Automated complex for stabilized straightening of low-stiff cylindrical parts

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Abstract. The analysis of problems and tasks in the field of technology editing. A block diagram of an automated complex for stabilized straightening of low-stiff cylindrical parts by cross-rolling with smooth plates is presented. A block diagram of a software package has been proposed, the main function of which is to automate the straightening of cross-facing with smooth plates, as well as to provide all the technological parameters of the process. To improve the productivity of editing and automation of operations, new automated devices for editing low-stiff rigid cylindrical parts such as shafts and axles have been designed.

Low-stiff rigid cylindrical parts such as shafts and axles are widely used in the agricultural, mining, automotive, aviation industries and household appliances [1, 2]. One of the problems arising in the manufacture of such parts is the distortion of their rectilinear geometric shape [3, 4]. To restore these parts one of the main technological operations is the editing operation [5, 6]. Because of the editing, it is required to obtain a working detail with the necessary set of consumer properties: wear resistance, heat resistance, heat resistance, corrosion resistance, etc [7, 8]. When repairing, straightening is used to restore both flat and cylindrical parts [9, 10]. The straightening operation must be performed on specialized correct equipment, preferably equipped with modern CNC systems [10, 11]. The quality of editing workpieces and parts depends on the correct design of equipment and process technology [12, 13]. The equipment management program should determine editing technology [14, 15]. The proposed cross-run correction with smooth plates is carried out in two stages [16, 17]. First, the workpiece is straightened by a transverse bend under the influence of a distributed load to ensure the straightness of the part [18, 19]. Then, the workpiece is hardened by means of surface plastic deformation, based on transverse rolling with smooth plates, which controls the residual technological stresses after bending, ensures the stability of the straight form of the part and forms equilibrium residual stresses [20, 21].

Tasks in the field of technology editing low-stiff cylindrical parts of the cross-running smooth plates [22]:

- Optimal management of equipment for editing;
- Tooling design taking into account the kinematic capabilities of the equipment;
- Assessment of the quality of parts after the editing operation.

In order to achieve precision accuracy of low-stiff parts such as shafts and axles, computer modeling was used for straightening by rolling in with smooth plates. Using the Ansys Workbench application program [23, 24], a model of the stress-strain state of editing of cylindrical parts by running with flat plates has been developed and implemented, which allows:
- Determine the optimal parameters of the straightening process, which ensure high quality of the surface layer and high geometrical accuracy of the parts after straightening [25];
- Determine the stress-strain state in the process of editing and residual stress after unloading parts [26].

The general block diagram for solving the problem in the Ansys Workbench program is presented in figure 1.

**Figure 1.** Flowchart modeling process editing using Ansys Workbench.

In terms of mass production to ensure high productivity, it is proposed to design a device for continuous dressing of cylindrical products with smooth slabs. Figure 2, a shows a diagram of the proposed device, a general view of the assembly, and figure 2, b shows a top view of this device.
Figure 2. A device for straightening cylindrical parts with smooth plates: a) - type of assembly; b) - top view.

The following numerical designations are assigned to the device elements:

1 - Limit Switch
2 - Guide
3 - Slider
4 - Movable deforming tool
5 - Frame
6 - Table
7 - Lower wedge
8 - Screw
9 - Boxes for machined parts
10 - Upper wedge
11 - Fixed deforming tool
12 - Protrusion
13 - Workpieces
14 - Pusher
15 - Bunker
16 - Automated device for controlling the
      diametral dimensions and the curvature of
      the shape of parts such as shafts and axles
17 - Computer
18 - Supports
19 - Indicator
20 - Tray
21 - Sensor

The device comprises a frame 5 on which a table 6 is mounted with a mechanism for adjusting the height of a fixed deforming tool 11 consisting of an upper wedge 10, a lower wedge 7 and a screw 8, as well as guides 2 in which a slide-forward 3 moves with a reciprocating motion 4 with a protrusion 12. The deforming tool 11 has two supports 18 for bending the workpiece during straightening. Drive slider 3 is a crank-rocker. A switch 1 is installed on the guides, which is triggered and gives a signal to the pusher 14 with the help of which the workpieces 13 are pushed out of the tray 20 into the side of the processing zone. Installed box 9 for placing finished products. An automated device 16 for controlling the diametrical dimensions and the curvature of the shape of parts such as shafts and axles is connected to computer 17, which works as follows: after loading a batch of parts, the monitoring device and the computer turn on. The indicator 19 is connected to the computer 17 to measure the total deflection. Screw 8 serves to regulate the value of the absolute compression.

The device works as follows. The automated device 16 measures the diametrical dimensions and the curvature of the workpiece shape, which gives a signal to the computer 17. The computer 17 determines the total deflection of the workpiece, and information is transmitted to the device 19. Next, the workpiece moves to the tray 20 through the hopper 15 and here the sensor 21 controls the direction of...
At the approach of the slider 3 to the extreme right position, the slider acts on the switch 1, which gives a signal to the pusher 14. As a result, the workpiece 13 from the tray moves to the machining zone. Next, the slider 3 moves to the right and stops after touching the workpiece 13 with the protrusion 12. Then the slider 3 continues to move to the right by the amount of total deflection. When moving the slide 3 in the direction from right to left, the billet 13 is gripped and the billet is transversely rolled. At the end of the stroke of the slide 3, the finished product is moved to the receiving box 9. After this, the operation of the device is repeated.

The use of a wedge mechanism for adjusting the height of a stationary deforming tool in conjunction with the other essential features allows for a quick readjustment of the device to the processing of other standard parts and precise installation of the technological closed height between the tools. In the process of rolling cylindrical parts with smooth plates, the absolute compression value is the main parameter that influences the effect of the dressing process, including the distribution of the uniformity of residual stresses, the magnitude of the residual deformation, the depth and degree of work hardening, and the surface roughness. Thus, the exact installation of a closed height between the tools allows you to achieve the desired processing effect with high reliability of the device, as well as to expand its technological capabilities.

**Conclusions**

Thus, the proposed automated system for stabilized straightening of low-stiff rigid cylindrical blanks has advanced technological capabilities, such as straightening blanks with different diameters and the possibility of straightening blanks of different curvature. Automated complex provides high performance editing process, high quality of the surface layer and high stability of the shape of machine parts.

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