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Technological parameters determination of faced rolls combined treatment

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Abstract
In the paper, the combined method of profiling rolls shaping is considered, and a mean for this method implementation and technological parameters determination of faced rolls combined treatment are suggested.

Key words: PLANETARY GEAR, FACED SURFACE, EDGE CUTTING MACHINING, ABRASIVE MACHINING

Machine components with different sections design are used in different machinery. The machine components, which have faced surface, are used the most frequently. The new treatment solutions research of this machine components types is the relevant objective of machine-building industry. In condition of market economy development while organization of industrial plants work, the main selection factors of one or another producing method are production costs, production efficiency and obtained surface condition.

Traditionally, universal dividing head milling machines are used for faced surface shaping. However, this method is inefficient. The using of CNC machines is alternative machining method for such surfaces. The weakness of this faced surfaces shaping method is high cost of CNC equipment, the software for CNC code preparation for profiled surface machining. All of this makes this method unreachable for small plants. In medium-sized and small-sized work condition, which is typical for most of machine-building plants, the use of universal equipment for general machine-building purpose makes the most sense. With this equipment faced surface shaping can be carried out using not only economical but highly productive method. This method requires the additional equipment [1].

Preliminary studies showed that the known treatment methods of machine components with areas, which cross sections are of the form of regular polyhedron, have low efficiency and high production costs. These methods also have limited capacity to form the required parameters of the surface layer (e. g. roughness); this does not meet the requirements of knowledge-based machine-building plants.

The efficiency upgrading of modern machinery production is achieved successfully by using of combined methods of treatment, which ensures labor intensity reduction due to operations combining as well as high quality of the in-process components surface layer [2].

The appliance for treatment of faced part of the roll is known [3]. This method involves supplying the cutting edge with complex motion trajectory by the planetary gear; this motion trajectory allows forming of profiling roll. However, elastic deformations, which have an effect on the workpiece while lathe turning, have a great impact on the shape of machine components under production. Surface treatment is supposed to perform on the ends of the roll or on surface, which is far from fixation. This workpiece will be under heavy loud due to the impact of elastic deformations (Figure 1).

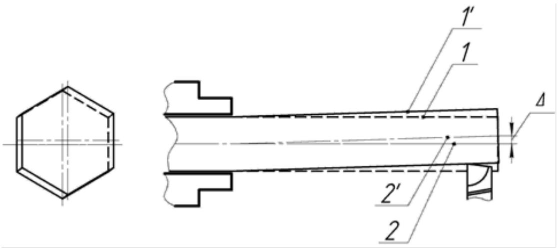

Figure 1. The treatment scheme of workpiece while lathe turning by one cutter.

In Southwest State University, the device for profiling rolls combined treatment on universal machines by the planetary gear has been developed. The planetary gear (Figure 2) consists of housing, which has internal gearing and is attached fixedly on lathe bed. The gear wheels 2, 3 throwing into gear with housing are arranged within the housing. The gear wheels shafts are fixed by bearings on the face-plate, which is fixed in lathe spindle, on the one side and on the cap 11 on the other side.

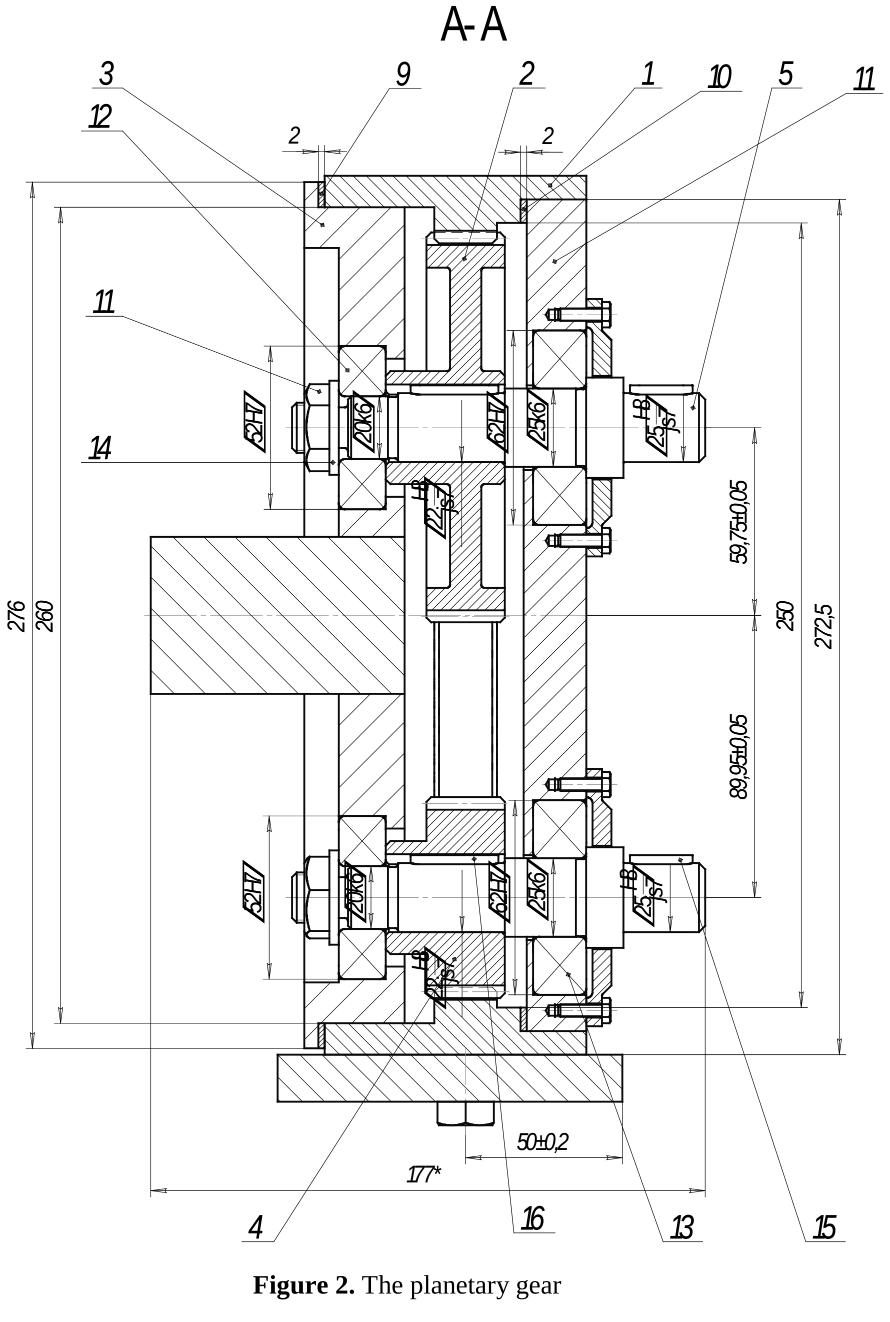

Figure 2. The planetary gear

When combined treatment, two methods of planetary instruments motion are implemented; the toolss motion scheme is shown in Fig. 3. This is the method of polyhedron straight line approximation by the elongated hypotrochoid line, where the instrument unit is fixed on the gear wheels shaft. The ratio of gear and fixed wheels is 1/N, where N – the polyhedron faces number for finishing. The method of polyhedron straight line approximation by hypotrochoids in the form of ellipses is that the cutter block is fixed on the gear wheel shaft. The cutters number of this block is selected from the condition that each cutter forms two sides of treated polyhedron. The ratio of fixed and gear wheels is1:2 for edge cutting machining. The cutter block, suitable for adjustment of cutters overhang, is used for fixing of edge cutting tool [4].

Finishing can be carried out by the abrasive tool.

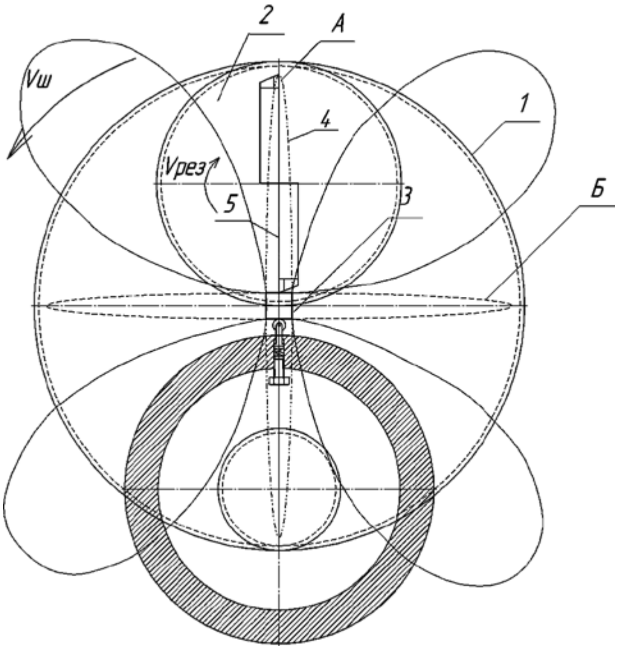

Figure 3. The faced surface shaping scheme by combined tools motion

Suggested design solution allows not only providing good dynamic properties for this appliance due to equal mass of cutter blocks (an equal distance of dynamic system mass from the center with equal angles relative to each other), but also ensuring a higher accuracy of manufacturing and improving the quality of treated surface.

The abrasive tool pressure force on the machine component is designated by equal tangential cutting force.

The formula for cutting force fixation, while abrasive machining, is known [5].

$$P_z = \sqrt{\frac{\pi \cdot tg\gamma \cdot HV \cdot \sigma_{compr}}{1-\eta}} \cdot \frac{B \cdot V_{comp} \cdot t}{V_{ab}} \qquad (1)$$

where σ_{compr}, HV - ultimate compressive strength of treated material and Vickers hardness number respectively, γ – half the vertex angle of conical grain; V_{comp} - component rate; V_{ab} – abrasive rate; t – removal stock; B – abrasive tool width; η - nondimensional coefficient, which considers the bluntness ratio of circle grains and varies within 0…1 $\eta \to 0$ for acute grain, $\eta \to 1$ for blunted circle grain; kinematic- geometrical meaning of this coefficient, when steady polishing process with stably maintained altitude characteristics of cutting relief of circle working surface, is considered in detail [6].

From there, the abrasive tool determination resolves itself into parameter B determination.

$$B = \frac{P_z \cdot V_{circ}}{V_{comp} \cdot t} \cdot \sqrt{\frac{1-\eta}{\pi \cdot tg\gamma \cdot HV \cdot \sigma_{compr}}} \qquad (2)$$

Obtained cross section profile has the form of regular polyhedron with curved outward (convex) sides. Not without interest is determination of parameter t, that is obtained profile form deviation from desired regular polyhedron, because this parameter is numerically equal to stock removal rate for abrasive machining.

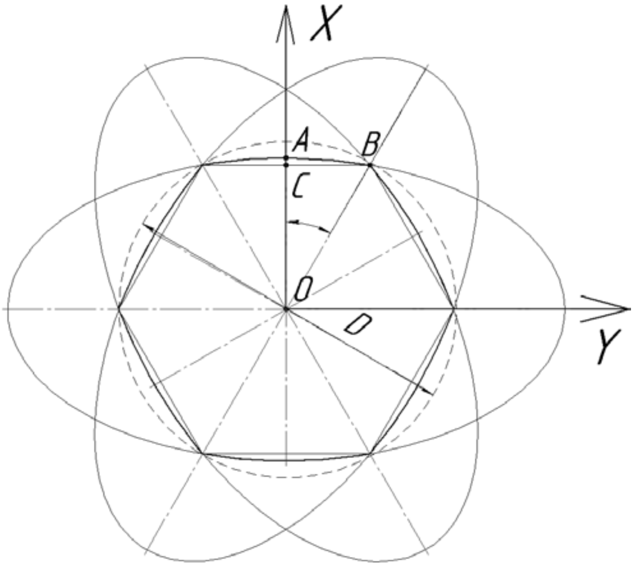

Figure 4. Design model

Parametric equation of hypotrochoid γ:

$$\begin{cases} x(\varphi)=(R-r)\cdot\cos(\varphi)+d\cdot\cos\left(\dfrac{R-r}{r}\cdot\varphi\right) \\ y(\varphi)=(R-r)\cdot\sin(\varphi)-d\cdot\sin\left(\dfrac{R-r}{r}\cdot\varphi\right) \end{cases} \qquad (3)$$

where φ – angle parameter ranging from 0 to 2π; x, y - point positions of hypotrochoid in the plane relating to coordination center O in coordinate system XOY; R - fixed wheel radius; r - radius of wheel with the cutter support on the shaft; d - the distance from cutter support axle to treated workpeace.

The parametric equations of hypotrochoids α and β can be obtained by rotation of the figure γ by the angles $\frac{\pi}{3}$ and $\frac{2\pi}{3}$ respectively.

In our case, the formula $\frac{R}{r}=2$ is constant; equation system (1) works out to [7]:

$$\begin{cases} x(\varphi)=r\cdot\cos(\varphi)+d\cdot\cos(\varphi)=(r+d)\cdot\cos(\varphi \\ y(\varphi)=r\cdot\sin(\varphi)-d\cdot\sin(\varphi)=(r-d)\cdot\sin(\varphi) \end{cases} \quad (4)$$

For t (AC) evaluation of obtained polyhedron, cross point positions of hypotrochoids must be found. The point B of hypotrochoid γ with positions $x(\varphi_0)$, $y(\varphi_0)$ is satisfied. At that, parameter φ_0 value can be determined in the following way.

As a first step, let us calculate the angle between the rays OA and OB (Fig. 4):

$$\varphi_0=\frac{\pi}{2}\div N,$$

where N – cutters number (for six-faced profile N = 3);

let us write tangent of an angle φ equation

$$tg\varphi=\frac{BC}{OC}=\frac{x(t_0)}{y(t_0)}=\frac{r+d}{r-d}\cdot ctg(\varphi_0)=\frac{r+d}{r-d}\cdot\frac{1}{tg(\varphi_0)} \quad (5)$$

From the equation 2.12 let us find t_0 value

$$\varphi_0=arctg\left(\frac{r+d}{r-d}\cdot\frac{1}{tg(\varphi)}\right)=arctg\left(\frac{r+d}{r-d}\cdot ctg(\varphi)\right) \quad (6)$$

Then the distance from hypotrochoid center to top of hypotrochoid can be found

$$OA=y\left(\frac{\pi}{2}\right)=r-d \qquad (7)$$

The unknown absolute accuracy of the form is found by formula:

$$t=AC=\left|OA-y(\varphi_0)\right| \qquad (8)$$

Inserting the equation (2.13) into second formula of system (2.11) we obtain:

$$y(\varphi_0)=(r-d)\cdot\sin\left(arctg\left(\frac{r+d}{r-d}\cdot ctg(\varphi)\right)\right) \qquad (9)$$

Let us insert equations (2.14) and (2.16) into equation (2.15) and we obtain:

$$t=\left|r-d-(r-d)\cdot\sin\left(arctg\left(ctg\left(\frac{\pi}{2\cdot N}\right)\frac{r+d}{r-d}\right)\right)\right|$$

(10)

After inserting of removal stock value (10) into equation (2) we obtain the thickness of abrasive tool.

The abrasive block is adjusted in such a way that the cutting force is equal to zero in point A in design model (Fig. 4), and is equal to cutting force when lathe turning in point B.

Consequently, the method of faced surfaces treatment by planetary lathe turning is suggested in the article. The determination of abrasive tool thickness parameter is described.

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