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APPLICATION OF POLYMER COMPOSITES IN THE CONSTRUCTION OF AGRICULTURAL MACHINES FOR SOIL TREATMENT

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Introduction. Ukraine is one of the largest agrarian countries. The area of arable land in Ukraine was more, than 32531 thousand hectares. The largest latifundists, which occupied about 15% of arable land, were such agroholdings as Ukrlandfarming (630000 hectares), NCH (430000 hectares), KernelGroup (700000 hectares) and others [1]. Small farms occupied 12, and about 73% - other agro-enterprises of different sizes and forms of ownership. At the same time about half of the crop of early grain and leguminous crops for export. These crops were grown for intensive, industrial technologies using modern methods of seed preparation, chemical protection and plant care, and others. Most of these enterprises are used in the cultivator processing system for presowing continuous tillage.

We have investigated that it is possible to increase the rate of work on surface tillage (cultivation) by using new materials that have high tribological properties and do not require maintenance (lubrication). Such materials include polymeric composites.

Technological progress was based exclusively on the use of natural materials - wood, stone, metals, by the beginning of the twentieth century.

The human used natural polymers for many years: cellulose, rubber, leather. Synthetic polymers were first obtained in the first half of the twentieth century, this is the beginning of the century of synthetic polymer materials.

Now a special place in the modernization of machines belongs to plastics, increasing their reliability, reducing metal consumption. The unique properties of plastics improve designs, improve their quality, reduce cost, increase labor productivity [2, 3].

Plastics used in engineering are divided into five groups: decorative, structural, antifriction, anticorrosive, electrical insulating.

To improve the technical level of machines and agricultural machinery use structural and antifriction plastics. For this purpose: polyamides, polyethylene with various dispersed and fibrous fillers are often used [5, 6].

Today, the use of complex plastics with different modifiers and fillers form a new group of high-tech materials - polymer composite materials. Application of polymeric composite materials in engineering and agriculture occupies an important place. This also applies to soil-cultivating machinery, which is improved for agronomic requirements [4, 8].

Machines for surface tillage combine the methods of processing with different tools to a depth of up to 16 cm. These are lushchilniki, skating rinks, harrows and cultivators. Cultivators are equipped with a parallelogram mechanism to ensure the most qualitative preparation of the soil, the main task of the mechanism is to copy the soil surface and ensure a stable seedbed.

Parallelogram mechanism of cultivators (Fig.1) is a multi-hinged system for fastening the four-link mechanism, the links constitute a parallelogram. Such a system ensures high-quality copying of the field relief and a constant angle of the working element with respect to the field. During the operation of the parallelogram mechanism of cultivators КПС-4,0, КРН-5,6, КПС-8 Voskhod and others, faults were detected, such as intensive and premature wear of the axis of the links of the mechanism. This leads to a violation of the technological process of cultivation and non-compliance with agrotechnical requirements. The manufacturing plants introduced system lubrication of hinges with plastic materials. The frequency is 48 ... 100 hours. But, for wide-spread cultivators, the maintenance of mechanisms leads to significant overstrain of the aggregates, which leads to a violation of the agrotechnical terms of cultivation.

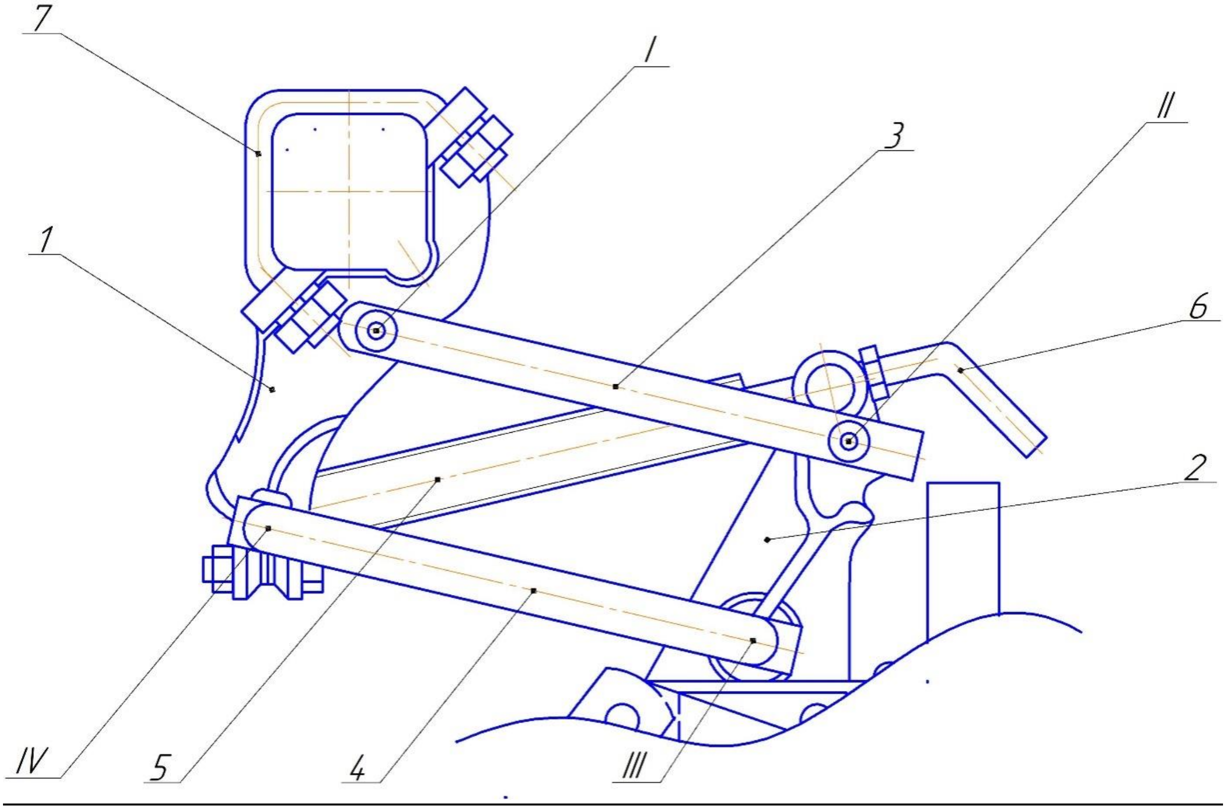

Fig. 1 - Parallelogram mechanism: 1 - the front bracket, 2 - the rear bracket, 3 - the upper link of the mechanism, 4 - the lower link of the mechanism, 5 - the spring, 6 - the adjusting screw, 7 - the bracket clamp, I, II, III, IV, - places of wear.

Positions I, II, III, IV are the axes that are most worn out during the movement of the links of the parallelogram mechanism. We suggest placing them in bushings made of polymer composite materials that will have good physicomechanical and tribological properties.

Scientists Kozachenko O. V., Shkregal O. M., Svirin O. M., Babitsky L. F., Kuvshinov A. A., Tarasenko V. I., Mancinskiy Y. O. were engaged in the improvement of cultivator designs and their working organs. They investigated the stability of rectilinear motion, the oscillatory device of the cultivator paws, and improved the design of the working organs. However, these works were not aimed at the introduction of polymer composite materials in their design.

Based on the conducted studies, we can conclude that a promising direction in improving the design of the parallelogram mechanism is the introduction into the design of parts made of polymer composite materials.

In [10, p. 45] describes the use of polymeric composite materials based on aliphatic polyamide CCPA-6-40 in this mechanism, but its increased hygroscopicity led to wedging of the hinges of the mechanism after seasonal storage. Also, sometimes materials that have a complex, low-productivity and energy-intensive processing technology [11] have been proposed for use in similar mechanisms.

Previously, we found that polymer composite materials based on aliphatic polyamides provide a stable process of friction and wear in similar mechanisms [7].

The introduction of polymer-composite materials in the construction of mobile compounds of agricultural machines requires careful experimental studies of the characteristics and properties of polymer-composite materials, structural designation, especially tribotechnical, resource, operational, etc.

Materials and Methods. The manufactured samples for the research of relative abrasive stability were linear dimensions 53 × 29 × 7 mm, which comply with GOST 23.208-79.

The research of samples on the relative abrasive resistance was carried out on a specially laboratory equipment installed on the basis of the friction machine СМЦ-2.

The essence of the method was that under the same conditions, forced wear of the studied and reference samples was carried out. Wear was carried out using an abrasive non-rigidly fixed material (electric iron No. 16-N, GOST 3643-71), which was fed to the friction zone and pressed to the specimen with a rotating rubber roll.

Before the test, the abrasive was dried to a relative humidity of no more than 0.16%. The spinning of the roller was carried out by friction method on the surface of a grinding paper type 2 (GOST 6456-75) with grainy number 8P (GOST 3647-71), fixed in a sample holder on a flat steel plate. After spin, the roll was washed in gasoline.

Tribotechnical characteristics of parts of mobile joints with PCM when not rubbed greased were determined on a friction and wear machine СМЦ-2.

Indicators of the potentiometer КСП-2 were fixed on a special chart paper GOST 7826-75. The tests were performed according to the "disk-block" scheme. The radius of the sample was R = 0.025 m.

Before the beginning of each test, the samples were cleaned. This was done so that the friction surfaces of the samples had a parallel shape and the contact area was at least 85%.

The temperature in the friction zone was measured using the chromed-alumel electronic thermocouple "Termometer 301 Type K". The hole for measuring the temperature is carried out at a depth equal to half the diameter of the sample, and at a distance of 1 mm from the surface of the friction.

The contact area of the tribo-connection "disk-block" was 2 cm2. Study mode: p = 0.5 MPa, v = 0.785 m/s. The process of rubbing occurred in the following modes: maximum specific pressure p = 0,25 MPa, slip velocity v = 0,785 m / s. It the curing process was completed when reaching the contact area of the pad with a conjugate sample of 85% of the projection area.

The number of repetitions of all experiments is 3.

Thermal treatment method for protection against environmental impact.

In order to solve the problem of protection of PCM from the negative influence of the external environment, it is proposed to heat the finished parts processing with PCM in the following lubricants: MS-20, PMS-400, and I-40.

Thermal treatment of composite materials:

- temperature - 393 K;
- heating and cooling mode - 1 °C / min .;
- exposure time - 120 min.

Results and Discussion. Six types of high-molecular compounds were used to study materials of parts made of polymer-composite materials: № 1 – Nylon 66; № 2 – PA-6-210X; №3 – PA6 / 6.6 R196-GF30; № 4 – KocetalGF705; № 5 – KocetalK300 and № 6 – CCPA-6-30. The research carried out on the relative abrasive stability of polymer composite materials, which showed (Fig.4), that sample № 1 (Nylon 66) has the highest relative abrasive resistance and substantially differs positively from other materials. The visual ranking of samples according to the criterion of relative abrasive stability showed, that the Kocetal GF705 material (5times lower than standard) has the lowest abrasive durability.

Table 1 – Properties of polymeric-composite

Properties/Sample	№1	№2	№3	№4	№5	№6
Relative abrasive stability	1	0.607	0.511	0.233	0.353	0.436
The value of weight deterioration with friction without lubricating, g	0.00908	0.00667	0.00506	0.015	0.00846	0.00083
Friction of coefficient	0.49	0.22	0.34	0.33	0.21	0.16
Temperature on the friction surface, °C	119	87	97	95	80	68

The general view of the experimental parts made of polymeric-composite material CCPA-6-30 is shown in Fig. 1

a

b

Fig. 1 - General view of experimental details: *a* - details of the upper lever; *b* - details of the lower lever.

We have developed methods for heat treatment in oils [23], which make it impossible to hygroscopic PKM based on aliphatic polyamides in volumes that led to a change in geometric dimensions or changes in properties.

Table 2 – Influence of heat treatment in oil on the strength of polymeric composite materials of grade CCPA-6-30.

Parameter	Control	After processing	Deviation,%
Strength of compression strength σ, MPa	134,7	133,1	- 1,18
Modulus of elasticity E, MPa	1883,1	1743,9	- 7,39

The results of the research have shown that the Nylon 66 PCM, which provides relative abrasive stability, is 39% higher than the PA-6-210X composite and 77% higher than Kocetal GF705.

It is not recommended to use as abrasive resistant materials Kocetal GF705 and Kocetal K300.

On the basis of the obtained data it can be assumed that the materials of the specimens for №№2, 5, 6 are antifriction because they have a coefficient of friction f <0.3, and the materials of the specimens for №№1, 3, 4 are frictional materials with moderate high coefficient of friction, therefore their use in movable connection of cultivators is inappropriate.

The research of the dependence of friction coefficient f on the duration of the experiment showed that the stabilization f for all samples comes after 3 ... 22 min. from the beginning of the test. For samples №2 - 6, during 120 minutes, *f* did not increase, or its deviations were within the measurement error. Only when tested with a Nylon 66 PCM sample this indicator slightly increased steadily. The growth rate of this parameter was 0.01 $(h)^{-1}$.

In order to ensure the stable operation of mobile machines and mechanisms operating under conditions of friction without lubrication and a small amount of abrasive, it is recommended to use a polymer composite - UPA-6-30, which at a specific pressure p = 0.5 MPa and slip velocity v = 0,785 m / s provides a minimum friction coefficient (f = 0,16), temperature in the friction zone (T = 313 K); their own wear, which is an order of magnitude smaller than the other samples being studied. This composite has stable performance over long periods of operation.

In general, the proposed method of heat treatment [23] reduced the hygroscopicity of this polymer composite material, and the amount of moisture accumulated during the storage of equipment decreased from 0.70% to 0.35.

This technology is realized in Development Enterprise "Soyuz-Composite" [12] and recognized as cost-effective.

This material may be use in construction tillage machines, designed Harran University (Turkey).

Fig.3. Agricultural machine for tillage, designed Harran University (Turkey).

Conclusion. The use of polymer composite materials in hinged joints of parallelogram and other mechanisms of soil tillage machines will improve the quality of the implementation of agrotechnical requirements, eliminate the cost of idle time during the maintenance of mechanisms, reduce the cost of operation and maintenance of modernized cultivators.

References:

1. Statistichniy schorIchnik UkraYini za 2014 rIk. Derzhavniy komItet statistiki UkraYini. – K.: /"Konsultant"/, 2015. – 534 s. (Ukr).
2. Derkach O.D. Vikoristannya shirokozahvatnoyi tehniki v umovah prirodnogo zemlerobstva / O.D. Derkach, D.O. Makarenko // Prirodne agrovirobnitstvo v UkraYinI: problemi stanovlennya, perspektivi rozvitku: MIzhnar. nauk.-prakt. konf. – DnIpropetrovsk: DDAEU, 2015. – S. 52-54. (Ukr).
3. Derkach A., Makarenko D., Naumenko N. Primenenie ugleplastikov v shirokozahvatnyh posevnykh mashinakh. Mechanization in agriculture / International scientific, scientific applied and informational journal. YearLXI, 2/2015, Sofia, c. 3-6. (Rus).
4. Burya A. Modernizatsiya pantographnogo mekhanizmu kultivatora KP-6 "Maksym". The international scientific and practical conference "Complex zabezpechennya jakcosti tehnologichnykh protsessiv ta sistem". - 2015. - P. 45-46. (Ukr).
5. Gatskov V. S. Progressivnyie tehnologii izgotovleniya detaley iz antifriktsionnyih materialov: Uchebnoe posobie. – M.: NIYaU MIFI, 2011. – 152 s. (Rus).
6. Kashitskiy V. P. NaukovI pIdhodi do stvorennya samozmaschuvalnih epoksikompo-zitnih tribomaterIalIv / V. P. Kashitskiy, P. P. Savchuk // NaukovI notatki. – 2015. – Vip. 50. – S. 76-80. (Ukr).
7. Derkach O.D., Burya O.I. Pidvischennya tehnIchnogo rIvnya elektro-, avtomobIlnogo tran-sportu ta sIlskogospodarskoYi tehnIki za rahunok vikoristannya novih materIalIv. NaukovI rekomendatsIYi: DnIpropetrovsk: DDAU. – 2011. – 71 s.(Ukr).
8. MurgasM. Wear resistant materials for agricultural machinery // Mech. Zemed. – 1990. Vol. 40, №10. – P. 451-453.
9. Carbon fibre hoops hesten repair of fertilizer tower// Atv. Compos. Bull.-2002. Apr. –P. 4–5.
10. Kobets A., Derkach A., Makarenko D., Shapoval A., Kabat O. Decreasing the environment influence on composite materials / НаучниИзвестия. Scientific Technical Union of Mechanical Engineering, Year XXIV, ISSUE 16 (202), June 2016. IV International Scientific and technical Congress "Agricultural Machinery", 22-25.06.2016, Varna, Bulgaria, c.13-15.
11. Derkach O., Artemchuk V., Muranov Ye. Do pytannia tekhnologichnosti otrymannya detaley z polymernykh compozytiv dlya posivnoi tekhniky. . Visnik HNTUSG im. Petra Vasilenka, - 2017. № 181, p. 157-167. (Ukr).
12. http://soyuz-composite.com.ua