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RESEARCH ARTICLE

RESEARCH OF THE TENSE STATE OF SOIL AND WORKINGS ORGANS OF TILLAGE MACHINES AND THEIR INFLUENCE ON HAULING RESISTANCE

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Abstract

Nowadays, the management issues of wear of working organs of tillage machines (WOTM) process due to the interaction with soil and that of the resistance opposed by the soil have not been sufficiently studied. The research method on the tense soil and WOTM is developed with the use of sensors and complex measures .This method is intended for the transformation of pressures' difference by placing sensors. The sensors are placed in the environment where the work hardening methods for cutting edge of WOTM are certain on one side paw and cutter example. This is enable to get wear proof coverage with sufficient hardness. The method of measuring WOTM hauling resistance is developed and basic indexes powers are certain. At tillage of soil cultivating machines working organs, the transitions of soil are considered environmentally. Through routine the separated phases of various soil offer resistance to the power actions of WOTM and influence on deformation of soil. Influence of change of the tense-deformed state of environment of soil is exposed on character and size of wear of working organs of it. Dependence of distributing of size of tension is investigational in soil with distance from the working surface of WOTM, it depends both on the type of WOTM and layer depths soils. Character of hauling effort change of standard one-sided paws and chap cutter is probed on a size at the different sizes of tensions in soil. Dependences of hauling resistance of one-sided paws and chap cutter are got on work, then taking into account the mode of deformation (MD) of soil.

Keywords: soil, mode of deformation, hauling resistance, phase state, cutting element, working organ, aggregate composition of soil, wear.

1. Introduction

During operating of WOTM on soil changes it tensely is the deformed state MD, an initial structure is violated [1-3]. We will notice that the state of soil here will be unstable. And, the process of tillage the several of energies is tricked into, so, maximal possible effect is arrived by the purpose of purposeful change of properties

and realization of the basic requirements which a maximally possible effect is arrived. Thus an important task is above all things adjusting of structure and structure layer of soil, adjoining to WOTM during tillage. A change of the closeness of soil influences not only on the change of agroidexes but also on character of wear of WOTM. The value of closeness and maintenance of hard phase of soil influences on this factor [4-5]. Comparing the natural closeness of hard phase of soil to optimum one, it is possible to define the rational method of tilling and degree of influence on soil, and also to create the terms of the least expense of energies at its tillage.

WOTM in the process of exploitation cause the compressions of some volume of soil except for loosening, and also formations of overstock blocks and skip-row. At last requires the additional loosening, when the energy is outlaid very much. In the process of co-operating WOTM with soil, the compression kernel is squeezed out between soil and WOTM. So, there is a permanent getting up to make more compact layer of soil on a surface during the forward movement of WOTM that appears in strata. Closeness in a soil kernel in 1,6 time higher, than in the undisturbed layer of soil. A kernel of compression and close-settled layer of soil are reasons of education before the surface of WOTM of overstock area, which causes their intensive wear and increases hauling resistance.

The problem of management wearproofness of WOTM decides for today, mainly, by the increase of physical-mechanical properties of surfaces of friction by the methods of work-hardening and change of geometrical form of workings surfaces. But it is not enough the questions of management processes of wear of WOTM which are considered at co-operating with soil, as heterophase environment and change of its properties and state. It is not enough attention it is spared to the question of determination of size of tensions of environment of soil, to conformities to the law of its change on the depth of the processed layer and influence on the size of hauling resistance and character of wear of WOTM at tillage of soil.

A question of measuring of size of tensions of soil is not exposed on a depth, his distributing at tillage the different types of WOTM [6]. Research of change of properties and distributing of MD on the depth of superficial layer of soil will allow defining new conformities. The law of flowing of friction's processes and wear at co-operating of WOTM with soil, displays of specific rheological properties of soil. Thus one of important tasks of experimental and theoretical researches is an exposure of properties change and the soil tensely-deformed state in the environment. All this happens in the process of co-operation with WOTM on a different depth by different workings organs (WO) and their influences on the size of hauling resistance of WOTM.

2. Materials and methods

2.1 General description of soil and WOTM

Soils, prevailing on territory of the Kirovograd′s area of Ukraine, were subject research: black hard loamy soil, sandy loam and middle loam. The choice of workings organs of tillage machines is conditioned different (spatial) character by placing their cuttings elements; they also engulf the different types of existent models of wedge. In-process probed affecting soil of one-sided paws and chap cutters.
An one-sided paw and chap cutter is made from steel of 65G, chemical composition of which is resulted in table 1.

Table 1: Chemical composition in % steel 65G (State Standard 14959-89)

C	Si	Mn	Ni	S	P	Cr	Cu
0,62…0,7	0,17…0,37	0,9…1,2	till 0,25	till 0,035	till 0,035	till 0,25	till 0,2

Work-hardening of cutting edge of one-sided paw and chap cutter is conducted by welding deposition of electrodes of T590, that allowed to get wear proof coverage with sufficient hardness, minimum porosity and high durability of tripping $\overline{\sigma}_{cö}$ =342 MPa.

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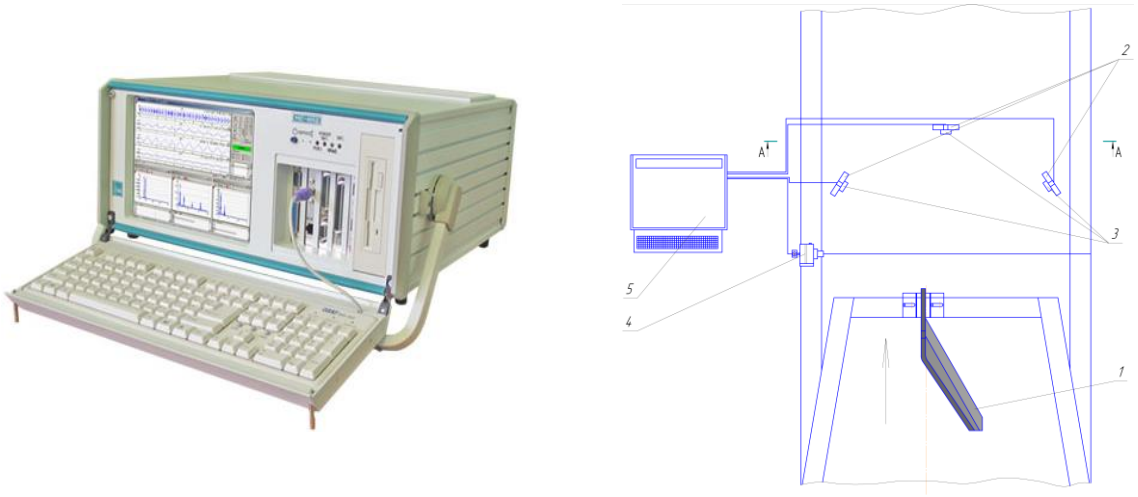
2.2 Method of research of the tense state of soil and WOTM

The MD of soil at operating of standards cuttings elements (CE) and WOTM are probed on the base of soil channel and the experimental field of the Kirovograd National Technical University. The method of measuring was developed with the use of special strain sensors of model of LPX 5000 with parameters [5]: working transitivity: 2 mV/V, combined error: 0,1%, class of defense: IP67, working temperature range: -30 ... +50°C, possible overload: 150%, material: nickel-plated steel, maximal loading 50 кN. As a recording apparatus drew on a measuring complex MIC 400D (Fig.1 a), which is intended for transformation of difference of pressures to the places of placing of the strain sensors in the medium of soil in the output compatible signal of mutual inductance with linear dependence.



a) b)

Figure 1: Complex measure MIC 400D (a) and chart of setting on determination of MD of medium of soil (b)

A complex measure allows real-time to conduct measuring and processing of the got data that are passed on an interface. Synchronization at times of measuring work ducting of strain sensors and photocell is carried out by the module of ME-020 which forms the managing signals of synchronization of complex MIC 400D and measuring information in a single time-scale. Research's method essence of soil MD that affects its WOTM consists as the following. In a soil channel (Fig.1 b.) before WOTM 1 on the depth of its tillage, on the special holders 2 were set three cylindrical strain sensors 3. Initial distance from the line of photocell 4 to the place of setting of strain sensors is equal 0, 7 m. The rate of movement of WOTM was accepted the equal operating (3 m/s).

At passing of WOTM of line, photocell 4 gave a signal on a complex and the value of tension in the places of soil was fixed, where strain sensors are located. Distance from the line of photocell to strain sensors was diminished through each by 0,1 m. On certain distances experiments repeated three times. From got data on each the fixed distance built the isobars of distributing of tensions in this horizontal plane, located on a certain depth. Utilizing the described method of determination of MD for the fixed plane of soil, conducted the indicated measuring, changing the depth of immersion of sensors through each 5 cm: 0, 5, 10, 15, 20, 25, 30 cm. From got data set dependence of tension in soil from distance of sensor to CE WOTM, or to the certain plane of his working surface, at the unchanging depth of immersion of sensors, and also from the depth of immersion of sensors, disposed on certain distance from CE or working surface of WOTM. From got data built the spatial distributing of MD at co-operating of CE WOTM with soil, and also distributing of tension on the axes of co-ordinates.

Estimation of the field of tensions in material of CE WOTM in the process of co-operating of him with soil carried out the method of eventual elements on the personal COMPUTER. An analysis and calculation of the field of tensions and deformations on the workings surfaces of CE executed by the package of COSMOS Works computer-integrated in the CAD-system of SolidWorks on the developed method [5].

2.3 Method of measuring of hauling resistance

The basic power index of WOTM is their hauling resistance. For registration of hauling resistance in laboratory and field terms utilized dynamograph. The chart of device for measuring of hauling resistance of WOTM in operating terms (Fig.2) consists of corps 1, in which rod moves 2, combinable with by the bar of fastening of WOTM. On the frame of aggregate workings organs 4 are fastened. Longitudinal moving of rod in a corps 1 limited to the spring 5 and by support 6. Character of moving in a horizontal plane is passed to the writing down mechanism 7 through leverage 8. Connections of this device with facilities of unitization carried out by a beared device 9. A writing down mechanism consists of electric motor 10, extensive device 11 with a spool and capacities for piling of paper ribbon with written in information.

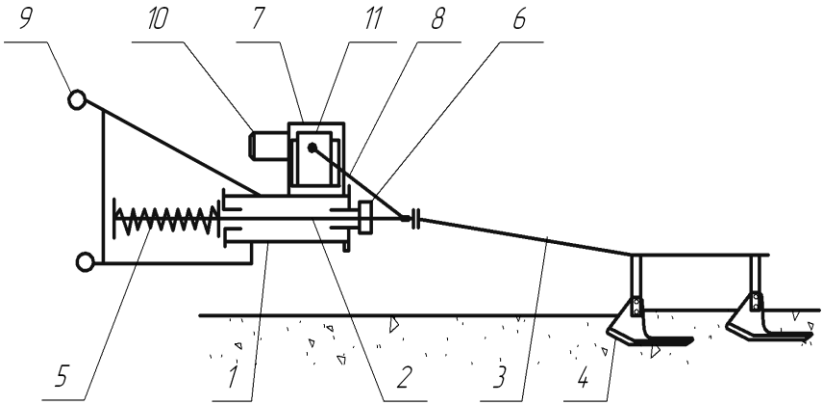


Figure 2: Chart of device for determination of hauling resistance of WOTM in operating terms

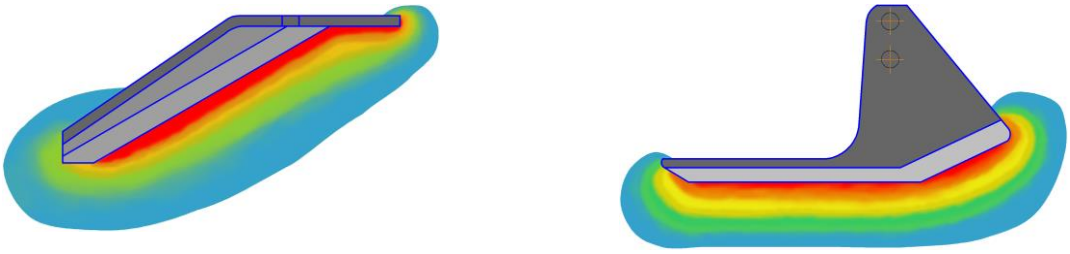
A device for measuring of hauling resistance works as follows. By a mounted device, that are one whole with a corps it unites with a tractor. A writing down mechanism is refueled a diagram paper, that writing down element, fastened on leverage, is set on. At moving in soil, WOTM test resistance is passed through rod on a spring, squeezing it on the proper size. Proportionally rod moves the compression of spring in relation to a sending corps. The size of moving of штока depends on the size of resistance of soil. The indicated moving of levers the system is passed to the writing down element. The proper record is carried out on a paper with permanent speed. The rejection of curve on a paper from an antipolar is proportionally to the moving of beam consequently to the size of hauling resistance. It's determinated by using the calibration scale. Gauging of dynamograph was conducted on a break machine. Middle instrumental error was 1,9%.

Before the beginning of experimentation on the experimental field of the Kirovograd National Technical University, mark out an area, that consist of testing area long 30 m for the record of the proper parameters on the set speed, and also two areas long 5 m, which are needed for an acceleration and conclusion of aggregate on the necessary speed and for the exit of aggregate from a test area. Cultivator KPS-4 and chisel plow - chap cutter CHN - 2, 8 building-block approach with a tractor MTZ-80. The working width of capture of cultivator made 4,0 m, a rate of movement is 1,5 m /s, depth of tillage - 7 ... 8 cm for an one-sided paw and 35 ... 40 cm for chap cutter. On workings aggregates set the complete sets of one-sided paws and chap cutters, standard and work-hardened by electro arc welding of electrodes T-590.

3. Results

3.1 Mode of soil deformation at co-operating with an one-sided paw and chap cutter.

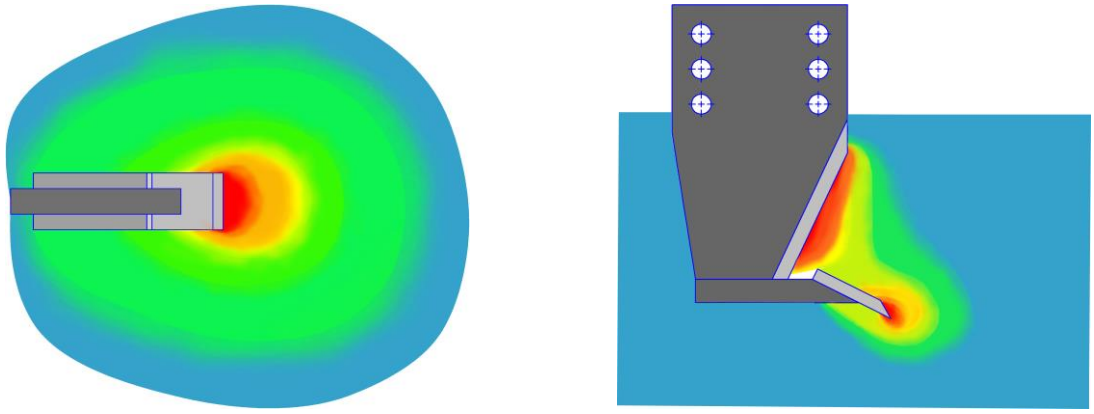
The importance of distributing tension's results, the process of its co-operation with WOTM is explained that nascent picture of tensions, lines of sliding of soil particles and their tearing away from the working surface of WOTM. So the WOTM substantially influences on the quality of tillage and receipt of dependences, characterizing a change the closeness of hard phase of soil from the basic parameters of WOTM and physical-mechanical properties of soil. High-quality description of the field of tensions, involved in motion of layers of soil, adjoining to the workings surfaces of one-sided paw presented on a fig. 3, and chap cutter - on a fig. 4.



a) b)

Figure 3: Layout of the field of tensions in the horizontal (a) and vertical (b) planes of soil before CE of one-sided paw

The got picture of the field of tensions in different planes testifies that areas of concentration most of environmental soil tensions observed in area of adjoining to sock part and middle of CE of one-sided paw (fig. 3). Unlike co-operating of soil environment with an one-sided paw, when the layer of soil is involved by a less thickness, in the case of co-operation of soil with chap cutter is a thickness of layer of soil on much anymore and the looked after picture of the field of tensions has other character (fig. 4).



a) б)

Figure 4: Layout of the field of tensions in the horizontal (a) and vertical (b) planes of soil before cuttings parts of chap cutter

In this case a considerable concentration of tensions is exactly on the area of soil environment, where the chisel of chap cutter (fig. 4 a) operates and there is splitting off of layer of soil. Whereupon split off layer is cut vertical CE (fig. 4 b), therefore most tension is on its underbody and with approaching to the surface of soil diminishes. In the process of treatment as far as blunting of cutting edge of CE MD changes. The results of researches of distributing of size of tensions in the horizontal and vertical planes of environment of soil affect its one-sided paw are resulted at fig. 5, and chap cutter - at fig.6. Distributing of tensions in a horizontal plane before an one-sided paw (fig. 5.a) and its bar (fig. 5.b) testifies that the concentration of tensions is concentrated before a cutting edge. It is possible to see that the closeness of isolines of tensions in soil, built on results experimental researches with a delete from the surface of one-sided paw, diminishes in horizontal and vertical planes, and the size of tension goes down. Character of distributing of isobars before CE WOTM is analogical of isolines tensions, arising up in sandy soil under the action of stamps or vertical knives.

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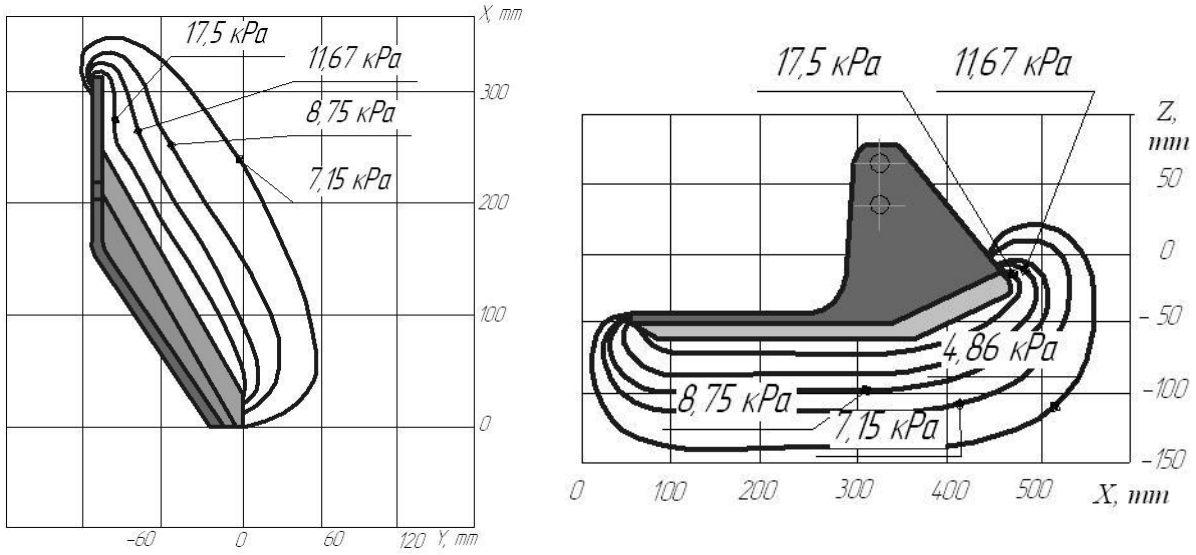
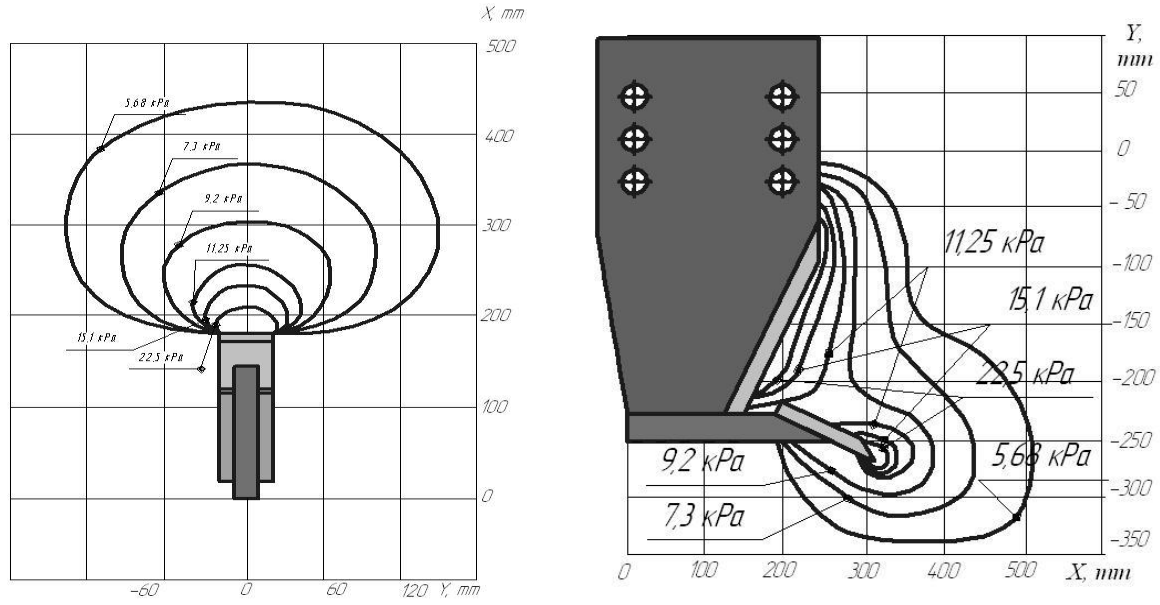


а) б)

Figure 5: Distributing of isolines of tensions before an one-sided paw, in a horizontal plane (a) and before the vertical bar of one-sided paw (b) (black earth loamy, humidity of W - 12%, a depth is 5 cm)

Results of research of distributing of isolines of tensions in soil observed for the proper planes before chap cutter resulted at a fig. 6.



а) б)

Figure 6: Distributing of the field of tensions (isobars) in the horizontal plane of soil (depth 5 cm, black hard loam soil, W = 12%) before the vertical bar of chap cutter (a) and isolines of tensions $\sigma_{сц}$ by the vertical bar of chap cutter (b) (black hard loam soil, W = 12%)

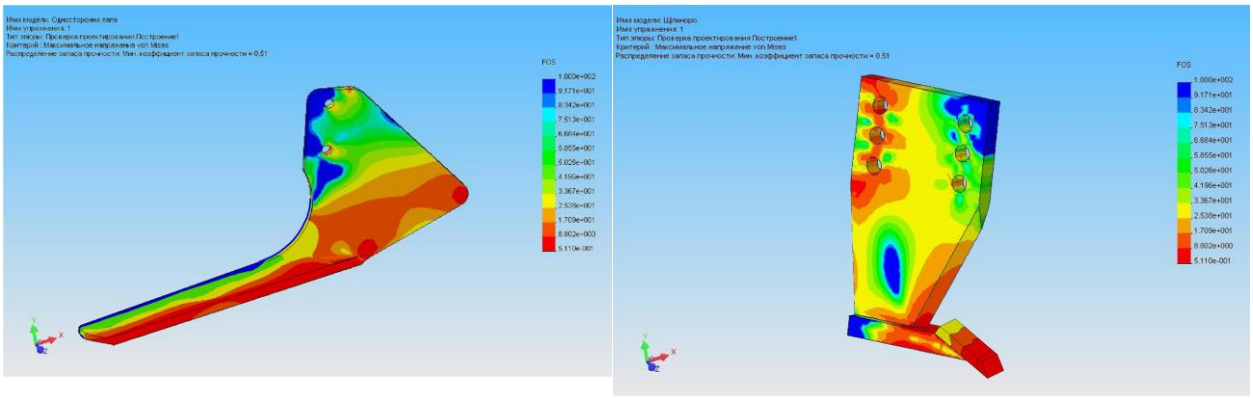
It is possible to see that the form of isolines of tensions at affecting soil of chap cutter differs from results presented at a fig. 5, both in a horizontal plane (ideally round) and in a vertical plane, where on the small depths of line come steeper, on large - smoother. Such conduct of curves explained the deformation's difference of soil in the area of loosening and area of resilient and plastic deformations.

Experimental results testify that conformities to the law of distributing of size of tension in soil with distance from the working surface of WOTM depend both on the type of WOTM and layer depths soils. Except for it the following is exposed:
- in the area of loosening, the area of resilient and plastic deformations of soil, the laws of tension's distributing are analogical and have the appearance of exponential curves;
- in the area of loosening of soil the crooked tensions come steeper as compared to by curves in the area of resilient and plastic deformations;
- isobars are disposed symmetric in soil in relation to normal, by passing through the center of symmetry of CE WOTM;
- in the vertical planes of soil, consoling with normal, passing through the centers of CE, tensions are distributed unevenly;
- size of tensions and character of their dependence on the depth of cutting is a determined distance from the ax of crack which is cut through in soil.
- layer elements soils adjoining to WOTM, are parts of different terms of deformation that depend on a depth.

The different tense consistence of soil in a area of loosening, area of resilient and plastic deformations is generated distinction in character of moving of structural aggregates. So consequently the distinction of character and size of wear of workings surfaces of WOTM are involved. It is set on the basis of the conducted researches in the area of loosening soil, squeezed out to the opened surface and in the area of resilient and plastic deformations; the bulk of soil is assembled in the walls of the cut out furrow.

3.2 Tensely deformed state of WOTM at co-operating with a soil

An analysis and calculation of the field of tensions of WOTM is conducted at the design of co-operating with the soil. That cooperation works with the use of method in eventual elements of package of COSMOS Works computer-integrated in the Solid Works CAD-system. As a result distributing of the fields of tensions is got on the surfaces of one-sided paw (fig.7 a) and chap cutter (fig.7 b).



а) б)

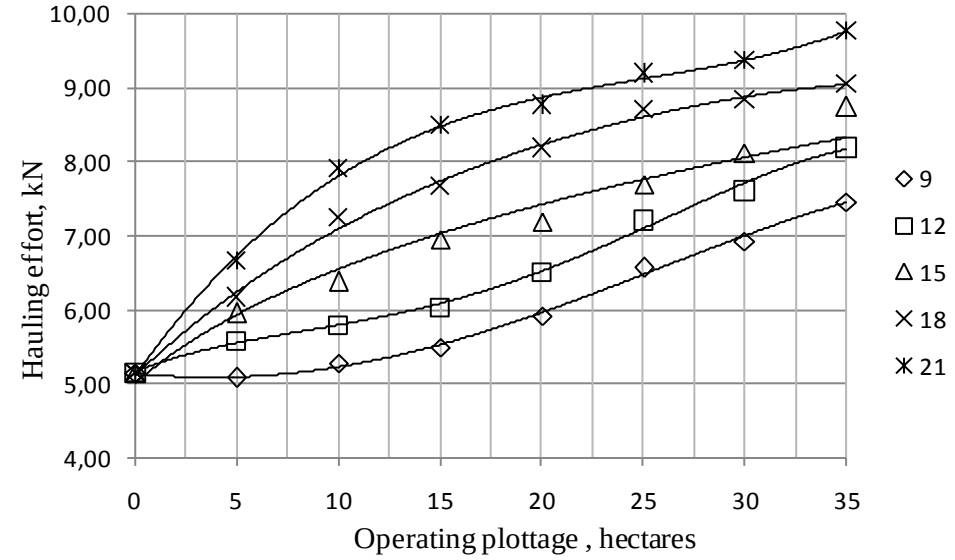
Figure 7: Distributing of the field of tensions on-the-spot one-sided paw (a) and chap cutter (b)

Analyzing the results of design of process of static and dynamic charges of one-sided paw, it is possible to see that a maximal level of tensions, and consequently and most intensity of wear, is on its nasal part and area of cutting edge. At a delete from the areas of splitting off of soil layer size tension falls. It is explained character of co-operation of one-sided paw with soil, through power inputs on paring, deformation of soil layer and on passing to kinetic energy at transporting of the particles of soil isolated during his treatment. The crumbled stream of soil rounds the working surface of CE here.
At the increase of radius of rounding of cutting edge the area of maximal tensions is increased. Thus characteristically, that before blasted a cutting edge soil is made more compact, that requires additional power

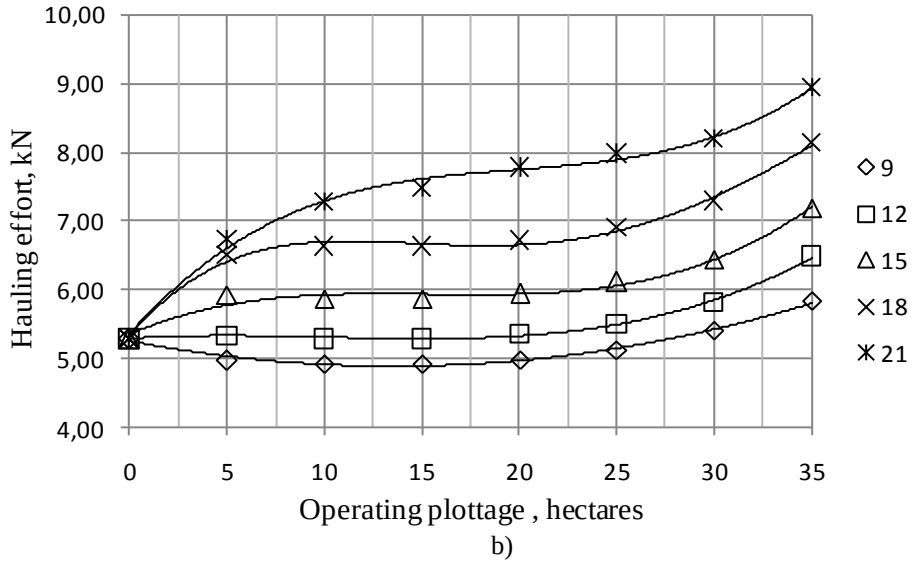
expenses on moving of CE and crumble of soil. Except for it, as researches show, the area of tense material of WOTM is substantially increased. At moving of CE in the environment of soil, at certain terms, cervical фаска can appear. Here, the area of maximal tensions is moved toward the lower surface of CE. It is possible to see that at work-hardening of lower surface of CE, the area of tense material is mainly observed in an area, adjoining to the topside of CE and cutting edge. The presence of the just the same tense state testifies to the origin and development of process of self-sharpening of CE.

3.3 Dependence of hauling resistance of one-sided paws and chap cutters on work taking into account MD of soil

The conducted experimental researches allowed for defining and comparing the sizes of hauling resistance of one-sided paws and chap cutters depending on work at the different types of tensions in soil (fig.8).



a)



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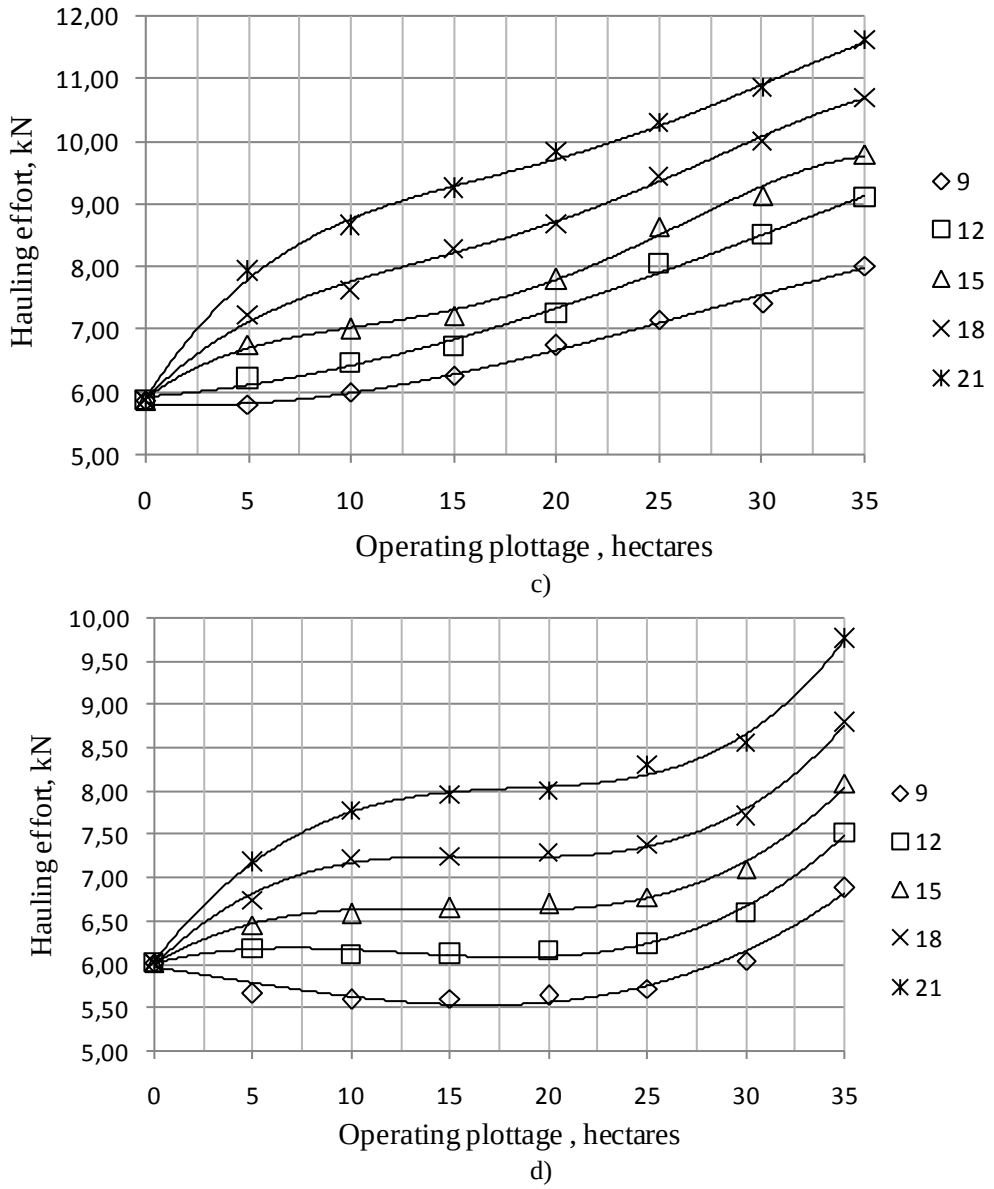

Figure 8: Dependence of hauling resistance of WOTM on work at the fixed size of tension of soil: standard (a) and work-hardened (b) one-sided paws standard (c) and work-hardened (d) chap cutters

On figures 8a and 8b change's dependences in size of hauling resistance are routine standard and work-hardened by electro arc welding of one-sided paws. And this is from work of the different size of tensions (σ = 9.21 кPa) in soil. At work when working more than 10 hectares hauling resistance of standard one-sided paws grows after curvilinear dependence. At the increase of work, hauling resistance diminishes and his optimum values correspond work 5 ... 15 hectares. It is for the offered method of work-hardening, and for standard by volume heat treatment - 5 ... 10 hectares. It is explained that forming and stabilizing of form for cutting edge of CE goes in this period. Further growth of work for one-sided paws, work-hardened by volume heat treatment results in the increase of radius of rounding CE and, as a result, increase of hauling resistance on 15% (to 6,5 кN) as compared to initial values. More smooth character of curve of hauling resistance is observed at the least value of size tension of soil.

Character of change of hauling effort of standard one-sided paws, and chap cutters is alike between itself but differentiate on one size. It should be noted that the dependences of hauling resistance of one-sided paws, work-hardened electro arc welding the electrodes of T – 590 (fig. of 8.á) but the work substantially differ from analogical dependences of standard one-sided paws. For paws, work-hardened of offered technologies, some decline of hauling resistance in the moment of running-in. And the stability of his values is characteristic to

work 20 ... 25 hectares or more. This state is characterized self-sharpening of CE. Then, as far as the wear of the work-hardened layer, there was an increase of resistance from 4,8 to 6,1 κN. Chap cutters have a few greater hauling resistance with one-sided paws as work on no-bottoms and accordingly perceive large tensions of soil. As be obvious from the graphs on a fig. 8, application of suggested technology of work-hardening is given by possibility to look after more smooth character of increase of hauling resistance. In the process of treatment of WOTM, based on technology of work-hardening of standard WOTM, which positively influences both on the economy of fuels and lubricants materials and the increase of resource of WOTM.

4. Discussion

The resulting image of the stress field in the horizontal and vertical planes revealed a maximum area of stress concentration in the floor areas adjacent to the share point and the middle of the CE of the plowshare. In the case of co-operation soil with chap cutter thickness of its layer far anymore and picture of the field of tensions of completely has other character. The closeness of isolines of tensions in soil which is built on results experimental researches, with a delete from the surface of one-sided paw, diminishes in horizontal and vertical planes. And the size of tension goes down. The form of curves of dependence in horizontal planes is ideally round, and in a vertical plane on the small depths of line and come steeper on large - flatter. Such conduct of curves explained the difference of deformations of soil in the area of loosening and area of resilient and plastic deformations. At moving of CE in the heterophase structure of soil, at certain terms can appear the back head edge. The area of maximal tensions is here moved toward the lower surface of CE. At work-hardening of lower surface of CE, the tense area material of WOTM is mainly observed in an area, adjoining to the topside of CE and cutting edge. The presence is just the same tense state that testifies the origin and development of process of self-sharpening of CE. The difference between the tense soil consistence in the area and loosening area of resilient and plastic deformations is generated distinction in character of moving structural aggregates, consequently by distinction of character and size of wear of workings surfaces of WOTM.

At the increase of work hauling resistance diminishes and his optimum values corresponded work - 5 ... 15 ha for the offered method of work-hardening, and for standard by volume heat tillage 5 ... 10 ha. It is explained that forming and stabilizing of the form of cutting edge goes in this period. Further growth of work for paws, work-hardened by volume heat treatment results in the increase of radius of rounding of cutting edge and, as a result, it in increases the hauling resistance on 15% (to 6,5 kH) as compared from the initial values. Character of change of hauling effort of standard one-sided paws and chap cutter are alike between itself and differ on one size. It should be noted that the got curves of dependences of one-sided paws, work-hardened electro arc welding with electrodes of T–590 wich in grain substantially differ from standard one-sided paws. Chap cutter has a few greater hauling resistances of one-sided paws as work on a greater depth and accordingly perceive large tensions of soil. It can be explained that in the process of running-in on the workings surfaces of paws there is sticking of soil.

5. Conclusion

It is exposed that on character of dependence of hauling resistance of aggregates with WOTM from work both phase composition of soil, his wearing down ability and method and variant of work-hardening of working surface, and also realization of effect, influence self-sharpening of CE. The form of curves of dependence of hauling resistance differs: as in a horizontal plane (ideally round), and in a vertical plane on the small depths of line come steeper, on large - flatter. Such conduct of curves explained the difference of deformations of soil in the area of loosening and area of resilient and plastic deformations. The difference between the tense soil consisting in the area of loosening and area of resilient and plastic deformations is generated distinction in character of moving of structural aggregates. Consequently this happens by distinction of character and size of wear of workings surfaces of WOTM and hauling resistance.

References

[1] Panov A.I. Physical bases of soil mechanics / A.I. Panov// Scien.works. VIM.- V.131.-2000.-P. 46-51.
[2] Aulin V.V. Conformities to the law of co-operation of workings organs of tillage machines with soil in the

process of tillage / V.V. Aulin, A.A. Tihyi / Announcer of Engineering Academy of Ukraine. – 2011.– №2 – C.144-149.

[3] Aulin V.V. Phase composition of soil and its wearing down capabilities / V.V. Aulin, V.M. Bobritskiy, A.A. Tihyi // Problems of tribology. Khmel'nickiy. KhNU, 2009. – №2 – P.91-99.

[4] Aulin V.V. Wearing down ability of soil environment and conformity to the law of wear of details of workings organs of tillage machines / V.V. Aulin, М.И.Черновол, А.А. Тихий// Problems of tribology. Khmel'nickiy. KhNU, 2010. – №2 – P.6-10.

[5] Chernovol M.I., Solovuh E.K,, Warouma A. Application of powder materials based on iron for obtaining anti-wear coating. Problem of increasing the safety and longevity of machines // Kirovograd: IMAK- 1996-p.53-64».

[6] Aulin V.V. Conformities to the law of change of mode of soil deformation at operating on workings organs of tillage machines / V.V. Aulin, A.A. Tihyi, A.D. Martinenko/ Announcer of Kharkov.nat. tech.. univ. of agriculture nam.. P.Vasilenko. – Vol.. 118 – Kharkov, 2011 – P. 263-267.