Ann. For. Res. 65(1): 10048-10057, 2022
ISSN: 18448135, 20652445

THE MECHANISM FOR MOVING ELASTIC CONTAINERS ON A COTTON PICKER

Alikulov Sattat Ramazanovich,[1] Eshkobilov Olim Kholikulovich[2]
[1,2]Karshi Institute of Engineering and Economics

Abstract - The elimination of the shortcomings of the existing methods of harvesting raw cotton by increasing the productivity of machines by increasing the row and volume of the bunker did not lead to significant results. The container method of raw material harvesting, widely used in foreign countries, allows to significantly reduce technological downtime of both harvesting and transport equipment and, at the same time, maintain the quality of the grown raw material.
Keywords: Raw cotton, Cotton picker, Vehicle, Container, Container moving mechanism, Chain conveyor.

Introduction

The existing method of harvesting and transporting raw cotton does not meet the requirements of modern cotton production, and has a number of significant drawbacks [1]. Their elimination is carried out mainly by increasing the productivity of cotton pickers, which is achieved by increasing their rows and the volume of the bunker, as well as by compacting the cotton mass in the bunker [2].

Until now, increasing the productivity of the machine by compacting the cotton in the hopper was considered the most effective [3]. However, the poor flow of cotton from the bunker, the need for manual labor when unloading (loosening the cotton) from the bunker into the trailer body and a number of other shortcomings do not allow us to consider it an ideal method [4].

Containerization is one of the most efficient methods of transportation, allowing rational use of harvesting vehicles [5]. As can be seen from the special literature, in the United States a significant part of agricultural cargo is transported in containers. The use of containers reduces labor costs by up to 80%, the cost of containers by up to 50%. Specialized transport and loading and unloading machines have been created for container transportation [6].

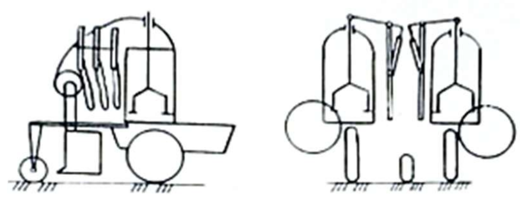
The paper describes a set of equipment for harvesting cotton in a container way with the formation of large bales on the field - containers formed on interchangeable pallets, in which they are delivered to the cleaning point. Also noteworthy is the modular system for stacking and transporting cotton, which includes a set of machines and mechanisms, the use of which eliminates manual labor when transporting cotton [7]. The essence of the modular system is that cotton is unloaded from the bunker of the cotton picker into a special trailer, which delivers it to a special mobile riot former and unloads cotton into it by tilting the body. After compacting the cotton with long-stroke special hydraulic cylinders located in the upper part, the bunker is lifted by special hydraulic jacks, then it is removed from its original position, having previously opened the tailgate, and the formed cotton riot module remains in this place [8].

Methods

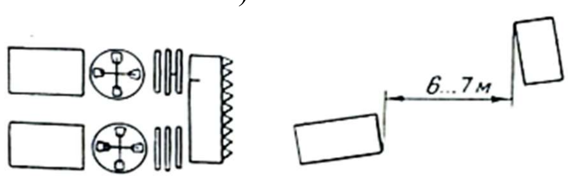
The whole cotton modules are delivered to the ginneries by a vehicle consisting of a tractor and a semi-trailer with a tilting platform [9].

Scientists from the Tashkent Institute of Textile and Light Industry have proposed a scheme for a device for transporting and storing raw cotton in containers. To implement this technology, the cotton picker is equipped with a frame-mesh container mounted on the forks of the lifting mechanism [10]. Consolidation is made by a large-mesh lattice. The use of this method increases the productivity of vehicles by increasing their carrying capacity and increasing labor productivity in loading and unloading operations at cotton harvesting stations. But the productivity of the harvesting equipment remains the same as with the existing technology, since in this case such operations as the approach of the cotton picker to the vehicle, unloading and loading containers and related downtime are not excluded [11].

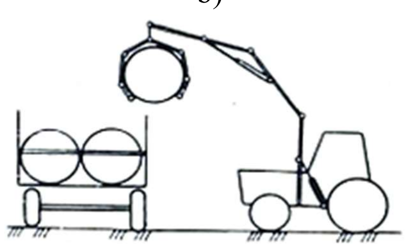
The Research Institute of Agricultural Mechanization of Uzbekistan conducted research on the development of technology and technical means for harvesting, loading and unloading and transporting raw cotton in a container way. The container method of cotton harvesting and its transportation includes the following technological operations: harvesting - container and compaction of cotton - dumping filled containers onto the headland of the field - loading containers into vehicles - transporting containers to the cotton harvesting station (fig.1) [12].



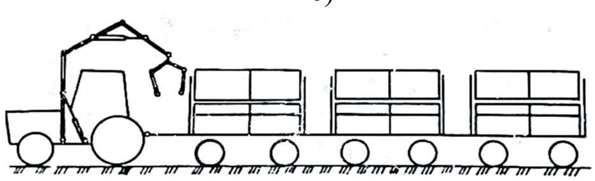
a)



b)



c)



d)

Figure 1: Technological scheme of harvesting and transportation of raw cotton in a container way.

a) cleaning b) unloading; c) loading; d) transportation

b) With this technology, the cotton picker must have a magazine for empty containers, seals for stuffing raw cotton into containers, a mechanism for replacing a filled container with an empty one from the magazine, and reserve tanks for storing filled containers until the machine enters the headland of the field [13].
c) In the process of harvesting, raw cotton from the harvesters enters two containers and is compacted in them. The container filled with cotton is moved by the replacement mechanism to the machine's reserve device, and at the same time another empty container is fed from the store instead of it, the compactor is lowered into the container, the whole process is repeated [14].
d) The reserving device for filled containers is a pallet on a supporting wheel with a sidewall that can be folded down by means of a hydraulic cylinder. In this reserving device, the filled container is placed in a horizontal position [15].
e) The cotton harvester, continuing to pick cotton, takes the filled container in the reserve tank to the headland and unloads it during the turn so that the location of the containers on the headland does not interfere with the operation of the harvesting vehicles [16].
f) Also, studies have substantiated that the most effective compaction of raw cotton in an elastic container of a cylindrical shape occurs with layer-by-layer compaction from top to bottom. In this regard, elastic containers filled with cotton in a vertical position, a scheme of a store and a mechanism for replacing containers has been developed, in the form of two push-type chain conveyors located in series, the first of which is a store for empty containers, and the second is necessary to transfer the filled container to a reserve tank and supply of an empty container for filling with cotton (Fig. 2) [17].
g) With the rotation of the leading sprockets (kinematically interconnected and having equal angular speeds), the container located first in the store moves to the overload zone, where it is captured by the shaped links of another pair of chains and fed under filling [18]. After filling with the same pair of chains, the container is transferred along the guides to the reserve device and at the same time the next container is captured from the store and fed for filling [19].
h) The mechanism for changing containers consists of two chain conveyors of a pushing type located in series, one of which is a store for empty containers. The traction element is chains with shaped links that allow reloading containers from one conveyor to another [20].

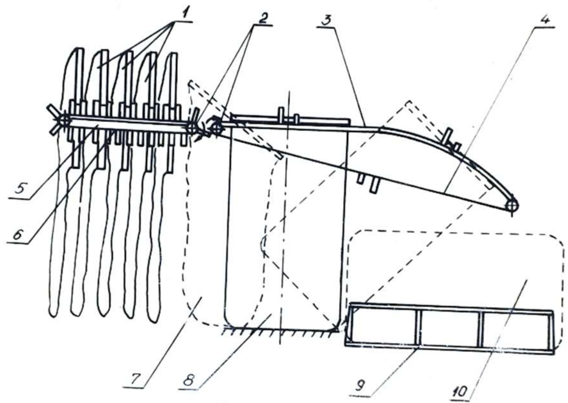


Figure 2: Scheme of the store and the mechanism for replacing containers. 1-container in the store; 2-leading stars; 3-guides; 4-chain circuit for moving containers into a reserve tank; 5-container shop; 6-chain contour with shaped links; 7-container supplied for filling; 7-empty container; 8-filled container; 9-reserving device; 10-filled container in the reserve device

The reliability of container reloading is largely affected by the angle φ, which can be rotated by the shaped link, moving the container by the trunnion along the guides. Let us determine the maximum angle φ. The design scheme of the device is shown in Fig. 3 [21].

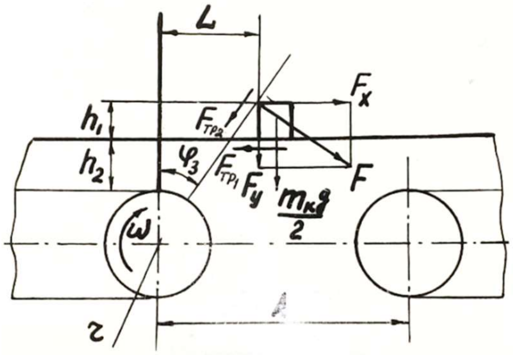


Figure 3: Calculation scheme of the reloading device

In order to simplify the diagram, the shaped link is shown on it with a straight line. The movement of the container along the guides occurs under the action of force F, with which the shaped link acts on the pin of the container [22]. At the moment of the beginning of the turn and with further rotation of the link, there is an additional movement of the pin of the container along the shaped link. Friction forces F_{mp1} and F_{mp2} arise at the sliding points. The movement of the container will stop when the projection of friction forces on the x-axis is equal to or greater than the horizontal component of the force F, i.e. [23]:

$$F_x = F_{\text{тр } 1} - F_{\text{тр}2} \sin\varphi_3 = 0 \quad (1)$$

The horizontal component of the force F is equal to:

$$F_x = F \cos \varphi_3 \quad (2)$$

Friction forces:

$$F_{mp1} = (F \sin \varphi_3 + \frac{m\ g}{2})\ \mathrm{f} \qquad (3)$$

$$F_{mp2} = F f \qquad (4)$$

where: m_k - mass of an empty container, kg; g - free fall acceleration, m/s^2.
Substituting the values (2), (3) and (4) into equation (1), we obtain

$$F \cos\varphi_3 - (F \sin \varphi + m_k g / 2) f' - F f \cdot \sin \varphi_3 = 0 \qquad (5)$$

Or

$$\cos\varphi_3 - \frac{mk\ g\ f}{2F} - 2 f \sin \varphi_3 = 0 \qquad (6)$$

If we take into account that the force *F* is infinitely large to obtain the maximum angle φ3max, then in expression (6) the member mk *gf/2F* can be neglected and then we obtain:

$$\varphi_3 = arctg\ \varphi \frac{1}{2 f} \qquad (7)$$

From expression (7), it follows that with sufficient force that the shaped link acts on the pin of the container, the maximum angle of rotation of the link φ_{3max} depends only on the coefficient of friction between the pin and the guides and shaped links [24].

In addition, the radius of the drive sprockets *r* affects the performance of this mechanism. To determine *r*, at which the movement of the container *L* will be more efficient, we write the ratio of the movement of the container to the radius of the sprocket *L= L/r* when the link rotates through some angle φ_3.

$$L = (r+h_1+h_2)\ tg\ \varphi_3 / r \qquad (8)$$

where: h_1 - height of the protruding part of the guides, mm; h_2 - container trunnion height, mm.

From the analysis of expression (8) it follows that at constant values of h_1 and h_2, the relative displacement *L* is greater for the sprocket with a smaller radius. In addition, the radius of the sprockets *r* determines the center distance A and the height of the shaped links, therefore, in order to reduce the dimensions of the reloading device, it is also necessary to use drive sprockets with the minimum allowable number of teeth (smallest diameter) [25].

To test the operability of the circuit and determine some of its parameters, a model of a mechanism with an electric drive was designed and manufactured (Fig. 4) [26].

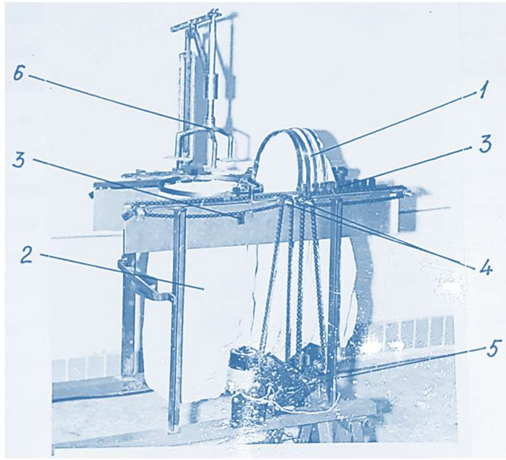


Figure 4: Container replacement mechanism model
1-containers in the mechanism store; 2-container filled with cotton; 3-shaped links; 4-sprockets of the reloading device; 5-mechanism drive; 6-seal

Experiments carried out on the model showed that the movement of the container along the guides is fully provided by the shaped links of the chains and the process of reloading the containers proceeded in the best way (without jamming and dynamic shocks, without tearing off the axles of the wheels mounted on the neck of the movement mechanism filled from the guides) when installing sprockets with the number teeth 7 [28].

Results and Discussion

Directly on the same model, the maximum angle φ_{3max} of rotation of the shaped link was determined when the container was moved by the trunnion of the ring along the guides. For this purpose, with the electric motor turned off, using a torque wrench, the chain of the container mechanism was set in motion by the nut of the drive sprocket. The rotation was carried out until the container trunnion was jammed between the guides and the shaped links (the torque on the torque wrench was 3-3,5 kgm), in this position the angle of rotation of the shaped link was measured [29].

As a result of the experiments carried out on the model of the mechanism for replacing containers, the angle $\varphi_{3max}=61^0$-63^0 was determined, which allows us to assume that the movement of the container, which will occur at such an angle of rotation of the shaped link, is quite sufficient to capture the container by the shaped links of another pair of chains [30].

The average value of the friction coefficient was $f=0,195$. According to formula (8), $\varphi_{3max}=68,7^0$ was obtained, which is very close to the value of the angle obtained in experiments [31].

On the frame of a serial cotton picker, on special brackets, hinges and braces, container replacement mechanisms are fixed, each consisting of guides and two pairs of chain circuits with shaped links. The number of containers in the cotton picker magazines is 16 [32].

The raw cotton collected from the bushes by the harvesting machines of the machine enters two containers through a pneumatic transport system that separates part of the air flow, where it is filled and sealed with special seals. After filling one of the containers with cotton, the hydraulic cylinder is turned on and the filled container is moved to the reserve device of the machine (Fig. 5) [33].

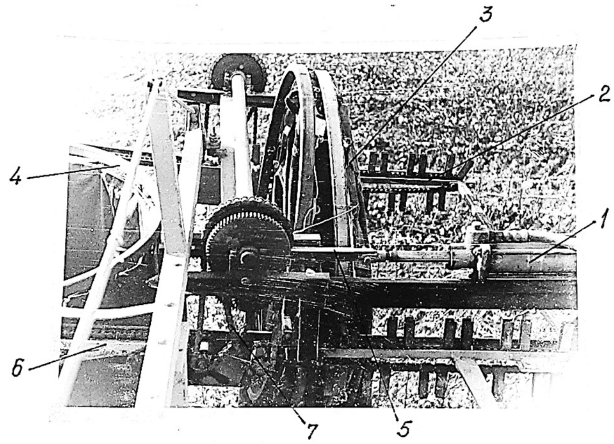


Figure 5: Mechanism for changing containers on a cotton picker. 1 - hydraulic cylinder; 2 – store of empty containers; 3 - container in the store; 4 – container ring; 5 - gear rack; 6 - guides; 7 - drive chains

At the same time, an empty container is taken from the store, which is installed for filling, and the whole process is repeated without stopping the technological process of the machine in the rows of cotton.

Conclusions

The optimal time (8-9 s.) needed to replace a filled container with an empty one was determined from the conditions of reliable and smooth operation of the replacement mechanism. With decreasing time, i.e. increasing the speed of moving the container to the reserve device, the mechanism worked with strong dynamic shocks when the shaped links captured empty containers from the store, and increasing the time is inappropriate, because. when the entire cotton-air mixture is directed to one of the containers, the speed of the air flow also increases, which can at some point lead to blowing the raw cotton out of the container.

Laboratory and field tests of the container replacement mechanism in the general technological process of machine harvesting of raw cotton were carried out on a mock-up sample of a cotton harvester.

Certain operational and technological indicators of a cotton harvester for collecting into containers, equipped with a mechanism for replacing them, served as the initial data for the economic evaluation of the machine.

References

[1] The new cost effective system for the transportation of crops. World Crops, 1973, N5.
[2] US patent cl. 21/49 At 65. 57/00. No. 3703966. Intermediate storage of raw cotton.
[3] The operation of the cotton picker without stopping for unloading. Implem and Tract, 1970, 93, No. 6, p.26.

[4] US patent cl. 100\100 (B 30, B 15/00, D 01) No. 4127061. Container cotton harvesting system.

[5] Jabbar, O.S. Efficiency of containers for raw cotton. // Mechanization of cotton growing. 1980, No. 12, p. 13-15.

[6] Rashidov, N.R., Alikulov, S.R. et al. Possibilities of using containers for the collection and transportation of raw cotton. // Mechanization of cotton growing. 1983, No. 9, p. eleven.

[7] Rashidov, N.R., Alikulov, S.R. Technology of harvesting and transportation of raw cotton in a container way. // Mechanization of cotton growing. 1984, No. 5, p. 5-11.

[8] US patent. B 346867. Cotton picker with quick-release cylindrical container

[9] Rashidov, N.R., Alikulov, S.R., Kim E.G. A mechanism for reserving and feeding containers on a cotton picker. // Mechanization of cotton growing. 1984, No. 9, pp. 11-12.

[10] Adler, Y.P. Planning an experiment in the search for optimal conditions. M: Nauka, 1976, 280 p.

[11] Melnikov, S.V. Planning an experiment in the research of agricultural processes. M:, Kolos, 1980, 280 p.

[12] Alikulov, S.R. Research of the cotton sealing process in facilities of a frame-type. Journal of critical reviews, –Malaysia, 2020. Vol 7, Issue 8. –P. 1831-1840.

[13] Alikulov, S.R. Analysis of the Conditions of Cotton Packing in Containers with Flexible Casing. **Revista geintec-gestao inovacao e tecnologias,** Vol.11. **–Brazil, 2021.**–P. 871-882. DOI: https://doi.org/10.47059.

[14] Negmatov, S.S., Abed, N.S., Gulyamov, G., Eshkobilov, O.Kh. Features of contact interaction of composite polymer materials with raw cotton in the process of friction. IOP Conference Series: Materials Science and Engineering, Volume 1030, VII International Scientific Conference "Integration, Partnership and Innovation in Construction Science and Education" (IPICSE 2020) 11-14th November 2020y, Tashkent, Uzbekistan. DOI: 10.1088/1757-899X/1030/1/012172. ISSN: 1757899X 17578981.

[15] Abed, N.S., Eshkobilov, O.Kh. Gulyamov, G., Tuhtasheva, M.N. Engineering composite materials for the cotton processing industry. E3S Web of Conferences 264, 05053 (2021). International Scientific Conference “Construction Mechanics, Hydraulics and Water Resources Engineering”. DOI: 10.1051/e3sconf/202126405053. ISSN: 25550403.

[16] Eshkobilov, O.Kh. Gulyamov, G. Composite polypropylene polymer materials that work in contact with raw cotton. E3S Web of Conferences 264, 05055 (2021). International Scientific Conference “Construction Mechanics, Hydraulics and Water Resources Engineering”. DOI: 10.1051/e3sconf/202126405055. ISSN: 25550403.

[17] Zotikov, V.B. Determination of the coefficient of friction of cotton fiber // Bulletin of THREAD, 1934, No. 3. - From 143-152.

[18] Eshkobilov, O.Kh., Negmatov, S.S., Abed, N.S., Gulyamov, G. "Investigation of the process of electrification of composite polymer coatings in the case of frictional interaction with the fibrous mass", AIP Conference Proceedings 2432, 050009 (2022) https://doi.org/10.1063/5.0089709.

[19] Eshkobilov, O.Kh., Tuhtasheva, M.N. Development of a disc tribometer and determination of its optimal parameters and modes of contact interaction of composites with raw cotton. (2021) *International Journal of Mechatronics and Applied Mechanics,* 1 (10), pp. 214-221.

[20] Hafizov, I.K. Investigation of the interaction of the main working organs of roller gin with raw cotton // Abstract of the dissertation of the Candidate of Technical Sciences. Tashkent, 1970. - 32 p.

[21] Eshkobilov, O., Negmatov, S., Abed, N., Gulyamov, G. Anti-Friction-Wear-Resistant Composite Polypropylene Materials Working in Conditions of Contact with Raw Cotton. Journal of optoelectronics laser. Volume 41, Issue 6, 2022. DOI: 10050086.2022.06.97. ISSN:1005-0086.

[22] Eshkabilov, Kh., Berdiyev, Sh. Structure and properties of the modified diffusion nitride-oxide surface layer.E3S Web of Conferences 264, 05055 (2021). International Scientific Conference "Construction Mechanics, Hydraulics and Water Resources Engineering" (CONMECHYDRO - 2021). DOI: 10.1051/e3sconf/202126405054. ISSN: 25550403.

[23] Eshkabilov, Kh., Berdiyev, Sh., Kamolov, B. Hardening of cutting tools by combined gas nitriding method. IOP Conference Series: Materials Science and Engineering, 2021, 1030(1), 012019. DOI:10.1088/1757-899X/1030/1/012019. ISSN: 17578981.

[24] Negmatov, S.S., Saipidinov, A.A., Irgashev, A.S., Eshkabilov, Kh.K. Modeling the process of real contact area formation during friction interaction of fibrous masses with polymer counterbody surface.(1985) *Soviet Journal of Friction and Wear (English translation of TrenieiIznos)*, 6 (4), pp. 125-128.

[25] Bukharov, S.N., Tuleiko, A.S., Sergienko, V.P., Abed, N.S., Alexiev, A.R. Advanced Sound Absorbing Materials to Reduce Noise and Improve the Environmental Situation in Production Facilities and Transportation. International Conference on New Technologies, Development and Application. Volume 233, 2021, Pages 450-457. Sarajevo, Bosnia and Herzegovina, 24 th-26th June 2021. DOI: 10.1007/978-3-030-75275-0_50.

[26] Abed-Negmatova, N.S., Negmatov, S.S., Gulyamov, G., Negmatov, J.N. Antifriction wear-resistant composite materials and details made from them for working bodies of cotton machines and mechanisms. Advanced Materials Research. 2nd International Conference on Energy, Environment and Sustainable Development. Volume 616-618. Jilin, China. 12th-14th October 2012. Pages 2005-2008. DOI: 10.4028/www.scientific.net/AMR.616-618.2005.

[27] Abed-Negmatova, N.S., Negmatov, J., Gulyamov, G., Yuldashev, A., Eminov, Sh., Bozorboev, Sh., Aripova, A., Negmatov, S., Xojimuradov, D. Composite polymer materials and the details made of them for cotton machines and mechanisms.Advanced Materials Research. 2nd International Conference on Energy, Environment and Sustainable Development. Volume 413. Jilin, China. 7th-8th January 2012. Pages 535-538. DOI: 10.4028/www.scientific.net/AMR.616-618.2005.

[28] Abed-Negmatova, N.S., Gulyamov, G., Negmatov, S.S., Hodzhikariev, D.M., Negmatov, J.N., Eminov, Sh.Sh., Bozorbaev, Sh., Aripova, A., Negmatova. Durability of composite polymer materials working in contact with pulp. 6th International conference on times of

polymers (top) and composites. AIP Conference Proceedings. Volume 1459, Issue 1. 11th-14th July 2012. DOI: 10.1063/1.4738470.

[29] Yuldashev, A.Kh., Negmatov, S.S., Abed-Negmatova, N.S., Abdurakhmanov, A.G., Bozorov, Sh.A., Eminov, Sh.Sh., Aripova, A., Khodjikariev, D.M. Melt index of low-density polyethylene and its effect on rotational molding. 6th International conference on times of polymers (top) and composites. AIP Conference Proceedings. Volume 1459, Issue 1. 11th-14th July 2012.DOI: 10.1063/1.4738491.

[30] Negmatov, S.S., Shernaev, A.N., Gulyamov, G., Abed-Negmatova, N.S., Saidov, M.M., Musabekov, D.H., Negmatov, Sh.S., and Negmatova, M.I. Wear-resistant polymer composite filled with finely dispersed wood and carbon/graphite powders. TableofContents.6th International conference on times of polymers (top) and composites. AIP Conference Proceedings. Volume 1459, Issue 1. 11th-14th July 2012. DOI: 10.1063/1.4738486.

[31] Musabekov, D., Abed-Negmatova, N.S., Gulyamov, G., Shernaev, A., Khodjimuradov, D., Negmatov, S.S. Effective Composite Materials for Friction Pairs of Working Bodies of Cotton Machines.Advanced Materials Research. Volume 413. December 2011. Pages 548-550. DOI: 10.4028/www.scientific.net/AMR.413.548

[32] **Negmatov, S.S., Abed, N.S., Gulyamov, G., Eshkobilov,** O.Kh. Installation and methodology for determining of antifrictional properties of antistatic-heat-conducting composite polymeric materials interacting with fibrous mass (cotton-raw) //Technical science and innovation// Issue 2. –Tashkent, 2018y. –P. 20-23.

[33] Eshkobilov, O., Negmatov, S., Abed, N., Gulyamov, G. Anti-Friction-Wear-Resistant Composite Polypropylene Materials Working in Conditions of Contact with Raw Cotton. Journal of optoelectronics laser. Volume 41, Issue 6, 2022. DOI: 10050086.2022.06.97. ISSN:1005-0086.