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Dynamics of wear of the cutting elements of tillers

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Abstract: *Dynamics of wear of the cutting elements of tillers.* The paper discusses theoretical studies of wear of the cutting elements of working bodies of tillers to develop their technological process of hardening, providing on the one hand increase their longevity, and with another – providing quality tillage. It shows the dependence of the wear rate on the length of the cutting edge cultivator paws. The interaction of the blade working organs of tillers of the soil with the environment was characterized. The diagram of the forces acting on the blade body and working movement direction in the soil was given. The analysis presents dependence between the linear wear lancet cultivators paw thickness and such factors as the way of friction, normal specific dynamic pressure of the soil, the hardness of the material clutches, friction area. The paper shows the effect of the angle between the polar axis and the radius of curvature of the cutting edge of the blade cultivator paws on the value of its wear. The regularities of changes in the intensity of wear feet are observed along the length of its cutting edge.

Key words: cultivator paw, deformation, technological process, abrasive wear, wear rate

INTRODUCTION

Insufficient reliability of agricultural machinery causes significant costs of spare parts and, consequently, increasing cost of their operation and maintenance.

Restoration of details allows repair companies to reduce downtime, increasing the quality of maintenance and repairing, positive impact on improvements in the reliability and the use of technology [Dudnikov et al. 2011a, Dudnikov et al. 2011b].

The economic aspect of the advisability of carrying out works on recovering remediation parts is to reduce the cost of repair by reducing the cost of new parts and to reduce production costs of their operation.

Particular interests are the working bodies of tillers, the technical condition which significantly affects the yield of crops. When you restore these items are necessary to improve the geometry of the support and seats, improve the hardness and wear resistance of the working surfaces, which can be achieved in developing and applying advanced technologies to significantly improve the quality indicators of restored parts of agricultural machines [Ribak 2003, Bilous 2007].

RESULTS OF ANALYSIS

A major shortcoming of the existing wing shares with planar warp is of poor quality soil loosening, because their effect on the lateral faces of the reservoir at the same time loosening. Intensification of such effects by the wear of the cutting edges of the blade paws has a negative impact on the energy of the process. In addition there is a destruction of bioactive soil structure to dust, easily subject to erosion.

In this connection there is an interest for research wear tines, as the lack of adequate physical and mathematical model of abrasive wear and the formation of the geometry of the cutting elements. Disclosure of the basic laws of the abrasive wear of the cutting elements and the formation of the optimal geometry is an important task in the problem of increasing resource of tillers [Zayika 2001].

It was established that the interaction of the working bodies of tillers of the soil with an abrasive media during their movement is characterized by the influence of the abrasive soil wedge on a flat work surface. An effect on soil wedge depends on the nature of deformation of the material, parameters of the wedge, the physic mechanical properties and condition of soil, the speed of its movement.

During the moving of the layer of soil on the wedge at the point M on the work surface forces: mass of the layer – Q, the dynamic pressure – N, force of friction – F_{mp}, causing the wear of surface of the working body (Fig. 1).

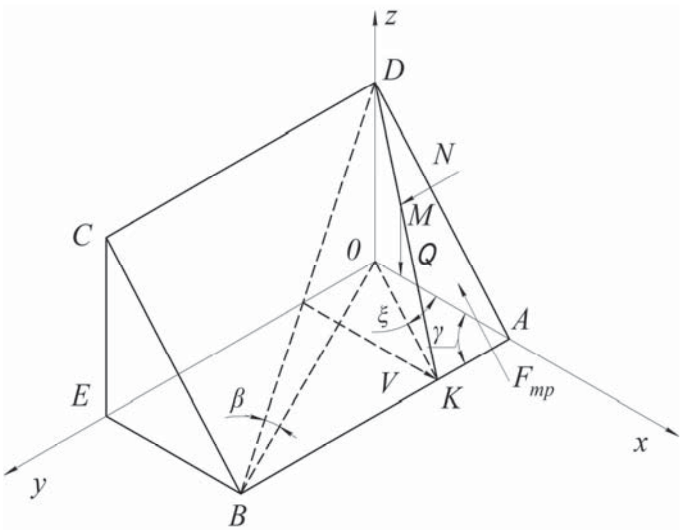

FIGURE 1. Diagram of the forces action and the direction of movement of soil particles on the blade working body

The value of abrasion paw on thickness ($И_h$) can be expressed as a function of the following factors:

$$И_h = f(Г_\rho, L, H_\mu, m, S) \quad (1)$$

where:
$Г_\rho$ – normal resistivity dynamic pressure of the soil;
L – the way of friction [m];
H_μ – the hardness of paw material;
m – parameter of wear ability of the abrasive;
S – area of friction [m^2].

The mass of soil element that located at the wedge can be defined by the formula:

$$Q = abl\Gamma_{\rho} g \quad (2)$$

where:
a, b – the thickness and width of the layer respectively [m];
l – length of element of layer [m];
g – acceleration of free fall [m/s^2].

Projection of force (N) on the direction of normal to the surface of the wedge is:

$$N = abl\rho g \cos\xi \quad (3)$$

where:
ξ – the angle between the polar axis and the radius of curvature of the cutting edge (Fig. 1) [°];
ρ – density of the soil [kg/m^3].

The friction force can be defined by the following relationship:

$$F_{mp} = fab\Gamma_{\rho}(V_{nep}^2 \sin\xi \sin\gamma + gl\cos\xi) \quad (4)$$

where:
V_{nep} – the forward speed of the wedge [m/s].

Analysis of this equation leads to the conclusion that with the increasing of the angle (ξ) setting the working surface of the reservoir is complicated by the rise of the soil is strongly deformed and complicated front wedge.

We can assume that in this case will increase the normal pressure on the soil wedge which will reduce the speed of relative sliding layer on the working surface. Thus at the wedge formed stagnation zones of soil particles and the amount of wear is reduces [Opalchuk et al. 2013].

Wear of the cutting edges of paws cultivators irreversible processes determining soil degradation in the performance of work. The size and nature of wear are determined primarily patterns of distribution of stresses on the working surfaces cultivators paws.

To ensure durability of paws, reducing the value of their wear need to reduce the ability of the abrasive wear out and provide such options of the paws that will reduce the dynamics of their wear.

It is found that the highest intensity of wear wing shares cultivator is characteristic of the sock. At the distance from the tip intensity of the wear of the cutting edge reduces.

Based on the experimental results, the dependence of the wear rate in the zones length legs can be described by the differential equation [Tkachev 1970, Boyko and Balabukha 2000]:

$$\frac{di}{dl} = -ki \quad (5)$$

where:
i – the wear rate;
k – coefficient of proportionality.

The coefficient k depends on the physical properties of the parts and the soil, and operational factors: velocity of the machine, the specific load on the working part and others.

Taking into account the above factors, as well as the dimensions of the method in the preparation of analytical expressions [Voytyuk et al. 2004, Dudnikov et al. 2014], the proportionality factor becomes:

$$k = \frac{H_{\mu} X}{H_a} \sqrt{\frac{E_M S}{\Gamma_{\rho} T}} \quad (6)$$

where:
H_μ, H_a – the hardness of paw and abrasive materials, respectively;
X – empirical constant that takes into account the optimal factors;
E_M – coefficient of elasticity of the paw material;
S – area of the working surface of the paw [m^2];
Γ_ρ – unit load per paw of soil;
T – operating time on one paw [ha].

After integration of equation (5) as an equation with separable variables and taking into account the relation (6), we obtain:

$$\frac{di}{i} = -\frac{H_\mu X}{H_a}\sqrt{\frac{E_M S}{\Gamma_\rho T}}\,i$$
$$\int_0^l \frac{di}{l} = -\int_0^l \frac{H_\mu X}{H_a}\sqrt{\frac{E_M S}{\Gamma_\rho T}}\,i \qquad (7)$$

For the conditions of abrasive wear we have:

$$\ln i = -\frac{H_\mu X}{H_a}\sqrt{\frac{E_M S}{\Gamma_\rho T}} \cdot l + \ln C \qquad (8)$$

Since the intensity of wear paws at $l = 0$ is equal to $i = i_0$, the constant of integration is equal to:

$$\ln i_0 = -\frac{H_\mu X}{H_a}\sqrt{\frac{E_M S}{\Gamma_\rho T}} \cdot l + \ln C; \quad C = C_0 \qquad (9)$$

Taking into account expressions (8) and (9) after some transformations, we obtain the pattern of change of the wearing rate on the length of cutting edge of paw:

$$i = i_0 l^{-\frac{H_\mu X}{H_a}\sqrt{\frac{E_M S}{\Gamma_\rho T}}\cdot l} \qquad (10)$$

Thus, the wear rate of the cutting edge lancet paws depends mainly on the physical and mechanical characteristics of its material hardness soil developments.

CONCLUSIONS

On the basis of these investigations the conclusion can be drawn:
1. Uneven wear of cultivator paws on length can be explained by the uneven pressure of the soil elements on the elements of its length.
2. The wear rate of the cutting element along the length of a lancet paws depends on physical properties of its material, soil type, soil developments uneven pressure around the perimeter.
3. The resulting patterns of wear intensity perimeter lancet cultivator legs allow to develop a method of modeling the dynamics of its abrasive wear of the cutting elements for the appointment of an effective recovery technology.

REFERENCES

BILOUS Y.K. 2007: Problems of realization of technical policy in agriculture. ESC “IAE”, Kyiv.
BOYKO A.I., BALABUKHA O.V. 2000: Analysis of the distribution of effort on the cutting elements of tillage tools. TNTU, Ternopil.

DUDNIKOV A.A., PYSARENKO P.V., BILOVOD O.I., DUDNIKOV I.A., KIVSHYK O.P. 2011a: Designing of technological processes of service enterprises. Naukova Dumka, Vinnitsa.

DUDNIKOV A.A., BELOVOD A.I., DUDNIK V.V., KANIVETS A.V., KELEMESH A.A. 2011b. Effect of part cutting type on stress state of material. Annals of Warsaw Agricultural University, Agriculture 58: 85–87.

DUDNIKOV A.A., BELOVOD A.I., PASYUTA A.G. 2014: Analiz metodov vosstanovleniya i uprochneniya rezhushchih elementov rabochih organov pochvoobrabatyvayushchih mashin. Materialy Mezhdunarodnoy nauchno-prakticheskoy konferentsii "Tehnicheskoe i kadrovoe obespechenie innovatsionnyh tehnologiy v selskom hozyaystve". Minsk: 104–106.

OPALCHUK A.S., AFTANDILYANTS E.G., ROGOVSKIY L.L. 2013: Materialoznavstvo i tehnologiya konstruktsiynih materialiv. Nizhin.

RIBAK T.I. 2003: Poshukove konstruyuvannya na bazi optimizatsiyi resursu mobilnih silskogospodarskih mashin. VAT "VPK", Ternopil.

TKACHEV V.N. 1970. Induktsionnaya naplavka tverdyh splavov. Mashinostroenie, Moscow.

VOYTYUK D.G., DUBOVIN V.O., ISHCHENKO T.D. 2004: Silskogospodarski ta meliorativni mashini. Vishcha osvita, Kyiv.

ZAYIKA P.M. 2001: Teoriya silskogospodarskih mashin. Oko, Harkiv.

Streszczenie: *Dynamika zużycia elementów kultywatora pracujących w glebie.* W artykule przedstawiono teoretyczne rozważania dotyczące zużycia elementów kultywatora, które pracują w glebie. W tym kontekście celem podjętych rozważań było wskazanie na czynniki doskonalenia procesu utwardzania powierzchni elementów roboczych, a w efekcie wydłużenia czasu ich pracy i jakości realizacji zadań roboczych kultywatora. Wskazano na zależność stopnia zużycia od długości krawędzi tnącej zębów roboczych. Przedstawiono problemy interakcji między elementami roboczymi kultywatora i środowiskiem glebowym. Zaprezentowano wykres sił działających na ostrze redlicy w glebie w powiązaniu z kierunkiem ruchu narzędzia. Analiza obejmowała zależność między zużyciem łukowej części łapy kultywatora i takimi czynnikami, jak kierunek sił tarcia, stopień ugniecenia gleby, sprężystość zębów i obszar tarcia. W artykule rozwinięto kwestię wpływu kąta osi ustawienia zęba i promienia krzywizny redlicy podcinającej kultywatora na wielkość zużycia powierzchni roboczej. Regularność zmian intensywności zużycia łap kultywatora jest obserwowana wzdłuż długości krawędzi tnącej.

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