SUSTAINABLE DEVELOPMENT – SIMULATION OF A CLASSICAL TECHNOLOGICAL PROCESS

Pantea Ioan
University of Oradea, e-mail: ipantea@uoradea.ro

Abstract
The problem of calculating the geometry of the knives used for toothing conical gears with curved teeth is the following: having been given the generating curve of the plane wheel, the profile of the knife's chipping edge and the profile of the abrasive tool used for relieving must be determined so that there is a minimum amount of errors during the resharpening process. The optimum shape of the positioning surfaces of the knife, as a mathematical expression of the conditions imposed on the tools, is an Archimedes's helix. The chipping edge's profile in the calculus section is determined by the intersection of the chip bearing surface of the knife with the generating surface. The paper determines the normal line to the helically relieved surface with the purpose of using it on simulating the kinematics of the technology of processing knives used for toothing conical gears with curved teeth.

Key words: normal line, tangent, relative speed, chipping edge, toothing knife

INTRODUCTION

In this paper, the tangent vector to the lateral positioning surface of knives used for toothing conical gears with curved teeth (profiled surface) is determined with the purpose of using it on simulating the kinematics of the processing technology of the profile of toothing knives. The problem of calculating the geometry of the toothing knives used for milling conical gears with curved teeth is the following: knowing the generating curve of the plane wheel it is required to determine the profile of the chipping edge of the knife and the profile of the abrasive tool used for relieving that would ensure a minimal amount of errors on resharpening. The optimal form of the positioning surfaces of the knife, as a mathematical expression of the conditions imposed upon the tool, is Archimedes' helix. The profile of the chipping edge in the calculus section is determined by intersecting the relieving surface plane and the generating surface.

MATERIAL AND METHODS

The generating curves of the flanks of the plane generating wheels are defined through the parametric equations (Pantea I., 2002):

$$X_p = \begin{bmatrix} x_p(p) \\ y_p(p) \\ z_p(p) \end{bmatrix} \qquad (1)$$

where p is an independent parameter.

The toothing knife is positioned with the definition section of the generating curve in an axial plane. The M_{dp} matrix (Pantea I., 2004) is considered and it represents the transfer from the system linked to the generating curve to the system linked to the relieving device. The position vector of the S_d surface (figure 1) is:

$$X_d = M_{dp} X_p = \begin{bmatrix} x_d(p,v,\varepsilon) \\ y_d(p,v,\varepsilon) \\ z_d(p,v,\varepsilon) \end{bmatrix} \tag{2}$$

where p and v are the independent parameters of the S_d surface and ε is an angular parameter that positions P_γ in S_d.

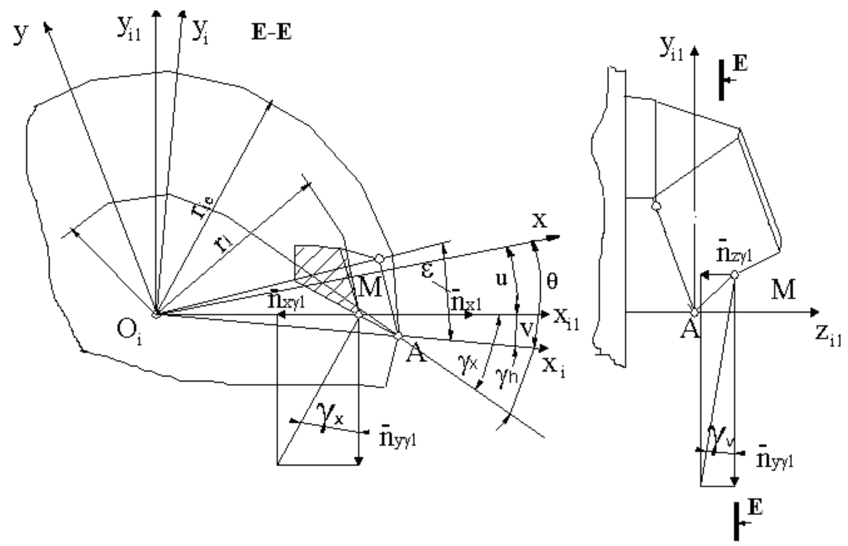

Fig. 1 Tangent to edge producer and relative speed in detalonarii process

By definition, the exact chipping edge M_a is the intersection curve between the generating surface of the S_d device and the liberation plane of the P_γ knife. Taking into consideration that the P_γ liberation plane passes through a point in which the director parameters A, B, C of the N_γ normal line to it are defined, its expression is:

$$A \cdot x + B \cdot y + C \cdot z + D = 0 \tag{3}$$

The intersection between (2) and (3) is written:

$$A \cdot x_d + B \cdot y_d + C \cdot z_d + D = 0 \tag{4}$$

or:

$$f_1(p, v, \varepsilon) = 0 \tag{5}$$

For an imposed ε and discrete values of the p parameter, the v rotation parameter is determined and the M_a exact chipping edge's equation is:

$$X_a = \begin{bmatrix} x_a(p,\varepsilon) \\ y_a(p,\varepsilon) \\ z_a(p,\varepsilon) \end{bmatrix} = X_a(p,\varepsilon) \tag{6}$$

RESULTS AND DISCUSSIONS

The normal line to the chipping edge is determined from the vector perpendicularity condition of the tangent to the chipping edge and the relative speed in the relieving process:

$$\overline{N} = \bar{t} \times \bar{v} \tag{7}$$

or under component form:

$$N = \begin{bmatrix} n_x \\ n_y \\ n_z \\ 0 \end{bmatrix} = \begin{bmatrix} t_y \cdot v_z - t_z \cdot v_y \\ t_z \cdot v_x - t_x \cdot v_z \\ t_x \cdot v_y - t_y \cdot v_x \\ 0 \end{bmatrix} \tag{8}$$

In order to obtain the equations of the theoretical profile of the disk and of the normal line to the relieving surface in the contact points of the chipping edge with the disk's surface, that define the contact conditions (Pantea I., 2004), the projections of the relative displacement speed vector in the $x_i y_i z_i$ system must be determined and, for the profile of the chipping edge with various degrees of resharpening, the projections of the vector in the $x_k y_k z_k$ system (fig.1).

The projections of the v_i vector will be proportional to the partial derivatives, found from the equations of the coordinate systems' transformation after the θ parameter.

$$\begin{bmatrix} v_{xi} \\ v_{yi} \\ v_{zi} \\ 0 \end{bmatrix} = \begin{bmatrix} -y_i + \frac{\partial A_x}{\partial \theta}\cos(\theta) \\ x_i + \frac{\partial A_x}{\partial \theta}\sin(\theta) \\ -\frac{\partial A_z}{\partial \theta} \\ 0 \end{bmatrix} \tag{9}$$

The projections of the v_i vector in the xyz system are obtained using the coordinate transformation matrixes (Pantea I., 2002):

$$\begin{bmatrix} v_{xi} \\ v_{yi} \\ v_{zi} \\ 0 \end{bmatrix} = \begin{bmatrix} -y_i + \frac{\partial A_x}{\partial \theta} \\ x \\ -\frac{\partial A_z}{\partial \theta} \\ 0 \end{bmatrix} \tag{10}$$

The t_i tangent to the chipping edge is obtained as an intersection line of the P_γ relieving plane determined by the n_γ vector and the P_e tangent plane to the positioning surface determined by the n_e vector in the considered point of the profile. In the $x_{i1}y_{i1}z_{i1}$ coordinate system, the N_γ normal line to the relieving plane and the N_i normal line to the generated surface are situated in a plane normal to the chipping edge.

The tangent to the edge is given by the expression:

$$\overline{t_i} = \overline{n_\gamma} \times \overline{n_{ie}} \tag{11}$$

or under component form on the coordinate axes:

$$t_i = \begin{bmatrix} t_{xi} \\ t_{yi} \\ t_{zi} \\ 0 \end{bmatrix} = \begin{bmatrix} n_{y\gamma}n_{zi} - n_{\gamma i}n_{zi} \\ n_{z\gamma}n_{xi} - n_{zi}n_{x\gamma} \\ n_{xy}n_{yi} - n_{xi}n_{y\gamma} \\ 0 \end{bmatrix} \tag{12}$$

for the helical surface which will be noted with the e index;

γ_x is the relieving angle in the considered M point.

$$\gamma_x = \gamma_h + v \tag{13}$$

$$n_{e1} = \begin{bmatrix} n_{x1} \\ n_{y1} \\ n_{z1} \\ 0 \end{bmatrix} = \begin{bmatrix} \tan(\gamma_x) \\ -1 \\ -\tan(\gamma_v) \\ 0 \end{bmatrix} \tag{14}$$

$$n_{\gamma e1} = \begin{bmatrix} n_{xi1} \\ n_{yi1} \\ n_{zi1} \\ 0 \end{bmatrix} = \begin{bmatrix} 1 \\ 0 \\ \dfrac{1}{\tan(\alpha)} \\ 0 \end{bmatrix} \tag{15}$$

The projections of the tangent to the chipping edge in the $x_{i1} y_{i1} z_{i1}$ are:

$$t_{i1} = \begin{bmatrix} t_{xi1} \\ t_{yi1} \\ t_{zi1} \\ 0 \end{bmatrix} = \begin{bmatrix} \cos(\gamma_x)\dfrac{1}{\tan(\alpha)} \\ -\sin(\gamma_x)\dfrac{1}{\tan(\alpha)} + \tan(\gamma_v)\cos(\gamma_x) \\ -\cos(\gamma_x) \\ 0 \end{bmatrix} \tag{16}$$

The projections of the tangent to the chipping edge in the xyz system are obtained by replacing the θ parameter with u.

$$t_i = \begin{bmatrix} t_{xi} \\ t_{yi} \\ t_{zi} \\ 0 \end{bmatrix} = \begin{bmatrix} \cos(u+\gamma_x)\dfrac{1}{\tan(\alpha_i)} + \sin(u)\cos(\gamma_h)\tan(\gamma_v) \\ -\sin(u+\gamma_x)\dfrac{1}{\tan(\alpha_1)} + \cos(u)\cos(\gamma_h)\cdot\tan(\gamma_v) \\ -\cos(\gamma_x) \\ 0 \end{bmatrix} \tag{17}$$

with :

$$u = \theta - v \tag{18}$$

By introducing in (8) the tangent values from (17) and the relative speed ones form (9), the following normal line is obtained:

$$N = \begin{bmatrix} \cos(u+\gamma_x)\dfrac{1}{\tan(\alpha)} + \sin(u)\cos(\gamma_h)\tan(\gamma_v) \\ \sin(u+\gamma_x)\dfrac{1}{\tan(\alpha)} + \cos(u)\cos(\gamma_h)\tan(\gamma_v) \\ -\cos(\gamma_x) \end{bmatrix} \times \begin{bmatrix} -y \\ x \\ A_z \end{bmatrix} \qquad (19)$$

CONCLUSIONS

For the modeling of the assembly made up of a I order tool and a II order tool, after establishing the axes system for determining the generating surface, the chipping edge, it is necessary to calculate the normal line, the tangent and the relative speed on relieving, so that the motion equations obtained under a matrix form lead through solving to determining the abrasive tool's surface, the real positioning surface and the real chipping edge.

REFERENCES

1. Aron, I. s a., Angrenaje conice cu dinți curbi. Editura Casa Cărții de Ştiință, Cluj-Napoca, 1999.
2. Grămescu, Tr. ş.a, Tehnologii de danturare a roților dințate. Manual de proiectare. Chişinău, Ed.Universitas, 1993
3. Guja, N., Tendințe şi noutăți în domeniul angrenajelor. Construcția de maşini 1/1999.
4. Maşala, I., Simularea dinamicii procesului de frezare. Construcția de maşini 6/1995.
5. Mihăilă, I., Tehnologii mecanice. Ed. Universității Oradea, 2004.
6. Minciu, C., Scule aşchietoare. Îndrumar de proiectare. Bucureşti, Editura tehnică, 1995.
7. Litvin F. L., (1994) Gear Geometry and Applied Theory. University of Illinois, Chicago. PTR Prentice Hall, Englewood Cliffs, New Jersey 0763. ISBN-13-211095-4, 1994.
8. Pantea I., Contribuții privind tehnologia sculelor de danturat roți dințate conice cu dinți curbi.Teză de doctorat, Universitatea din Oradea, 2004.
9. Pantea, I. (2002). Studiul teoretic al sculelor de danturat roți conice cu dinți curbi. Sisteme de coordonate, matrici de transformare. Analele Universității Oradea, pg. 215-218.
10. Pantea I., (2002) Studiul teoretic al sculelor de danturat roți conice cu dinți curbi. Suprafața generatoare. Analele Universității Oradea, 2002, pg. 219-223.