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Milled Conical Poliform Surfaces

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Abstract

In this paper, is proposed an analytical and numerical modeling of some type of milled conical poliform surface. Generation of conical poliform surfaces is performed with a mono-edge tool, on gear cutting machine with warm gear.
Keywords: surface, poliform, conical, helicoidal, generatrix

1. Introduction

There were conceived [1], [2], [3] cinematic schemes for the generation through milling of the poliform surfaces, on machine - tools.

The tools, generally mono-edge, with right or helicoidal cogs, execute the splintering motion, having been set on the port – mill shaft. The semi-product solidary to the machine's plate; executes a rotation (motion), in correlation with the rotation (motion) of the tool.

There have been created analytical models for these schemes of generation of the poliform shafts; and, also there have been elaborated software products in order to model numerically the profiles form.

In this paper, it is proposed a cinematic scheme and an analytical model, for the generation of some conical poliform surfaces (shafts).

2. The kinematics of the generation process

In figure 1, are represented the relative positions of tool and semi-product axis, the cinematic of the process as well as the reference systems:

xyz – is the mobile reference system with the z axis solidary to the rotation axis of the semi-product;

$x_0y_0z_0$ - fixed system, with the x_0 axis solidary to the single-cog mill axis;

XYZ - mobile system solidary with tool;

$\xi\eta\zeta$ - mobile system, solidary with generated shaft.

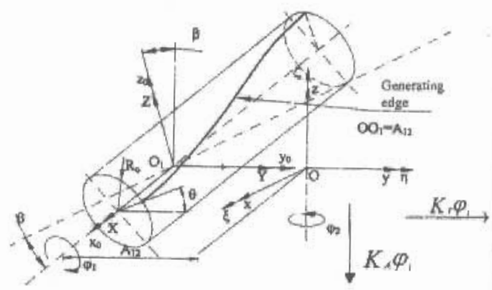

Fig.1 Generation scheme

The kinematics of the generation proce[ss] supposes the coordination of the next motions:
- the rotation of the generating tool, around i[ts] own axis, of angle φ_1;
- the rotation of the semi-product around the [z] axis, of angle φ_2, in correlation with the ang[le] φ_1;
- the translation of the system $\xi\eta\zeta$, along t[he] axis η with the parameter $(k_T\cdot\varphi_1)$.

The motions of the reference system[s] jointly to the tool and semi-product [are] described by the transformations:

$$X_0 = \omega_3^T(-\varphi_1)\cdot X_1,$$

meaning the rotation (motion) of the X system, solidary with the G helical generat[rix] (the edge tool);

$$X = \omega_3^T(\varphi_2)\cdot\xi,$$

meaning the rotation (motion) of the se[mi-]product;

$$X_0 = \beta(X - a),$$

meaning the translation of the rotation axis of the semi-product,

$$\beta=\begin{Vmatrix}\cos\beta & 0 & -\sin\beta\\ 0 & 1 & 0\\ \sin\beta & 0 & \cos\beta\end{Vmatrix};\quad a=\begin{Vmatrix}0\\ -A_{12}-k_T\cdot\varphi_1\\ -k_A\end{Vmatrix},\quad(4)$$

where k_A and k_T are the sizes of the axial and transversal advances of the mono-edged tool in comparison with the axis of the semi-product.

The ensemble of motions (1), (2), (3) and definitions (4) determine the relative motion,

$$\xi=\omega_3(\varphi_2)\left[\beta^T\cdot\omega_1^T(\varphi_1)X+a\right]\quad(5)$$

or, detailed,

$$\begin{Vmatrix}\xi\\ \eta\\ \zeta\end{Vmatrix}=\begin{Vmatrix}\cos\varphi_2 & \sin\varphi_2 & 0\\ -\sin\varphi_2 & \cos\varphi_2 & 0\\ 0 & 0 & 1\end{Vmatrix}\cdot\left[\begin{Vmatrix}\cos\beta & 0 & \sin\beta\\ 0 & 1 & 0\\ -\sin\beta & 0 & \cos\beta\end{Vmatrix}\cdot\begin{Vmatrix}1 & 0 & 0\\ 0 & \cos\varphi_1 & \sin\varphi_1\\ 0 & -\sin\varphi_1 & \cos\varphi_1\end{Vmatrix}\cdot\begin{Vmatrix}X\\ Y\\ Z\end{Vmatrix}+\begin{Vmatrix}0\\ -A_{12}-k_T\varphi_1\\ -k_A\cdot\varphi_1\end{Vmatrix}\right]\quad(6)$$

3. The geometric model of the conical poliform surface

If it is considered, now, the helical generatrix representing the form of the splintering edge of the tool G:

$$G\begin{vmatrix}X=-p\cdot\theta;\\ Y=R_o\cdot\cos\theta;\\ Z=R_o\cdot\sin\theta.\end{vmatrix}\quad(7)$$

Are defined:

θ - the angular variable parameter;

P - helical parameter;

R - radius of the support cylinder of the edge tool.

Through replacing equations (7) in (6) is determined the family of trajectories of the points belonging to the generating edge – G – front of the reference system of the semi-product.

For β=0 (the axis of the generating tool is perpendicularly to the semi-product axis) from (6) and (7) result:

$$\begin{Vmatrix}\xi\\ \eta\\ \zeta\end{Vmatrix}=\begin{Vmatrix}\cos\varphi_2 & \sin\varphi_2 & 0\\ -\sin\varphi_2 & \cos\varphi_2 & 0\\ 0 & 0 & 1\end{Vmatrix}\cdot\left[\begin{Vmatrix}1 & 0 & 0\\ 0 & 1 & \sin\varphi_1\\ 0 & -\sin\varphi_1 & \cos\varphi_1\end{Vmatrix}\cdot\begin{Vmatrix}-p\cdot\theta\\ R_0\cdot\cos\theta\\ R_0\cdot\sin\theta\end{Vmatrix}+\begin{Vmatrix}0\\ -A_{12}-k_T\varphi_1\\ -k_A\cdot\varphi_1\end{Vmatrix}\right].\quad(8)$$

or, in the end:

$$(T_i)_{\varphi_1}\begin{vmatrix}\xi=-p\cdot\theta\cdot\cos\varphi_2+\left[R_0\cdot\cos(\varphi_1-\theta)-(A_{12}+k_T\cdot\varphi_1)\right]\sin\varphi_2;\\ \eta=p\cdot\theta\cdot\sin\varphi_2+\left[R_0\cdot\cos(\varphi_1-\theta)-(A_{12}+k_T\cdot\varphi_1)\right]\cos\varphi_2;\\ \zeta=-R_0\cdot\sin(\varphi_1-\theta)-k_A\cdot\varphi_1.\end{vmatrix}\quad(9)$$

It is defined the ratio of transmission $\varphi_2=i\varphi_1$ (i=3/4, 4/3), for a shaft with 3 or 4 sides.

The cross section of the poliform surface is determined of the equations (9), to which is added the condition ζ=0, i.e.

$$\theta=\varphi_1+\arcsin\left[\frac{k_A}{R_0}\cdot\varphi_1\right].\quad(10)$$

4. Numerical examples

Based on the presented soft product were realized numerical models graphic expressed of the cross-section of the poliform shaft generated accordingly to the scheme proposed.

In figures (2..7) and tables (1) and (2), are presented examples of such shafts modeled through the proposed algorithm.

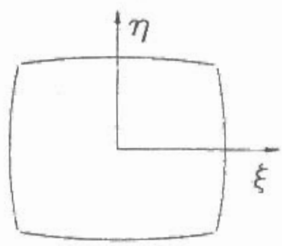

Fig 1. Cross – section of a poliform shaft. (i=1/4; R_0=50mm; p=50mm; k_A=0,05; k_T=0,05; semi-product radius - 54,8mm, in correlation with table 1)

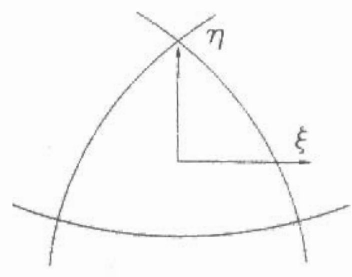

Fig 2. Cross - section of a poliform shaft (i=1/3; R_0=50mm; p=50mm; k_A=0,05; k_T=0,05; semi- product radius – 54,8mm, in correlation with table 2)

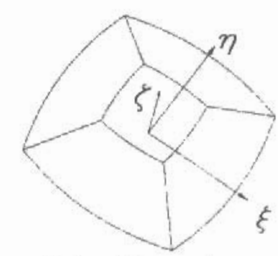

Fig .3. Four – sides' poliform surface (i=1/4; R_0=50mm; p=50mm; k_A=0,05; k_T=0,05 in correlation with table 1)

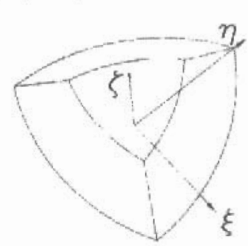

Fig.4. Three sides' poliform surface (i=¼; R_0=50mm; p=50mm; k_A=0,05; k_T=0,05, in correlation with table 2)

Table 1		Table 2	
ξ [mm]	η [mm]	ξ [mm]	η [mm]
38.70193	-11.32313	17.90078	-18.44617
38.33445	-11.49395	16.78786	-18.63327
37.96637	-11.66313	16.23333	-18.72195
.	.	.	.
.	.	.	.
.	.	.	.
1.98494	-19.96651	2.80970	-19.95935
1.58799	-19.97645	2.24984	-19.97344
1.19102	-19.98465	1.68993	-19.98455
0.79402	-19.99110	0.56500	-19.99784
0.39701	-19.99581	0.00500	-19.99997
0.00000	-19.99878	-0.55500	-19.99912
-0.39702	-20.00000	-1.67996	-19.98839
-0.79403	-19.99948	-2.23990	-19.97856
-1.19103	-19.99721	-3.36462	-19.94980
-1.58802	-19.99320	-3.92439	-19.93099
.	.	.	.
.	.	.	.
.	.	.	.
-36.87332	-12.22558	-16.22654	-18.75895
-37.24342	-12.06203	-16.78129	-18.67854
-37.61295	-11.89681	-17.89469	-18.48687

Conclusions

The proposed analytic model and the realized soft products allow a good representation of the conical poliform surfaces geometrical forms.

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Suprafeţe poliforme conice frezate

Universitatea "Dunărea de Jos" din Galaţi

Rezumat

În lucrare, se prezintă modelarea generării prin frezare cu scule cu mono-tăiş a suprafeţelor poliforme conice.

Se consideră o generatoare elicoidală – muchia de aşchiere a unui dinte al unei freze cilindrice mono-dinte, montată pe arborele principal al unei maşini de frezat cu sculă-melc.

Scula execută, simultan, două mişcări de translaţie: axială faţă de semifabricatul montat pe arborele port-freză; radială faţă de semifabricat.

În acest fel, muchia aşchietoarea a sculei generează o suprafaţă poliformă conică.

Maşinile - unelte de danturat au capacitatea de a executa, simultan şi corelat, cele două mişcări de avans.

Surfaces poliformes coniques fraiseés

Université "Dunărea de Jos" du Galaţi

Résumé

Dans cette oeuvre, il est presenté le modelage de la génération par fraisage avec des outils à un seule tranchant de la surface poliforme conique.

On développe un algorithme pour générer la surface poliforme de trois ou quatre côtés.