UDK 621.623

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3D-MODELING DESIGN OF MAIN AND ROD JOURNALS WITH CROSSED AXES CRANKSHAFT AND CIRCLE GRINDING PROCESS

Based on research of developed 3D-modeling prototypes, a new method was introduced providing the technology of main and rod journals with crossed axes crankshafts and circle grinding process in one setting, which provides stabilization of allowance removal and feeding on a circuit.

Requirements for precise machining of crankshafts used in automotive, aircraft, tractor, shipbuilding and other modern engineering industries are constantly increasing. It also should be provided high performance processing, which requires the development of more effective all-purpose crankshaft grinding techniques.

For the first time machining of main and rod journals in one setting was introduced by the company Junker (Germany) [1, 2]. Machining of main journals is like on a grinding machine. When machining of rod journals its contact with the circle occurs due to reciprocating motion in a plane passing through the axis of tool and crankshaft rotation which provides journal running per one workpiece cycle. During crankshaft rotation contact point wheel with the workpiece is out of the plane passing through the axis of tool and workpiece rotation, which leads to a change in the insert depth, and it is always larger than the allowance removal. This results in uneven allowance removal, reduces productivity and performance of machining.

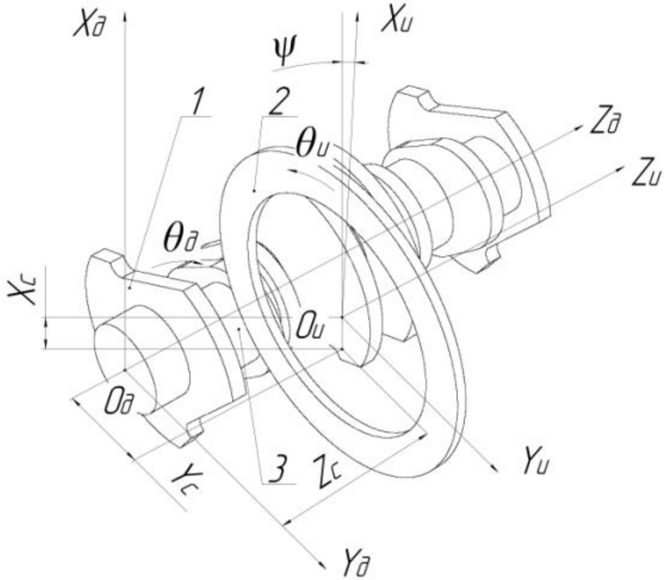
The aim of this work is to improve the performance and accuracy of main and rod journal machining in one setting by a narrow circle of supersolid materials at high speed deep grinding with crossed axes of the tool and the crankshaft due to stabilization of cutting depth stabilization, circuit feeding and allowance removal area at a uniform workpiece rotation. This can be achieved by synchronous vertical and transverse movements of the grinding wheel in case of rod journals machining.

The scheme of the new method of main and rod journals with crossed axes deep grinding 2 and workpiece 1 (Fig. 1), which after tapping, roughing allowance is removed with wheel face due to the longitudinal displacement, and finish grinding of main and rod journals are performed by periphery. The use of narrow circle provides versatility. Since the forces act towards the axial direction – the direction of maximum stiffness of crankshaft, it improves machining performance.

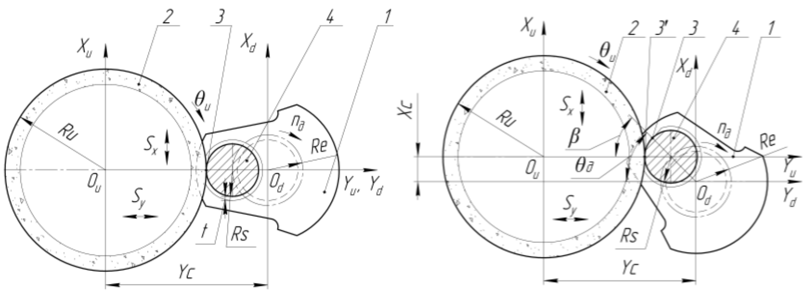
At a uniform rotation of the crankshaft 1 by an angle θ_∂ (Fig. 2, б) the point of contact with 3 laps 2 workpiece 1 moves at an angle $\beta=\theta_\partial$ from the horizontal plane of the rod journal 4. Due to synchronous vertical and transverse movements of the grinding wheel a constant cutting depth t (Fig. 2a) (depth is equal to the allowance), the circuit feeding and allowance removal area is provided. This improves the machining performance and quality. Circuit feeding is equal to

$$S_к = R_S \cdot \beta, \qquad (1)$$

where R*s* – semidiameter of rod journal crankshaft (Fig. 2, б); β – angle between contact points 3 та 3'.



Scheme1 – The design scheme of crankshaft grinding



a b

Scheme 2 – Scheme design rod journal new method

Semidiameter-vector of the machined crankshaft surface is described by the product of the crankshaft tool module, orientation and shaping module. [4, 5]

$$\overline{r}_{\partial} = C^{\phi}_{z_{\partial}\cdot\theta_{\partial}\cdot y_c} \cdot S^{o}_{\psi\cdot x_c} \cdot C^{u}_{z_u(i)\cdot\theta_u\cdot R_u(i)} \cdot \overline{e}4, \quad (2)$$

where $C^{u}_{Z_u(i)\cdot\theta_u\cdot R_u(i)}$ – cylinder module tool surface; $S^{o}_{\psi\cdot x_c}$ – spherical module orientation of the grinding wheel on the workpiece coordinate system; $C^{\phi}_{z_{\partial}\cdot\theta_{\partial}\cdot y_c}$ – forming a cylindrical module, which defines the movement of the tool relatively to the workpiece; subscript ψ, x_c, $z_∂$, $θ_∂$, y_c, $z_и(i)$, $θ_и$, $R_и(i)$ – reasons of one-coordinate matrix.

The workpiece surface depends on 6 parameters. These equations illustrates

$$z_∂ = θ_∂ \cdot p, \tag{3}$$

$$X_c(θ_∂) = R_e \cdot \sin θ_∂, \tag{4}$$

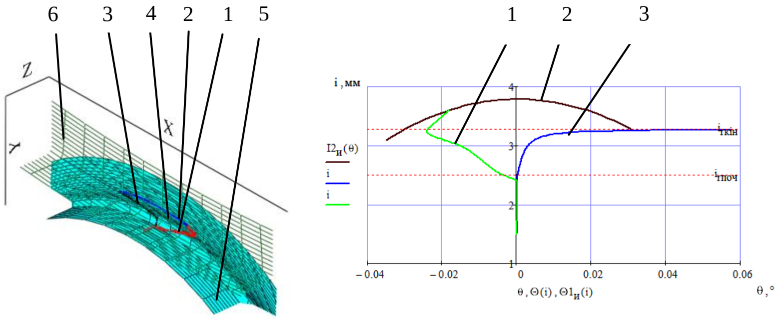
$$Y_c(θ_∂) = R_u + R_s + R_e \cdot \cos θ_∂. \tag{5}$$

$$\overline{V} \cdot \overline{n} = 0, \tag{6}$$

where R*e* – the eccentricity of (the semidiameter rotation of the rod journal relatively to the main journal axis of the crankshaft); R*u* – semidiameter of the grinding wheel; $\overline{n}$ – the unit vector normal to the surface of the tool; $\overline{V}$ – the relative velocity vector tool in the workpiece coordinate system.

Contact patch of cervical grinding wheel 4 under the machining of the cylindrical portion is shown in the Scheme 3, and by the intersection 1, 2, 3 based grinding wheel 6 and the end of the workpiece 5.

The Scheme 3b shows the lines : 1 – the intersection of the grinding wheel and the workpiece end; 2 – the intersection of the outer cylinder and workpiece grinding wheel; 3 – contact [5, 6].



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Scheme 3 – Intersection of the grinding wheel and shaft journal
a – contact patch of a workpiece with grinding circle
b – intersection line of grinding wheel and shaft journal

Specific grinding performance Q(i) is calculated by the formula

$$Q(i) = \int_{θ1(i)}^{θ2(i)} Vn(θ, i) \cdot Ru(i) dθ, \tag{7}$$

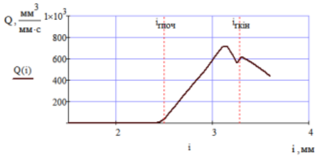
where Vn – the projection of the relative velocity in the direction normal to the surface of the circle; R*и* (*i*) – *i*-semidiameter of grinding wheel; θ1(i), θ2(i) –entry and exit angles of grinding workpiece wheel.

Contact area S is derived from the equation

$$S = \int_{i1}^{i2} \int_{θ1(i)}^{θ2(i)} Ru(i) dθ di, \tag{8}$$

where i1, i2 – limits of intergration.

The Scheme 4 shows specific capacity deployed on the x-axis which coincides with the periphery of the circle.



Scheme 4 – Distribution of the specific grinding performance under shaft journal machining

Conclusion

Three-dimensional geometric modeling of the tools is proposed as well as allowance removal and shaping of main and rod journals of crankshafts based on three standardized modules: the instrumental one, orientation and formation. Based on research modeling prototypes, a new method was introduced providing the technology of main and rod journals with crossed axes crankshafts and circle grinding process in one setting, which provides stabilization of cutting depth, feeding on a circuit and allowance removal area at uniform workpiece rotation. Machining is performed by one narrow wheel improving versatility of new technology and enables to machine main and rod journals of various crankshafts.

This technique can be applied to various complex profile cylindrical surfaces with crossed axes of the tool and workpiece grinding processes.

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