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INFLUENCE OF GEOMETRIC PARAMETERS OF THE TREATMENT SHOWER ON THE DEFORMATION CHARACTERISTICS OF THE SOIL WHEN FORMING A CAVITY FOR AN ANTI-FILTRATION SCREEN

The article presents the results of studies of the interaction of the plowskin part of the mole farmer with soil. The purpose of the study is to determine the rates of relative deformations depending on its geometric and kinematic parameters. This will make it possible to determine the magnitude of the stress components and soil density functions that depend on these stresses. In addition, this will allow us to determine the strength of the soil resistance to the movement of the plow share of the mover.

The soil is presented in the form of a model of a viscoelastic medium in such a way that bigaromic potential functions can be used to analyze the interaction, since the final equations are reduced to a system of elliptic equations. Such a statement of the problem and its solution make it possible to obtain dependences of the relationship of the geometric parameters of the ploughshare part of the mover with the components of the strain rates of the soil, as well as the mechanical properties of the soil on the surface of its contact with the ploughshare. These expressions are the initial ones for the further determination of the components of stresses in the soil, which make it possible to determine the compaction of the soil on the walls of the formed cavity for drawing the anti-filter screen and the components of the resistance forces to the ploughshare.

Obtaining the final expressions of soil compaction on the molehill walls together with the dependences of the resistance forces will allow us to determine the geometric parameters of the working body, with various mechanical properties of the soil, to ensure the stability of the molehill walls with minimal energy consumption.

Such a solution is common for a certain class of problems on the interaction of the working body with the soil, which is represented by a deformable medium in order to determine the directions of changes in deformations or their velocities in order to use them to determine stress components that will allow you to find zones of possible plastic deformations and destruction of soil continuity.

Keywords: *components of deformations or stresses, component of traction resistance, ploughshare working body, biharmonic potential function, components of displacement velocities, continuum theory, component of relative deformations, component of stresses in soil, ploughshare share.*

Formulation of the problem. To preserve moisture (reduce the penetration of water into the deeper layers of the soil) and better distribute it horizontally during intra-soil irrigation of agricultural plants, it becomes necessary to lay humidifiers together with an anti-filter screen [1]. At the same time, for the formation of a cavity in which the screen should be laid by the broaching method, it is possible to use a share working body, the justification of the geometric parameters and operating modes of which is an urgent scientific task.

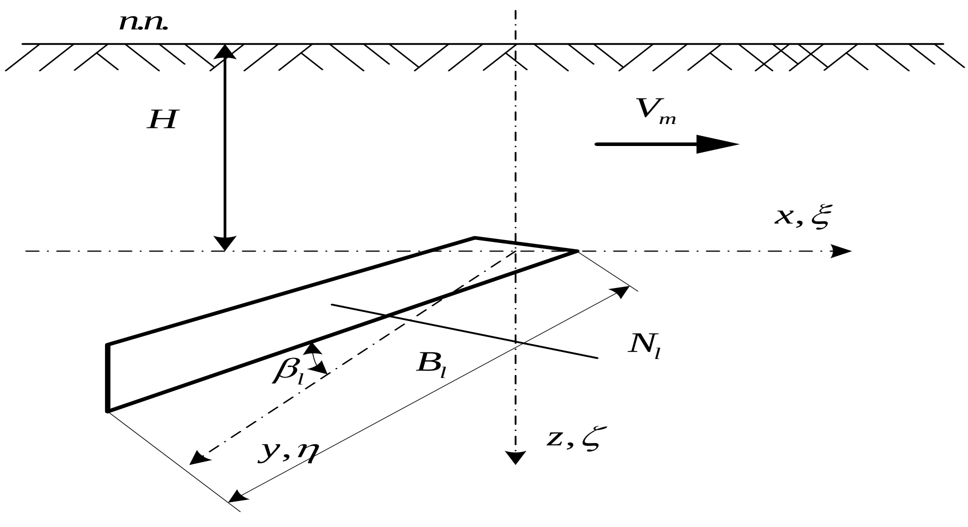
The solution to this problem allows us to establish functional dependences of the influence of the geometric parameters of the working body and the mechanical properties of the soil on the distribution of the rates of its deformations and stress components. This makes it possible to predict the presence of zones in which the ratios of stress components correspond to the transition to a plastic state up to destruction of continuity for a certain plasticity criterion during the interaction of a working body with soil.

An analysis of research and publications [2-7] shows that in order to solve this problem, formalization of the soil as the medium on which the action of the working body is directed, as well as formalization of the interaction of the working body itself with the soil, is necessary. Most often, models are used that are more reminiscent of interaction with an absolutely solid body, or models used in the classical theory of soil mechanics, which are based on the mechanics of granular media [8]. In addition, when constructing interaction models, either one-dimensional models are used, or in the best case, flat solutions that do not always reflect the real process of changes in the properties of the soil (soil) under the action of the working body [6, 7]. Recent publications indicate that the soil is often presented as a viscoplastic or purely plastic medium. For this, either experimental research methods or numerical modeling methods using finite element methods are used [10-12]. However, such research methods do not make it possible to obtain functional dependences of the relationship between the components of the strain rates and stresses depending on the geometric parameters of the working body, and therefore, numerous physical or numerical experiments are necessary.

It should be noted that the soil density under the influence of the working body changes in the function of changing all six components of the deformations or stresses, which cannot be displayed in a flat statement of the problem, and even more so in a one-dimensional one. In addition, such statements of the problem do not allow us to determine all three components of the resistance to movement of the working body in the soil. Therefore, the problem of the interaction of the working body with the soil in a three-dimensional setting with the establishment of the relationship of geometric parameters and operating modes of the working body itself and changing the properties of the soil, as well as the component of traction resistance, is urgent and requires a solution.

In this regard, the aim of the study is to determine the rates of relative deformations in the contact zone of the plowshare plow share with the soil, depending on its geometric and kinematic parameters. This will make it possible to determine the magnitude of the stress components and soil density functions that depend on these stresses. In addition, this will allow us to determine the strength of the soil resistance to the movement of the plow share of the mover.

The results of the study. For the formation of a cavity in which the screen should be laid by the drawing method, a ploughshare working body can be used, the movement scheme of which is shown in Figure 1. The following notation is used in the figure: coordinate system xyz



represents the coordinates of the half-space of the soil and coincides with the coordinate system of the ploughshare of the mover $\xi\eta\zeta$, H – ploughshare stroke depth relative to the field surface $n.n.$, B_l – working width of the share, N_l – normal to the share plane.

The equation of the working part of the ploughshare surface in the coordinate system $\xi\eta\zeta$ idem xyz has the form of a plane equation:

$$f_l = \frac{\xi}{a} + \frac{r-\eta}{b} + \frac{(r/2)-\zeta}{c} = 0$$

where a, b, c – are the coefficients that determine the slope of the plane to the corresponding coordinate axes $o\xi, o\eta, o\zeta$, r – the height of the vertical projection of the share, which is determined by the installation height at the attachment point.

The introduction of the latter into the equation determines the displacements of the center of the plane to the origin in the axis direction $o\zeta$.

The cosines of the angles of inclination of the normal to the surface to the coordinate axes are expressed by the dependencies:

$$l_l = \frac{\partial f_l/\partial\xi}{\sqrt{(\partial f_l/\partial\xi)^2 + (\partial f_l/\partial\eta)^2 + (\partial f_l/\partial\zeta)^2}} = 1\Bigg/\left(a\sqrt{\frac{1}{a^2}+\frac{1}{b^2}+\frac{1}{c^2}}\right)$$

$$m_l = \frac{\partial f_l/\partial\eta}{\sqrt{(\partial f_l/\partial\xi)^2 + (\partial f_l/\partial\eta)^2 + (\partial f_l/\partial\zeta)^2}} = -1\Bigg/\left(b\sqrt{\frac{1}{a^2}+\frac{1}{b^2}+\frac{1}{c^2}}\right)$$

$$n_l = \frac{\partial f_l/\partial\zeta}{\sqrt{(\partial f_l/\partial\xi)^2 + (\partial f_l/\partial\eta)^2 + (\partial f_l/\partial\zeta)^2}} = -1\Bigg/\left(\sqrt{\frac{1}{a^2}+\frac{1}{b^2}+\frac{1}{c^2}}\,c\right)$$

The speeds of soil movement on the ploughshare surface are determined on the basis that the projection of the velocity on the normal to the ploughshare surface has the form $V_{Nl} = V_m / l_l$.

$$v_{l0} = V_{nl}\, m_l = -aV_m/b;\, w_{l0} = V_{nl}\, n_l = -aV_m/c;\, u_{l0} = V_{nl} l_l = V_m$$

Analytical solutions for contact problems are possible only in an elastic or elastic-viscous formulation. Moreover, these solutions are allowed only for the case when, with successive substitutions of geometric equations in the physical equations for the relationship of stresses with strains and further substitution of the obtained stress components in the equations of static (dynamics) of a continuous medium, elliptic equations are obtained. In this case, a solution can be found using biharmonic potential functions that satisfy the conditions on the contact surface of the body (coordinate system) and the medium with which it interacts (coordinate system x, y, z), i.e. when $x-\xi=0,\ y-\eta=0,\ z-\zeta=0$ velocity components (displacements) are equal to their initial values. For our case, this means that the velocity components for the ploughshare have the form: $u_l\big|_{x-\xi=0,y-\eta=0,z-\zeta=0} = u_{l0}$, $v_l\big|_{x-\xi=0,y-\eta=0,z-\zeta=0} = v_{l0}$, $w_l\big|_{x-\xi=0,y-\eta=0,z-\zeta=0} = w_{l0}$. The second condition, which biharmonic potential functions must satisfy to determine the velocity components, has the form: $u_l\big|_{x-\xi=\infty,y-\eta=\infty,z-\zeta=\infty} \to 0$, $v_l\big|_{x-\xi=\infty,y-\eta=\infty,z-\zeta=\infty} \to 0$, $w_l\big|_{x-\xi=\infty,y-\eta=\infty,z-\zeta=\infty} \to 0$. Such biharmonic potential functions, according to [9] have the form:

$$u_l = \int_{r}^{B}\int_{-r}^{r} \frac{a_0\, u_{l0}(x-\xi_l+\delta)}{((x-\xi_l+\delta)^2+(y-\eta_l+\delta)^2+(z-\zeta_l+\delta)^2)^{3/2}}\,\mathrm{d}\zeta_l \mathrm{d}\eta_l\,;$$
$$v_k = \int_{-r}^{r}\int_{0}^{L_k} \frac{a_0\, v_{l0}(y-\eta_k+\delta)}{((x-\xi_l+\delta)^2+(y-\eta_l+\delta)^2+(z-\zeta_l+\delta)^2)^{3/2}}\,\mathrm{d}\xi_l \mathrm{d}\zeta_l\,; \tag{1}$$
$$w_l = \int_{r}^{B}\int_{0}^{L_l} \frac{a_0\, w_{l0}(z-\zeta_l+\delta)}{((x-\xi_l+\delta)^2+(y-\eta_l+\delta)^2+(z-\zeta_l+\delta)^2)^{3/2}}\,\mathrm{d}\xi_l \mathrm{d}\eta_l\,,$$

where $L_l = -BCos(1/a)$ – projection of the share length in the direction of the axis $o\xi$, B – projection of the share length in the direction of the axis $o\eta$, $a_0 = \frac{1}{\pi}\frac{4}{Log[-\delta+\sqrt{3}\sqrt{\delta^2}]-Log[\delta+\sqrt{3}\sqrt{\delta^2}]}$ – a coefficient ensuring the fulfillment of the initial conditions when introducing a small quantity, which eliminates the singularity of expressions (1). Biharmonic potential functions must satisfy the equation $\Delta^2 f = 0$, where $\Delta -$ Laplace operator, $f = \{u_l, v_l, w_l\}$.

Due to the complexity of integrating equations (1), which are the components of the speeds of movement of soil in space in front of the working body, in general, the problem of finding the distribution of speeds of movements, rates of relative deformations, stress components in a differential form, like this was proposed in [5]. The essence of the method is that to find the components of the strain rates, it is assumed that the equations (1) are differentiated according to geometric equations (Cauchy equations) of the theory of continuous media. This allows you to get rid of the complex operations of integrating equations (1) in a general way, and perform research in the form of differential components, and switch to the integral form at the stage where the final dependencies are determined. At the same time, due to the cumbersomeness of expressions, at the last stage, numerical integration methods can be applied.

For this, it is possible to transform equations (1) in such a way that as a result, the components of the differential components of the components of the displacement rates of the soil (soil) in front of the working body will be obtained:

$$du_l = \frac{d^2}{d\eta_l d\zeta_l}\int_0^B\int_{-r}^r \frac{a_0 u_{l0}(x-\xi_l+\delta)}{((x-\xi_l+\delta)^2+(y-\eta_l+\delta)^2+(z-\zeta_l+\delta)^2)^{3/2}}\mathrm{d}\zeta_l \mathrm{d}\eta_l =$$
$$= \frac{15 a_0 V_m (z+\delta-\zeta_l)(y+\delta-\eta_l)(x+\delta-\xi_l)}{((z+\delta-\zeta_l)^2+(y+\delta-\eta_l)^2+(x+\delta-\xi_l)^2)^{7/2}};$$

$$dv_l = \frac{d^2}{d\zeta_l d\xi_l}\int_{-r}^r\int_0^{L_l} \frac{a_0 v_{l0}(y-\eta_k+\delta)}{((x-\xi_l+\delta)^2+(y-\eta_l+\delta)^2+(z-\zeta_l+\delta)^2)^{3/2}}\mathrm{d}\xi_l \mathrm{d}\zeta_l =$$
$$= -\frac{15 a\, a_0 V_m (z+\delta-\zeta_l)(y+\delta-\eta_l)(x+\delta-\xi_l)}{b((z+\delta-\zeta_l)^2+(y+\delta-\eta_l)^2+(x+\delta-\xi_l)^2)^{7/2}};$$

$$dw_l = \frac{d^2}{d\eta_l d\zeta_l}\int_r^B\int_0^{L_l} \frac{a_0 w_{l0}(z-\zeta_l+\delta)}{((x-\xi_l+\delta)^2+(y-\eta_l+\delta)^2+(z-\zeta_l+\delta)^2)^{3/2}}\mathrm{d}\xi_l \mathrm{d}\eta_l =$$
$$= -\frac{15 a\, a_0 V_m (z+\delta-\zeta_l)(y+\delta-\eta_l)(x+\delta-\xi_l)}{c((z+\delta-\zeta_l)^2+(y+\delta-\eta_l)^2+(x+\delta-\xi_l)^2)^{7/2}}. \tag{2}$$

From equations (2), one can obtain the differential components of the strain rates of the soil (soil) using geometric equations (Cauchy equations):

$$d\dot{\mathrm{T}}_{xl} = \frac{d}{dx}du_l = \frac{15 a_0 V_m (z+\delta-\zeta_l)(y+\delta-\eta_l)((z+\delta-\zeta_l)^2+(y+\delta-\eta_l)^2-6(x+\delta-\xi_l)^2)}{((z+\delta-\zeta_l)^2+(y+\delta-\eta_l)^2+(x+\delta-\xi_l)^2)^{9/2}};$$

$$d\dot{\mathrm{T}}_{yl} = \frac{d}{dy}dv_k = \frac{105 a\, a_0 V_m (z+\delta-\zeta_l)^2(y+\delta-\eta_l)(x+\delta-\xi_l)}{c((z+\delta-\zeta_l)^2+(y+\delta-\eta_l)^2+(x+\delta-\xi_l)^2)^{9/2}} -$$
$$- \frac{15 a\, a_0 V_m (y+\delta-\eta_l)(x+\delta-\xi_l)}{c((z+\delta-\zeta_l)^2+(y+\delta-\eta_l)^2+(x+\delta-\xi_l)^2)^{7/2}};$$

$$d\dot{\mathrm{T}}_{zl} = \frac{d}{dz}dw_l = 15 a_0 V_m (\delta-\zeta_l+z)\times$$
$$\times\frac{\left(\begin{array}{l}\dfrac{7a(\delta-\xi_l+x)^2(\delta-\eta_l+y)}{b} - \dfrac{a(\delta-\eta+y)((\delta-\xi_l+x)^2+(\delta-\eta_l+y)^2+(\delta-\zeta_l+z)^2)}{b} - \\ -7(\delta-\xi_l+x)(\delta-\eta_l+y)^2+(\delta-\xi_l+x)((\delta-\xi_l+x)^2+(\delta-\eta_l+y)^2+(\delta-\zeta_l+z)^2)\end{array}\right)}{((\delta-\xi_l+x)^2+(\delta-\eta_l+y)^2+(\delta-\zeta_l+z)^2)^{9/2}}; \tag{3}$$

$$d\dot{\gamma}_{xyl} = \frac{d}{dy}du_l + \frac{d}{dx}dv_l = 15 a_0 V_m (\delta-\zeta_l+z)\times$$
$$\times\frac{\left(\begin{array}{l}\dfrac{7a(\delta-\xi_l+x)^2(\delta-\eta_l+y)}{b} - \dfrac{a(\delta-\eta_l+y)((\delta-\xi_l+x)^2+(\delta-\eta_l+y)^2+(\delta-\zeta_l+z)^2)}{b} - \\ -7(\delta-\xi_l+x)(\delta-\eta_l+y)^2+(\delta-\xi+x)((\delta-\xi+x)^2+(\delta-\eta_l+y)^2+(\delta-\zeta_l+z)^2)\end{array}\right)}{((\delta-\xi_l+x)^2+(\delta-\eta_l+y)^2+(\delta-\zeta_l+z)^2)^{9/2}};$$

$$d\dot{\gamma}_{xzl} = \frac{d}{dz}du_l + \frac{d}{dx}dw_l = 15a_0V_m(\delta-\eta_l+y)\times$$

$$\times\frac{\left(-\frac{a(\delta-\zeta_l+z)((\delta-\xi_l+x)^2+(\delta-\eta_l+y)^2+(\delta-\zeta_l+z)^2)}{c}+\frac{7a(\delta-\xi_l+x)^2(\delta-\zeta_l+z)}{c}+\right.\\ \left.+(\delta-\xi_l+x)((\delta-\xi_l+x)^2+(\delta-\eta_l+y)^2+(\delta-\zeta_l+z)^2)-7(\delta-\xi_l+x)(\delta-\zeta_l+z)^2\right)}{((\delta-\xi_l+x)^2+(\delta-\eta_l+y)^2+(\delta-\zeta_l+z)^2)^{9/2}};$$

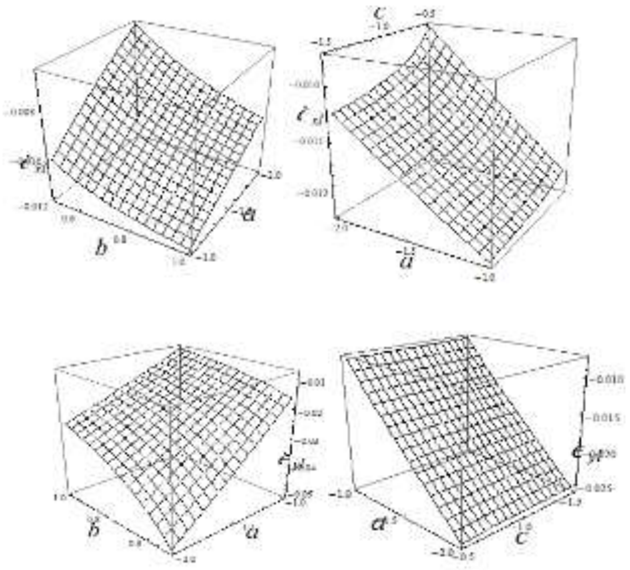
where $d\dot{\varepsilon}_{xl}$, $d\dot{\varepsilon}_{yl}$, $d\dot{\varepsilon}_{zl}$, $d\dot{\gamma}_{xyl}$, $d\dot{\gamma}_{xzl}$, $d\dot{\gamma}_{yzl}$ – components of the differential velocity components of the relative normal and shear deformations of the soil before the share.

To understand the nature of the impact of the working body in the zone of direct contact with the soil (soil), namely its geometrical shapes and sizes, the changes in the components of the relative deformations of the expression can be integrated (3), according to the expressions (1). In this case, it should be borne in mind that the zone of direct contact is subject to analysis, namely the conditions: $\{\zeta_l - z = 0,\ \eta_l - y = 0,\ \xi_l - x = 0\}$, This greatly simplifies expressions (3). Unfortunately, in expanded form, give the final expressions of the strain rate components $\dot{\varepsilon}_{xl}$, $\dot{\varepsilon}_{yl}$, $\dot{\varepsilon}_{zl}$, $\dot{\gamma}_{xyl}$, $\dot{\gamma}_{xzl}$, $\dot{\gamma}_{yzl}$, within the article is not possible due to the cumbersomeness of the final expressions. A graphical interpretation of these expressions is shown in Figures 2 and 3.

The analysis showed that the influence of the coefficients of the plane equation on the change in the normal components (Fig. 2) of the strain rates is characterized by the following relationships:

1) a decrease in the angle of inclination of the surface to the longitudinal with respect to the direction of movement of the axis leads to an increase in the rates of normal deformations $\dot{\varepsilon}_{xl}, \dot{\varepsilon}_{zl}$ (compression) and a decrease in the normal strain rate transverse to the direction of motion $\dot{\varepsilon}_{yl}$.

2) change in the inclination of the normal to the plane to the axis transverse to the direction of motion b, leads to a decrease in strain rate components $\dot{\varepsilon}_{xl}, \dot{\varepsilon}_{yl}$ and at very small values, to a decrease in the component $\dot{\varepsilon}_{zl}$; with an increase in the inclination of the normal to the plane to the axis oz (value c) the components of the strain rate decrease $\dot{\varepsilon}_{xl}, \dot{\varepsilon}_{zl}$, and the component $\dot{\varepsilon}_{yl}$ remains unchanged.



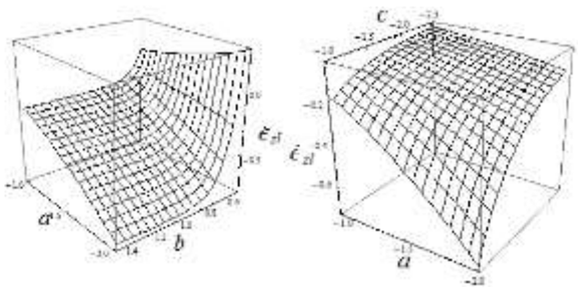


Fig. 2– Graphs of the normal components of the rates of relative normal deformations of the soil $\dot{\varepsilon}_{xl}, \dot{\varepsilon}_{yl}, \dot{\varepsilon}_{zl}$ depending on the coefficients a, b, c plane equations

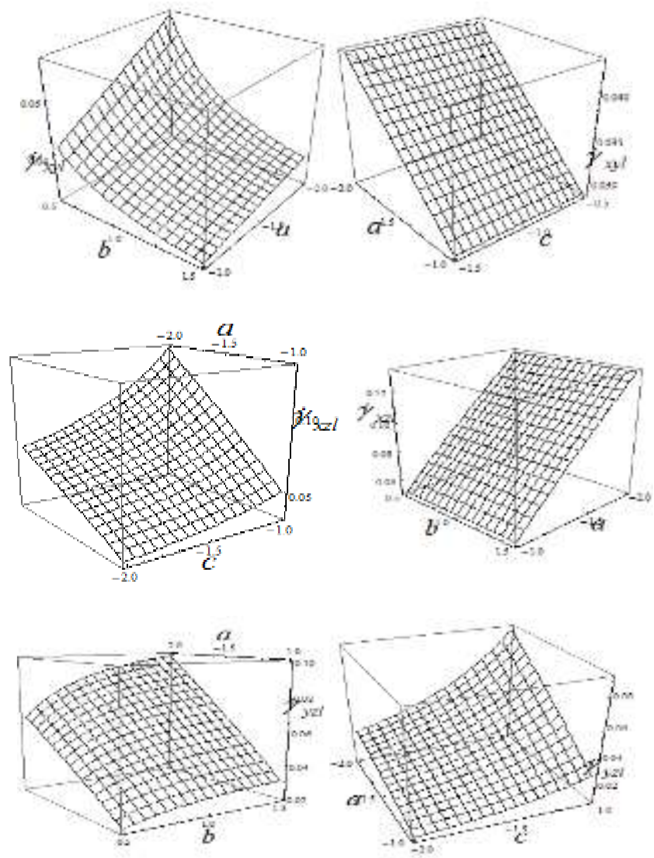


Fig. 3– Graphs of tangent (shear) components of the relative deformation rate of the soil $\dot{\gamma}_{xyl}, \dot{\gamma}_{xzl}, \dot{\gamma}_{yzl}$, depending on the coefficients a, b, c plane equations

It should be noted that the decrease in the angle of inclination of the normal to the plane a leads to a decrease in all three components of the shear strain rate $\dot{\gamma}_{xyl}, \dot{\gamma}_{xzl}, \dot{\gamma}_{yzl}$; increase in the angle of inclination of the normal to the plane c – to decrease $\dot{\gamma}_{xzl}, \dot{\gamma}_{yzl}$, wherein $\dot{\gamma}_{xyl}$ becomes unchanged. Decrease in value b leads to an increase in components $\dot{\gamma}_{xyl}, \dot{\gamma}_{yzl}$ and does not affect the change $\dot{\gamma}_{xzl}$ (fig. 3).

Findings. As a result of the analysis, the components of the rates of relative deformations of the soil on the surface of contact with the plowshare share are obtained. These expressions are the initial ones for the further determination of the components of stresses in the soil, which make it possible to determine the compaction of the soil on the walls of the formed cavity for drawing the anti-filter screen and the components of the resistance forces to the movement of this working body. Obtaining the final expressions of soil compaction on the molehill walls together with the dependences of the resistance forces will allow us to determine the geometric parameters of the working body, with different mechanical properties of the soil, to ensure the stability of the molehill walls with minimal energy.

Such a solution is common for a certain class of problems on the interaction of the working body with the soil, which is represented by a deformable medium in order to determine the directions of changes in deformations or their velocities in order to use them to determine stress components that will allow you to find zones of possible plastic deformations and destruction of soil continuity.

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ВПЛИВ ГЕОМЕТРИЧНИХ ПАРАМЕТРІВ ЛЕМЕХА КРОТОВАТЕЛЯ НА ДЕФОРМАЦІЙНИХ ХАРАКТЕРИСТИК ГРУНТУ ПРИ СТВОРЕННІ ПОРОЖНИНИ ДЛЯ ПРОТИФІЛЬТРАЦІЙНОГО ЕКРАНА

У статті наводяться результати досліджень взаємодії лемішної частини кротователя з ґрунтом. У зв'язку з цим метою дослідження є визначення швидкостей відносних деформацій в зоні контакту лемішної частини кротователя з ґрунтом в залежності від його геометричних і кінематичних параметрів. Це уможливить визначення величин компонент напружень і функцій щільності ґрунту, які залежать від цих напруг. Крім того, це дозволить нам визначити силу опору ґрунту переміщенню лемеші кротователя.

Ґрунт представлений у вигляді моделі в'язкопружного середовища таким чином, що для аналізу взаємодії можливе використання бігаромнічних потенційних функцій, оскільки кінцеві рівняння зводяться до системи еліптичних рівнянь. Така постановка задачі і її рішення дозволяють отримати залежності зв'язку геометричних параметрів лемішної частини кротователя з компонентами швидкостей деформацій ґрунту, а також механічних властивостей ґрунту на поверхні її контакту з лемішем. Ці вирази є вихідними для подальшого визначення компонент напружень в ґрунті, які дозволяють визначити ущільнення ґрунту на стінках утвореної порожнини для протягування протифільтраційного екрана і складові сил опору руху леміша.

Отримання кінцевих виразів ущільнення ґрунту на стінках кротовини спільно з залежностями сил опору дозволять визначити геометричні параметри робочого органу, при різних механічних властивостях ґрунту, для забезпечення стійкості стінок кротовини при мінімальних витратах енергії.

Таке рішення є загальним для певного класу задач про взаємодію робочого органу з ґрунтом, яка представлена деформуючим середовищем з метою визначення напрямів зміни деформацій або їх швидкостей з метою

використання їх для визначення компонент напружень, які дозволять знайти зони можливих пластичних деформацій і руйнування суцільності ґрунту.

Ключові слова: компоненти деформацій або напружень, компонент тягового опору, лемішний робочий орган, бігармонічна потенційна функція, компоненти швидкостей переміщень, теорії суцільних середовищ, компонент відносних деформацій, компонент напружень в ґрунті, леміш кротователя.

ВЛИЯНИЕ ГЕОМЕТРИЧЕСКИХ ПАРАМЕТРОВ ЛЕМЕХА КРОТОВАТЕЛЯ НА ДЕФОРМАЦИОННЫЕ ХАРАКТЕРИСТИКИ ПОЧВЫ ПРИ ОБРАЗОВАНИИ ПОЛОСТИ ДЛЯ ПРОТИВОФИЛЬТРАЦИОННОГО ЭКРАНА

В статье приводятся результаты исследований взаимодействия лемешной части кротователя с почвой. В связи с этим целью исследования является определение скоростей относительных деформаций в зоне контакта лемеха кротователя с почвой в зависимости от его геометрических и кинематических параметров.Это сделает возможным определение величин компонент напряжений и функций плотности почвы, которые зависят от этих напряжений.Кроме того, это позволит нам определить силу сопротивленияпочвы перемещению лемеха кротователя.

Почва представлена в виде модели вязкоупругой среды таким образом, что для анализа взаимодействия возможно использование бигаромнических потенциальных функций, поскольку конечные уравнения сводятся к системе эллиптических уравнений. Такая постановка задачи и ее решение позволяют получить зависимости связи геометрических параметров лемешной части кротователя с компонентами скоростей деформаций почвы, а также механических свойств почвы на поверхности ее контакта с лемехом. Эти выражения являются исходными для дальнейшего определения компонент напряжений в почве, которые позволяют определить уплотнение почвы на стенках образованной полости для протягивания противофильтрационного экрана и составляющие сил сопротивления движению лемеха.

Получение конечных выражений уплотнения почвы на стенках кротовины совместно с зависимостями сил сопротивления позволят определить геометрические параметры рабочего органа, при различных механических свойствах почвы, для обеспечения устойчивости стенок кротовины при минимальных затратах энергии.

Такое решение является общим для определенного класса задач о взаимодействии рабочего органа с почвой, которая представлена деформируемой средой с целью определения направлений изменения деформаций или их скоростей с целью использования их для определения компонент напряжений, которые позволят найти зоны возможных пластических деформаций и разрушения сплошности почвы.

Ключевые слова: *компоненты деформаций или напряжений, компонент тягового сопротивления, лемешный рабочий орган,бигармоническая потенциальная функция,компоненты скоростей перемещений, теории сплошных сред,компонент относительных деформаций,компонент напряжений в почве, лемех кротователя.*

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