ALGORITHM FOR "FREDASCON" WORM CUTTER WITH STAGGERED TEETH DESIGN

Conf. dr. ing. Căpăţînă Nicu, Ş. L. ing. Teodor Virgil
Universitatea "Dunărea de Jos" din Galaţi

SUMMARY

In this paper are make important determinations regarding the constructive designing of the "Fredascon" involute gear worm cutter, profiled by helical correction, in assembled state.

In order to assure the "Fredascon" worm gear performances is necessary to know: the right profile of the actives cutting edges, the staggered of the teeth in order to reduce the unevenness of the cutting at the teething, the possibility to correct the lateral back edge and from the teeth top, directly on the tool's body, by continuous helical sharpening, the optimum position of the teeth on the tool's body which assure the geometrical parameters recommended by the cutting theory.

Keywords: *Fredascon, worm cutter, helical correction, staggered.*

1. Introduction

In anterior papers it was showed that the involute gear worm cutter with teeth the staggered on an helix and with the fastening of these in conical bore drive to an appreciable attenuation of the teething unevenness and permit the intensification of the character of duty with 1.5-2 time beside the possibilities of the standard worm cutter. Also it was showed that the solution of the continuous sharpening of this type of worm cutter assures more important advantages:

-the replacement of the clearance with a continuous correction of the back edge of the teeth;

-the improvement of the actives surfaces quality;

-the improvement of the profiling precision of the teeth;

-the improvement of the durability of the worm cutter.

2. The worm cutter's teeth shape

The teeth of the involute gear worm cutter have two distinct parts (see figure 1), the active part (1) and the fastening part (2). For the right positioning at sharpening or in cutting is used a cylindrical pin (3) forced fit in the teeth's body.

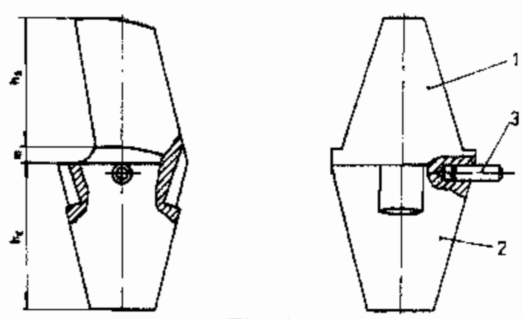

Fig. 1.

In a section normal on the teeth helix, the worm cutter has the profile of the reference rack-gear with the standard module and gearing angle. The profile of the active part of the teeth is differently for roughing and for finishing or according the goal (relief, chamfering etc.).

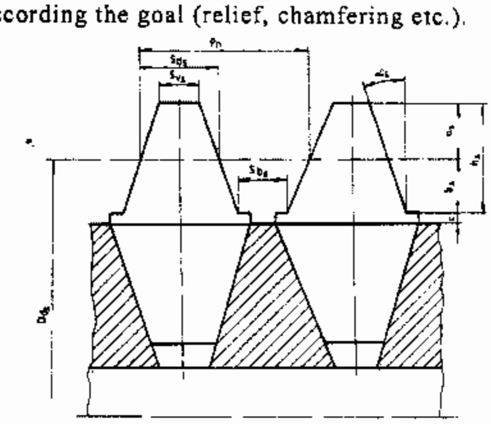

Fig. 2.

The geometrical elements of the profile are:

- The teeth pitch in normally section, which is equal to the normal pitch of the teethed wheel
$$p_n = \pi \cdot m_n \quad (1)$$
- The profile's angle $\gamma_n = 0^\circ$ (2)
- The tooth point's height
$$a_s = (1+c) \cdot m_n \quad (3)$$
- The tooth root's height $b_s = a_s$ (4)
- The teeth's active height
$$h_s = a_s + b_s \quad (5)$$
- The teeth thickness on the pitch cylinder;

for finishing $s_{ds} = \pi \cdot m_n / 2$ (6)

for roughing $s_{ds} = \pi \cdot m_n / 2 - 2\Delta$ (7)

- The tooth point's width.
$$s_{vs} = s_{ds} - 2 \cdot a_s \cdot tg\alpha_s \quad (8)$$

3. The fastening part's shape

The fastening part of teeth is conical (see figure 3) and is fastened in a conical bore on the worm cutter's body. The point angle of the fastening cone is 24° in order to avoid the teeth's self-locking at fastening in conical bore.

In the tooth's bottom is a thread hole for teeth's fastening on sharpening devices or for the fastening on the worm cutter's body.

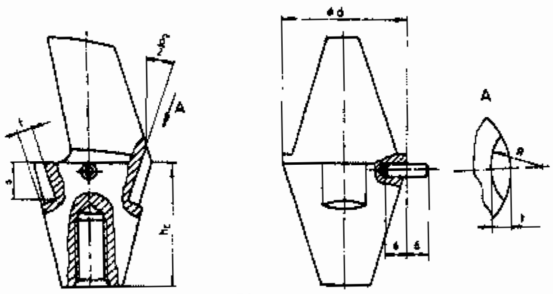

Fig. 3.

4. The "Fredascon" worm cutter's constructive elements

The worm cutter's external diameter

The value of the external diameter may be calculated with the relation:
$$D_{es} = 8.6 \cdot m_n + 140 \quad (9)$$
where a and b have different values according the destination, the module and the precision of the toothing.

The pitch cylinder's diameter
$$D_{ds} = D_{es} - 2a_s - \frac{k}{2} \quad (10)$$

The worm cutter's body diameter
$$D_c = D_{es} - 2H \quad (11)$$

The teeth helix and the chip's channel helix angle

The angles of helix under the teeth are disposed on the body is calculated with relation:
$$\omega_c = \operatorname{arctg}\left(\frac{D_{ds}}{D_c} tg\omega_{ds}\right) \quad (12)$$

The angle of the chip's channel:
$$\omega_{kc} = \operatorname{arctg}\left(\frac{D_c}{D_{ds}} tg\omega_k\right) \quad (13)$$

The channel pitch's is determined with relation:
$$p_k = \frac{\pi \cdot D_{ds}}{tg\omega_k} \quad (14)$$

The positioning of the conical bore for the teeth fastening

The number of teeth may be calculated with relation:
$$z_k = \frac{360^\circ}{\arccos\left(1 - 4.5 \cdot \frac{m_n}{D_{es}}\right)} \quad (15)$$
which result from the uniformly milling at teething.

The cylindrical coordinates of the positioning on the body of the worm cutter's teeth are:

-The real angular pitch for worm cutter with helical channel for chip's releasing will be:
$$\delta_r = \frac{360^\circ}{z_k} \cos^2 \omega_{ds}. \quad (16)$$

-The axial coordinate among two successive teeth on the "Fredascon" worm cutter is determined with:
$$x_{ci} = \frac{\pi \cdot m_n}{z_k} \cos \omega_{ds}. \quad (17)$$

The fulfillment of the back edge of the top on the worm gear's body, owing to the staggered of this toward the axial plane, demand optimal values of the constructive parameters "a" and "h".

The external radius in the sharpening position of the teeth on the worm cutter body is determined by:
$$R_a = \sqrt{R_{es}^2 - 4ah}. \quad (18)$$

The back angle is adopted among the limits $\alpha = 6 \div 10^\circ$ thus the lateral back angle to be minimum 2÷3°.

The toothing length of the worm cutter must be at least the projection of contact line on the reference line of the generating rack-gear enlarged with the double of the axial pitch:
$$L = h_s \cdot ctg\alpha_s + 2p_a. \quad (19)$$

The calculus performed based on the design algorithm for a "Fredascon" worm cutter with the modulus of 12 mm, are showed in following table.

Table 1.

Date:	m_n=12 mm	Reference rack-gear STAS 821-82 $\alpha_0 = 20^0$; $f = 1{,}00$; $c = 0{,}25$	
Symbol	Form	Calculus	Value
1	2	3	4
p_{ns}	$\pi \cdot m_n$	$\pi \cdot 12$	p_{ns}=37,699111mm
S_{ds0}	$0{,}5 \cdot p_{ns}$	0,5·37,699111	S_{ds0}=18,849555mm
S_{ds}	$S_{ds0} - 0{,}182\sqrt[3]{m_n}$	$0{,}5 \cdot 37{,}699111 - 0{,}182\sqrt[3]{12}$	S_{ds}=18,432879mm
a_s	$b_1 = (f + c)m_n$	$(1 + 0{,}25) \cdot 12$	a_s=15 mm
b_s	$a_1 + j = (f + c_1)m_n$	$(1 + 0{,}25) \cdot 12$	b_s=15 mm
h_s	$a_s + b_s$	15+15	h_s=30 mm
$h_{s\,min}$	$a_s + b_{s\,min}$	15+12	$h_{s\,min}$=27 mm
S_{dv0}	$S_{ds0} - 2a_s \cdot \mathrm{tg}\alpha_s$	18,849555-2·15·tg20°	S_{dv0}=7,9304481mm
S_{dv}	$S_{ds} - 2a_s \cdot \mathrm{tg}\alpha_s$	18,432879-2·15·tg20°	S_{dv}=7,5137721mm
r_1	$(0{,}2 \ldots 0{,}3) \cdot m_n$	(0,2...0,3)	r_1=3,5 mm
D_{es}	$8{,}6m_n + 140$	8,6·12+140	D_{es}=240 mm
z_k	$\dfrac{360^0}{\arccos\left(1 - 4{,}5 \cdot \dfrac{m_n}{D_{es}}\right)}$	$\dfrac{360^0}{\arccos\left(1 - 4{,}5 \cdot \dfrac{12}{240}\right)}$	z_k=9,5 canale
α_v	$\mathrm{arctg}\dfrac{2a\sqrt{R_{es}^2 - (a+h)^2}}{R_{es}^2 - 2a(a+h)}$	$\mathrm{arctg}\dfrac{2 \cdot 7\sqrt{120^2 - (7+12)^2}}{120^2 - 2 \cdot 7(7+12)}$	α_v=6° 58' 37"
e	$\dfrac{R_{es}}{2} \cdot \sin\alpha_v$	$\dfrac{120}{2} \cdot \sin 6^0 58' 37''$	e=7,2882036 mm
k	$\dfrac{\pi \cdot D_{es}}{z_k} \cdot \mathrm{tg}\alpha_v$	$\dfrac{\pi \cdot 240}{9{,}5} \cdot \mathrm{tg}6^0 58' 37''$	k=9,7125809 mm
H	$h_s + k + r$	30+9,7+1,3	H=40 mm
d	$(0{,}2 \div 0{,}3)D_{es}$	(0,2÷0,3)·240	d=50 mm
D_{d0}	$D_{es} - 2a_s$	240-2·15	D_{d0}=210 mm
D_{ds}	$D_{es} - 2a_s - \dfrac{k}{2}$	$240 - 2 \cdot 15 - \dfrac{9{,}7}{2}$	D_{ds}=205 mm
ω_{ds}	$\arcsin\dfrac{m_n}{D_{ds}}$	$\arcsin\dfrac{12}{205}$	ω_{ds}=3° 21' 21"
ω_k	$\omega_k = \omega_{ds}$	$\omega_k = \omega_{ds}$=3° 21' 21"	ω_k=3° 21' 21"
p_a	$\dfrac{\pi \cdot m_n}{\cos\omega_{ds}}$	$\dfrac{\pi \cdot 12}{\cos 3^0 21' 21''}$	p_a=37,771924mm
D_c	$D_{es} - 2H$	240-2·40	D_c=160 mm
p_k	$\dfrac{\pi \cdot D_{ds}}{\mathrm{tg}\omega_k}$	$\dfrac{\pi \cdot D_{ds}}{\mathrm{tg}\omega_k}$	p_k=10984 mm

ω_{k0}	$\text{arctg}\left(\frac{D_{d0}}{D_{ds}}\text{tg}\omega_k\right)$	$\text{arctg}\left(\frac{210}{205}\text{tg}3^\circ 21'21''\right)$	ω_{k0}=3° 26' 15"
ω_{kc}	$\text{arctg}\left(\frac{D_c}{D_{ds}}\text{tg}\omega_k\right)$	$\text{arctg}\left(\frac{160}{205}\text{tg}3^\circ 21'21''\right)$	ω_{kc}=2° 37' 13"
ω_c	$\text{arctg}\left(\frac{D_{ds}}{D_c}\text{tg}\omega_{ds}\right)$	$\text{arctg}\left(\frac{205}{160}\text{tg}3^\circ 21'21''\right)$	ω_c=4° 17' 47"
L	$h_s \cdot \text{ctg}\alpha_s + 2p_a$	30·ctg20°-2·37,77192	L=158 mm
D_0	$D_c - 20$	160-20	D_0=140 mm
d_1	d+35	50+35	d_1=85 mm
h_c	$0{,}5(D_c - d_1)$	0,5(160-85)	h_c=37,5 mm
H_d	$H + h_c$	40+37,5	H_d =77,5 mm
R_a	$\sqrt{R_{es}^2 - 4ah}$	$\sqrt{120^2 - 4\cdot 7\cdot 12}$	R_a=118,59173 mm
d	$\frac{360^\circ}{z_k}$	$\frac{360^\circ}{9{,}5}$	d=37° 53' 41"
δ_r	$\frac{360^\circ}{z_k}\cos^2\omega_{ds}$	$\frac{360^\circ}{9{,}5}\cos^2 3^\circ 21'21''$	δ_r=37° 45' 53"
x_{ci}	$\frac{\pi\cdot m_n}{z_k}\cos\ \omega_{ds}$	$\frac{\pi\cdot 12}{9{,}5}\cos 3^\circ 21'21''$	x_{ci}=3,9615229 mm
p_{cc}	$\frac{\pi\cdot D_c}{z_k}$	$\frac{\pi\cdot 160}{9{,}5}$	p_{cc}=52,911034 mm
p_{cr}	$\frac{\pi\cdot D_c}{z_k}\cos^2\omega_{ds}$	$\frac{\pi\cdot 160}{9{,}5}\cos 3^\circ 21'21''$	p_{cr}=52,729732 mm
p_{adiv}	$\frac{\pi\cdot m_n}{D_{ds}}\sqrt{D_{ds}^2 - m_n^2}$	$\frac{\pi\cdot 12}{205}\sqrt{205^2 - 12^2}$	p_{adiv}=37,634467 mm
R_b	$\frac{m_n\cdot D_{ds}\cdot\cos\alpha_0}{2\cdot\sqrt{D_{ds}^2\cdot\sin^2\alpha_0 + m_n^2\cdot\cos^2\alpha_0}}$	$\frac{12\cdot 205\cdot\cos 20^\circ}{2\cdot\sqrt{205^2\cdot\sin^2 20^\circ + 12^2\cdot\cos^2 20^\circ}}$	R_b=16,275717 mm
a	$0{,}5\cdot R_b$	0,5·16,275717	a=8,1378588 mm

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ALGORITM DE PROIECTARE A FREZEI MELC CU DINŢI DECALAŢI TIP "FREDASCON"

În lucrare se fac precizări importante privind proiectarea constructivă a frezelor melc modul "Fredascon", profilate prin rectificare elicoidală, în stare asamblată.

Pentru realizarea performanţelor frezei melc de tip "Fredascon" este necesar ca încă de la proiectare să se stabilească următoarele:

- profilul corect al tăişurilor active;
- dispunerea decalată a dinţilor în scopul reducerii neuniformităţii aşchierii la danturare;
- posibilitatea rectificării feţelor de aşezare laterale şi de la vârful dinţilor, direct pe corpul sculei, prin ascuţire continuă elicoidală;
- poziţia optimă a dinţilor pe corpul frezei care să sigure obţinerea parametrilor geometrici recomandaţi de teoria aşchierii metalelor.

ALGORITHME DE PROJECTATION D'UNE OUTIL-FRAISE "FREDASCON"

Dans l'ouvrage il sont faites des precisoin importantes relatif à la projectation constructife d'outil-fraise "Fredascon", profile par rectification helicoidale, en etat asamble.

Pour la realisation du performances du outil-fraise "Fredascon" il este necesaire le connaissance du cette elements :

- le corectement profile du profile d'arete ;
- le disposition decale du dents pour le reduction du non uniformement du couper en denturage;
- la posibilite du rectification du faces de depouille et du pointe du dent, directement at corp d'outil, avec aiguisage helicoidale continue;
- le position optime du dents sur le corp d'outil quelle assurer l'obtenu du parameters recomande par la theorie du coupage du metals.