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Improvement of the environmental safety of weaving equipment by reducing the wear of contact surfaces

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Abstract. The purpose of the work is improvement of the environmental safety of weaving equipment by reducing the wear of contact surfaces. For the environment, minimizing the wear during the operation of weaving equipment is of great importance. Nevertheless, the physical-chemical interaction of metal surfaces with the environment in its individual sections is uneven due to its polycrystalline structure and heterogeneity. At the same time, the value of their residual stresses (microstresses), the degree of plastic deformation, etc., have a significant effect on the physical and chemical activity of separate surface grains. The article covers the causes of wear of the batten mechanism of a shuttleless loom because of friction. In order to ensure the environmental safety of weaving equipment, methods of increasing the wear resistance of the batten mechanisms of shuttleless looms have been proposed. The article substantiates that an effective method for improving the efficiency of the batten mechanisms of shuttleless looms can be the method of surface plastic deformation of the inner surface of the batten teeth shed. As a result, the uniformity of the physical-chemical interaction of metal surfaces with the environment is ensured, as the resistance to wear and fatigue failure increases.

1 Introduction

Considering the matters of environmental safety of sewing and weaving equipment, many authors [1-3] identify a number of possibilities that are aimed at increasing the efficiency of the physical-chemical interaction of metal surfaces with the environment and reducing the wear of contact surfaces. It is important to minimize the wear and tear of weaving equipment during its operation over a long period. The statistics of accounting for downtime of shuttleless looms (SLL) at textile industry enterprises shows that 28% of downtime is caused by breakdowns of the elements of the batten mechanism, with the most frequently observed failure of such elements as the batten shaft and reed [4].

In [5, 6] it is shown that the most common malfunction of the batten mechanism of the SLL-type looms is the wear of the batten teeth (guide comb), which leads to a noticeable increase in warp thread breakage and reduces the quality of gray cloth due to defects. The

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characteristic wear of the working surfaces of the teeth of the batten (Figure 1) occurs in force sliding contact with the thread plotter.

Fig. 1. Wear of the inner contact surfaces of the batten teeth.

The thread plotter moves from the receiving box of the loom to the breakage box with the help of a conveyor, and from 13 to 17 thread plotters are in operation on the loom at the same time. The movement of the thread plotter through the shed at a moment of pick imparts the combat mechanism of SLL-type looms, which differs significantly in design from the breakage mechanisms of shuttle machines. The strength of the breakage depends on the potential energy of the twisted torsion shaft and does not depend on the speed of the loom. Looms with lamellar weft layers have a main shaft speed of 160-260 min^{-1}, depending on the width of the loom and the presence of a multi-color weft mechanism.

Theoretical speed of the guide increases with time as the torsion shaft unwinds and reaches its maximum value by the end of acceleration. The accelerated guide breaks away from the race at a moment the oil brake starts to act when the torsion shaft is unwound by about 14°, reaching a speed of 22-24 m/s. The initial speed of the thread plotter when processing combed wool yarn is set at about 24 m/s, and when processing hardware yarn is 16-18 m/s [7].

2 Materials and methods

In order to ensure reliable operation of the breakage mechanism of SLL-type loom, it is necessary that the oil brake completely absorb all the kinetic energy of the breakage mechanism after the weft layer accelerates.

The wear of the contact surfaces of the batten teeth occurs under conditions of high-speed relative sliding of the thread guide with lubrication. Careful inspection and analysis of the friction surfaces on the shed showed the following. The wear of the friction surfaces (Figure

1) on the tooth after their operation is uneven, which may be due to different values of local specific pressures and relative slip velocities on the friction surface, unequal penetration of the lubricant into the contact zone, etc.

The most intense wear occurs on a short section of the shed, which can be estimated by the main characteristic of parts wear, i.e. the linear wear U, measured in the direction perpendicular to the friction surface. As linear wear develops, its transformation and the appearance of the so-called wear dimple with some curvature are observed. This formation has nothing to do with the wear hole on the front surface of tools when cutting metals, when its formation is associated with chip formation and the degree of interaction between the machined and tool materials.

Initiation of a clearly defined wear hole on the contact surface of the batten tooth, apparently, is also associated with the curvilinear profile of the working surfaces of the thread guide, corresponding to a half-cylinder. As a result of the initiation of a wear hole, considering the conjugated pair “thread guide – batten tooth” as temporary and fleeting, they change relative to their position at a high speed of sliding of the filament guide over the batten teeth, which cannot but cause additional dynamic loads in the zone of their contact. This can lead to an increase in the breakage of the warp threads, all other things being equal in the process.

3 Results and discussion

Wear caused by friction of conjugated surfaces is the most typical type of damage to most machines and their mechanisms. In accordance with GOST 16429-70, wear is a process of gradual change in body dimensions during friction, which can be seen in the separation of the material from the friction surface and (or) its permanent deformation [8].

In general, during the contact of two mating surfaces and their relative movement in the surface layers, mechanical and molecular interactions arise, which ultimately lead to the destruction of surface microvolumes, i.e. to their wear.

Considering the cyclic repeated loading of batten teeth at dynamic contact with the thread guide, and analyzing the wear surfaces, it can be stated that mechanical wear takes place, i.e. one of the three types of wear according to the above standard. In this case, it can be assumed that mechanical wear is realized through its variety, such as fatigue wear.

Theory of fatigue wear [9] is based on idea that the main reason for the destruction of surface layers is the occurrence of fatigue cracks and the separation of microscopic flakes of the material or its oxides. The wear process is considered as a summing action of individual factors under repeated loading of friction bonds, which ultimately leads to the separation of a wear particle. Separation of particles can occur because of work hardening of the surface layer, which becomes brittle and deforms (sometimes called brittle fracture wear).

Distribution of macrostresses in the surface layer of blanks, for example, after cutting, in the first approximation, is explained by the action of two factors, i.e. mechanical (plastic deformation), which provides only compressive stresses, and thermal (heating of the surface layer), which is the cause of the formation of only tensile stresses. This scheme can be violated if the cutting process is accompanied by phase transformations, which are sometimes a stronger source of macrostress formation in surface layers than mechanical and thermal factors.

The real picture of the occurrence of macrostresses must also consider the direction of the force load acting on the surface layer during the processing of the part, i.e. both tensile and compressive stresses can be created in the surface layer of the part depending on the direction of the force field.

The main process that occurs during the friction of materials and leads to wear is elastic-plastic deformation because of the interaction of surface microreliefs. In turn, this process generates and is accompanied by a whole complex of derivatives of mechanical (for example, hardening, fatigue failure) physical and chemical processes occurring on surfaces and in surface layers of rubbing bodies.

It is necessary to distinguish between contact fatigue of surface layers, which occurs during pure rolling and manifests itself in the development of local centers of destruction, and fatigue wear, when, during sliding friction, the separation of surface microvolumes, as noted above, is associated with the fatigue nature of deformation.

The quality indicators of product manufacturing, which are the result of the adopted technological process, have a direct impact on such a main operational property as surface wear resistance. One of the main methods for producing reliable products is to ensure the reliability of the technological process itself, and to create a margin in the values of the parameters that determine the performance of the product.

Among the trends in the development of modern technological processes, it is necessary to note such important areas as the development and dissemination of hardening technology methods, especially for hardening special parts of the working bodies of technological machines, obtaining a high quality surface layer, [10, 11] the use of coatings, etc., which are necessary a condition for the production of reliable engineering products.

Special types of processing that increase wear resistance, fatigue strength and corrosion resistance of products can increase the safety margin of the process. For these purposes, technological processes are used that strengthen the surface layer, which acquires special properties. This includes, first, hardening technology based on the surface plastic deformation (SPD methods), as well as chemical-thermal treatment processes and other special methods [12].

When applying SPD methods, because of cold hardening (strain hardening), crystal grains are transformed in the surface layers, hardness increases, favorable compressive residual stresses are formed, which contribute to an increase in wear resistance and fatigue fracture resistance.

Elastic-plastic deformation during machining changes the structurally sensitive physical and chemical properties of the surface layer of the metal in comparison with its initial state. In the crystal lattice, the number of dislocations, i.e. linear imperfections, vacancies and other lattice defects sharply increases. The shape and size of the grains change, near the surface they are crushed (grain breakage into fragments and blocks with an angular orientation) and elongated, oriented in the direction of the deformation force (in this case, texture formation is possible).

In the deformed surface layer, deformation resistance characteristics increase; strength characteristics change under long-term static and cyclic loading at high temperatures; plasticity characteristics are reduced (relative elongation and narrowing); increases hardness, brittleness (impact strength decreases), internal friction; the density decreases.

In order to determine the parameters of strain hardening (depth, degree, and gradient of work hardening), the methods of measuring microhardness along the surface of oblique cuts and with layer-by-layer chemical etching, as well as methods of X-ray diffraction analysis, are most widely used.

Residual stresses arise in their surface layer because of the temperature-force impact of various technological processes of mechanical processing of parts. Although each technological process has its own characteristics, the mechanism of formation of residual stresses is based on an irreversible inhomogeneous distribution of deformation over the volume of the part. The appearance of residual stresses that exist and balance inside a solid body after the elimination of the causes of their occurrence is associated with the conditions of manufacture and operation of parts. The surface of the metal has an increased chemical activity because the atoms here have unilateral bonds in the bulk of the body, so the metal in the boundary zone is in an unstable state. In real conditions, the metal surface adsorbs the atoms of the elements of the environment, becoming covered with layers of absorbed gases, water vapor and fats. The impact of the external environment also leads to the formation of various compounds on the metal surface, primarily various oxides under the influence of atmospheric oxygen.

4 Conclusion

It should be observed that, because of diffusion, chemical compounds of the base material with substances penetrating from outside can occur in the surface layer. The diffusion mobility of atoms can lead to a redistribution of the concentration of alloying elements in the surface layer, which is observed, for example, as decarburization in steels, depletion of chromium and aluminum in heat-resistant nickel alloys at high temperatures, etc.

Physical-chemical interaction of metal surfaces with the environment in its individual sections is uneven due to its polycrystalline structure and heterogeneity. Under such conditions, the value of their residual stresses (microstresses), the degree of plastic deformation, etc., have a significant effect on the physical-chemical activity of individual surface grains.

Thereby, it can be supposed that the method of surface plastic deformation of the inner surface of the teeth shed of the batten can be an effective method for improving the efficiency of the batten mechanisms of SLL-type looms. As a result, resistance to wear and fatigue deformation can be increased, which will have a positive effect on the quality of the cloth produced and the efficiency of the process due to the reduction in the breakage of the warp threads during non-impact high-speed sliding of the thread guide over the teeth of the comb. Following this technology, we implement an environmentally friendly approach that will ensure the environmental safety of weaving equipment by reducing wear on the contact surfaces.

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