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INSTALLATION AND METHODOLOGY FOR DETERMINING OF ANTIFRICTIONAL PROPERTIES OF ANTISTATIC-HEAT-CONDUCTING COMPOSITE POLYMERIC MATERIALS INTERACTING WITH FIBROUS MASS (COTTON-RAW)

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The paper Presents a disk tribometer installation and allows to determine the antifriction properties of machine-building composite antistatic-heat-conducting polymer materials working in interaction with the fibrous mass (raw cotton). A method for determining the friction force, temperature and electrostatic charge values arising in the friction zone is developed. The friction of the fibrous material is carried out on the flat surface of the rotating disk sample from the material under study at specified clamping pressures and sliding speeds. Values of friction forces, temperatures and values of electrostatic charges of the tested sample in a zone of friction with cotton-raw are measured by means of sensors.

Keywords: *polymer, composition, composite material, tribometer, friction coefficient, temperature in the friction zone, electrostatic charge, pulp, raw cotton.*

The friction of structural materials interacting with raw cotton is distinguished by the variety and complexity of simultaneously occurring processes [1]. Therefore, many researchers, based on the complexity of the research task, simulated friction with raw cotton in various equipments. Based on this, we have developed a setup and method for determining antifriction properties — friction coefficient, temperature and electrostatic charge of machine-building composite antistatic heat-conducting polymer materials interacting with fibrous mass (raw cotton), which were determined on a disk tribometer operating in the range pressures from 0.001 to 0.05 MPa and velocities from 0.5 to 10 m/s.

The essence of the method lies in the fact that the friction of the fibrous material is carried out on the flat surface of a rotating disk sample from the material under study at a number of preset values of the clamping pressures P and sliding velocities v, the values of the friction forces, temperatures and electrostatic charges of the test sample in the friction zone with cotton are measured raw, after processing the measurement results, one can judge the range of acceptable values of P, V and determine the working conditions of the test material.

Disk tribometer. Schematic diagram of a disk tribometer for determining antifriction properties (friction coefficient, temperature and electrostatic charge in the friction zone) of structural polymer and composite materials with raw cotton is shown in Fig. 1 [2].

Disk tribometer works as follows. A vertical shaft with a horizontal disk 3 mounted on it is driven from the electric motor 1 and gearbox 2. A sample 4 of the material being tested is placed on the disk. To prevent axial and radial runout, the disk shaft is mounted on two radial and one thrust bearings. The cylindrical box 5, located on eight deep groove ball bearings 6, moves in the longitudinal direction. The use of deep groove ball bearings reduces the frictional force between the side walls of the box and the guide frame.

The guide frame can, if necessary, move vertically from the inside of the wall; there are four vertical channels 7 filled with balls.

Ropes are attached to the box on both sides. One of them is thrown through block 8 and serves for calibration loading. Another cable is also connected to the box, and its other end to the strain gauge (HX711) 9. The incoming signals from the strain gauge are transmitted to the computer 10 through the Arduino UNO R3 microcontroller, where the antifriction properties of antistatic heat-conducting composite polymer materials interacting with fibrous are plotted in graphs mass (raw cotton) [3].

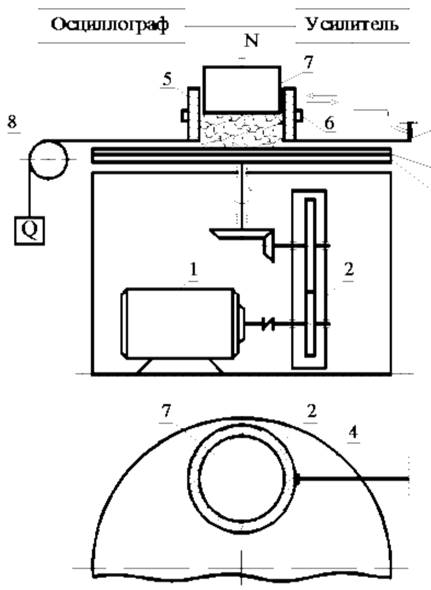

Fig. 1. Schematic diagram of a disk tribometer: 1 - electric motor; 2 - gear; 3 - disk; 4 - a sample with a polymer coating or composite material; 5 - box; 6 - ball bearing; 7 - a piston; 8 - block; 9 - strain gauge HX711; 10 - microcontroller Arduino UNO R3; 11 - computer

Methodology for determining the friction force of composite antistatic heat-conducting polymer materials when interacting with pulp (raw cotton). Raw cotton is laid inside a cylindrical box, and a piston with loads is placed on top. When the disk rotates, the sample - composite polymer material carries with it a cylindrical box with a sample of raw cotton and thereby pulls the cable, which, in turn, bends the strain gauge. Mechanical strain with the help of strain gauges is converted into electrical vibrations. After finding the friction force, the coefficient of friction between the composite polymer material and the raw cotton is calculated by the well-known formula:

$$f = \sum \frac{f_i}{n}, \quad (1)$$

where $f_i = \frac{F}{N}$; F is the friction force, N; N - the normal force acting on the rubbing pairs, N; n - the number of experiments performed.

A sample of the test material (Fig. 2) must be electrically isolated from the bed of the test device.

A sample of the test material is made in accordance with Fig. 2.

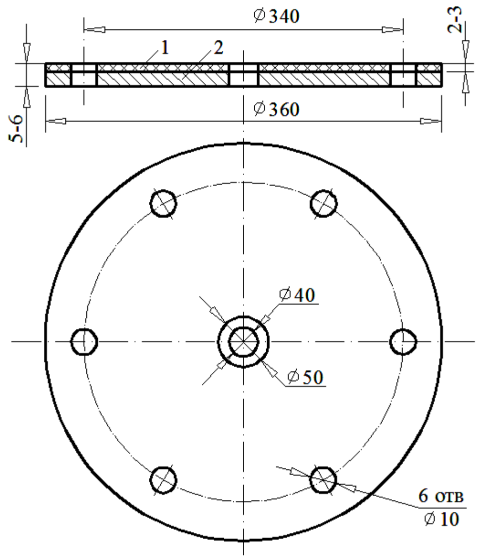

Fig. 3. A sample of the test material:
1-steel disc; 2 - test coating or composite material

Methods of measuring electrostatic charge and temperature In the friction zone. Installation for measuring electrostatic charge and temperature in the friction zone is shown in Fig. 3.

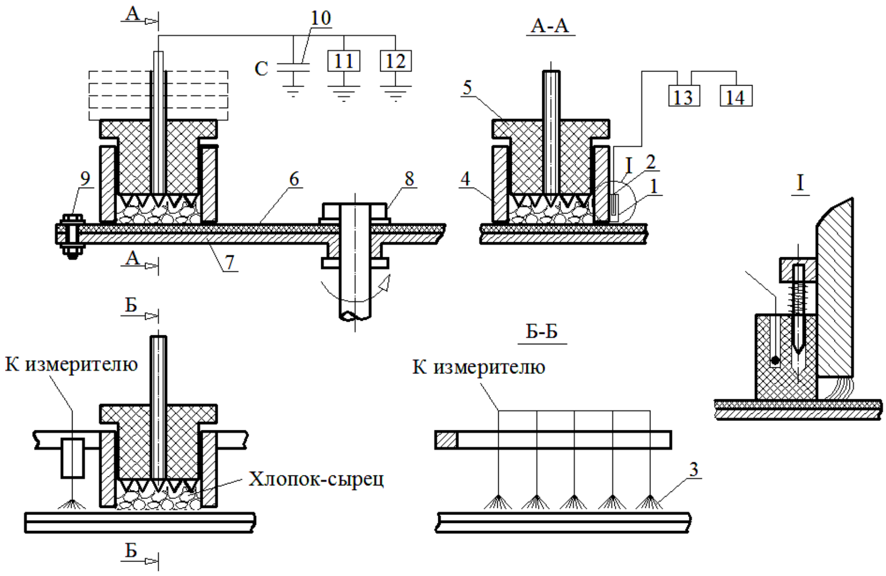

Fig. 3. Installation for measuring electrostatic charge and temperature in the friction zone:
1 - carbon-graphite electrode; 2 - thermocouple; 3 - a metal brush; 4 - golky electrode; 5 - insulating sleeve; 6 - insulating gasket; 7 - disk; 8 - a sample with a polymer coating; 9 - a piston; 10 - additional capacity; 11 - static voltmeter; 12 - capacity meter; 13 - potentiometer; 14 - thermostat

The resulting charges in the friction zone were removed using electrodes. The values of the charges of static electricity were determined by measuring the value of the potential using a S-50 voltmeter according to the procedure described in the works. Copper electrodes 4 for measuring the voltage of static electricity on the pulp should simultaneously serve to fix the pulp, preventing it from rolling during testing.

To prevent leakage of charges formed as a result of friction, individual parts and units of the tribometer were isolated with fluoroplastic gaskets. The resulting charges in the friction zone were removed using electrodes. The magnitudes of the charges of static electricity and their density were determined by measuring the magnitude of the potential with a S-50 voltmeter. The charge was removed using a metal brush, at the ends of which flexible wires were attached. With this measurement of charges, an additional error appears due to the electrification of the brush itself.

We used a sensor that is installed at a certain distance from the charged surface of the polymer coating, but which makes it easier to obtain reliable data. The sensor is a metal plate with needle electrodes immersed in cotton. The magnitude of the charge is measured by a static voltmeter, which is transmitted from the charged surface to the sensor by electrostatic induction. At the same time, experiments have shown that the accuracy of measurements of the magnitudes of charges in contact and non-contact charge removal is almost the same. The sensor is isolated from the installation housing with PTFE gaskets. Isolation of the friction zone using the high dielectric properties of the fluoroplastic increases the accuracy of the measurement of electrostatic charges. The additional capacitance in the measuring circuit also contributes to this.

According to the known system capacity and potential measured by a static voltmeter, the charge value was determined by the formula:

$$Q = U(C_{КВ} + C_C + C_{КД})\sum \frac{f_i}{n}, \qquad (2)$$

where $C_{КВ}$ - the static capacity of the voltmeter;
C_C - capacity of the rubbing pair;
$C_{КД}$ - capacity of the additional capacitor;
U - voltage measured by a static voltmeter.

The maximum charge of static electricity is achieved at different friction times with raw cotton. As a result of the study of the kinetics of the formation of charges of static electricity, it was found that the formation time of the maximum charge for all polymeric materials varies from 20 to 145 s. Therefore, in all experiments, the magnitude of the charges of static electricity was measured 180 s after the start of the experiment.

Method for determining the temperature in the friction zone. The temperature in the friction zone was measured using a DS18B20 temperature sensor from -55°C to 125°0C. The incoming signals from the temperature sensor through the Arduino UNO R3 microcontroller are transmitted to a computer 10, where the antifriction properties of the antistatic heat-conducting composite polymer materials interacting with the fibrous mass (raw cotton) are shown in graphs.

Literature

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