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Research of the value of linear distortion of renewable surface of part during rotary processing of bulky items without dismantling unit

J A Bondarenko, M A Fedorenko, A A Pogonin

Belgorod State Technological University named after V.G. Shoukhov, Kostyukova St., 46, Belgorod, 308012, Russia

E-mail: kdsm2002@mail.ru

Abstract. The loading and unloading units and grinding mills of raw devices have internal cone type or pipe screw perceive load of incoming and outgoing material. The main part of the support assembly is a pin. Mounting seats for the pipe screws cone have traces of deformation and work hardening, while they themselves have wear of pins and deformation of the inner and outer cylindrical working surface. In the mill body, there are constantly acting dynamic forces causing vibration, which are transmitted to the stud and inner accelerating elements. Under the influence of stress and vibration, the housing spigot is in the stress-compressed state and stretched vertically and horizontally. As a result, the insertion element is deformed and weakened in the fixture. A moving element appears in the gap leading to the fact that it drops lfeedstock and under the influence of variable loads it is destroyed, as well as the seating surfaces of the insert pin member.

1. Introduction

In the process of changing the shape of seating surfaces, regenerative repair is difficult to set a new standard element [1].

To restore the efficiency of the mill, it is necessary to restore the desired shape of the seat to ensure a high dimensional accuracy, to ensure concentricity of the inner and outer cylindrical surfaces, which is possible to operate only when they are basing on the outer surface of the movable Hydro, providing immobility of the pin axis of rotation in space and while processing the inner surface of the provided machine based on the Hydro case, because the basic journal, special equipment [2] should be used for this purpose. In order to obtain the desired surface finish, geometrical sizes, to increase productivity, it is necessary to produce hardening treated surface when reduction treatment pins use cup tools [3].

2. Informative Part

Construction peculiarities of these cutters and rotary processing lead to a change in the treated surface roughness of the product, the value of which depends on the linear distortion of the normal section cutting surface in view of the availability of the radii of curvature of the cutting blade cup tool and the workpiece and the rotation of the tool axis in the horizontal and vertical planes [4].

Features and rotary processing designs of the tool undulations give rise to the treated surface. The wave on the treated surface of the cylindrical member has the form of a multi-start helical spiral flat shape with rounded peaks and valleys. The curl arises from the radial and axial run-out circular cutting edge rotary cutter and interferences it traces on the treated surface of the article. The value depends on the waviness linear distortion changes of the normal section of the cut surface due to the presence of the radii of curvature of the cutting edge rotary cutter and the work piece and the tool axis of rotation in two planes: vertical and horizontal [5].

In the theoretical study of the linear distortion of the normal section of the cutting surface, it is necessary to make assumptions: the projection of the cutting edge in the vertical plane perpendicular to the axis is replaced by a circle with a radius equal to the radius of the ellipse of the curvature at the top of the tool. The diameter of the cutting cup rotary tool is large, and the depth of cut is relatively small. This is assumption forces to make minor error, which one can neglected. Let us use the following designations: t - depth of cut; R - radius of the treated surface of large parts; ρ - radius of curvature of the ellipse (the projection of circular radius r of the rotary cutter of the cutting edge) at the top of cutter A. A scheme to determine the linear distortion in the processing of large holes of parts is shown in Fig. 1.

The system of equations of the circle (a rotary tool in the cross section and the surface details of the hole) is:

$$\begin{cases} x^2 + y^2 = \rho^2 \\ y^2 + \left[(R-\rho)+x\right]^2 = (R-t)^2 \end{cases}.$$

After conversion, there is:

$$x = \frac{2R\rho - 2Rt - 2\rho^2 + t^2}{2(R-\rho)}.$$

The equation is:

$$\rho - x = \delta.$$

Then:

$$\delta = \rho - \frac{2R\rho - 2Rt - 2\rho^2 + t^2}{2(R-\rho)}$$

$$\delta = \frac{2Rt - t^2}{2(R-\rho)}.$$

Let us find the derivative to find the radius of curvature of:

$$y = \pm\frac{b}{a}\sqrt{a^2 - x^2};$$

$$y' = \left(\pm\frac{b}{a}\sqrt{a^2 - x^2}\right)' = \mp\frac{bx}{a\sqrt{a^2 - x^2}};$$

$$y'' = \left(\mp\frac{bx}{a\sqrt{a^2 - x^2}}\right)' = \mp\frac{ab}{\sqrt{(a^2 - x^2)^3}}.$$

Let us define the radius of curvature at the vertex of the tool:

$$\rho = \frac{\sqrt{\left[1 + (y')^2\right]^3}}{|y''|}.$$

As a result of reforms, the following relationship is obtained:

$$\rho = \frac{1}{r^2 \sin\varphi}\sqrt{\left(r^2 - x^2\cos^2\varphi\right)^3},$$

where x - coordinate of the top of the rotary tool when it is installed:

$$x = \frac{r \cdot tg\omega}{\sqrt{\sin^2\varphi + tg^2\omega}},$$

$$\rho = \frac{1}{r^2 \sin\varphi}\sqrt{\left(r^2 - \frac{r^2 tg^2\omega\cos^2\varphi}{\sin^2\varphi + tg^2\omega}\right)^3} = \frac{r \cdot \sin^2\varphi}{\sqrt{\left(\sin^2\varphi\cos^2\omega + \sin^2\omega\right)^3}}.$$

The dependences of the linear distortion of the normal section are:

$$\delta = \frac{2\left(Rt - t^2\right)\sqrt{\left(\sin^2\varphi\cos^2\omega + \sin^2\omega\right)^3}}{2R\sqrt{\left(\sin^2\varphi\cos^2\omega + \sin^2\omega\right)^3} - 2r\sin^2\varphi}.$$

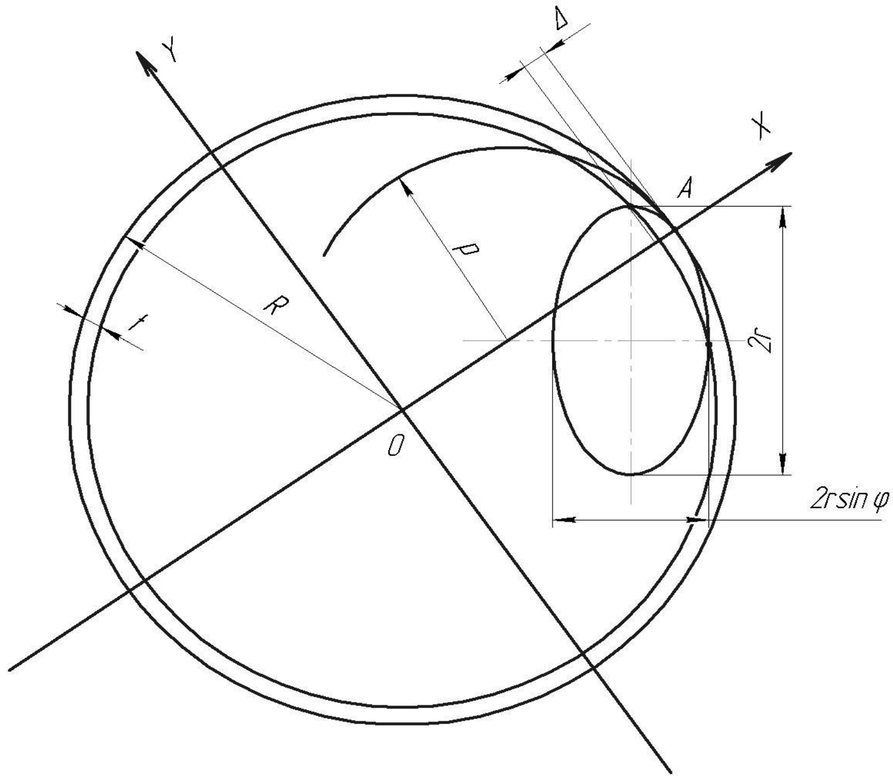

Figure 1. Estimated distortion circuit for normal sections of the cutting surface of the processing of holes

The dependence of the linear distortion cross-section surface normal of the cutting tool, machining the cup, depends on the cutter diameter, the diameter of the processed hole of parts and installation angles of the cutter, cutting depth during recovery [6].

Precision machining of working surfaces of internal support assemblies trunnions defined operating requirements during processing the conventional cutting tool, which is not achieved due to the fact that the tool life completion does not provide one full stroke, so the use of cup cutters for machining internal surfaces of rotating parts of support units of large rotating machines has a number of advantages [7].

When restoring external working surfaces of large parts of support assemblies, the size of the linear distortion is defined by a radius of curvature of the cutting blades of the rotary tool and the workpiece [8]. Due to the fact that the ratio of t / r is a small quantity, elliptical contact rotary tool cutting edge with a normal section of a detail area can be approximated by a circle with a radius equal to the radius of curvature of the ellipse at the upper contact of the tool cutting plates with the workpiece (Fig. 2).

Let us obtain the following expression:

$$x^2 + y^2 = r_k^2,$$
$$[x - (r_k - R_k)]^2 + y^2 = (R_k + t)^2,$$

where r_k - radius of curvature of the ellipse at the contact point of the cutting edge of the rotary tool with the outer surface of the workpiece.

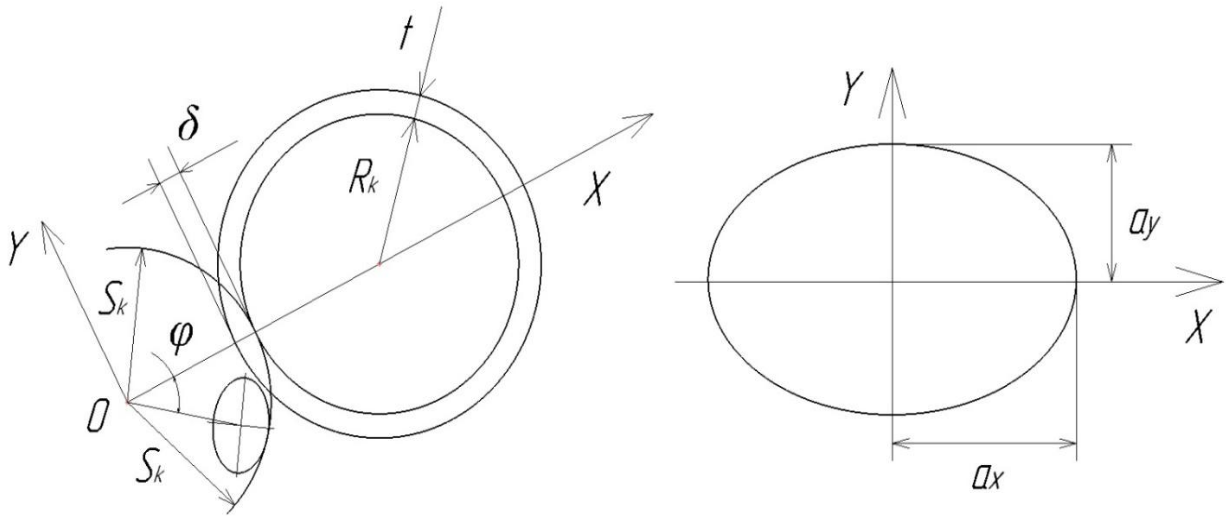

Figure 2. Distortion for normal sections of the cutting surface of the processing of the external surfaces

There is:

$$y = \pm\sqrt{r_k^2 - x^2}.$$
$$[x - (R_k + r_k)]^2 + r_k^2 - x^2 = (R_k + t)^2.$$
$$2x(R_k + r_k) = 2R_k r_k + 2r_k^2 - 2R_k t - t^2.$$

Let us define:

$$x = \frac{2R_k r_k - 2R_k t + 2r_k^2 - t^2}{2(R_k - r_k)}.$$

The number of linear distortions is:

$$\delta = r_k - x.$$
$$\delta = \frac{2R_k t + t^2}{2(R_k + r_k)}.$$

To find the r_k radius of the curvature at the point of contact with the tool parts of the outer surface, let us write the expression, defining the parameters of the ellipse:

$$\frac{x^2}{a_x^2} + \frac{y^2}{a_y^2} = 1,$$

where the half-line and a_x a_y ellipse are, respectively:

$$a_x = r,$$

$$a_y = r\sin\varphi.$$

Then:

$$r_k = \frac{\left[1+\left(y_x'\right)^2\right]^{3/2}}{\left|y_{xx}''\right|},$$

where y_x '- the first derivative; y_{xx}" - the value of the second derivative.
Let us get:

$$y = \pm a_y\sqrt{1-\left(\frac{x}{a_x}\right)^2}.$$

$$y_x' = \pm\frac{a_y\left(-\frac{2x}{ax^2}\right)}{2\sqrt{1-\left(\frac{x}{a_x}\right)^2}} = \mp\frac{a_y}{a_x^2}\cdot\frac{x}{\sqrt{1-\left(\frac{x}{a_x}\right)^2}},$$

$$y_{xx}'' = \mp\frac{a_y}{a_x^2}\cdot\frac{\sqrt{1-\left(\frac{x}{a_x}\right)^2}+\frac{2x\cdot x}{2\sqrt{1-(4a_x)^2}}}{1-\left(\frac{x}{a_x}\right)^2} = \mp\frac{a_y}{a_x^2}\cdot\frac{1}{\left[1-\left(\frac{x}{a_x}\right)^2\right]^{3/2}},$$

$$[1+(y_x')^2]^{3/2} = \left[1+\frac{a_y^2}{a_x^4}\cdot\frac{x^2}{\left[1-\left(\frac{x}{a_x}\right)^2\right]}\right]^{3/2} = \left[\frac{1-\left(\frac{x}{a_x}\right)^2+\frac{a_y^2}{a_x^2}\left(\frac{x}{a_x}\right)^2}{1-\left(\frac{x}{a_x}\right)^2}\right]^{3/2}.$$

Then:

$$r_k = \frac{a_x^2}{a_y}\left[1-\left(\frac{x}{a_x}\right)^2+\frac{a_y^2}{a_x^2}\left(\frac{x}{a_x}\right)^2\right]^{3/2}.$$

One obtains:

$$r_k = \frac{r^2}{r\sin\varphi}\left[1-\left(\frac{x}{r}\right)^2+\sin^2\varphi\left(\frac{x}{r}\right)^2\right]^{3/2} = \frac{1}{r^2\sin\varphi}\cdot\left(r^2-x^2+x^2\sin^2\varphi\right)^{3/2} =$$

$$= \frac{1}{r^2\sin\varphi}\cdot\left(r^2-x^2\cos^2\varphi\right)^{3/2}.$$

There is:

$$r_k = \frac{(r^2)^{3/2}}{r^2\sin\varphi}\left(\frac{\sin^2\varphi+\mathrm{tg}^2\omega-\mathrm{tg}^2\omega}{\sin^2\varphi+\mathrm{tg}^2\omega}\right)^{3/2} = \frac{r\sin^2\varphi}{(\sin^2\varphi+\mathrm{tg}^2\omega)^{3/2}}.$$

The dependences of the linear distortion of the normal section are:

$$\delta = \frac{\left[2\left(R_0-\frac{R_0-r_0}{L}\varepsilon\right)+t\right]\cdot t\cdot(\sin^2\varphi+\mathrm{tg}^2\omega)^{3/2}}{2\left[\left(R_0-\frac{R_0-r_0}{L}\varepsilon\right)(\sin^2\varphi+\mathrm{tg}^2\omega)^{3/2}+r\sin^2\varphi\right]}.$$

3. Conclusion

Analysis of the obtained dependence indicates that the motion of the rotary tool along the outer surface of the work piece with the linear distortion decreases.

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Analytical dependences, allowing one to do theoretical research of the magnitude of the linear distortion of the normal section of the surface-treated cutting, the inner surface of the large surface of the treated details and exterior details in the processing of the rotary cutter.

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