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STEEL WIRE DRAWING IN DOUBLE DIES: PROCESS FEATURES

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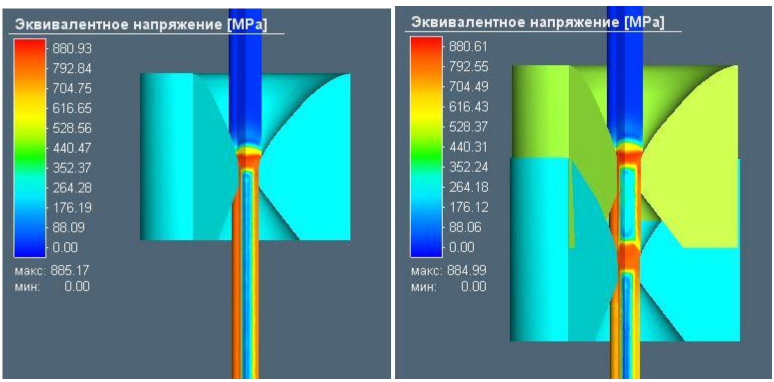
To increase productivity of metal working processes, a double die wire drawing process is proposed. This process provides high productivity by improving the uniformity of stress distribution across the wire cross section [1]. In this case breakage during wire drawing and equipment downtime can be reduced.

With the help of three-dimensional scanning, the geometrical parameters of the drawing channel were obtained. Based on the obtained geometrical parameters, a numerical model of double- and single-die drawing was built [2]. Based on the simulation results, it was confirmed that the stress state corresponds to the hardness distribution obtained by processing the experimental results.

To determine the equivalent stress distribution in the wire cross-section during the drawing process from the ratio of the extracts of the first die to the second die, additional calculations were made in intermediate versions of the relations of the extracts of the die. The results of the uniformity of equivalent stresses distribution are shown in Figure 1.



a) b)

Fig. 1. The results of the uniformity of equivalent stresses distribution:
a) single die; b) double die

Figure 1 shows that the stress values in the deformation zone of the first and the second drawing die are almost equal. The stress distribution is uniform in the wire cross section in the deformation zone. After drawing, the stress distribution in the wire is such that the stresses are rising from the center to the surface with no abnormal transition zones. A uniform stress distribution in the wire means a more complete deformation of the wire cross section, which is confirmed by the obtained data on the distribution of microhardness across the cross section. The uniformity of microhardness distribution across the wire cross section after double die drawing is approximately twice higher compared with that in a single die drawn wire. The uniformity evaluation criterion is the standard deviation of the hardness values.

Based on the results of the experiment, it was determined that the most uniform distribution of microhardness across the steel wire cross section is observed in the double die drawn specimens (the standard deviation is 26 units for a double die versus 54 units for a single die). The double die drawn wire has a higher overall hardness compared with the single die drawn wire.

The dependence of the stresses in the wire on the Kd ratio in the investigated section is described by the formula (1):

$$\sigma_{avrg} = 8381.4Kd^3 - 23130Kd^2 + 21391Kd - 5862.8 \quad (1)$$

where σ_{avrg} – the average drawing stress in deformation zones during drawing, MPa;
Kd – a ratio between drawing in the first die and drawing in the second die.

Based on the research results, it was determined that the highest drawing stress occurs when drawing in a single die. The double-die wire has a higher hardness compared with the single-die wire. This means more intense wire hardening when drawing in a double die. An increase in Kd leads to an increase in the drawing stress. According to the results of numerical simulation, the most uniform stress distribution is observed at Kd = 0.927. The distribution of drawing stresses in the numerical model corresponds to the distribution of microhardness across the cross section of a thin wire after the experiment, which confirms the adequacy of the constructed model.

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NEW TECHNIQUE OF METAL SURFACE RESTORATION AND REINFORCEMENT

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At some heavy-manufacturing plants, up to 30% of the output consists of large composite components, in which the working surfaces—for example, for rollers in rolling mills, drive gears, and universal spindles—may be restored so as to extend the working life [1, 2]. This approach is particularly useful for large products such as rollers, each of which may be of mass 230 t in thicksheet mills. The wear of the working surface of the roller barrel is no more than 5–7% of the initial diameter when the roller