}{Y_M^k - Y_V^k}) + A \tag{3}$$

In the expression (3) A is a coefficient and it can by determined from the condition that the straight line described by (3) is tangent with the basic circle which equation is:

$$Z^2 + Y^2 = R_r^2 \tag{4}$$

If the expression (3) is insert in expression (4) it results:

$$Y^2(\frac{Y_M^k - Y_V^k}{Z_M^k - Z_V^k})^2 + A^2 - 2AY\frac{Y_M^k - Y_V^k}{Z_M^k - Z_V^k} + Y^2 - R_b^2 = 0 \tag{5}$$

The single point tangent condition is that the two solutions of the equation (5) are identical:

$$A^2(\frac{Y_M^k - Y_V^k}{Z_M^k - Z_V^k})^2 - [1 + (\frac{Y_M^k - Y_V^k}{Z_M^k - Z_V^k})] \cdot (A^2 - R_b^2) = 0 \tag{6}$$

If $$B = \frac{Y_M^k - Y_V^k}{Z_M^k - Z_V^k} \tag{7}$$

From expression (6) results:

$$A^2B^2 - A^2 + R_b^2 - A^2B^2 + B^2R_b^2 = 0, \quad \text{or}$$

$$A^2 = R_b^2\,(1 + B^2), \text{ or}$$

$$A = R_b \cdot \sqrt{1 + B^2} \tag{8}$$

It is possible now to determine the expression (3):

$$Z = -B \cdot Y + A \tag{9}$$

From the expression (2)

$$D = -Y_V^k \cdot \frac{Z_M^k - Z_V^k}{Y_M^k - Y_V^k} + Z_V^k,$$

then, (9) become:

$$Z = \frac{Y}{B} + D \tag{10}$$

In these conditions, the C point is situated at the intersection between the straight lines with the equations (9) and (10)

$$\begin{cases} Y_C^k = \dfrac{B \cdot (A - D)}{1 + B^2} \\ Z_C^k = \dfrac{A + B^2 \cdot D}{1 + B^2} \end{cases} \tag{11}$$

The involute that goes through the C^k point leads to:

$$\gamma_k = tg\alpha_k - \alpha_k, \quad \text{where} \tag{12}$$

$$\alpha_k = arccos \frac{R_b}{R_C^k}, \quad \text{and}$$

$$R_C^k = \sqrt{Y_{C^k}^2 + Z_{C^K}^2}$$

Similarly, the involute that goes through *I* point leads to:

$$\gamma_i = tg\alpha_i - \alpha_i, \quad \text{where} \tag{13}$$

$$\alpha_i = arccos\frac{R_b}{R_i}, \quad \text{and}$$

$$R_i = \sqrt{Y_{C_i}^2 + Z_i^2}$$

The angle δ_I is determined with:

$$\delta_I = arctg\frac{Z_C^k}{Y_C^k} - arctg\frac{Z_i}{Y_i} \quad (14)$$

Finally, it is obtained the ε_I angle:

$$\varepsilon_I = \gamma_i - \delta_I - \gamma_k \quad (15)$$

The poligonallization error, - a_p -, can by determined with the expression:

$$a_p = R_b \cdot \varepsilon_I \quad (16)$$

Conclusions

The presented calculus model leads to the followings conclusions:

- The maximum profile error at a cutting worm processing with uncompleted edges from carbide plates, like in figure 2, is 53µm.

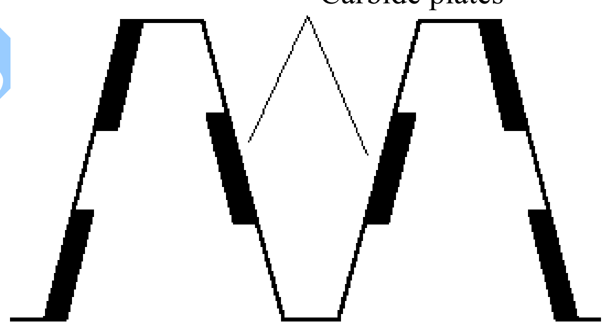

Figure 2. Uncompleted cutting edges from carbide plates

- In order to process an entire profile there are necessary two cutting tooth, like in figure 2.

The construction of one of the cutting tooth is presented in figure 3.

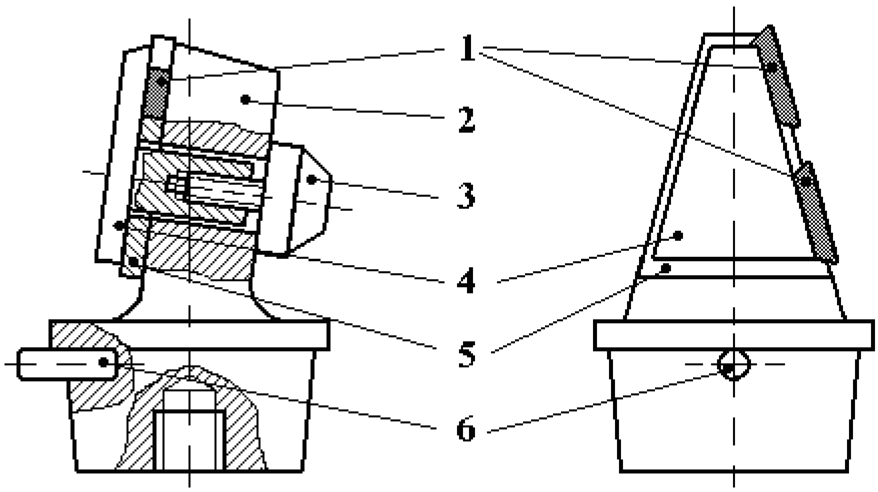

Figure 3. Cutting tooth construction
1- Carbide plates, 2 – Cutting tooth, 3, 4 – fixing device,
5 – guiding piece, 6 – centering bolt

Both situations show that the cutting worm with carbide plates may be also use at the finishing processing.

- The calculus method and the technical solution (figure 3) represent an original contribution to the precise tooth generating with the cutting hob.

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