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Modelling of Surfaces Generation

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ABSTRACT

In the following, are presented the specific algorithms, based on the graphic method, for the generation modelling of some types of whirls of surfaces. The presented algorithms are accompanied by comparative numerical applications to a classic analytic method, in order to validate the new method.

1. Introduction

The physical realization of edged-tools (or of tools of other nature) is always accompanied by errors of generation, errors that affect, sometimes in great measure, tools profile, see figure 1, in which is represented the profile of a worm-gear, increased under a microscope.

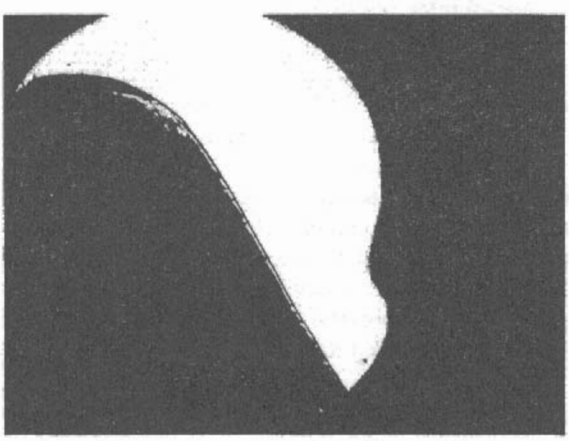

Fig. 1.Realization errors of tool's profile (image caught through the microscope eyepiece)

In this conditions, can appear situations when the errors of tools profiles transposed on the generated parts, lead to form and dimensions modifications, sometimes, unacceptable.

Thus, the geometric modelling of profiles, effective generated on semi-products, can constitute a prediction method of the processed surfaces error level.

In this way, through the generation modelling, starting from the tools measured profiles can be eliminated possible loss through scrap after processing surfaces with tools having profiles (cutting-edges) affected by errors.

In the following, are presented the specific algorithms, based on the graphic method, for the generation modelling of some types of whirls of surfaces.

2. Geometric modelling of the generation of surfaces generated with tools associated to some centroids in rolling - specific algorithms

The problematic of modelling process refers to two known situations: generation with the cog-rack and generation with cutters-wheel.

Through direct measurement of tool's cross profile, the obtained coordinates determine an effective profile measured in form

$$C_{Se} = \begin{Vmatrix} \xi_1 & \xi_2 & \cdot & \cdot & \xi_n \\ \eta_1 & \eta_2 & \cdot & \cdot & \eta_n \end{Vmatrix}, \qquad (1)$$

with **n** big enough, for an exact description of the effective profile.

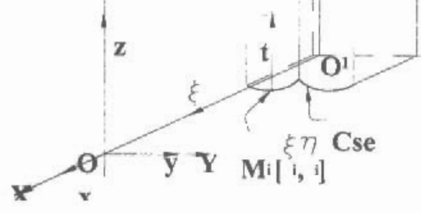

Fig. 2. Modelling of the geometric generation with the cog rack

Through extrusion of the profile **C**, in the direction of cog-rack's generatrix **t**, it is modelled the solid of the effective rack-**S**. Solid **S** height (**h**), isn't significant for the geometric modelling process.

The relative motion of a certain point of the solid **S**, be it $M_i[\xi_i, \eta_i]$, face to the semiproduct reference system (**XYZ**) is given from

$$X = \omega_3(\varphi) \cdot [\xi + a], \quad (2)$$

with: $a = \| -Rr_p \quad -Rr_p \cdot \varphi \quad 0 \|$; (3)

Rr_p - semiproduct rolling radius;
φ - angular parameter of rotation.

In (2), the matrix "ξ" has the meaning of a matrix formed with the coordinations of the point **$M_i[\xi_i, \eta_i]$**

$$\begin{Vmatrix} X \\ Y \end{Vmatrix} = \begin{Vmatrix} \cos\varphi & \sin\varphi \\ -\sin\varphi & \cos\varphi \end{Vmatrix} \cdot \left[\begin{Vmatrix} \xi_i \\ \eta_i \end{Vmatrix} - \begin{Vmatrix} Rr_p \\ Rr_p \cdot \varphi \end{Vmatrix} \right] \quad (4)$$

from which, results the trajectory of point **M_i**:

$$T_i \left| \begin{array}{l} X = [\xi_i - Rr_p] \cdot \cos\varphi + [\eta_i - Rr_p \cdot \varphi] \cdot \sin\varphi; \\ Y = -[\xi_i - Rr_p] \cdot \sin\varphi + [\eta_i - Rr_p \cdot \varphi] \cdot \cos\varphi. \end{array} \right. \quad (5)$$

3. Model of the cog-rack

In figure 3 and table 1, are presented worm profile's form and coordinates, zone 0-1, and in table 2, the coordinates of the profile in zone 0-2, for **D**=10 mm; **d**= 0,12D; **k**=60; **p**= 8.66 mm.

NOTE. The portion 0-2 is made up, constructive, of an arc of radius **R**=0,42D.

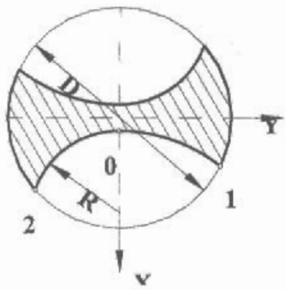

Fig. 3. Profile of borer's worm

Table 1

Zona 0-1	
X[mm]	Y[mm]
0.6	0
0.600005	0.008314
0.60002	0.016628
0.600044	0.024941
0.600078	0.033255
:	:
:	:
2.157759	4.470587
2.163138	4.477536
2.168527	4.484481
2.173924	4.49142
2.179329	4.498355

Table 2

Zona 0-2	
X[mm]	Y[mm]
0.6	0
0.6002	-0.04
0.6008	-0.08
0.6018	-0.11998
0.6032	-0.15996
:	:
:	:
3.113361	-3.71348
3.150569	-3.72816
3.187922	-3.74246
3.225417	-3.7564
3.263049	-3.76996

Drill worms can be obtained through warm forging, using "rolling dies" that materialize the conjugated rack.

Thus, see figure 2, can be determined the profile of the cog-gear reciprocal enveloped to the profile 0-1,0-2, observing the condition of rolling

$$\lambda = D/2 \cdot \varphi. \quad (6)$$

Tool's profile numerically represented, see tables 1, 2, generates a family of profiles in system ξη solidary to the cog-rack:

$$\begin{aligned} \xi &= X \cdot \cos\varphi - Y \cdot \sin\varphi - \frac{D}{2}; \\ \eta &= X \cdot \sin\varphi + Y \cdot \cos\varphi - \frac{D}{2} \cdot \varphi, \end{aligned} \quad (7)$$

with φ- variable parameter.

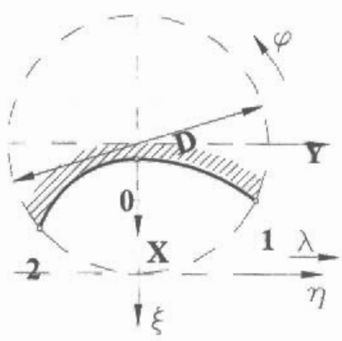

Fig. 4. Rack-tool (frontal profile of the rolling die

Is determined the profile, numeric identified of cog-rack's cross-section, of form

$$C_S = \begin{Vmatrix} \xi_1 & \eta_1 \\ \xi_2 & \eta_2 \\ \cdot & \cdot \\ \cdot & \cdot \\ \xi_n & \eta_n \end{Vmatrix}, \quad (8)$$

profile that will allow the construction in the mobile system $\xi_1\eta_1\zeta_1$ of the "solid model"of the rolling die, through extrusion of the profile C_S, figure 5, taking into consideration the direction of the generatrix,

$$\vec{t} = \sin\beta\vec{j} + \cos\beta\vec{k}, \quad (9)$$

with $\beta = arctg\frac{D}{2p}$ (usually $\beta=30^0$).

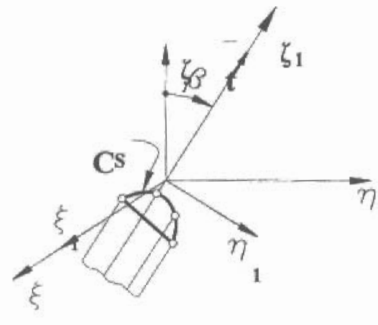

Fig. 5. Solid model of the rolling die

The realisation of the solid model of the rolling dies supposes the knowledge of rack's profile in a plane perpendicular on generatrix **t** direction, through coordinates changing:

$$\begin{vmatrix} \xi_1 = \xi_i; \\ \eta_1 = \eta_i \cdot \cos\beta, \end{vmatrix} \quad (10)$$

the coordinates $\xi_i\eta_i$ being given by C_S (8).

Starting from (8), through extrusion is obtained the solid model of the rolling die (solid model of the cog-rack, figure 7)

4. Borer's worm generation modelling

In figure 6, is presented the relative position of rack's and semiproduct's solid models (helical drill), in rolling on the circle of diameter D and the plane containing the axis η and perpendicular on the axis ξ .

Modelling can emphasize the influence on the generated profile of cog-rack's errors (rolling die).

In this direction, it is modelled a modification of the profile C_S (8), through decrease with 1% of the coordinates ξ of rack's cross profile in zone 1-0 (table 3a). The section of the borer generated with a modified rack results with significant modifications, which are presented in table 3b.

Table 3a

Rack's section, zone 1-0					
	Unmodified		Modified		Difference
Nr.	ξ_1	η_1	ξ_2	η_2	$\xi_1-\xi_2$
1	-0.01	4.849742	-0.0099	4.849742	-0.0001
2	-0.53	4.76314	-0.5247	4.76314	-0.0053
3	-0.86	4.676537	-0.8514	4.676537	-0.0086
4	-1.11	4.589935	-1.0989	4.589935	-0.0111
5	-1.33	4.503332	-1.3167	4.503332	-0.0133
:	:	:	:	:	:
:	:	:	:	:	:
25	-4.34	0.69282	-4.2966	0.69282	-0.0.434
26	-4.35	0.606218	-4.3065	0.606218	-0.0435
27	-4.36	0.519615	-4.3164	0.519615	-0.0436
28	-4.37	0.433013	-4.3263	0.433013	-0.0437
29	-4.38	0.34641	-4.3362	0.34641	-0.0438
30	-4.39	0	-4.3461	0	-0.0439

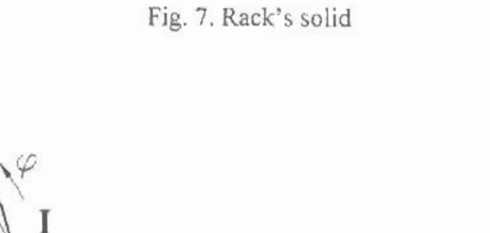

Fig. 7. Rack's solid

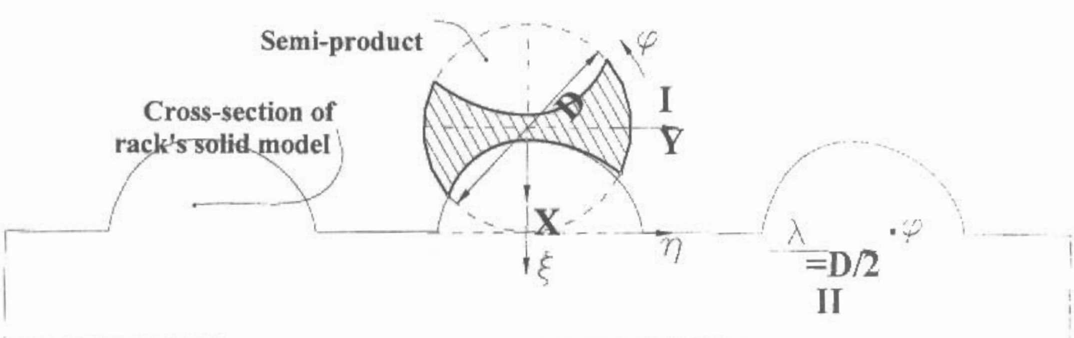

Fig. 6. The rolling between the semi-product and the solid model of the rack.

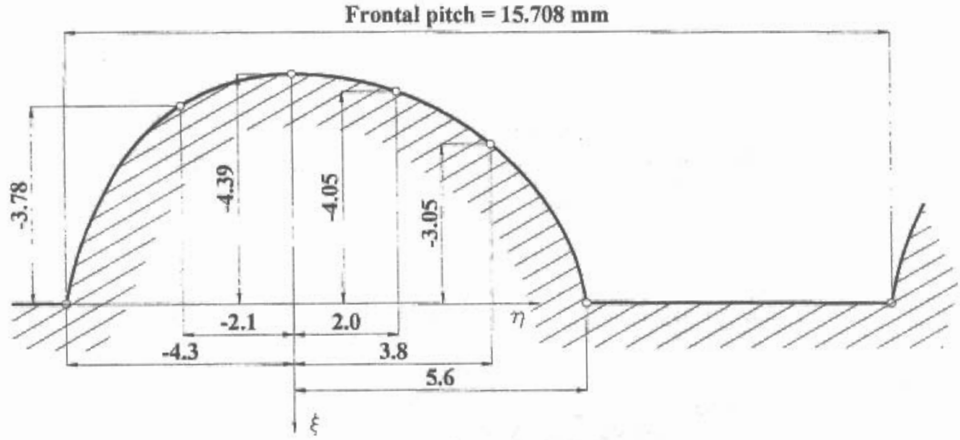

Fig. 8. Rack's frontal section for drill's processing

Table 3b

Drill's section					
	Unmodified		Modified		Difference
Nr.	X1	Y1	X2	Y2	X1-X2
1	-1.9362	-4.2	-2.6417	-4.2	0.7055
2	-2.1738	-3.9	-2.9627	-3.9	0.7889
3	-2.6735	-3.6	-3.2527	-3.6	0.5792
4	-3.0432	-3.3	-3.4944	-3.3	0.4512
5	-3.3448	-3	-3.6949	-3	0.3501
:	:	:	:	:	:
:	:	:	:	:	:
25	-3.3454	3	-3.8151	3	0.4697
26	-3.1562	3.3	-3.7258	3.3	0.5696
27	-2.9428	3.6	-3.5865	3.6	0.6437
28	-2.7116	3.9	-3.3737	3.9	0.6621
29	-2.4523	4.2	-3.0783	4.2	0.626
30	-2.1428	4.5	-2.7783	4.5	0.6355

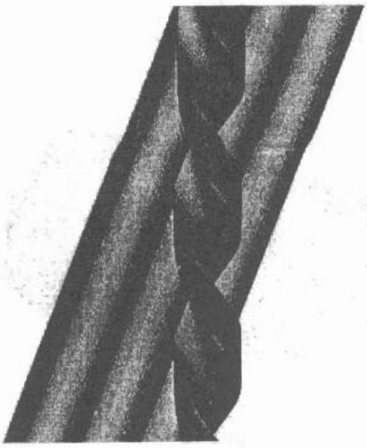

Fig. 9. The helical drill and the rolling die (solid models, D=10 mm)

In figure 7, is represented the rack (created solid model of the rolling die), and in figure 8, is represented the frontal section, dimensioned, of the rack.

The ensemble of motions I and II (figure 6), simulated through the programme "solburg2modif3.lsp", leads to the obtaining of the helical drill solid, see figure 9. Rack's and borer's solids were sectioned and identified numerically, and the results were written down in tables 3a and 3b and figure 8.

5. Modelling of the generation through rolling of a cycloid worm

In figure 10, is presented the cycloid worm cross-section. The generation (finishing) of these worms used in the construction of helical pumps is made frequently through shaving, with shavers-rack.

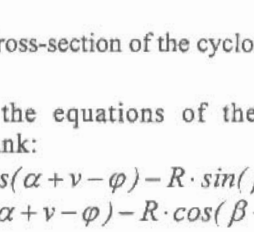

Fig. 10. Cross-section of the cycloid worm

Knowing the equations of the helicoid of the cycloid flank:

$$X = -2 \cdot R \cdot cos(\alpha + v - \varphi) - R \cdot sin(\beta - \varphi);$$
$$Y = 2 \cdot R \cdot sin(\alpha + v - \varphi) - R \cdot cos(\beta - \varphi); \quad (11)$$
$$Z = p \cdot \varphi,$$

with $\beta = v - \left[\frac{\pi}{2} - (\alpha + v)\right]$,

v and φ - variable parameters, through the

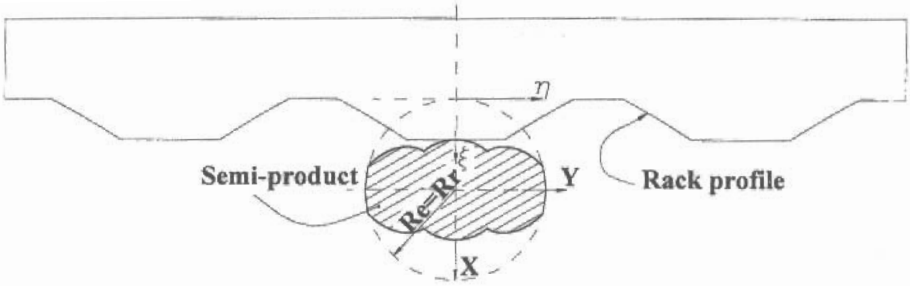

Fig. 11. Rack's rolling (shaver) with the semi-product

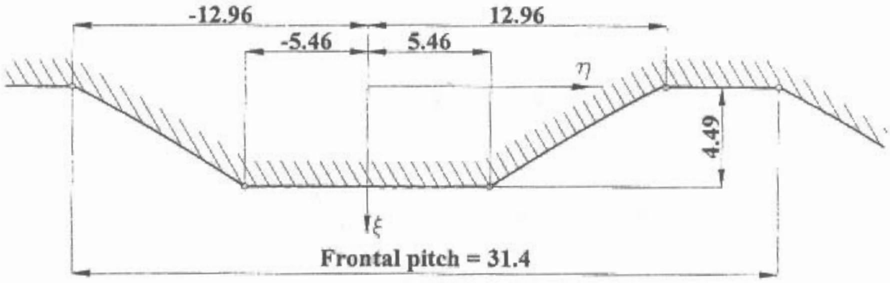

Fig. 12. Rack's frontal profile (numerically identified, see table 4a)

algorithm presented in chapter 3, is determined the solid model of the cog-rack, see figures 11, 12, 13, where are presented, the two profiles in rolling – figure 11, rack's frontal profile, numerically identified – figure 12 and rack's solid model- figure 13.

Table 4a

Rack's frontal section				
Nr.	Unmodified		Modified	
	ξ_1	η_1	ξ_2	η_2
131	4,49	0,04	4,4451	0,0396
142	4,49	1,14	4,4451	1,1286
154	4,49	2,34	4,4451	2,3166
166	4,49	3,54	4,4451	3,5046
185	4,49	5,44	4,4451	5,3856
:	:	:	:	:
:	:	:	:	:
205	3,23	7,44	3,1977	7,3656
225	2,02	9,44	1,9998	9,3456
145	0,87	11,44	0,8613	11,3256
260	0,07	12,96	0,0693	12,8304

In table 4b, are presented the results of the processing of a cycloid worm with a rack whose coordinates of the profile (see table 4a) were decreased with 1% of its value. There are written down the coordinates of the worm profiled with an unmodified rack as well as the coordinates resulted after profiling with a modified rack.

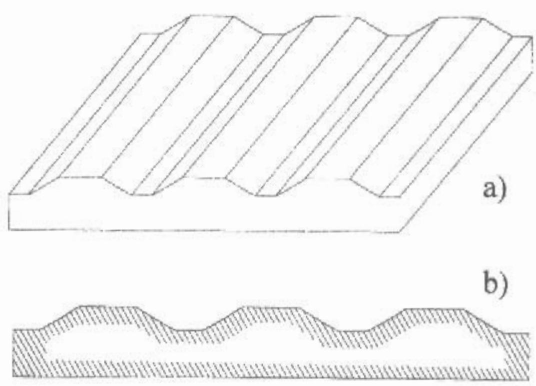

Fig. 13. Solid model of the cog-rack: a) – the solid; b) – frontal section

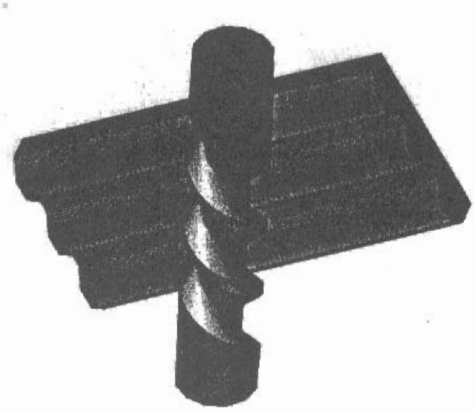

Fig. 14. Rack's solid and the generated worm solid.

6. Conclusions

The modelling of surface generation can be realised, adequately, through 3D method.

The presented algorithms permit the modelling of surfaces effective generated in the case of the generation with the cog-rack, or disk-tool (for helical surfaces) and with worm-gear, of the surfaces whirls.

These numerical examples certify method's capacity to emphasize, rigurously, the generation errors owed to effective tools errors.

The presented algorithms can be used for applications and in other known generation situations.

7. References

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MODELAREA GENERĂRII SUPRAFEŢELOR

(Rezumat)

În lucrare, se prezintă algoritmi specifici, în baza metodei grafice, pentru modelarea generării unor tipuri de vârtejuri de suprafeţe. În acest fel, prin modelarea generării, pornind de la profilurile măsurate ale sculelor, se pot elimina eventuale pierderi prin rebuturi în urma prelucrării suprafeţelor cu scule având profiluri (muchii de aşchiere) afectate de erori.

Algoritmii prezentaţi sunt însoţiţi de exemple numerice, comparate cu rezultatele obţinute prin metodele analitice cunoscute, în scopul validării noii metode.

MODELER DE LA GÉNÉRATION DE SURFACES

(Résumé)

Dans le suivant, sont présentés les algorithmes spécifiques, basés sur la méthode graphique, pour modeler de génération de quelques types de mouvements giratoires des surfaces. Les algorithmes présentés sont accompagnés des applications numériques comparatives à une méthode analytique classique, afin de valider la nouvelle méthode.