Module Worm Cutter with Active Surfaces Generated by Continuous Sharpening

PhD. Eng. Nicu CĂPĂȚÎNĂ, PhD. Eng. Virgil TEODOR
„Dunărea de Jos" University of GALAȚI

Abstract

First circles arc relieved tools, showed in the technical specialized literature, starting with 1953, was the worm cutter with detachable rack-gear [1] and the profiled side mill [2]. At these tools, the machining of curve surface with optimized back angle is made by a continuous grinding on universal sharpening machines, on grinding machines or on profile grinding machines. In order to allow this, the detachable teeth or rack gear are rotated with the crossing back angle, getting a position appropriate for sharpening. After sharpening, by rotating and fixing the teeth in working position, the cutting angles needed are obtained.
Another solution is the sharpening and re-sharpening of rack-gear by mounting these in "false bodies" (special devices). After the back faces are grinding, the detachable rack gear or teeth are mounted in the worm cutter body, resulting the needed back angle.
The module worm cutter constructive variants with individually teeth, mounted in conical bore, allow the shifted teeth position regarding the conventional position from the standard worm cutter, assuring better cutting conditions and teething precision. The improvement of this worm cutter allows the continuous teeth grinding, assuring the machining precision for teethed wheel, in condition of keeping the advantages obtained by teeth displacement. The teeth back surface generation is made directly on the tool body by helical continuous sharpening.
Keywords: *module worm cutter, continuous sharpening, Fredascon.*

1. Module Worm Cutter with Detaching Grinded Rack Gear

The worm cutter rack gear is positioned in grinding device as see in figure 1, as will realized a back-rake angle γv = αv, after this being cylindrical grinding after exterior circle directrix. In worm cutter body, the rack gear is positioned with chip bearing surface radial oriented (γ_v = 0°), so the cylindrical back face make the α_v angle. In figure 1 is presented also the Archimedes's spiral for teeth relieving.

This back face grinding method make that the lateral back angles to be bigger with 1°÷2° than in the relieving after an Archimedes's spire (figure 2). More, the continuous relieving of back face and not the relieving after an Archimedes's spire make possible to use the grinding wheel with the diameter more bigger then these used for relieving (fig. 3). This fact has some advantages: smaller roughness, a bigger profiling precision, the avoiding of the deviations inducted by the relieving as non-continuous operation etc.

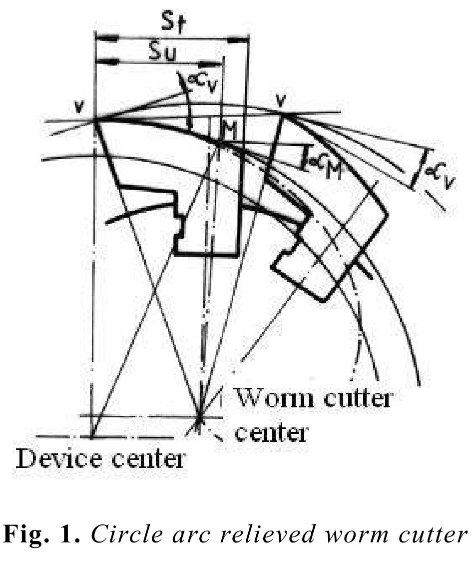

Fig. 1. *Circle arc relieved worm cutter*

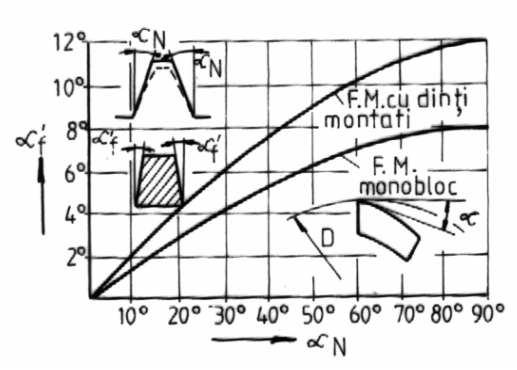

Fig. 2. *Back angles variation*

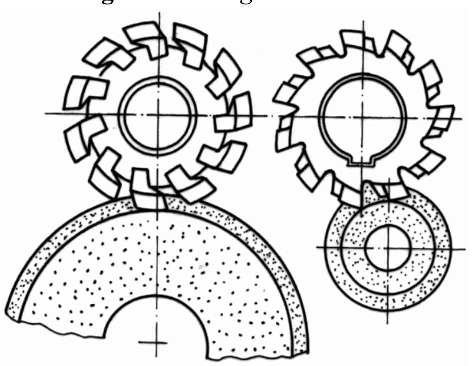

Fig. 3. *The grinding wheel diameter*

In figure 4 is showed a worm cutter composed by the cutter body (1), where are mounted the rack-gear (2) with the radial wedges (3) and the lateral lids (4). The lids are simultaneous centered on the cylindrical zone of rack-gears and wedges. The great advantage of these worm cutters is the certainty of fixing of the rack-gears and of the wedges. The reason for the radial wedges placement behind the rack-gears is confirmed by the experimental research and long term industry proofing [1], [2].

In figure 5 is showed a worm cutter with detachable rack-gear, which allow a number of re-sharpening by 2 or 3 times bigger, and a productivity improvement with 30% better than a normal worm cutter.

The worm cutter body (1) has rectangular channels where are pressed the rack-gear (2). The lateral lids fixed the rack-gears in radial direction and are used for rack-gear fixing in axial direction. The rack-gear profile is machined on thread grinding machines using a special device with a precise centering.

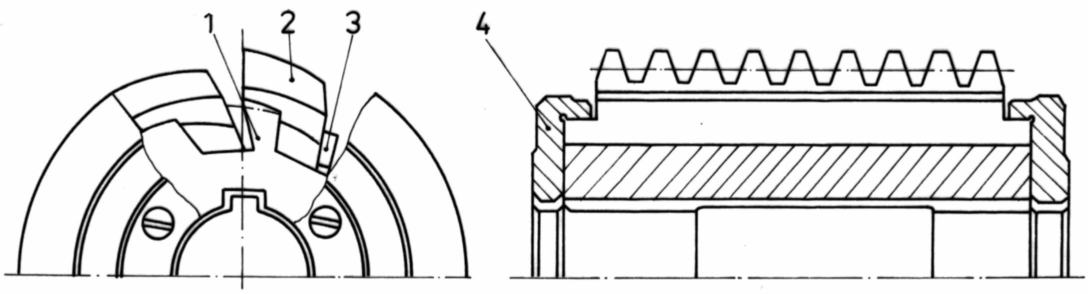

Fig. 4. *Worm cutter with grinded modified rack-gears*

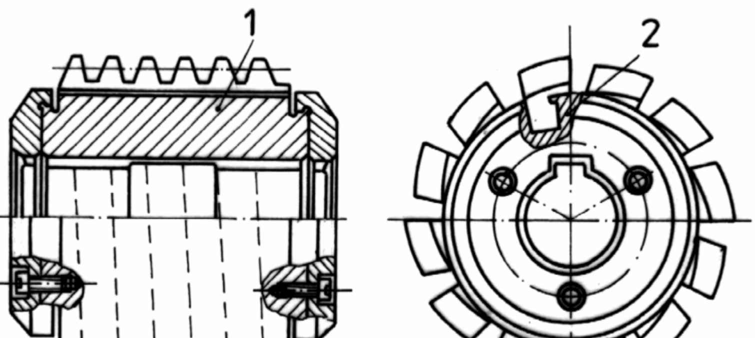

Fig. 5. *Worm cutter with detachable rack-gear*

After the mounting of rack-gear in working body the centering is made by axial shift. The disadvantage is the complicated way used to fix the rack-gears in the body channel and to set these in axial direction.

A modern variant is that when the tool technological body is also the working body [1], [2], [4].

In figure 6 is showed a module worm cutter constitute by a body (1), where are machined longitudinal cylindrical channels for rack-gear (2) mounting. The axial setting of the rack-gears are made by a half-ring key (3) and by front flanges (4), fixed with screws (5). For sharpening, the rack-gears are rotated with the αv lateral back angle (Fig. 6. b.), the positioning being make by the "b" cylindrical bossage with radius R_3, and for working position (Fig. 6. a.) by the "a" cylindrical bossage with radius R_2. Because in the sharpening position the back surfaces are bringing on the helical surfaces, the sharpening and re-sharpening are reduced at continuous helical grinding on thread grinding machines or on general grinding machines using devices for helical grinding.

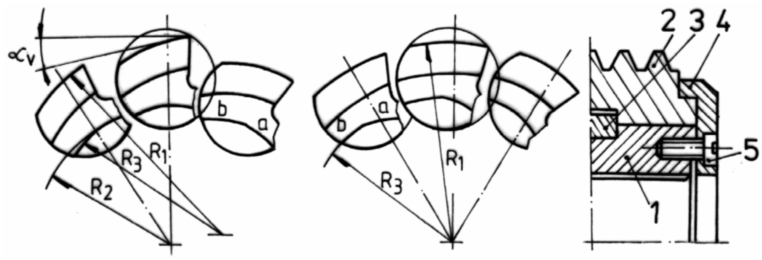

Fig. 6. *Worm cutter with reversed rack-gear*

In figure 7 is showed the variant of using worm cutter with rack-gear fixing channels in rectangular shape. Rotating this with 180° regarding the working position determine the sharpening positioning. After machining and grinding, the reversible rack-gear are bringing back to working position. The rack-gear setting in axial direction is assured by the two half-circle keys and fixing is making by double radial wedges and lateral lids, fixed with screws.

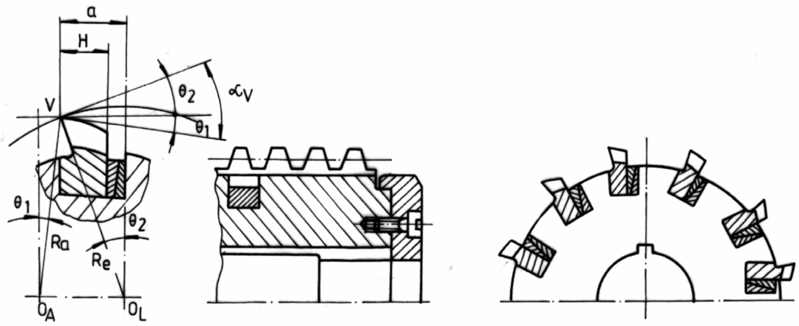

Fig. 7. *Reversible rack-gear worm cutter*

Another modern [2] variant is showed in figure 8, where the teeth, with shape of a radial wedge, is mounted on tool body in that way that the top face to be, in working position, contained in an axial worm cutter plane. For sharpening or re-sharpening, the tooth is rotated with 180° around the wedge bisector, so the back surfaces to be bring on revolution or helical surfaces.

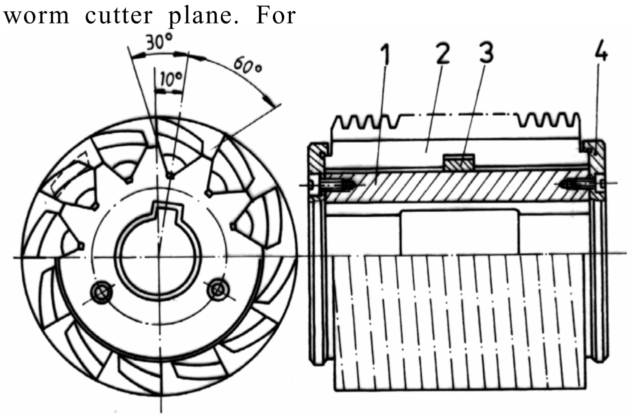

Fig. 8. Reversible rack-gear worm cutter

The worm cutter constructive elements are: the body (1), the rack-gears (2), two half-ring keys (3) and lateral lids (4) fixed with screws at rack-gear ends, on the worm cutter body. This solution is more technological, because the half-rings keys allow more precise centering in axial direction, and the cutting forces load the rack-gear in a profitable way.

Two half-ring keys make the axial position and lateral lids, fixed by screws, make the rack-gear fixing on the worm cutter body.

Considering that the fixing channel bisector is tangent on a circle with "a_0" radius, and the teeth top is raised with "h_0" regarding the rack-gear symmetry plane, is possible to determine the back angle, resulted after re-sharpening and the working position:

$$\alpha_v = arccos \frac{R_e^2 - 2 \cdot a_0 \cdot (a_0 + h_0)}{R_e \cdot \sqrt{R_e^2 - 4 \cdot a_0 \cdot h_0}} \qquad (1)$$

The variant showed in figure 8, realized by an Italian brand [2], has as main characteristic the trapezoid channels for the reversible rack-gear mounting, the channels laterals have with the worm cutter axial plane unequal angles (30° and 60°). This make possible to fix the rack-gear in sharpening position and after this, by rotating with 180°, in working position.

2. Module worm cutter with individual teeth mounted in conical bore

Next we will present some constructive types of worm cutters with individual mounted teeth, Fredascon, machined in Building Machines Department laboratories of "Dunărea de Jos" University of Galaţi.

2.1. Worm Cutter with Individual Mounted Teeth Fastened by Inside

At some worm cutter with 10÷20 mm module was used the following constructive principle, with teeth fastening by inside tool body. In figure 9 is showed a worm cutter with 12 mm module which due of the dimension increasing, allow to fasten the teeth by screws, by profiling washers.

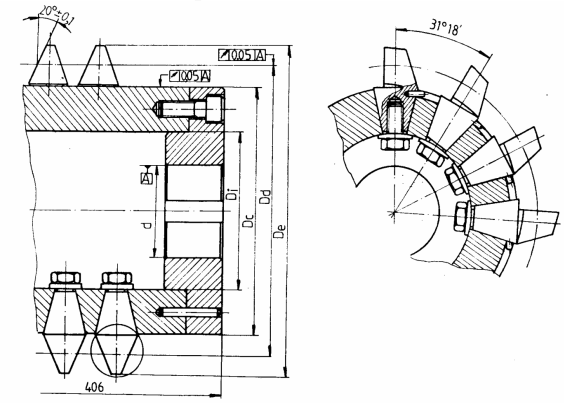

Fig.9. *Fredascon worm cutter with teeth fixing by inside of the body*

2.2. Worm cutter with individually fixed teeth by outside of the body

The constructive solution for big modules, applied for a 24 mm module worm cutter is showed in figure 10.

The teeth fixed from outside of worm cutter body has the advantage that the body is more rigid, from one single piece and is easy to replace the worm cutter teeth without disassembling the tool from the teething machine bolt.

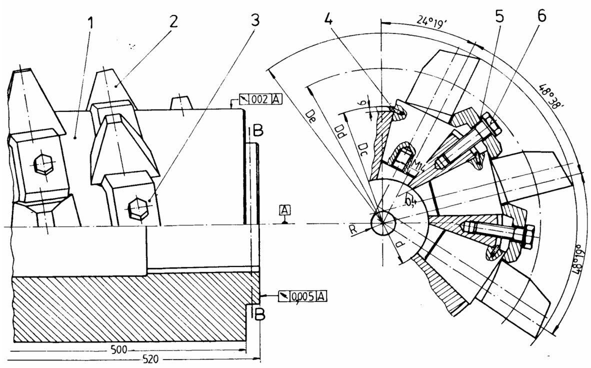

Fig.10. *Fredascon worm cutter with teeth fixed from outside of the body*

3. Conclusions

At worm cutter with detachable rack-gear and at the profiled side mill, the machining of curve surface with optimized back angle is made by a continuous grinding. In order to allow this, the detachable teeth or rack gear are rotated with the crossing back angle, getting a position appropriate for sharpening. After sharpening, by rotating the teeth in working position, the needed cutting angles are obtained.

Another solution is the sharpening and re-sharpening of rack-gear by mounting these in "false bodies". After the back faces are grinded, the detachable rack gear or teeth are mounted in the worm cutter body, obtaining the needed back angle.

The module worm cutter constructive variants with individually teeth, mounted in conical bore, allow the shifted teeth position regarding the conventional position from the standard worm cutter, assuring better cutting conditions and teething precision. The improvement of this worm cutter allows the continuous teeth grinding, assuring the machining precision for teethed wheel, in condition of keeping the advantages obtained by teeth displacement. The teeth back surface generation is made directly on the tool body by helical continuous sharpening.

Bibliography

1. **Căpăţînă, N.,** *Teoria şi tehnologia sculelor melc cu ascuţire continuă "Fredascon". Editura Cartea Universitară, ISBN 973-731-065-9, Bucureşti, 2004;*
2. **Căpăţînă, N.,** *Contribuţii la perfecţionarea constructiv funcţională a frezelor melc modul cu dinţi decalaţi.* Teză de doctorat, Universitatea "Dunărea de Jos" din Galaţi, 1998;
3. **Căpăţînă, N., Mihăluţă, M., Teodor, V.,** *Profilarea sculelor abrazive pentru ascuţirea continuă a frezelor melc cu dinţi decalaţi.* În: Analele Universităţii "Dunărea de Jos" din Galaţi, Fasc. V, 2006, pag. 102-104, ISSN 1221-4566;
4. **Căpăţînă, N., Teodor, V.,** *Algoritm de proiectare a frezei melc cu dinţi decalaţi tip "Fredascon".* În: Analele Universităţii "Dunărea de Jos" din Galaţi, Fasc. V, 2004, pag. 54-58, ISSN1221-4566

Freză melc modul cu suprafeţe active generate prin ascuţire continuă

Rezumat

Primele scule detalonate după arce de cerc, prezentate în literatura tehnică de specialitate începând cu anul 1953, au fost frezele melc cu piepteni demontabili [1] şi frezele disc profilate [2]. La astfel de scule, realizarea unor suprafeţe curbilinii cu unghi de aşezare optimizat, se face printr-o rectificare continuă pe maşini universale de ascuţit, de rectificat sau pe maşini de rectificat profiluri, scop în care dinţii sau pieptenii demontabili se rotesc cu unghiul de aşezare transversal, ocupând o poziţie corespunzătoare ascuţirii. După ascuţire, prin rotirea şi fixarea dinţilor în poziţia de lucru se obţin unghiurile necesare la aşchiere.

O altă soluţie este aceea în care ascuţirea şi reascuţirile pieptenilor se fac prin montarea în „corpuri false" (dispozitive speciale). După rectificarea feţelor de aşezare, pieptenii sau dinţii demontabili se montează în corpul frezei rezultând unghiurile de aşezare necesare.

Variantele constructive de freze melc modul cu dinţi individuali, fixaţi în alezaje conice, permit amplasarea decalată a dinţilor faţă de poziţia convenţională de la frezele standard, asigurând îmbunătăţirea condiţiilor de aşchiere şi a preciziei la danturare. Perfecţionarea construcţiei acestor freze melc permite rectificarea continuă a dinţilor, fapt ce asigură precizia de prelucrare necesară a roţilor dinţate, în condiţiile păstrării avantajelor rezultate prin decalarea dinţilor. Generarea suprafeţelor de aşezare ale dinţilor se face direct pe corpul de lucru al sculei prin ascuţire continuă elicoidală.

Fraise taraud module avec les surfaces actives produites par l'affilage continu

Résume

Le premier entoure les outils soulagés par arc, montrés dans la littérature spécialisée technique, commençant par 1953, était la fraise taraud avec les dents détachable [1] et le moulin latéral profilé [2]. À ces outils, l'usinage de la surface de courbe avec l'angle arrière optimisé est fait par un meulage continu sur l'universel affilant des machines, sur des machines de meulage ou sur des machines de meulage de profil. Afin de permettre ceci, les dents ou la vitesse de support détachables sont tournées avec le croisement en arrière pêchent, obtenant une position appropriée pour l'affilage. Après affilage, en tournant et en fixant les dents en position fonctionnant, les angles de découpage requis sont obtenus.

Une autre solution est l'affilage des dents de support en montant ces derniers dans les « faux corps » (les dispositifs spéciaux). Après que les visages arrière rectifient, la vitesse ou les dents de support détachable sont montées dans le corps de coupeur de ver, résultant l'angle arrière nécessaire.

Les variantes constructives de coupeur de ver de module avec individuellement des dents, alésage conique de montant, permettent la position décalée de dents concernant la position conventionnelle du coupeur standard de ver, assurant de meilleurs états de découpage et précision de démarrage. L'amélioration de ce ver que le coupeur permet le meulage continu de dents, assurant la précision de usinage pour fabrication la roue, en état de maintenir les avantages obtenus par déplacement de dents. La génération extérieure arrière de dents est faite directement sur le corps d'outil par l'affilage continu hélicoïdal.