Study of the Influence of Rolling Modes and Regimes on the Physical and Mechanical Properties of the Thread

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ABSTRACT

The article presents studies of the regularity of the influence of the diameter of the workpiece for thread rolling on the resulting thread profile by rolling with two rollers on the stop.

Keywords: Microrelief, thread surface, physical and mechanical properties, microhardness, deformation, bolt, limit size, diameter, force, rolling, limit size.

The operational properties of machine parts are significantly determined by the physical and mechanical parameters of the working surface layer of the parts and the geometric characteristics of the micro-relief of the surface. During the process of thread rolling under the action of plastic deformation, the physico-mechanical properties of the surface layer of the metal change. A rivet is formed that increases strength and hardness, residual compressive stresses appear with the desired distribution along the cross-section of the part, the shape and orientation of the crystals are modified, a fibrous structure appears, the process of carbide formation occurs, blocking dislocation shifts and other changes. As a result, a modification of the shape and orientation of the crystals occurs. of these transformations increases the resistance of the surface layer to plastic deformation and destruction.

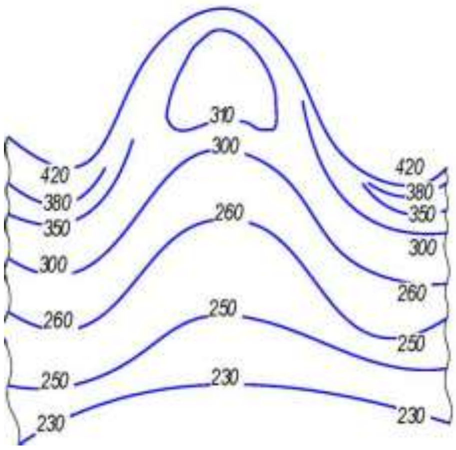
The fatigue strength of the parts is even more influenced by the change in the physical and mechanical parameters of the surface layer of the metal of the workpiece in the process of thread rolling. The cyclic strength of the parts is greaterly increased by the rivet of the surface layer formed during the rolling process and the texture of the metal. Residual compression stresses in the surface layer of the metal are also conducive to this.

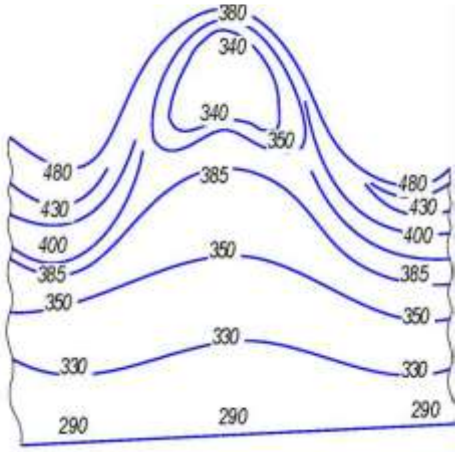
It is worth noting that in the process of rolling the thread there is a continuous relative slippage of the metal of the workpiece relative to the working surface of the tool. For this reason, threads obtained by the method of plastic deformation have a higher class of roughness of the profile surface than the roughness of the thread profile obtained by grinding. The highest concentration of voltages for high-load threaded parts occurs at the depressions of the thread profile. Therefore, to increase fatigue strength, it is necessary to strive to minimize the minimum parameter of surface roughness for such areas.

In the study of the influence of conditions and modes of rolling on the microhardness of the surface layers of bolt threads, microhardness was measured on the PMT-3 device by pressing a tetrahedral diamond pyramid with a load of 0.5 N. Measurements were carried out on longitudinal grinds in the region of the third and fourth turns from the end of the bolt in the cross-section with a plane passing through the bolt axis. Indentation was done at a distance of 0.02 ... 0.03 mm from the thread surface. To eliminate the influence of the grinding process on the degree of riveting of the metal, the bolt sample was cut, with preliminary grinding on small feeds with abundant cooling of the grinding surface, followed by electrolytic polishing of the sample surface.

Analysis of the results is shown in Figure 1, where it can be seen that the greatest microcurrency is observed in the zones of constrained deformation in the thread depressions, and the smallest - in the zones of free flow of the metal, i.e. near the axis of the rod and in the turns of the thread) [1].

In the case of thread rolling in conditions of an unfilled circuit with a small radial feed in the surface layers at a shallow depth, the rivet is localized (Fig. 1, (a), characterized by high heterogeneity within a single orbit.





a) b)

Rice. 1 - Scheme of distribution of microhardness on the longitudinal Thread cross-section

With an increase in radial supply:

- the depth of penetration of the deformation into the bolt or stud increases;
- there is an increase in the hardness of the metal in the coil and core of the bolt rod.

The additional riveting of the surface layers of the metal causes an increase in the rotation frequency of the rollers and the duration of rolling [3].

Analysis of the effect of the diameter of the workpiece for thread rolling on the resulting thread profile

One of the conditions for the formation of threads, on which the accuracy of the basic dimensions depends, and the shape of the threaded profile of the bolts is the formation of the thread taking into account the average values of the diameter of the workpiece and mechanical characteristics, however, as well as the parameters of the rolling modes. From this we can conclude that fluctuations in the diameter of the workpiece and the pressure in the hydraulic circuit (in the profile of knurling machines with hydraulic feed of tools) have the main effect on the spread of the dimensions of the threads of the bolts.

Consider the regularities of the influence of the diameter of the workpiece for thread rolling on the resulting thread profile. The object of this analysis will be the formation of a profile of metric threads by rolling two rollers on the stop, used in production conditions. The stop provides a high degree of accuracy of thread diameters, reducing the spread of thread diameters by limiting the radial movement of the rollers and thereby ensuring the maximum value of the rolling force.

To study the influence of the diameter of the workpiece for thread rolling on the resulting profile, let's take as an example the previously considered high-strength bolt M20-90 cd OST1-31103-80 with a hexagonal head and an increased turnkey size. This bolt is used mainly for connecting and fastening high-load threaded joints of steel structures in the aircraft industry. The workpiece has the following parameters: the rod with a length of 90 mm (±0.5 mm) up to the head has at the end a part with the right thread M20 length of 28 mm, a pitch of 1.5 mm and a tolerance field of 6e for cadmium coating, and the smooth part is made with a diameter equal to the nominal thread diameter with a tolerance of -0.75 and a length of 62 mm. The limiting dimensions of the screw thread of tolerance class 6e are presented in Table 1.

Table 1 - Maximum dimensions of screw thread M20x1.5 tolerance class 6e

Outer diameter		Medium diameter		Inner diameter
Not >	Not <	Not >	Not <	
19,650	19,315	18,026	17,856	16,944

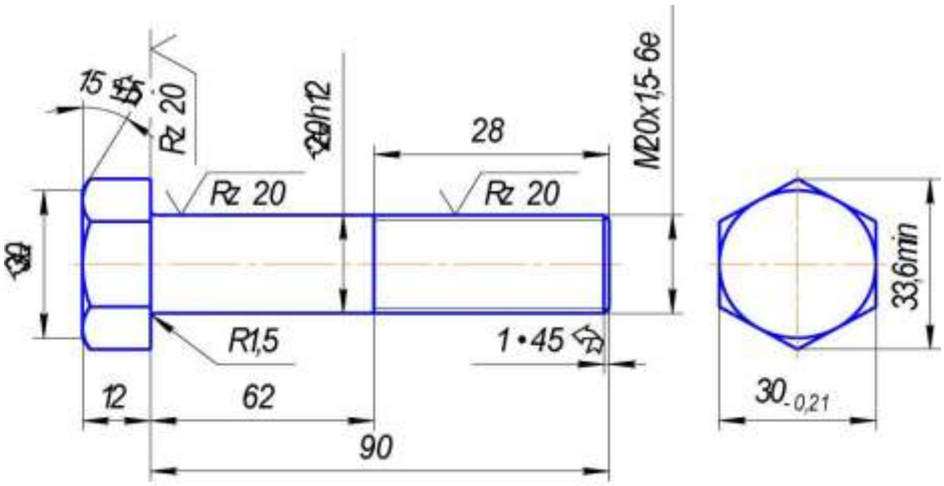


Fig. 2. Bolt M20-90 cd OST1-31103-80.

With the help of CAD systems, it is also possible to determine the diameter of the workpiece when rolling the external and internal threads. To do this, it is necessary to build 3D models of the vertices and depressions of the thread being rolled and achieve equality of their volumes." 3). Having calculated the diameter for knurling from the condition of equality of volumes, we get the diameterof the original workpiece equal to 18.9 mm [2].

Fig.3.Determination of the diameter of the workpiece for rolling thread M 20x1.5 using 3D modeling.

To identify the regularity of the influence of the diameter of the workpiece on the resulting thread profile, we need to find a rational diameter for the knurling. To do this, we will conduct several experiments using the result obtained. For the experiment of the samples, we will change the diameter of the section under the knurling d_{zag} with an initially unchanged body length of the bolt of the workpiece Lnach = 90 mm. The results of the measurements are given in Table 2.

Table 2. - Measurements of experimental results of choosing a diameter for knurling T_d = 236 µm.

Knurling workpiece diameter dzag=19.1 mm, Lnach=90 mm:					
Sample Number	№1	№2	№3	№4	№5
d internal, mm	16,95	16,95	16,95	16,95	16,95
D external, mm	19,9	19,85	19,95	19,85	19,9
L (length), mm	90,1	90,1	90	90,1	90
Knurling workpiece diameter d_{zag}=19 mm, L_{nach} =90 mm:					
N образца	1	2	3	4	5
d internal, mm	16,95	16,94	16,95	16,95	16,95
Dexternal, mm	19,7	19,6	19,75	19,7	19,65
L (length), mm	90	90,1	90	90	90
Knurling workpiece diameter d_{zag} = 18,95 mm, L_{start}=90 mm:					
Sample Number	№1	№2	№3	№4	№5
d internal, mm	16,95	16,94	16,94	16,94	16,94
D external, mm	19,45	19,47	19,55	19,5	19,55
L (length), mm	90	90	90	90	90
Knurling workpiece diameter d_{zag} = 18,9 mm, D_{start} = 90 mm:					
Sample Number	№1	№2	№3	№4	№5
d internal, mm	16,94	16,94	16,94	16,94	16,94
D external, mm	19,4	19,47	19,55	19,42	19,45
L (length), mm	90	90	90	90	90
Knurling workpiece diameter d_{zag} = 18,85 mm, , L_{nach} = 90 mm:					
Sample Number	№1	№2	№3	№4	№5
d internal, mm	16,94	16,94	16,94	16,94	16,94
D external, mm	19,2	19,2	19,2	19,1	19,3
L (length), mm	90	90	90	90	90

From the data obtained , it can be determined that the best result is obtained with the values of the diameter under the knurling d_{zag} = 18.95 mm, while the internal and external diameters of the knurled thread are within the tolerance.

Due to the presence of a stop, the bolt workpiece perceives only the necessary part of the rolling force, since the movement of the roller is limited, therefore, the inner and middle diameters of the bolt thread are practically independent of the diameter of the bolt workpiece for rolling. But the outer diameter of the bolt thread and the degree of filling of the thread contour largely depend on the deviations of the diameter of the bolt workpiece for rolling.

The regularities of the influence of the diameter of the workpiece for thread rolling on the resulting thread profile by rolling two rollers on the stop are investigated. It is established that due to the limitation of the greatest movement of the roller to the stop, the inner and middle diameters of the bolt thread are practically independent of the diameter of the bolt workpiece under the stop. rolling. But the outer diameter of the bolt thread and, as a result, the degree of filling of the circuit depend on the deviation of the values of the diameter of the bolt workpiece for rolling. The diameter for rolling the initial workpiece is calculated from the condition of equality of volumes, a rational diameter for knurling is revealed, which ensures the greatest compliance of the tolerance limits of the inner and outer diameters of the rolled thread.

Literature.

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