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DETERMINATION OF THEORETICAL ROUGHNESS PROFILE HEIGHT BY PERIPHERAL MILLING

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ABSTRACT

Milling is one of the most universal methods but, at the same time, more complicated machining method. Calculations by milling are more complicating with regard to others methods of cutting process. In this paper is presented more precise method for determination a theoretical roughness profile height by peripheral milling based on kinematics of cutting. Presented mathematical model give dependence of the theoretical roughness profile height in function from the geometry of milling cutter and parameters of cutting process.

Key words: *peripheral milling, roughness surface, kinematics of cutting*

1. INTRODUCTION

The accurate characterization of surface roughness has very great importance. Surface roughness determines, above all, serviceable characteristics of surface. On the one hand, surface roughness is a key factor affecting the function and reliability of a work piece, and, on the other hand, its measurement and analysis can prove to be an excellent diagnostic tool for monitoring the process that produced the surface in question. Roughness presents the finer irregularities of surface texture. Surface roughness is conventionally defined as variation of surface profile from default line. Roughness results from the inherent action of the machining process. These include traverse feed marks and other closely spaced irregularities produced by cutting tool. Surface roughness is in direct dependence from technology of machining.

Milling as machining process is not foreseen for finishes machining and researches of surface roughness for this operation has not been systematic as like it has been case by turning. Meanwhile, milling is often finish operation. This is a reason to find the relations between parameters of surface roughness and parameters of working process in goal to one-significant foresee the quality of surface roughness.

Calculations by milling are more complicating than at the others methods of cutting process. By calculation for determination of surface roughness by milling, path of milling cutters tooth in cutting process is approximated by circle arc. More precise method of calculation is based on kinematics of cutting. At finish machining by peripheral milling it is possible determinate the theoretical roughness profile height based on kinematics of cutting.

2 - THEORETICAL ROUGHNESS PROFILE HEIGHT BY PERIPHERAL MILLING

By peripheral milling the form of roughness profile determine the pats of two successive milling cutters tooth. These paths are cycloids. The form of roughness profile depends from method of milling, i.e. if it is word about up-cut milling or down-cut milling.

a) Up-Cut Peripheral Milling

By up-cut peripheral milling the milling cutters tooth paint the cycloid, which result to roll the circle of radius r without sliding along fictitious line Ax that is over the milling cutter. Centre of circle O coincide with axis of milling cutters transversal section, and its angular velocity is equal to angular velocity of milling cutter ω. At figure 1 is shown the model for determination theoretical roughness profile height by up-cut peripheral milling.

Equations, which paint the path of milling cutters edge by up-cut peripheral milling, cycloid, in coordinate system xAy, figure 1, are:

$$x = v_p t + R \sin\varphi = r\varphi + R \sin\varphi \qquad (1)$$

$$y = r + R \cos\varphi \qquad (2)$$

Where: r - radius of cycloids circle, R - radius of milling cutter, φ - angle of feed direction.

Feed rate by peripheral milling is defined by:

$$v_p = r\omega = nzs_z = ns_0 \quad (3)$$

Where: ω - angular velocity of milling cutter, n - rotational speed, z - number of teeth of milling cutter, s_z - feed per tooth, s_0 - feed per rotation.

Cutting speed is defined by

$$v = R\omega = 2\pi Rn \quad (4)$$

Radius of cycloids circle r can to determine from equation:

$$r = R\frac{v_p}{v} = \frac{s_o}{2\pi} \quad (5)$$

Theoretical roughness profile height by up-cut peripheral milling it can determine based on figure 1. Teeth 1 of milling cutter paint curve I, and tooth 2 of milling cutter paint curve II. Axis of milling cutter move by direction O'O by velocity v_p. Paths of these two successive teeth of milling cutter make form of surface roughness profile.

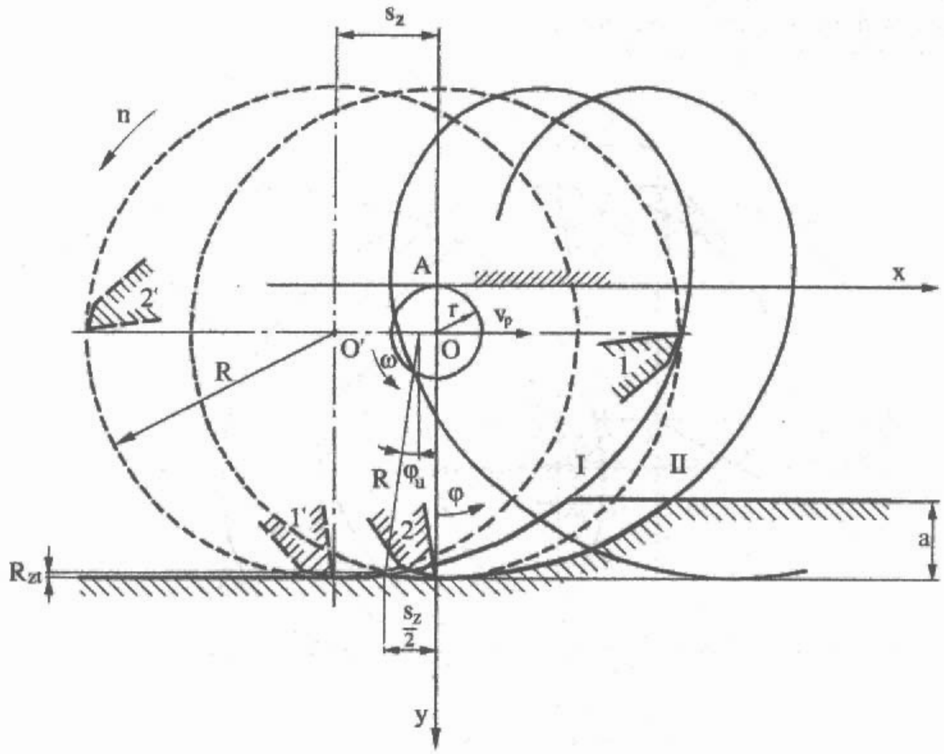

FIG. 1 Model for determination theoretical roughness profile height by up-cut peripheral milling

Theoretical roughness profile height, fig. 1, is defined by equation:

$$\begin{aligned} R_{zt} &= y_{max} - y_u \\ R_{zt} &= (r+R) - (r + R\cos\varphi_u) \\ R_{zt} &= R(1-\cos\varphi_u) \end{aligned} \quad (6)$$

Where: φ_u - angle of feed direction at the beginning of the cut.

Angle of feed direction at the beginning of the cut φ_u can to determine from equation

$$\begin{aligned} -\frac{s_z}{2} &= r(-\varphi_u) + R\sin(-\varphi_u) \\ \sin(-\varphi_u) &\approx -\varphi_u \\ \varphi_u &\approx \frac{s_z}{2(R+r)} \end{aligned} \quad (7)$$

Putting the value for φ_u from equations (7) in equation (6) it is given

$$R_{zt} = \left[1 - \cos\frac{s_z}{2(R+r)}\right] \quad (8)$$

Progress the function cos in potential row

$$\cos x = \sum_{k=0}^{\infty} \frac{(-1)^k}{(2k)!} \cdot x^{2k} = 1 - \frac{1}{2!}x^2 + \frac{1}{4!}x^4 - \frac{1}{6!}x^6 + \ldots$$

and taking only first two members it is given

$$\cos\frac{s_z}{2(R+r)} = 1 - \frac{1}{2!}\left[\frac{s_z}{2(R+r)}\right]^2 = 1 - \frac{s_z^2}{8(R+r)^2}, \quad (9)$$

Function R_{zt} from equations (8) and (9) have the form

$$R_{zt} = \frac{Rs_z^2}{8(R+r)^2} \quad (10)$$

b) Down-Cut Peripheral Milling

Model for determination theoretical roughness profile height by down-cut peripheral milling is shown at fig. 2.

Equations, which paint the path of milling cutters edge by down-cut peripheral milling, cycloid, in coordinate system xAy, figure 2, are

$$x = v_p t - R\sin\varphi = r\varphi - R\sin\varphi \quad (11)$$

$$y = -r + R\cos\varphi \quad (12)$$

Theoretical roughness profile height, fig. 2, is defined by equation

$$\begin{aligned} R_{zt} &= y_{max} - y_i \\ R_{zt} &= (-r+R)-(-r+R\cos\varphi_i) \\ R_{zt} &= R(1-\cos\varphi_i) \end{aligned} \quad (13)$$

Where: φ_i - angle of feed direction of the end of the cut.

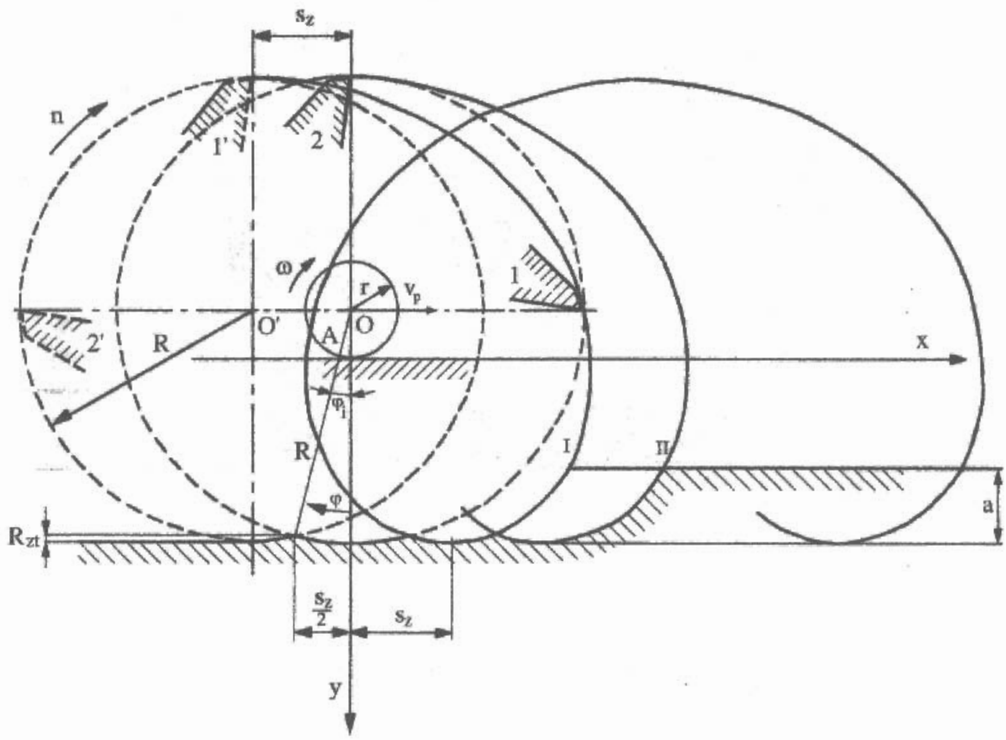

Fig. 2. Model for determination theoretical roughness profile height by down-cut peripheral milling

Angle of feed direction of the end of the cut φ_i can determine from equation

$$\begin{aligned} -\frac{s_z}{2} &= r\varphi_i - R\sin\varphi_i \\ \sin\varphi_i &\approx \varphi_i \\ \varphi_i &\approx \frac{s_z}{2(R-r)} \end{aligned} \quad (14)$$

Putting the value for φ_i from equations (14) in equation (13) it is given

$$R_{zt} = \left[1-\cos\frac{s_z}{2(R-r)}\right] \quad (15)$$

Progress the function cos in potential row and taking only first two members it is given

$$\cos\frac{s_z}{2(R-r)} = 1 - \frac{1}{2!}\left[\frac{s_z}{2(R-r)}\right]^2 = 1 - \frac{s_z^2}{8(R-r)^2} \quad (16)$$

Function R_{zt} from equations (16) and (15) have the form

$$R_{zt} = \frac{Rs_z^2}{8(R-r)^2} \quad (17)$$

In table 1 is shown equations for determination theoretical roughness profile height by peripheral milling.

Table 1. Roughness profile height by peripheral milling

Method		Roughness profile height
Peripheral milling	Up-cut milling	$R_{zt} = \frac{R s_z^2}{8(R+r)^2}$
	Down-cut milling	$R_{zt} = \frac{R s_z^2}{8(R-r)^2}$
Where, r-radius of cycloids circle, R-radius of milling cutter, s_z-feed per tooth		

3 - CONCLUSION

Equations for calculation theoretical roughness profile height by peripheral milling are based on kinematics of cutting. These equations give more precise results from geometrical equation. Differences in values of roughness profile height calculate based on geometrical equation and kinematical equation essentially differs by peripheral milling with big feed. By peripheral milling with small feed differences is neglect. Kinematical equations give various values for theoretical roughness profile height for up-cut peripheral milling and down-cut peripheral milling. It has not been case by geometrical equation.

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Determinarea înălţimii profilului rugozităţii teoretice la frezarea cilindrică

Rezumat

Frezarea este una dintre cele mai universale metode de prelucrare. Dar, în acelaşi timp, o este o metodă relativ complicată de prelucrare. Calculele legate de aceasta sunt mult mai complicate faţă de alte metode de prelucrare. În lucrarea de faţă se prezintă o metodă mai precisă pentru determinarea înălţimii profilului teoretic la frezarea cilindrică, metodă rezultată pe baza analizei cinematicii de generare. Modelul matematic prezentat dă o dependenţă între înălţimea profilului rugozităţii teoretice plecând de la geometria frezei cilindrice şi parametrii regimului de aşchiere.

Détermination de taille théorique de profil de rugosité par le fraisage périphérique

Résume

Le fraisage est un les méthodes de les plus universelles mais, en même temps, méthode d'usinage plus compliquée. Les calculs par le fraisage sont plus compliquants en ce qui concerne d'autres des méthodes de couper le processus. En cet article est présenté à une méthode plus précise pour la détermination une taille théorique de profil de rugosité par le fraisage périphérique basé sur la cinématique du découpage. La dépendance modèle mathématique présentée d'élasticité of du de la taille théorique de profil de rugosité dans la fonction de la géométrie le coupeur de fraisage et les paramètres du processus de découpage.