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The Constructive Geometry of the Hobbing Tools for Continuous Sharpening

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ABSTRACT

Modern variety of "Fredascon" gear hob, profiled through continuous sharpening, provide the accuracy in processing of gear pinions profile, in the terms of preserving the advantages results through tooth shifting. Tooth profiling through continuous sharpening tool remove the possibility to utilize machine of relief milling.

In this paper the proposed gear hob cutter permit the assembling of a sharpening tool, with the cutting edge placed in such a way to control the decrease of irregularity caused by teething and increase the precision of gear pinions process.

The paper presents the calculus relations of the passive angle of the hob-tool teeters, in the case of continuous grinding of their active, in assembly estates.

Keywords: Fredascon, gear hob, continuous sharpening.

1. Introduction

The gear hob cutter with "Fredascon" continuous sharpening are dispose with disassembling tooth fixed in conic bore, with the inclination of the axes comparing with the radial direction, fact that allows cutting.

In continuous sharpening tool profiling „A" (figure 1) the tooth gear hob, with 180° rotation comparing with initial work position "L", are placed with the emplacement faces on the periphery helical surfaces, removing the operation discontinuous relieving.

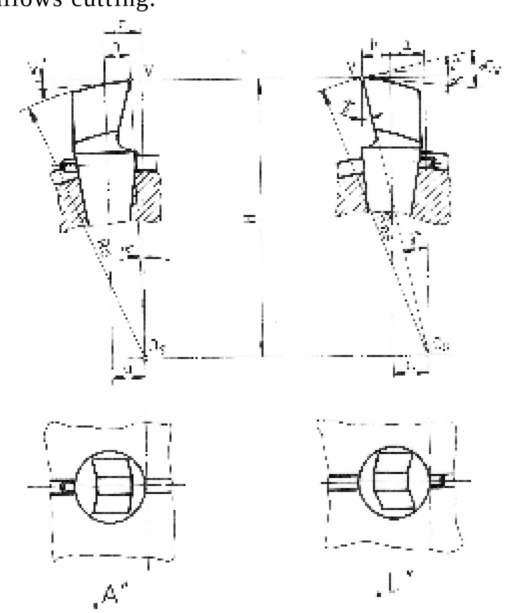

Fig. 1. *The auger gear position with continuous sharpening tool*
"A" - profiling tooth position "L" - the auger gear working position

After spiral alignment of the lateral surfaces setting and from the top, through tooth decrease in the initial working position, the geometric angle required for turning and the profile according to active edge are obtained.

The generate emplacement faces of the tooth gear hob through continuous sharpening tool is made using abrasive tools bounded of revolution profile surfaces [1], [2], [3].

The continuous sharpening of the tooth fixed on the rectification devices needs to bring the surfaces setting on the peripheral revolution profile surfaces.

The primary peripheral surface of the gear hob cutter „Fredascon" Σ_L, with the teeth fixed in working position, needs to be determinate the rotation surface S of profiled abrasive cage, covering with the spiral surface Σ_A, that contain the surfaces setting of tool teeth arranged for continuous sharpening profiling.

The rotation surface S of profiled abrasive cage is determined from the condition that spiral surface Σ_A to be covering of the family (S), in axes $\overline{V}$ spiral motion and the spiral parameter p [2], [3], [4].

During the rectification, the surface S is executing a rotation motion round its own axes and at the same time with the rotation motion round the surface axes to grind.

2. The surface of revolution generated by continuous sharpening of surfaces setting

Knowing the parametric equation of lateral cutting edge of the teeth of XYZ reference system, same with the device that must be grinded, through rotation motion describe by the transformation:

$$x = w_3^T(j)X \qquad (1)$$

will generate the surface setting of teeth gear hob cutting (figure 2).

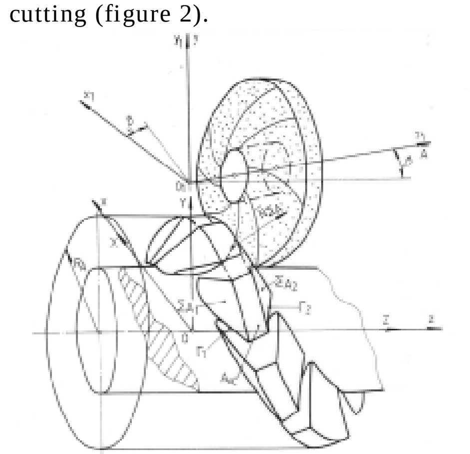

Fig. 2. *The helical back face generation*

$$\Sigma_{A_{1,2}}\begin{cases}\begin{cases} x = \sqrt{R_0^2 + u^2 \sin^2\beta_0}\cdot\cos(\varphi_c+\gamma+\varphi) \\ \quad +2a\cdot\sin\varphi; \\ y = \sqrt{R_0^2 + u^2 \sin^2\beta_0}\cdot\sin(\varphi_c+\gamma+\varphi) \\ \quad -2a\cdot\cos\varphi; \\ z = \dfrac{p\,p_c\cdot(\theta_c \mp \theta) \pm p_c u\cos\beta_0}{p+p_c} - \\ \quad -\dfrac{p\cdot u_c\cdot\cos\beta_c}{p+p_c} + p\cdot\varphi, \end{cases} \\ \varphi_c = \dfrac{p_c\theta_c \pm p\theta \mp u\cdot\cos\beta_0 - u_c\cdot\cos\beta_c}{p+p_c}; \\ u_c = \dfrac{\sqrt{R_0^2+u^2\sin^2\beta_0 - R_e^2\sin^2\gamma_v}}{\sin\beta_c}. \end{cases} \qquad (2)$$

that represents the parametric equations of the surfaces setting grinded by continuous sharpening for rotation surfaces.

The deducted relations may be customized for the active surface of the gear hob cutter teeth whose profile is usually used in practice.

3. Determining the seat angles achieved by continuous helical sharpening

After the helical correction of surface setting, by the return of the teeth in working position, 180° rotated comparing with the profiling position at continuous sharpening, is obtained the geometric angle of lateral setting and the top of the teeth, linked between them as in gear hob relieving case (figure 3).

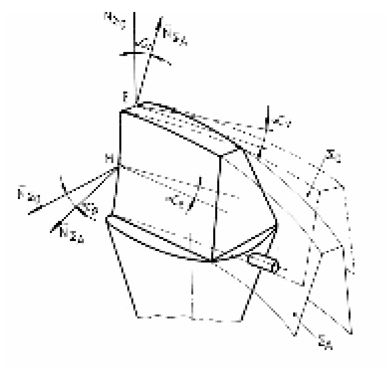

Fig. 3. *Working position of the gear hob teeth*

The lateral relief angle α_l, measured in certain point of the lateral cutting edge of the gear hob cutting tooth, is determined by relation (3).

$$\cos a_l = \frac{\overline{N}_{\Sigma_A} \cdot \overline{N}_{\Sigma_L}}{\left|\overline{N}_{\Sigma_A}\right| \cdot \left|\overline{N}_{\Sigma_L}\right|} = \frac{N_{X_A}N_{X_L} + N_{Y_A}N_{Y_L} + N_{Z_A}N_{Z_L}}{\sqrt{N_{X_A}^2 + N_{Y_A}^2 + N_{Z_A}^2} \cdot \sqrt{N_{X_L}^2 + N_{Y_L}^2 + N_{Z_L}^2}} \quad (3)$$

resulting from the definition of scalar product of two normal vectors at lateral side generated by continuous sharpening, Σ_A and primary peripheral surface generated during the process by the lateral cutting edge Σ_L. To achieve the side angles equal on both faces of the hob cutter calls for the orientation of the chip grooves perpendicular to the dividing helix of the reference hob.

After fixing the teeth in working position geometrical are obtained the angles of lateral and top setting, linked as in gear hob relieving case (figure 4).

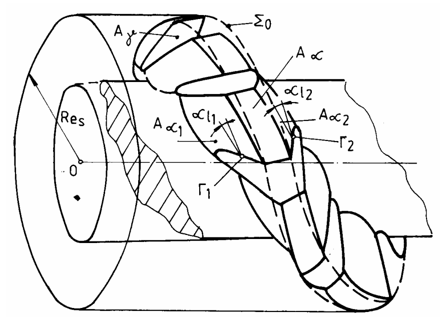

Fig. 4. *Constructive geometrical parameters*

3.1. The calculation of angle setting formed by helical continuous sharpening

The lateral relief angle α_l , measured in normal section on the lateral edge of the Archimedes gear hob cutter teeth, (figure 4) corrected by spiral continuous sharpening, is determined by the general equation:

$$\cos a_l = \frac{(p^2+u^2)\cos a_d - 2a(u\sin g - p\sin a_d \cos g)}{\sqrt{p^2+u^2}\sqrt{(p^2+u^2)\cos^2 a_d - 4a\cos a_d(u\sin g - p\sin a_d\cos g) + 4a^2(\sin^2 a_d + \cos^2 a_d \sin^2 g)}} \quad (4)$$

The relief angle from the normal plan on the gear hob axis, in a certain point on the tooth cutting lateral edge, is demonstrated by the general relation:

$$\cos a_X = \frac{(p^2+u^2\sin^2 a_d)\cos a_d + 2a(p\cos g - u\sin a_d \sin g)\sin a_d}{\sqrt{p^2+u^2\sin^2 a}\sqrt{(p^2+u^2\sin^2 a_d)\cos^2 a_d + 4a\cos a_d \sin a_d(p\cos g - u\sin a_d \sin g) + 4a^2\sin^2 a_d}} \quad (5)$$

3.2. Analytical model of continuous profiling, after revolution surfaces, of gear hob teeth

Without the spiral rectification machines, the profiling of the un-mount teeth of the gear hob "Fredascon" type can be made on special devices, with continuous generating of releasing faces after revolution surfaces (figure 5 and 6).

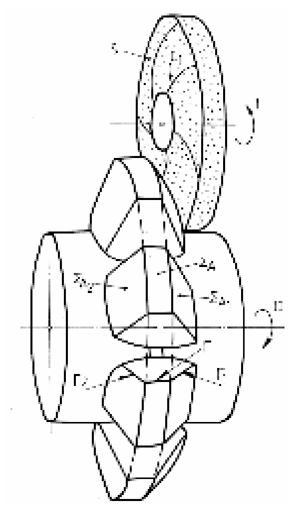

Fig. 5. *Continuous generating disk teeth*

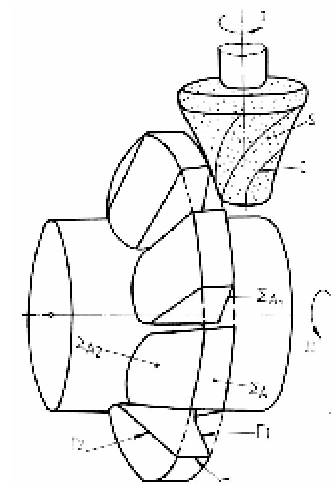

Fig. 6. *Continuous generating of tool-finger teeth*

3.3. The calculation of relief angles realized by continuous sharpening of the tooth after rotation surfaces

Presuming we lack the special hob grinder, the hob teeth may be sharpened separately mounted on a special work-holding device with taper holes, for the continuous sharpening of a certain number of teeth.

After sharpening, we obtain the necessary relief angle by fitting the teeth on the hob body where the helix angle is ω_d (see figure 4).

The lateral relief angle α_{ln}, measured in normal section on the lateral edge of gear hob teeth corrected by continuous sharpening if the revolution surfaces is given by relation:

$$\cos a_{\ln} = \frac{u\cos a_d - 2a\sin g}{\sqrt{u\cos a_d(u\cos a_d - 4a\sin g) + 4a^2(\sin^2 a_d + \cos^2 a_d \sin^2 g)}} \quad (6)$$

The constructive relief angle, measured in normal plan on gear hob axis in a certain point on the lateral edge of the tooth, is determinate by relation:

$$\cos a_{lX} = \frac{u\cos a_d - 2a\sin g}{\sqrt{u^2\cos^2 a_d - 4au\cos a_d \sin g + 4a^2}} \quad (7)$$

For the variation limits of the parameter u, $u_{\min} = R_i / \cos a_d \le u \le u_{\max} = R_{es} / \cos a_d$, it results the limit values of the relief angles.

Taking the case of hob type Fredascon with: m = 12mm, R_{es} = 125mm, R_i = 95mm, a = 7mm, h = 12mm, α_d = 20°, it result:

$$a_{1\text{int}} = 2°53'11'' \ge a_{1n} \ge a_{1ext} = 2°11'39'';$$

$$a_{v\text{int}} = 8°28'27'' \ge a_x \ge a_{vext} = 6°25'31''.$$

4. Conclusions

Starting from the need of obtaining high precision in cylindrical gear pinion machining, this paper brings useful contribution regarding gear hob cutting profiling with continuous sharpening Fredascon type.

The calculation relation obtained has generalization character and can be particularized for different cases of gear hob types usually used in cutting tool practice.

The method of second order tool profiling, proposed for continuous generation of spiral setting surfaces of gear hob teeth Fredascon type, allows numerical resolve of all finished cases.

The sharpening of gear hob cutting teeth of this type of correction machine, using devices of simultaneously placing of more teeth comparing with abrasive cage, present the following advantages:

- by re-sharpening on the setting faces, where the teeth wear is lower in depth, the total tool durability increase, keeping unchanged the teeth resistance;
- it can be obtained optimum cutting angles to reduce the milling forces and increasing the edge durability;
- improvement the active sharp surface quality and increases the precision in profiling of the teeth.

The processes of profiling by continuous sharpening of the teeth present the following properties:

- cinematic profiling processes by continuous generation is simple comparing to the cinematic processes of relieving known of standard gear hob ;
- the process of continuous sharpening, by specific cinematic, submit the possibility of automatization of the profiling teeth process ;
- from the precision point of view, the most advantages are given by helical continuous sharpening process, it's utilization being preferred and because of higher productivity;
- the proposed proceeding ensure „relieving" of setting surfaces, fact checked also by measurement made after assembling the teeth on the working cage of the hob tool.

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Geometria constructivă a sculelor melc modul cu ascuțire continuă

Rezumat

Variantele moderne de freze melc tip Fredascon, profilate prin ascuțire continuă, asigură precizia impusă profilului prelucrat al roților dințate, în condițiile păstrării avantajelor rezultate prin decalarea dinților.

Profilarea dinților sculei prin ascuțire continuă elimină folosirea maşinilor unelte de detalonat sau de ascuțit freze melc, provenite de regulă din import.

Freza melc modul propusă în cadrul lucrării permite asamblarea unei scule care, pentru condițiile concrete de lucru, să fie cu tăişurile astfel dispuse încât să conducă la reducerea neuniformității aşchierii la danturare şi la creşterea preciziei de prelucrare a roților dințate.

În lucrare se stabilesc relațiile de calcul pentru unghiurile pasive ale dinților frezei melc modul, ale căror suprafețe active se ascut prin rectificare continuă elicoidală, în stare asamblată.

La geometrie constructive des fraises-meeres a affutage continuu

Resumé

Les variantes modernes des fraises taraud module type Fredascon, dont le profile est obtenu par affilage continu, assurent la précision imposée au profil usine des roux dentes, a condition de la conservation des avantages dues au décalage des dents.

L'obtention du profil des dents par affilage continu élimine l'utilisation des machines-outils de soulagement ou l'affilage des fraises taraud, la plus parte étant de provenance étrangère.

La fraise taraud module propose permette l'assemblage d'un outil qui, dans des conditions donnes de fonctionnement, ont les facettes coupantes disposées d'une telle manière qu'elles conduisent a la réduction des non-uniformites du processus d'affilage des dents et a la croissance de la précision d'usinage des roux dentées.

Ce papier présent les relations de calcul établis pour les angles passifs des dents des fraises taraud, dont les surfaces actives sont obtenues par rectification continue, en état assemble.