PROCESSING OF LARGE LENGTH SHAFTS

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Annotation

Shafts over 1.5 m long can be classified as long. Those of them that have a length-to-diameter ratio of more than 10 can be classified as non-rigid. The most characteristic shafts of high precision are the rods of hydraulic cylinders, boreholes of boring machines, cylindrical guides, shafts and rolling pins of various mechanisms, sliding and rolling screws, etc. Processing of such products requires the use of additional devices in machines to overcome the effects of deformations under the influence of cutting forces and gravity, as well as the risk of self-oscillation.

Keywords: precision, control, processing, detail, measurement, surface, orientation, machine tool, accuracy, direction, bench, scheme

Introduction

The problems that arise when fixing the work pieces during their installation on the machine are very serious. For turning, in order to increase the rigidity of the technological system, the front end of the work piece is fixed with the cams of the clamping chuck. During this procedure, the work piece is given a certain position in space. No matter how precise the clamping cams of the self-centering chuck are, the position of the work piece will always have an angular deviation from the axis of the machine centers. Alignment in a four-cam chuck with independent movement of the cams ensures the correct position of the work piece only near the cartridge.

Figure 1. Shows a diagram of the installation of a long shaft blank for turning. The most characteristic error is as follows

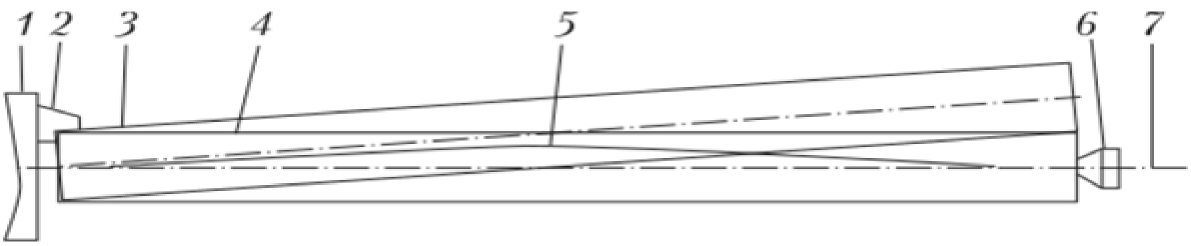

Figure 1. Installation diagram of a long shaft blank for turning

The work piece clamped by the cams 2 of the cartridge 1 assumes the position of the rear end of the work piece is offset from the axis of the centers of the machine 7 by a significant amount. When the rear center 6 is compressed, the work piece is deformed, its axis assumes a curved position 5. During the processing of the deformed work piece, its

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surfaces are given a position 4, concentric to the axis of the machine. But after loosening, it turns out that the processed part has a radial run out, determined by the position of the axis 5.

The question arises, how to get rid of the described processing errors?

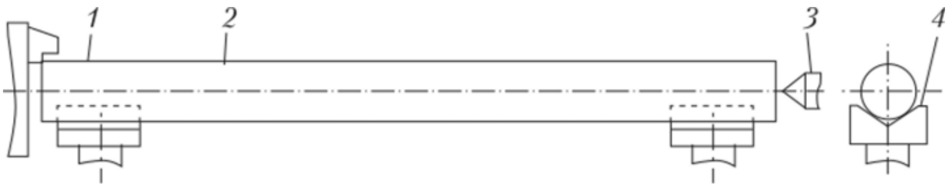


Fig. 2 Alignment of the long shaft

First, it is necessary to bring the work piece to the axis of the centers and only after that to fix it with the cams of 1 cartridge and press the rear center 3. There may be several solutions. Equip the machines with devices such as prismatic stands 4, which output a long blank to the axis of the centers both in height and on the side (Fig. 2). It is best if there are two such stands, for both ends of the work piece 2. You need to place the stands near the ends of the shaft.

It is even better to use not stands, but self-centering lunettes. It is even better to use not stands, but self-centering lunettes. There is no need for a large length of the clamping surfaces of the cams. It is enough to have one that will give the torque necessary for processing the work piece. Excessive length will lead to the likelihood of an increased angular displacement of the work piece from the axis of the machine centers during installation. The issue of finishing grinding of a long, non-rigid shaft deserves special attention. The most significant task is to eliminate the initial errors of the work piece, which are inherent in it after performing the previous processing and manifest themselves in the form of radial run out. In addition, it is necessary to obtain the exact dimensions. The processing is carried out in the fixed centers of the circular grinding machine, which eliminates the errors described above in fixing the chuck cams. When grinding, certain difficulties arise due to the low rigidity of the work pieces. The grinding wheel, when grinding, exerts a large radial force on the work piece, squeezes it. The diameter of the work piece will decrease, and the original radial run out will be preserved. Round-grinding machines are equipped with fixed lunettes, the use of which allows to increase the rigidity of the technological system. It is necessary to install the lunette cams on a surface that does not have a radial run out. Such a surface should be formed by grinding the necks under the lunettes. The first grinding by embedding is performed in a sufficiently rigid place of the work piece, i.e. close to the front or rear center. Radial run out at each revolution of the work piece is manifested by the approach of the outer surface to the grinding wheel and moving away from it. It is necessary to touch the surface of the work piece with the grinding wheel in such a way that a beam of sparks from the cutting zone occurs when the work piece approaches the circle and is interrupted at each revolution during the removal of the work piece from the circle. Radial feeding of the circle to the work piece is carried out only after the sparking stops completely. Each repeated radial feed of the circle should be so small that the intermittency of sparking is maintained. With each cutting cycle, the duration of contact of the grinding wheel with the work piece will increase. This indicates a decrease in radial run out. Such small-sized incisions can be stopped when the sparking on the polished neck becomes continuous. This shows that the radial runout has been eliminated. After that, you need to install the lunette cams on this neck and proceed to grinding the next place to install the second fixed lunette. The number of lunettes is determined by the length and rigidity of the work piece.

Installed in the centers and several fixed lunettes, the shaft blank of a large length is ground during the execution of a large number of working strokes.

The following operation of grinding a shaft of very low rigidity is proposed (Fig. 3).

1. Arrange the lunettes 6 along the length of the work piece, so that the distance between them, depending on the stiffness, is no more than 500-700 mm.

2. Put the clamp 2 on the end of the work piece (Fig. 10.76, a).

3. Put grease in the center holes: solidol or litol. Install the work piece 3 in the centers 1 and

4. Bring the lower cams of the lunettes under the work piece.

5. Using the lower cams of the lunettes, raise the work piece to the level of the axis of the centers.

6. Grind the neck closest to the spindle, lying on the lunette support, by cutting in to eliminate radial run out.

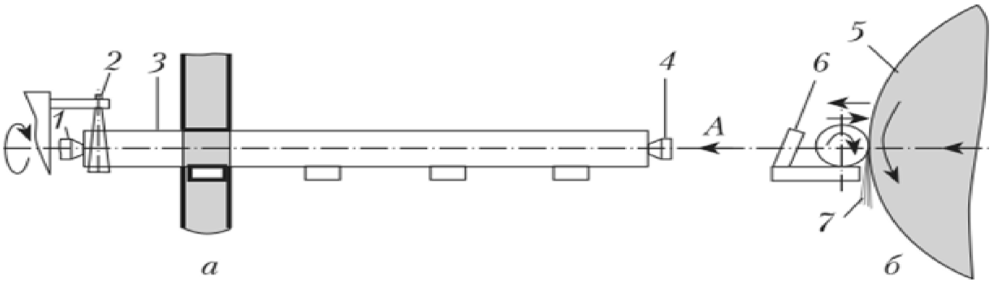
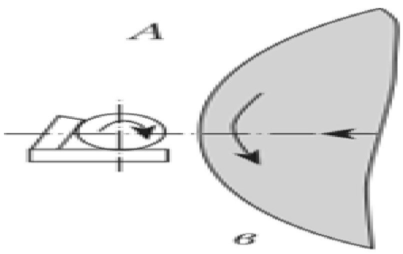


Figure 3. Long shaft grinding scheme



Such grinding has its own characteristics. ork piece lies freely on the lower support of ıette 6, and its radial runout is converted into erse movements (Fig. 10.76, b). Due to this ıent of the work piece, the rigidity of the ılogical system increases compared to the usly described free rotation of the work

It is important that the grinding wheel 5 comes into contact with the work piece when it moves along the cam of the lunette to the right. Grinding, as described earlier, becomes intermittent, as evidenced by a beam of sparks 7 from the cutting zone. It is necessary not to force the grinding and not to give the feed of the circle to the work piece until periodic sparking stops. After the complete cessation of sparking, it is necessary to apply a circle to the work piece in the transverse direction by a minimum amount until intermittent sparking appears. Grind until sparking stops. And repeat the minimum feed again. With each grinding cycle, the radial runout decreases, and the contact angle of the circle with the work piece increases.

The continuity of sparking at low pressure of the circle on the work piece indicates that the radial runout has decreased to zero.

7. Press the cams of the lunette to the polished surface of the work piece.
8. Proceed to a similar mortise grinding of the remaining places for the installation of the lunettes.
9. Install the lunettes alternately on each prepared surface.
10. Grind the outer surface of the work piece for its entire length with a significant number of working strokes.

The allowance is removed with a transverse feed S_n equal to 0.01—0.015 mm for each working stroke, during which the circle moves by a length /. At the end point, the transverse displacement of the h_p will be given again. The allowance is removed with a transverse feed s_n equal to 0.01—0.015 mm for each working stroke, during which the circle moves by a length /. At the end point, the transverse displacement of the h_p will be given again.

The rotation speed of the s_{Kp} work piece during round grinding of the steel shaft should not be less than 10 m/min in order to avoid surface burns. At the same time, the requirements of good roughness within Ra 0.8 microns does not allow to increase this speed to more than 15 m/min. It turns out a rather narrow range of rotation speed of the work piece, limiting the possibility of increasing productivity:

$$s_{\text{кр}} = \frac{\pi D n}{1000}, \quad n = \frac{1000 s_{\text{кр}}}{\pi D},$$

where D is the diameter of the ground surface, mm; n is the rotational speed of the work piece, rpm.

The longitudinal feed of the circle, mm, along the work piece in one revolution is equal to kV, and in one minute S_{np} = kW

$$s_{\text{пр}} = \frac{1000 k B s_{\text{кр}}}{\pi D},$$

where B is the width of the circle, mm; k < 1 is the fraction of the width of the circle.

The formula for calculating the basic time t_0, min, when grinding a surface with a length of I (in m) is as follows:

$$t_{\text{o}} = \frac{l\varepsilon}{2 s_{\text{пр}} s_{\text{п}}} + \frac{2l}{s_{\text{пр}}} = \frac{l}{s_{\text{пр}}}\left(\frac{\varepsilon}{2 s_{\text{п}}} + 2\right),$$

where 8 is the allowance for diameter, mm.

The second term in the equation reflects the need to perform two working strokes on the surface without transverse feed sn. These working passages are called nursing. The last of them, in order to obtain a good roughness, can be performed after straightening the circle on a slow feed, in which the abrasive grains will not be crumbled, but cut off.

The allowance for a diameter of 8 is divided by 2, since the grinding wheel during processing should only shift by half the amount of the allowance. For example, let's calculate the main time t_0 when grinding a circle with a width of 100 mm (with modes s_{Kp} = 12 m/min and S_n = 0.015 mm/stroke) of a shaft with a diameter of 100 mm, a length of 3 m, with an allowance for a diameter of 0.5 mm:

$$s_{\text{пр}} = \frac{1000 \cdot 0{,}5 \cdot 100 \cdot 12}{\pi 100} = 1911 \text{ мм/мин}; \quad t_{\text{o}} = \frac{3}{1{,}911}\left(\frac{0{,}5}{2 \cdot 0{,}015} + 2\right) = 29{,}3 \text{ мин}.$$

When grinding the surface of a relatively small length / shaft grinding performance can be increased by using a different processing scheme (Fig. 4) Pre-grinding is performed by transverse cuts to a depth slightly less than the value of the allowance e on the side, with the transition from the previous cut to the next at a distance almost equal to the width of the circle B. Then two nursing passes are performed along the entire the length of the work piece:

$$t_{o} = \frac{\varepsilon(l/B)}{s_{п} n} + \frac{2l}{s_{пр}},$$

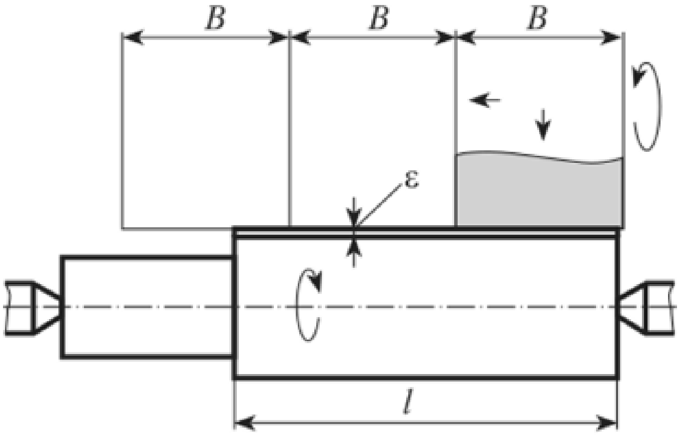


Fig.4 Grinding by embedding

where I/B is the number of cuts, which is rounded to the nearest integer.

It is possible to grind the outer cylindrical surfaces with the end of the circle. Figure 5 shows the grinding of a cylindrical surface in the form of a recess with two lateral end surfaces, which is typical for the support necks of turbine rotors and electric generators.

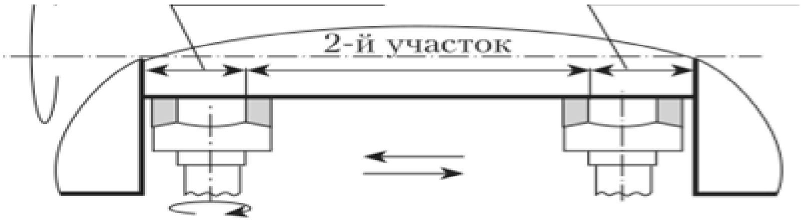


Figure 5 Grinding of the closed surface with the end of the circle

With such grinding, unlike face milling, the axis of the circle can be set according to the height of the centers. When the axes of the circle and the work piece are perpendicular to each other, a characteristic grid pattern appears on the second part of the surface — "fish scales" The method of face grinding of the rotor support necks, which have a relatively small diameter in comparison with neighboring surfaces, has proved itself well. It is almost impossible to reach the support necks with cylindrical circles. When grinding with the end of the circle, the axes of the tool and the work piece, unlike the end milling of cylindrical surfaces, lie in the same plane. To ensure high processing quality, it is necessary that the axis of rotation of the grinding wheel is strictly perpendicular to the axis of the work piece. In this case, the same surface quality is ensured at all three processing sites.

Figure 6 shows a photo of a Turning -grinding machine mod. RT958, designed for processing turbine rotors and electric machines

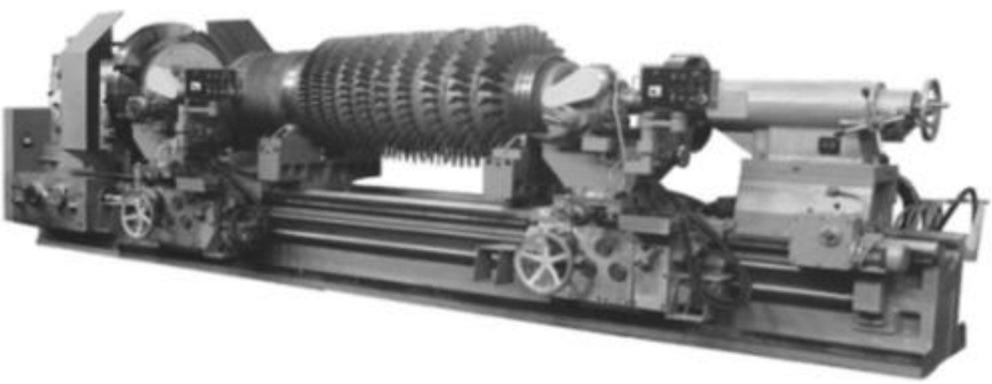


Figure 6. Turning and grinding machine.

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