INCREASE OF OPERATIONAL RELIABILITY OF HETEROCOMPOSITE POLYMERIC MATERIALS OF MACHINE-BUILDING DESIGNATION OPERATING UNDER CONDITIONS OF HYDRO ABRASIVE WEAR

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Abstract
The paper proposes new scientific and technological principles for the creation of machine-building materials of new generations and coatings based on local alternative raw materials and energy resources. The essence of the new principle lies in the formation of the target structure formation of heterocomposite materials and coatings from them based on both thermo-reactive and thermoplastic polymers and fillers with antifriction-wear properties providing high operational reliability under hydro abrasive wear conditions.

Key words: heterocomposite polymer materials, friction, epoxy resin, coatings, kaolin.

To create the most reliable heterocomposite polymer materials (HCPM) and coatings from them (HCPC) in operation, completely new methods and means of assessing the service properties of engineering materials are needed. Such properties of heterocomposite polymer coatings as applied to the conditions of cotton processing machines are their tribotechnical properties: coefficient of friction, temperature in the friction zone, density of triboelectric charge, intensity of linear wear of the surface of polymeric materials and mechanical damage to raw cotton.

Such a modern means of measuring these properties of tribo-pairs must take into account all the basic parameters for the operation of the machines [1].

Consider the interaction of raw cotton with the working surfaces of machines and mechanisms along the process of its processing (Fig. 1).

The first group of machines, the working bodies of which interact with raw cotton, are machines associated with the formation of riots of raw cotton, the storage of cotton in riots, its dismantling and filing in production. These are belt conveyors, movable receiving devices, riot disassemblers, a tunnel machine and a system of yard pneumatic transport.

The working organs of machines and mechanisms of the first group interact differently with raw cotton. So, when raw cotton is received from the bodies of vehicles by mobile receiving-feeding devices (Fig. 1b), the raw cotton is poured
into the hopper of the receiving device, to the inclined elevator, the strip of which is equipped with slats with pins. The mass of raw cotton coming to the elevator is captured by elevator pins, part of it is detached from the total cotton mass and then transported upwards to the discharge port.

The main parameters characterizing the operation of the elevator of the receiving device is the friction force of the raw cotton on the surfaces of the wedge-shaped pins, the strength of the clutch of cotton fibers between each other, the speed of the belt and the size of the working surfaces of the colt and the elevator bar, which depends on the height and width of the pins, and also the strength of tearing off the band from the tape, depending on the size of the spade, the speed of the elevator belt and the parameters of the raw cotton itself (grade, humidity and weediness).

Dismantling of raw cotton from riots is carried out with the help of markers RB (rotor razor) and RP (feeder razor), in which the working element is made in the form of a mill with tubular sections, the ends of which are fitted with bronze round tips. In this case, the following forces are acting: the force of friction of raw cotton in the area of that surface of the spike, which is in contact with the mass of cotton; the strength of the separation of raw cotton from the weight, depending on the adhesion of the cotton lobes in the riot, which, in turn, is determined by the variety of varieties, humidity, contamination and bulk density of raw cotton; force of lateral resistance, acting on the milling cutter when moving the boom of the buncher in the horizontal plane (Fig. 1a).

When storing cotton in riots in order to prevent the flow of self-warming process, tunnels breakthrough in the latter, through which the moist air is then sucked off. The digging of tunnels is carried out with the help of a tunnel machine, the working organ of which is made in the form of a truncated cutter with chimes.

The raw cotton that is selected from the thickness of the riot is transported to the inclined conveyor, by means of which it is loaded into the body of the transport trailer.

When the tunnel machine operates, the same forces act as when the rind picker is working, as well as when transporting the mass of raw cotton by the bands of the belt elevator of the mobile receiving devices. The raw cotton that is disassembled by the picker is placed in the pipeline (round section) of the pneumatic transport system of the cotton plant, to which it is transported from the storage area to the production workshops. On the straight sections of the pipes, the relative speed of movement of raw cotton reaches values of 20-25 m/s (Fig. 1c).

The raw cotton is transported, basically, in the lower part of the pipe-line (Fig. 1c). At lower velocities or large weight concentrations of the mixture (ie at high production rates), the raw cotton is in contact with the walls of the pipeline.
In this case, the important role is played by the friction force of cotton with the internal surface of the pipeline, as well as the surface condition, its roughness. The presence of large forces of friction or roughness leads to the fact that the transported raw cotton begins to harden into clods, resulting in the formation of flagella in the fiber. This is especially evident when changing the direction of flow of cotton and air in the bends of the pipeline.

**Fig.1.** The scheme of work of technological machines for processing raw cotton.
Along with pneumatic transport in the transport and distribution system of the cotton plant both inside the shops and between the workshops for transportation of raw cotton, feeding it from one technological process to the next and redistribution between the batteries of gins and purifiers, screw conveyors are widely used - screw conveyors (the second group machines). Screw conveyors are also used in cotton cleaners from small litter. In all these cases, there are specific features of the interaction of raw cotton with the elements of the screw pen and the casing of the screw conveyor (Fig. 1d).

As in the case of passing through pneumatic transport pipes, friction of raw cotton occurs here on the inner surface of the groove of the screw conveyor or on the surface of the grate (for worm cleaners). In the second case, cotton also interacts with the transition surfaces formed when holes are produced. In screw conveyors (conveyors), the crude cotton moves relative to the screw surface of the screw pen, the transitional surface of the screw itself to its periphery, taking on the effect of the friction forces of cotton on the surface of the screw, the forces of relative displacement, and also the centrifugal forces at a coefficient auger filling exceeding one.

In the process of interaction of raw cotton with basic and transitory surfaces, screw conveyors can be clogged with cotton, which causes sudden failures and reduces the reliability of their work. They are mainly related to changes in the conditions of friction of cotton. When the cotton interacts with the transition surfaces of the screws and the grid surfaces of the grate, micro-damage of the fibers can occur, especially during the faces.

Pneumatic transport installations have in their composition separators, serving to separate air from raw cotton and to clean the latter from small litter. The air separation takes place on a reticulated surface made of perforated sheet steel. Particles of cotton under the action of air flow are pressed against the surface of the separator grid, and the blades of the scraper drum are removed and sent to a vacuum valve. Here the main role is played by the frictional force on the inner surface of the mesh and over the surfaces of the mesh holes. The friction of the cotton in the separator leads to sudden failures due to the faces and micro-damage of the fibers.

The next group of machines are cleaners of small and large litter. The work of small litter cleaners was partially disassembled when considering the operation of screw conveyors.

It should be noted that raw cotton, supplied for processing, contains large (more than 8 mm) and small organic and mineral impurities. Organic weeds are parts of leaves, stems, leaflets of cotton capsules, etc., mineral - sand, dust, lumps of earth. They have to be removed during the process.
In accordance with the qualitative composition of weed impurities, two types of cleaners are used, as mentioned above:

- for removal of small weeds, where joint work of loosening drums and mesh surfaces;
- for removal of large weedy impurities having serrate and saw drums, a brush for stringing raw cotton particles onto the saw teeth and grate bars.

In the cleaners of coarse litter the main active surfaces interacting with raw cotton are the surfaces of the teeth of the nail files, saws and the surface of the grate (Figures 1e and 1f). Here, the more severe conditions for the fibers are observed, since there is a process of interaction with the transition surfaces. The nature of the nail files, the surface of the saws and grates, i.e. the friction of the cotton mass on the surface of the saw - a rounded or flat surface of the grate, the adhesion of the cotton fly, which prevents the release of weed.

The most complicated conditions for the interaction of raw cotton (wool, lint) with the working surface are observed in the following group of technological machines - in saw and valine gins, as well as fiber wipers and linters. In gins, the fiber is separated from the seeds. The raw roller formed in the working chamber of the gin must have a certain density so that under the action of the teeth the saws can rotate for continuous feeding of cotton to the teeth of the saw blades on the arc of their entry into the working chamber. Here, the effect of frictional forces on the surface of the saw, grate and seed combs, the forces of grasping the fibers with saw teeth, impact forces, etc. is observed.

The mechanical process of separating fibers from seeds in the working chamber occurs as a result of the interaction of raw cotton with a saw cylinder, a grate and a seed comb (Figs. 1g and 1h).

One of the basic requirements for the surfaces of the working chamber is the minimum resistance to movement of the raw roller. In the case of increased frictional forces when the characteristics of the incoming raw cotton change, the power consumption is increased and even the ginning process stops. Therefore, the correct selection of the microgeometries of the surfaces and materials of the working chamber is essential for improving the efficiency of gin.

The interaction of raw cotton with the transitional surfaces of saw teeth and grates in the working area leads to damage to the fibers. Simultaneously, these surfaces are subjected to intensive wear, as a result of which saws lose their workability.

After the genieing of raw cotton, cotton fiber enters the fiber cleaner to remove it from litter, ulyuk and other foreign impurities and vices. The main working elements in the fiber cleaner are the saw drum and grate. The main requirement for fiber wipers is the preservation of the natural physical and
mechanical properties of the fiber when interacting with the specified working organs, where, in addition to the frictional forces, the shock forces from the grate strips act on the fiber.

The fiber in the fiber cleaner with air flow enters the intake throat, is grasped by the teeth of the rotating saws of the saw cylinder and is tapped along the grate. In the result of interaction with the transitional surfaces of the saw teeth and grates, the fibers can be damaged. In addition, with impact interaction on the edge of the bars (as we mentioned above), the fibers that have received serious mechanical damage at previous transitions may burst, increasing the content of the fluff.

To fully take into account the operating conditions of machines in the cotton processing process, the State Technical Standard [2] and the tribometer [3] were created at the Tashkent State Technical University, which allowed obtaining the most reliable experimental results.

Analysing the obtained results of the study, it can be noted that with increasing pressure, sliding speed and clogging of raw cotton, the wear rate of PM increases. This is due to the increase in temperature, the density of charges of triboelectricity and contact pressure, which in turn leads to an increase in the interaction force in the friction zone and to a decrease in the strength properties of the surface layers of polymer materials. With increasing humidity, a certain decrease in the intensity of wear is observed, which can be explained by the presence of moisture, as well as by better conditions for free leakage of electric charges generated during friction. Reducing the temperature in the friction zone also leads to a significant decrease in the wear rate.

The study of the microstructure (Figure 2) of the surface of the HCPM before and after the test and analysis of the results of the study show that when friction of HCPM with cotton is observed, a complex form of wear is observed. If the raw cotton has a low moisture content and a very low clogging, then as a viscoelastic material, when rubbing through the polymer, it causes either molecular mechanical or fatigue wear even at high speed and pressure. The presence of microcracks on the surface of HCPM confirms this.

However, if the raw cotton has a low moisture content and, most importantly, contains many extraneous stiff impurities, the type of wear GKPM becomes predominantly abrasive, accompanied by deep micro cuts, especially at high speed and pressure. At a sufficiently high moisture content of cotton, a corrosion-mechanical appearance of wear is observed.

One of the main problems in the rational use of second raw materials and local energy resources in the creation of new generations of machine-building composite polymer materials is the search for more advanced methods and technologies for efficient structure formation in interphase layers at the interface of
phases "binder-binder", which mainly determines the complex of properties heterocomposite materials (see Table).

**Fig. 2.** Microstructure (x300) of the surfaces of HCPM before (a) and after (b) interaction with cotton.
When using fillers from second raw materials or local natural minerals, attention should be paid not only to their availability, easy accessibility, but also to the possibility of controlling the processes of structure formation at the development stage.

The paper shows that the most important aspects of the effective application of protective coatings are the cost and availability of components, their impact on environmental parameters and safe use under current industrial production conditions, as well as energy costs in the manufacture of semi-finished products and the formation of coatings, especially on the basis of local raw materials, in particular, local minerals with industrial output. It is justified that such mineral fillers are kaolins of AKF-78, AKS-30, AKT-10 brands, produced by Angren Kaolin LLC.

Some physical and mechanical properties of industrial polymer binders selected for the study are presented in the table.

Some mechanical and viscoelastic characteristics of polymer materials and coatings from them

<table>
<thead>
<tr>
<th>Coating materials</th>
<th>Coefficient of mechanical losses</th>
<th>Microhardness, MPa</th>
<th>Adhesive strength to steel surface at separation (MPa)</th>
<th>Peeling (N / m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polyethylene (HDPE)</td>
<td>0,111</td>
<td>45-50</td>
<td>30-40</td>
<td>1,4-1,6</td>
</tr>
<tr>
<td>Polypropylene</td>
<td>0,127</td>
<td>62-75</td>
<td>55-65</td>
<td>2-2,5</td>
</tr>
<tr>
<td>Polyacrylamide</td>
<td>0,105</td>
<td>110-120</td>
<td>75-95</td>
<td>1,8-2,2</td>
</tr>
<tr>
<td>Compounds based on: ED-16</td>
<td>0,018</td>
<td>220-250</td>
<td>150-200</td>
<td>3,0-4,5</td>
</tr>
<tr>
<td>ED-20</td>
<td>0,022</td>
<td>160-180</td>
<td>160-220</td>
<td>4,0-5,0</td>
</tr>
<tr>
<td>FAED-20</td>
<td>0,026</td>
<td>45-50</td>
<td>140-160</td>
<td>2,5-4,0</td>
</tr>
</tbody>
</table>

The results of the research showed that similar properties of heterocomposite polymer coatings with the use of Angren Kaolin minerals on the basis of the new principle of structure formation made it possible to obtain increased mechanical and viscoelastic properties by a factor of 1.3-1.6 with a reduction in material and energy costs in the 1.5- 2.0 times.

References

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