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METHOD OF PRECISION DIMENSIONAL ANALYSIS IN MODELLING OF TECHNOLOGICAL PROCESSES FOR SHAFTS MANUFACTURING

In this paper, we propose a method for conducting a dimensional - precision analysis of technological processes of making shafts using bench centers and consider the features of its application. A method for drawing up rotation error diagrams for processing shafts installed in the centers of lathes has developed, taking into account the principle of constancy of bases and the presence of an error in pre-centering the initial shaft workpiece

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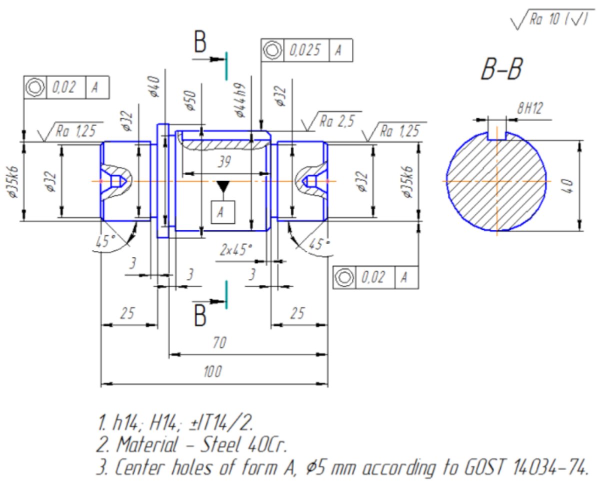
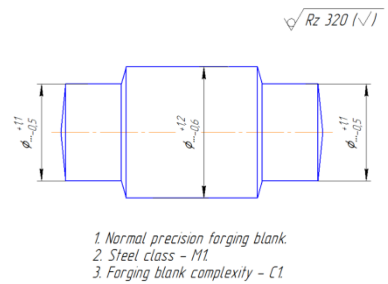
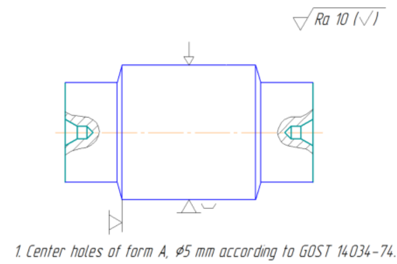
Figure 1 - Drawing for detail “Roller” and operating systems for its making using bench centers

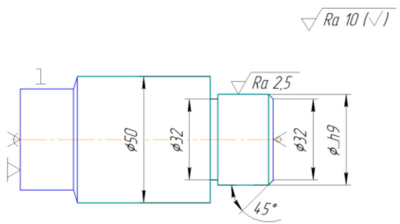




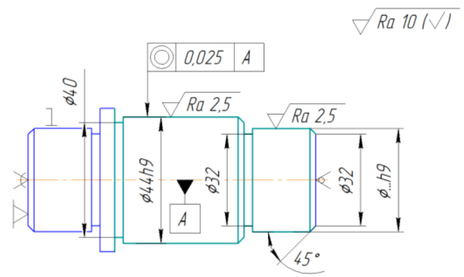
Operation 005 (OS1)



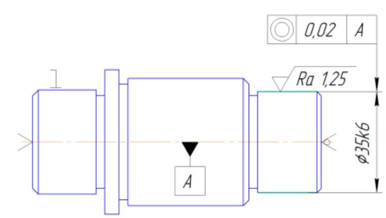
Operation 010 (OS2)



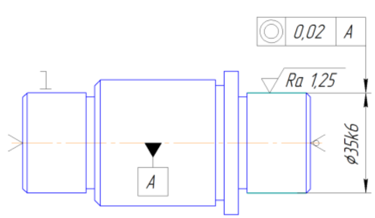
Operation 015 (OS3)



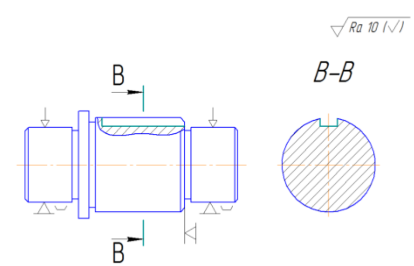
Operation 020 (OS4)



Operation 025 (OS5)

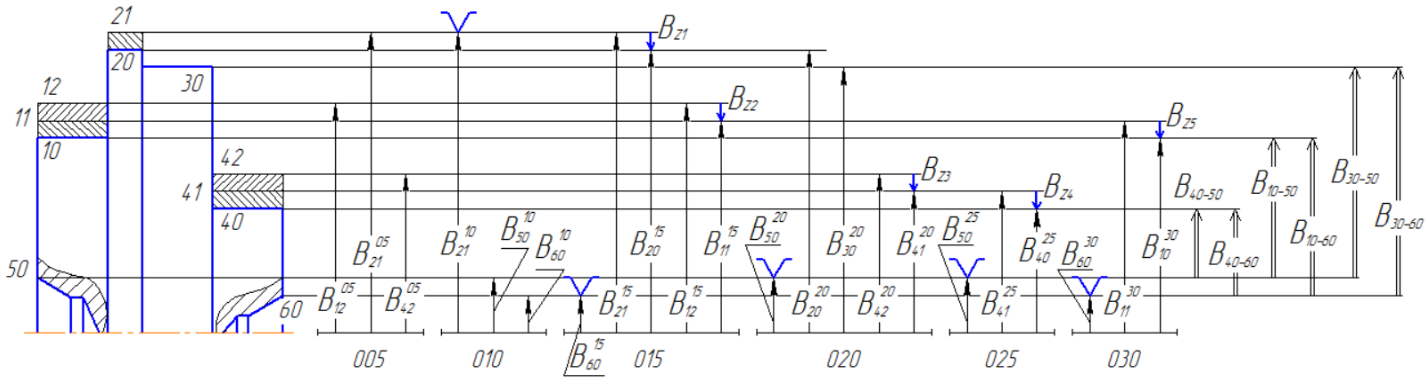


Operation 030 (OS6)

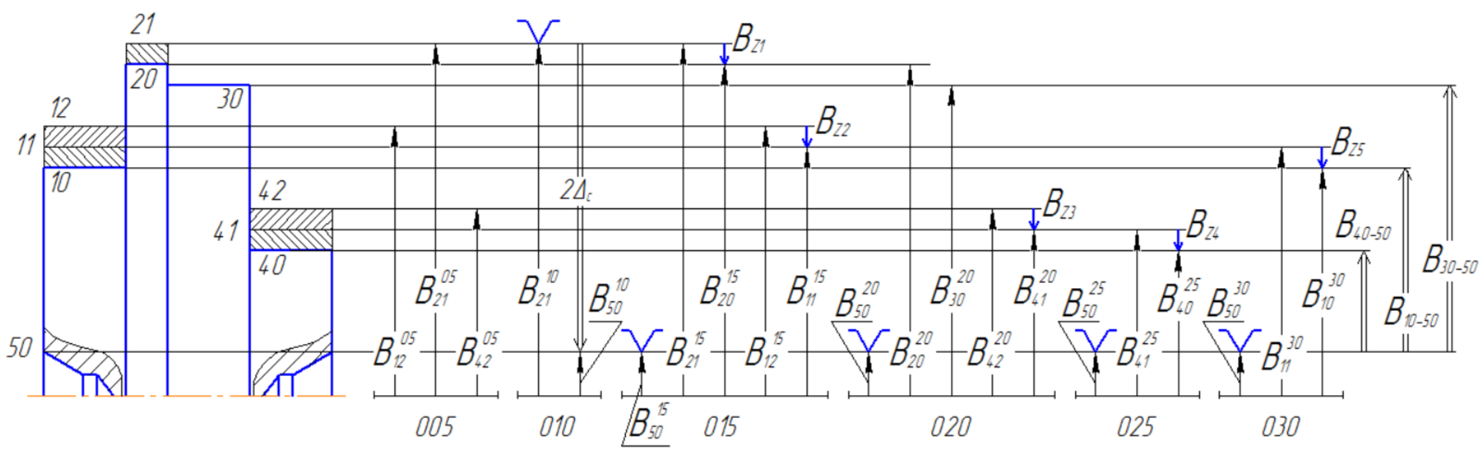


Operation 035 (OS7)

Figure 2 - Options for rotation error diagrams:
a – initial; b – final



a



b

Therefore, the rotation error equations of the processed rotation elements 12 and 42, respectively, at operations 015 and 020 are:

$$B_{12}^{15}=\sqrt{\left(B_{60}^{15}\right)^2+\left(B_{60}^{10}\right)^2+\left(B_{21}^{10}\right)^2+\left(B_{21}^{05}\right)^2+\left(B_{12}^{05}\right)^2} \qquad (1)$$

$$B_{42}^{20}=\sqrt{\left(B_{50}^{20}\right)^2+\left(B_{50}^{10}\right)^2+\left(B_{21}^{10}\right)^2+\left(B_{21}^{05}\right)^2+\left(B_{42}^{05}\right)^2} \qquad (2)$$

In equation (1), as one of the components of the rotation error chain, the rotation error of the base surface 60 is used (figure 2, a) that occurs when the workpiece is set to operation 015, and in equation (2), as one of the components of the rotation error chain, the rotation error is used the base surface 50 that occurs when the workpiece is installed in operation 020, that is, the rotation error of another base surface located in the TSW structure on the other side of the workpiece.

$$B_i^j=2\Delta_\Sigma \qquad (3)$$

Moreover, the total deviations Δ_Σ after drilling the hole, according to [8], are determined by the following formula:

$$\Delta_\Sigma=\sqrt{(\Delta_{dd}l)^2+C_{DAH}^2} \qquad (4)$$

$\boldsymbol{\Delta_{dd}}$ – drill drift value, microns per 1 mm; $\boldsymbol{l}$ – is the length of the drilled hole, mm; $\boldsymbol{C_{DAH}}$ – is the displacement of the axis of the hole, microns.

With this in mind, the final version of the rotation error diagram was developed, which is presented in figure 2, b. Therefore, a rotation error vector of center bevels (a single element at number 50) relative to the base surface (element at number 21) appeared, which is designated as 2ΔC. That is, in such cases, taking into account the above ratio B = 2e, this rotation error vector is considered as a doubled displacement of the axis of the chamfers because of the error in centering the workpiece. Using the rotation error diagram, it can be defined as follows:

$$2\Delta_C=\sqrt{\left(B_{50}^{10}\right)^2+\left(B_{21}^{10}\right)^2} \qquad (5)$$

$$\left(2\Delta_C\right)^2=\left(B_{50}^{10}\right)^2+\left(B_{21}^{10}\right)^2 \qquad (6)$$

In this case, the rotation error equations of the processed rotation elements 12 and 42, respectively, at operations 015 and 020 will look as follows:

$$B_{12}^{15} = \sqrt{\left(B_{50}^{15}\right)^2 + \left(B_{50}^{10}\right)^2 + \left(B_{21}^{10}\right)^2 + \left(B_{21}^{05}\right)^2 + \left(B_{12}^{05}\right)^2} = \sqrt{\left(B_{50}^{15}\right)^2 + \left(2\Delta_C\right)^2 + \left(B_{21}^{05}\right)^2 + \left(B_{12}^{05}\right)^2}$$

$$B_{42}^{20} = \sqrt{\left(B_{50}^{20}\right)^2 + \left(B_{50}^{10}\right)^2 + \left(B_{21}^{10}\right)^2 + \left(B_{21}^{05}\right)^2 + \left(B_{42}^{05}\right)^2} = \sqrt{\left(B_{50}^{20}\right)^2 + \left(2\Delta_C\right)^2 + \left(B_{21}^{05}\right)^2 + \left(B_{42}^{05}\right)^2}$$

Similarly:

$$B_{21}^{15} = \sqrt{\left(B_{50}^{15}\right)^2 + \left(B_{50}^{10}\right)^2 + \left(B_{21}^{10}\right)^2} = \sqrt{\left(B_{50}^{15}\right)^2 + \left(2\Delta_C\right)^2}$$

According to [11], the centering error ΔC – the offset of the workpiece axis as a result of the centering error relative to the workpiece base used in centering, is determined by the following formula:

$$\Delta_C = 0{,}25\sqrt{T^2 + 1} \qquad (7)$$

where T – is the tolerance on the diametric size of the base of the workpiece used for centering, mm.

$$B_i^j = 2\left(a_3\sqrt{D} + bL\right) \qquad (8)$$

where: D – diameter of the center chamfer; L – total length of the workpiece; $\boldsymbol{a_3}$ и $\boldsymbol{b}$ – coefficients depending on the accuracy of the installation: $\boldsymbol{a_3}$ = 0.006 and $\boldsymbol{b}$ = 0.00005 – normal installation accuracy, $\boldsymbol{a_3}$ = 0.0018 and $\boldsymbol{b}$ = 0.000015 – increased installation accuracy, $\boldsymbol{a_3}$ = 0.0009 and $\boldsymbol{b}$ = 0.000007 – high precision installation.

For the considered TP of making the “Roller” part according to formula (8), the rotation errors of the center chamfers (a single element at number 50) are determined in operations 015, 020, 025 and 030 (figure 2, b).