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ON THE INFLUENCE OF THE WEAR RESISTANCE OF GRATE BARS ON THE TECHNOLOGICAL GAP BETWEEN THEM IN FIBER SEPARATING MACHINES

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Abstract: The article presents materials on a comparative analysis of the influence of the wear resistance of cast iron grates on the technological gap between them, taking into account preliminary dynamic treatment with microballs and without treatment. An equation for the development of wear on gin grates was obtained based on data from experimental studies of their wear under operating conditions.

Keywords: grate, cast iron, wear, gap, fiber separating machine, hardening, microball, wear, tolerance.

In fiber separating machines (saw gins, linters) used in cotton processing, grate bars (Fig. 1) make up the grid of the same name and are an important part of the working chamber. They are designed to pass the saw blades through the gaps between them into the working chamber and freely carry out the fiber torn away from the seeds by the teeth of the saw blades.

The technological requirements for the grate provide for a deviation from flatness between individual grate bars in the working part equal to 0.6-0.8 mm, in the rest – 2 mm [1-3]. It is not allowed to pass the seeds through the gaps between the grate bars together with the fibers within the working area, which is 30 mm long (15 mm up and down) and within which the fiber is separated from the seed during ginning.

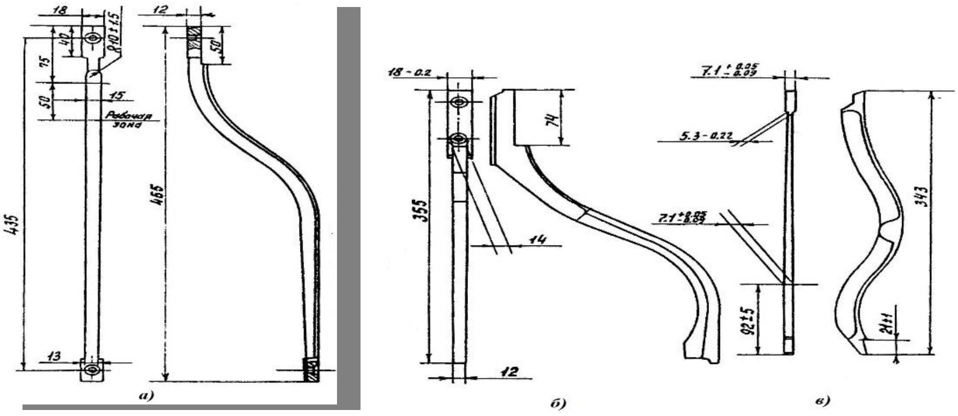

Fig. 1. Grates of fiber separating machine:
a- gin ordinary DP.ANbrand. 005
b- gin cantilever brand 5DP. .003
linter type EH109-67Б.

The number of grate bars in the grate is one more than the number of saws installed in the gin or linter saw cylinder. When the grate is set into the grate, technological gaps are provided for the passage of the cylinder saw blades between them, which are 3±0.2 mm for gins and 2.8±0.3 mm for linters. Observance of intergripper clearances is a prerequisite for the normal operation of the saw-gripper system of fiber separating machines.

In the process of ginning and lining, there is such a malfunction of the grate as the wear of the grate in the working part and, as a result, the expansion of the specified gap (slit) at the places of passage of the saw teeth, which can contribute to the ingress of whole seeds into waste and fibrous products. Therefore, the grate bars must have high wear resistance, which is the main criterion of operability for them.

The grate bars are made by casting from gray cast iron of SCh15 grade, having a ferritic or ferritic-pearlitic structure of a metal base with the following approximate composition [4]: 3.5-3.7% C; 2.0-2.6% Si; 0.5-0.8% Mn; ≤0.3% P; ≤0.15 S. Gray cast iron used as a structural material has the following mechanical properties: tensile strength $\sigma_{v.p}$= 115 MPa, hardness HB 113-129, elongation δ up to 0.5%. In the design practice, when designing machine parts from gray cast iron, one can use the approximate ratios between the tensile strength σ b, compression σ b and bending σ b [5]: $4\,{}_{\sigma}b = 2\sigma_b = \sigma_b$

Manufacture of grates from gray cast iron SCh15 is justified by the fact that they experience small loads in operation and therefore it is possible to use castings with a wall thickness of 10-30 mm. Mechanical treatment of grate bars is carried out on special equipment and the roughness of the surface coming into contact with the raw bead and seeds should be ensured equal to Ra= 1.25-0.63 μm, and the side surfaces in the workplace - Ra=0.63 μm.

For the normal operation of the saw-bar system of fiber separating machines, it is necessary to observe the recommended value of the technological gap in various parts of the grate (Table 1).

Table 1. The value of the technological gap in the working part of the grate between two replaceable grate bars.

Fiber separations-solid machine	Process clearances, S mm			Surface roughness Ra, μm	
	in the working part	TOP WIDTH	in the lower part	Pin length	In the side surface
Saw gin	3±0.2	$^{3.8+1.2}$	$^{3.8+1.2}$	1.25-0.32	0.63…0.32
Linter	2.5...3.0	3,0-3,5	3.5-4.75	2.5-0.63	1.25-0.63

In the process of fiber separation (ginning and lining), there is a loss of efficiency of the grate due to the wear of individual grate, the surfaces of which enter the working area of the cotton processing machine. Wear, in this case mechanical (abrasive), of parts of the working parts of machines is carried out in specific conditions: the contact of the working metal surfaces of parts (side faces of cast iron grate, teeth of steel saw blades) with the fibrous mass of cotton occurs within a very short time at the rotation frequency of the gin saw cylinder n=730 rpm; the fibrous mass of the processed raw cotton with variable humidity and debris contains solid weed impurities in the form of silicon dioxide (microhardness 10^4...$1.2\cdot10^4$ MPa), minerals of increased hardness (granite - $1.68\cdot10^4$ MPa; corundum - $2.29\cdot10^4$ MPa).

It is important to note that the hardness of the reduced abrasive particles significantly exceeds the hardness of structural materials (gray cast iron, carbon steel) for the manufacture of parts of the working body of fiber separating machines, which is an indispensable condition for microcutting when two solids come into contact during abrasive processing. The intensification of wear is enhanced by the moisture of the fibrous mass, which increases friction when in contact with the metal surface of the parts.

The wear resistance of the working part of the grate is increased by heat treatment [1], according to A.P. Gulyaev, for ordinary gray cast iron, heat treatment is rarely used, since it is not particularly effective [6]. Despite the low plasticity (δ=0.2...0.5%) of gray cast irons, experimental studies of deformation hardening [7] with impact on samples from gray pearlitic cast iron SCh24 showed an excess of the initial microhardness of 2625 MPa by 71.4% after reaching 10 impacts of the indenter (pile driver made of hardened steel ShKh15 with a microhardness of 9000 MPa). Therefore, the possibility of implementing the method of preliminary hardening by surface-plastic deformation (SPD) creates a technological advantage, expressed in the fact that it is possible to do without heat treatment and without the costs of alloying elements for hardening.

Among the dynamic DTS methods, the most effective with wide technological capabilities is the hardening with microballs with a shot diameter of d=0.3...0.4 mm. Compared to other methods of shot impact treatment (shot blasting, pneumodynamic, etc.), microbead hardening has a significant advantage in terms of the specific kinetic energy Eu (kJ/(mm^2·min)), which is a generalized criterion for assessing the modes of shot impact hardening. Thus, when microbeads are hardened, Ed =74 kJ/(mm^2·min), which significantly exceeds the specific kinetic energy of the shot with pneumodynamic hardening, equal to 20 kJ/(mm^2·min).

If at a value of E cd =5.352 kJ/(mm^2·min) there is a slander of gray cast iron [7], then when hardening with microballs with its level of specific kinetic energy, the manifestation of the effect of deformation hardening is obvious.

Experimental studies on the shot impact treatment of the side surfaces of the working sections of the grate with microballs were carried out on a conventional sandblasting machine. In the experiments, cast steel shot (DSL) made of low-carbon steel was used in accordance with GOST 11964-81E, which was quenched at a temperature of 860-890 ^{0}C with low-temperature tempering at 180-220^{0}C for 1.5-2 hours. The shot has a hardness of HV 365-545, the strength in the compression test by static load is not less than 6000 N.

Mode and conditions of shot impact treatment with microballs: compressed air pressure p=3-4 atm (0.3-0.4 MPa), diameter of microballs d=0.3-0.4 mm, angle of attack α=90^0, distance from the nozzle of the abrasive blasting gun to the hardened surface l=15-20 cm.

Cast iron grate bars were tested in production conditions after microbeads hardened their side surfaces in the working part. In accordance with the method and plan for conducting experiments, grate bars with a treated surface and without treatment in a set of 5 pieces were installed on one gin 7DP, which created the same operating conditions.

For the test, raw cotton of the 2022 harvest, selection "Sulton", "Namangan-77", grade 1,2 and 3 of manual harvesting, clogging from 3 to 12-14%, humidity from 6-7 to 20-22% were used. As evidenced by the data of experiments conducted on gin under the conditions of a cotton ginning plant, the grate reinforced by shot impact treatment with microbeads had linear wear Δa 1.7 times less than the grate without treatment (Fig. 3) with an average value of Δa =0.176 mm over a period of time t=105 working days. Wear of grate bars without prior dynamic treatment for the same period of time – Δa=0.304 mm.

The wear of the reinforced grate bars of the linter for the same test time averaged Δa=0.14 mm, and non-reinforced ones – 0.31 mm, i.e. the wear resistance exceeds 2.2 times.

Based on the value of the technological gap S (Table1),defined as the difference between the limiting values of 3±0.2 mm and constituting ΔS=0.4 mm, it is proposed to limit the wear value Δa of the grate bars to the value of ΔS, i.e. Δa≤ ΔS. Fig. 2 shows a comparison of the so-called field of tolerance for the technological gap and the value of the grate wear (one-sided).

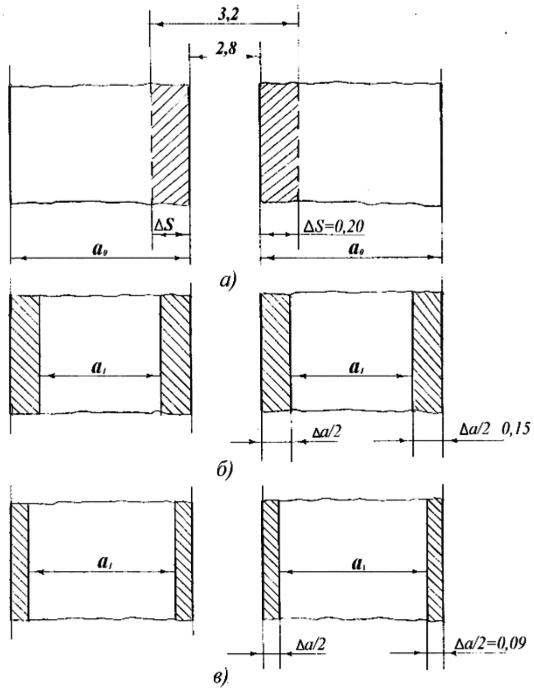

Fig. 2. Comparison of the results of grate wear with technological gap between us:
a) after allowing ΔS to the process gap;
b) wear of grate bars $\Delta a=a_0-a_1$ of gin without working surfaces treatment during the test time;
c) wear of reinforced grate bars $\Delta a=a_0-a_1$ gin during the test time

Taking into account the data of experimental studies of the wear resistance of gin grate bars, the following values were obtained: one-sided wear Δ a/2=0.09 and 0.15 mm respectively for reinforced grate bars and without treatment at a clearance tolerance of ΔS/2=0.2 mm. As can be seen from the comparison of the above wear data, there is still a significant reserve of operability for reinforced grate bars. For its numerical assessment and the ability to conduct a predictive assessment, it is necessary to draw up an equation for the development of wear, which, at a variable wear rate, is approximated by a parabola of the form [8]:

$$\overline{x(z)} = a + bz + cz^2, \tag{1}$$

where the parameters a, b and c can be determined from the equation obtained by the least squares method

$$am + b\sum z_i + c\sum z_i^2 = \sum x_i, \tag{2}$$

In equation (2), m is the number of observations; $\sum$ - varies from i=1 to m. In a particular case, it is possible to approximate a parabola of the form

$$\overline{x(z)} = cz^2, \tag{3}$$

when the parameters a=0, c =0.

Using the data of the study of the wear resistance of the grate for gins using equation (3), the equation of wear development is obtained

$$t=3389.7\Delta a^2 \quad (4)$$

where x(z)=t; z=Δa.

Similarly, the equation for the development of wear for cast-iron grate without prior slander is obtained:

$$t = 1136{,}2\Delta a^2;$$

According to the obtained equations of wear development (4) and (5), under the conditions of this experiment, it is possible to determine the durability of the grate during ginning, taking into account the preliminary slander treatment with microspheres and without treatment, which, respectively, amounted to 542 and 182 days when reaching the maximum wear of the grate, equivalent to the maximum tolerance for the technological gap between the grate of gin, equal to 0.4 mm.

Thus, based on the preliminary dynamic treatment of the working surfaces of the cast-iron grate of gins and linters with microballs, a significant increase in their performance was achieved due to the hardening of their surface layer. The obtained effect of deformation hardening makes it possible to maintain a regulated technological gap between the grate bars for a long time due to their increased wear resistance. The absolute value of linear wear of grate bars is proposed to be considered with the introduced concept of tolerance for the technological gap between the grate bars, which is in essence the criterion of wear.

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