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DEVELOPMENT AND COMPUTER TESTING OF EQUIPMENT FOR CUTTING SOILS WITH SPATIALLY ORIENTED KNIVES OF A BULLDOZER BLADE

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The paper uses approaches to the creation and computer testing of a model of an experimental installation for cutting soil with spatially oriented working bodies of earthmoving machines used on construction sites. Today, there is a need for the efficient performance of construction work related to the operation of construction machinery with blade equipment. This, in turn, poses the task of determining the productivity of mechanized earthworks in various working environments. The main method of mechanical soil development is cutting. The main geometric conditions are the position of the cutting wedge edge relative to the cutting direction and the surface of the massif, the contour of the cutting edge, the contour and number of working surfaces of the cutting wedge, the number of so-called side cutting surfaces and the so-called blocked cutting surfaces. The peculiarity of the digging process is that its power and energy indicators depend on the kinematic conditions and geometric parameters - thickness, width and cut area, as well as on the angles of orientation of the working body in space. The creation of such a computer model of the experimental setup is due to the need for continuous improvement of existing equipment and the creation of new equipment to meet existing needs. The model of the experimental setup was created in accordance with the working hypothesis, where the movement of the spatially oriented knife occurs perpendicular to the movement of the blade equipment, at different ratios of the speed of the blade and the movement of the knife, which creates a simple interaction with the working environment, and the deviation of the application of the full cutting force by an angle α. According to the working hypothesis, depending on the plan of movement of the spatially oriented knife, its geometric interaction with the working environment changes and the cutting force changes accordingly. The necessity to create more productive and efficient earthmoving equipment requires the use of modern design solutions. Using the calculations of soil cutting by spatially oriented earthmoving tools in the form of a dihedral blade of dump equipment, a computer study of stress equivalents, linear displacement, yield strength factor, tensile strength factor, and loss of stability factor was carried out. The results are summarized in the form of tabular data and graphical display.

Keywords: parametrization, computer testing, bulldozer blade, cutting force, spatially oriented, angle of rotation in plan, test stand, paraffin.

1. Introduction

Cutting is the main method of mechanical soil development. The main geometric conditions are proposed to be the position of the edge of the cutting wedge relative to the direction of cutting and the surface of the massif, the contours of the cutting edge, the contours and number of working surfaces of the cutting wedge, the number of the so-called side cut surface and the so-called blocked cut surfaces. Based on these characteristics, the varieties of the process are distinguished and a classification of types of cutting is created [1, 2].

A spatially oriented knife is mounted on a bulldozer blade. In addition to the shape of the knife itself, which in turn reproduces the formation of working forces during destruction by an oblique knife, it is given an additional movement in a direction perpendicular to the main movement of the bulldozer blade. This additional movement is formed with small amplitude (up to 150 mm) and different speeds, which provides different geometric interaction with the working environment, which in turn changes the power and energy parameters of cutting.

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2. Research analysis

A bulldozer is a universal earthmoving and transport machine, equipped with a curved shaft mounted on a frame, and designed to perform various construction works.

Most often, a bulldozer is used for preparatory work: for demolishing old buildings, uprooting tree stumps, clearing bushes, clearing construction sites of construction debris, etc.

Bulldozers perform significant volumes of work in reclamation construction during the construction of irrigation and drainage canals, backfilling of dams and embankment of paved roads, capital and operational planning of reclaimed lands, construction of ponds, development of pits for pumping stations [4, 5].

Bulldozers are used when performing the following types of construction work: clearing the territory of the vegetative layer of the soil, remnants of stumps, roots, planning the territory by cutting unevenness, filling depressions and removing excess soil; construction of embankment and pits during construction; development of wide trenches and pits; construction of dams; soil development on mountain slopes; backfilling of trenches; transportation of aggregates to receiving devices at warehouses of non-metallic building materials, etc [6, 7].

The lowered blade cuts small mounds with a knife and fills small depressions with the cut soil, thereby leveling the soil surface.

Large-scale planning works related to cutting humps, filling ravines, large trenches, pits, canals, etc., are usually performed by the joint work of scrapers and bulldozers [8].

For the planning of soil dumps made by excavators or dump trucks, conveyors, etc., it is most expedient to use bulldozers with side dump extenders, which increase the width of the grip and thereby significantly increase the productivity of bulldozers on loose soils.

Blade is attached equipment for bulldozers, motor graders, loaders, tractors and cars, which is used for soil development, snow removal and other works [9].

For the most part, the blade is a welded metal structure with a box section. Knives are attached along the lower edge of the blade. On both sides of the blade, side plates are welded, designed to prevent scattering of the transported material. With the help of a blade truck, the machine can move large volumes of cargo in one work cycle (over short distances), but, unlike buckets, blade are not suitable for loading soil onto vehicles.

Excavator knives are a special cutting pad that is attached to the working equipment of earthmoving and other machines.

The working hypothesis is based on the fact that the combination of the positive effects of reducing the energy intensity of destruction by a spatially oriented knife and high-speed cutting will allow for an overall reduction in the energy intensity of soil destruction by a blade. It is schematically depicted in (Fig. 1), in our opinion, this should ensure the cutting of the soil and its easy removal from the development zone. Thus, reducing the resistance that occurs during the operation of the bulldozer and increasing its productivity, as well as expanding the scope of use.

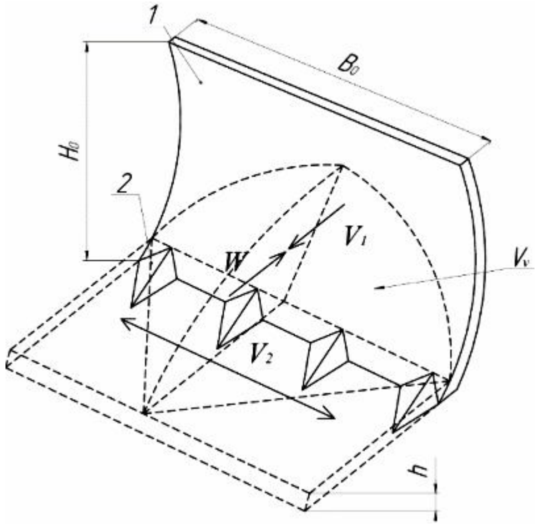

Fig. 1. Schematic representation of the trajectories of the working body: 1) a bulldozer blade; 2) a spatially oriented dynamic knife; V_1 - trajectory of the bulldozer movement; V_2 - trajectory of the spatially orientated knife; B_o – blade width; H_o - blade height; h - thickness of the layer to be cut

It is known that the interaction of a spatially oriented knife with the working environment consists of three composite cutting forces (Fig. 2): P – frontal cutting force; N – is the normal cutting force; P_o – is the orthogonal cutting force. These cutting forces are influenced by the following geometrical parameters: b – blade width; h – cutting depth; δ – cutting angle; γ_{pl} – angle of rotation in the plan.

Depending on the speed of movement of

the knife, the direction of application of the force changes and the angle of interaction of the spatially oriented knife with the soil changes, when the speed of movement of the knife and the feed rate are equalized (at 45◦), it starts to work as a rectangular cutting knife, since the trajectory is perpendicular to its side face, the calculation is carried out as for blocked cutting. If the speed is less than the feed rate, this affects the fracture zone, so the knife can be calculated using the formula for dihedral cutting, and if the knife speed is greater than the feed rate, the calculation is performed as for blocked dihedral cutting, since the second face of the knife does not participate in cutting the soil [3].

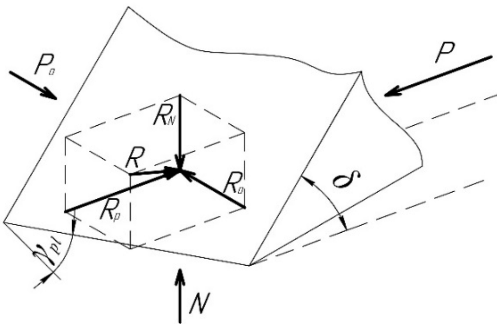

Fig. 2

To begin with, we set the ratio of the feed rates of the bulldozer blade and the movement of the spatially oriented knife. Then, using the data obtained from the graph shown in Figure 3, we determine the deflection angle α, which indicates the direction of deflection of the cutting force of the spatially oriented blade of dynamic action, taking into account the angle α, an indicator of the direction of application of the cutting force, and thus find its nature of movement and interaction with the soil. (Figs. 4, 5, 6) [10].

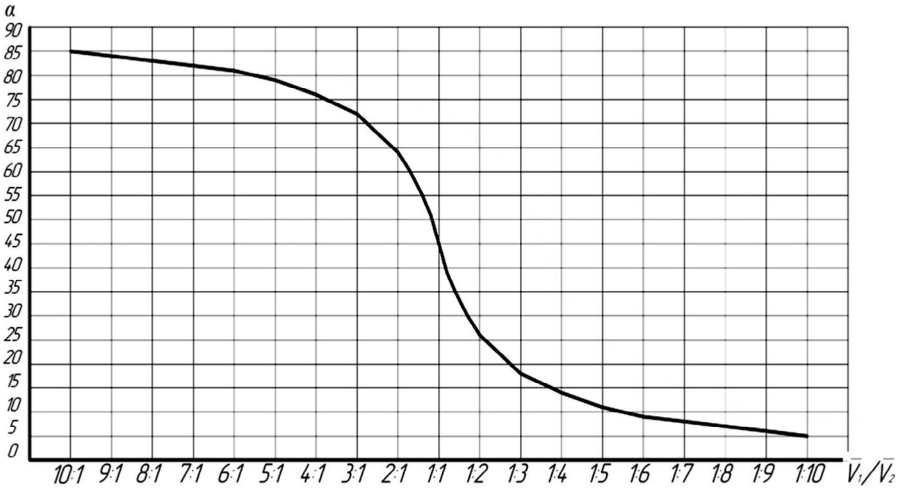

Fig. 3. The graph of the dependence of the angle α on the ratio of the traction speed of the working machine $\overline{V_1}$ to the speed of movement of the spatially oriented knife $\overline{V_2}$

After applying the vector of the direction of the cutting force with a spatially oriented knife and determining the plan of movement, it becomes clear that there will be a change in the geometric interaction of the spatially oriented knife with the workpiece, which leads to a change in cutting forces and a change in resistances that depend on the geometric parameters of the knife. These changes in geometric interaction are demonstrated in (Figs. 7, 8, 9) [11].

3. The aim of research

Using CAD systems, to create a test bench for recording cutting forces with a spatially oriented knife of dynamic action, and to provide controlled complex movement of the knife in an array of paraffin while simulating various types of work, loads, and resonance.

To solve the known shortcomings of the test bench and improve its design.

In accordance with the 3D model, create a real model of the longitudinal movement device and the spatially oriented knife itself with similarity coefficients, which will further allow for empirical measurements.

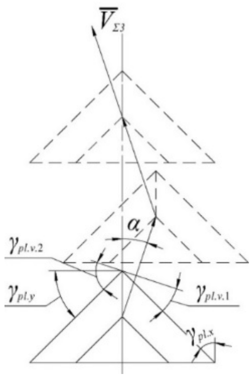

Fig. 4. Plan of movement of a spatially oriented knife at an angle α <45°

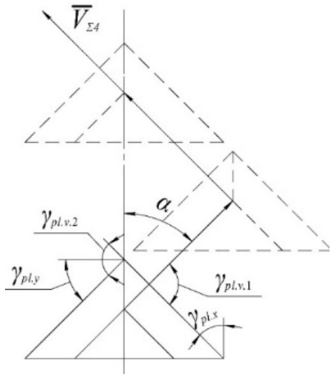

Fig. 5. Plan of movement of a spatially oriented knife at an angle α =45°

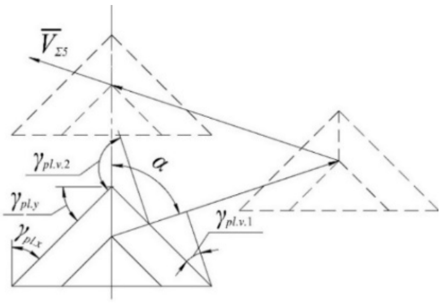

Fig. 6. Plan of movement of a spatially oriented knife at an angle α >45°

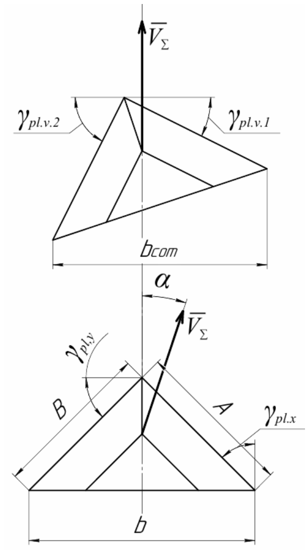

Fig. 7. Parameterization of spatial oriented knife when $\gamma_{pl.y} > \alpha < \gamma_{pl.x}$

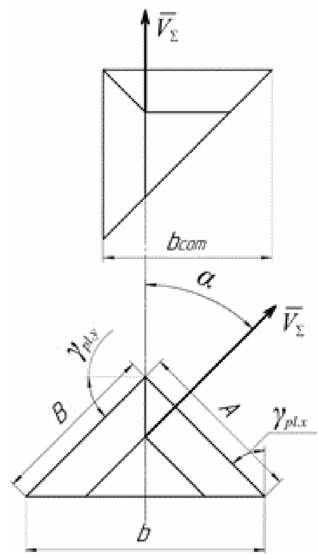

Fig. 8. Parameterization of spatial oriented knife when $\gamma_{pl.y} = \alpha = \gamma_{pl.x}$

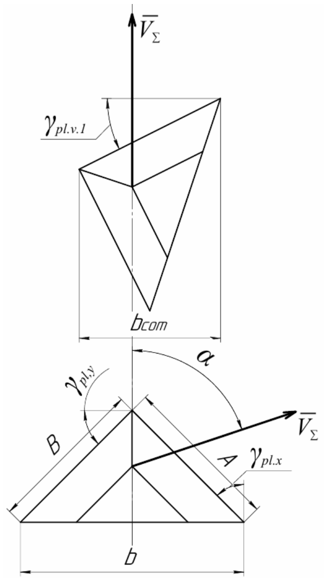

Fig. 9. Parameterization of spatial oriented knife when $\gamma_{pl.y} < \alpha > \gamma_{pl.x}$

4. Research results

For our study, the closest analogue in terms of technical essence is the stand for registering cutting forces (Declaration Patent of Ukraine for Utility Model № 13846, class G 01 L 5/16, 2006) [12], which is taken as a prototype and consists of a frame, a cutter holder, vertical and horizontal rods connecting the working body with strain-sensitive elements, made in the form of beams, each of which has a strain gauge (strain gauge) mounted on it, included in the arms of strain gauge bridges connected to the recording equipment, a cutter made of a prefabricated eyelet, two strain gauges, a metal plate acting as the frontal face of the cutter, and two metal plates covering the frontal face.

The peculiarity of this test bench is the use of a mechanism for horizontal movement of the trolley with a cutter holder through a screw-nut transmission and a V-belt transmission from the electric motor.

The disadvantage of this test bench is the impossibility of measuring cutting forces by adjusting the speed of horizontal movement of the working body mounted on the trolley.

Therefore, the main task is to improve the design of the dynamometric stand for recording the force load during the operation of a spatially oriented knife of dynamic action and controlling the speed of horizontal and orthogonal movement of the working body. The principles and approaches described in scientific papers were used to improve the test bench. [13 - 17].

The problem is solved by the fact that the dynamometric stand for registering the power load, consisting of a frame on which a trolley is mounted on the guide beams with rollers, a holder is fixed to it through strain gauges, while the trolley is equipped with a mechanism for lifting and lowering with a handle, and the possibility of horizontal movement of the trolley is carried out using a screw-nut transmission, a V-belt transmission from an electric motor, is characterized by the following that to ensure the cutting of soils with spatially oriented knives, a screw-nut transmission with a worm gear and its own electric motor and frequency converter is fixed in the holder perpendicular to the axis of movement of the trolley, and the drive motor is connected through a frequency converter, which allows changing the current frequency, which in turn leads to a change in the frequency of rotation of the motor shaft and the speed of horizontal movement of the trolley with the working body in the cutting zone.

Figure 10 shows a dynamometric force load recording stand (side view), which consists of a frame 1, on which a trolley 3 is mounted on guide beams using rollers 2, and a holder 6 is attached to it through strain gauge beams 4 and 5, in which the transmission screw-nut 8 is mounted through the eyelets, the movement of the spatially oriented knife of dynamic action 9 is carried out by an electric motor 10 through a worm gear 7, in turn, the electric motor is controlled by a frequency converter 11. The trolley 3 is equipped with a lifting and lowering mechanism 12 with a handle 13. The possibility of horizontal movement of the trolley 3 is realized by means of a screw-nut transmission 14-15, a V-belt transmission 16 and an electric motor 17 connected through a frequency converter 18. The hopper with the test material 20 is fixed on the mounting base 19.

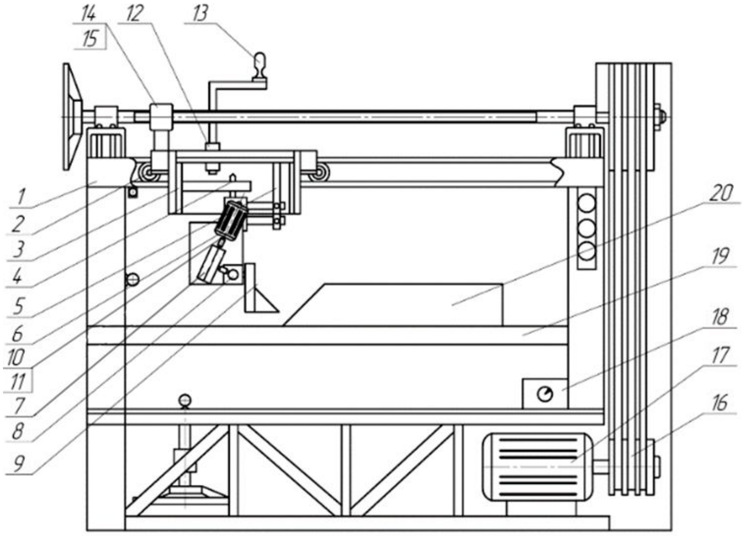

Fig. 10. Schematic of the improved test bench

The test bench will operate as follows. The hopper with the test material 20 is rigidly fixed on the mounting surface 19. By setting the frequency converter 18 to the appropriate current frequency of the electric motor 17, the required horizontal movement speed of the trolley 3 with the mechanism for moving the spatially oriented knife of dynamic action, the orthogonal movement of which occurs when the frequency converter 11 sets the appropriate current frequency of the electric motor 10.

Thus, the changes made to the design of the dynamometer for recording the force load make it possible to measure the cutting force of soils by spatially oriented knives of dynamic action and to regulate the speed of horizontal and orthogonal movement of the working body mounted on the trolley.

In Figure 11, a test bench for cutting soils with real geometric dimensions was created using CAD systems.

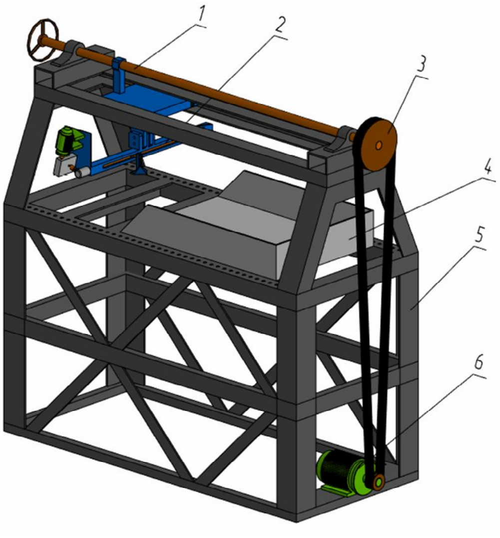

Fig. 11. 3D model of the test bench

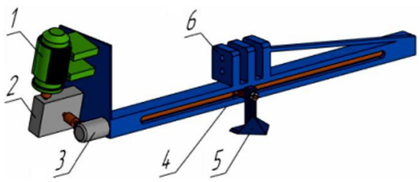

Fig. 12. 3D model of the construction of equipment for cutting soils with a spatially oriented knife

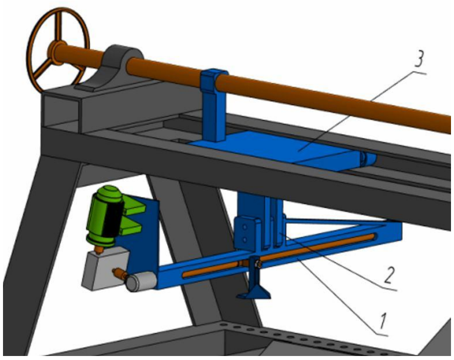

Fig. 13. Scheme of fixing equipment for cutting soils with a spatially oriented knife in a strain gauge trolley

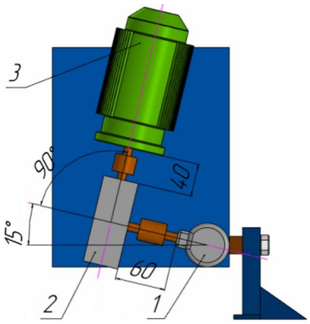

Fig. 14. Positioning of the knife drive motor and gears

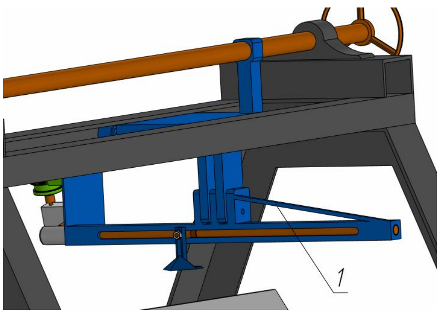

Fig. 15. The housing of the equipment for cutting soils with a spatially oriented knife

On the frame 5, a hopper 4 with the test material is installed, the movement of the working body 2 will correspond to the direction of the main movement of the bulldozer blade and will be carried out along the bench using a bench engine (P=2.5 kW, n=980 rpm) 6, through a V-belt transmission 3 with a gear ratio u=2.5, to the screw-nut transmission 1.

Figure 12 shows a drive for the longitudinal translational movement of a spatially oriented knife.

It is fixed on the stand through the eyelets 6. The movement of the spatially oriented knife 5, in turn, will be carried out by the motor (P=1.1 kW, n = 3000 rpm) of the spatially oriented knife 1, through the worm gear 2 with a gear ratio u = 8, to the bevel gear 3 with a gear ratio u = 2, and to the screw-nut gear 4. The motors will be controlled by separate frequency converters to ensure compliance with the speed ratios of the working hypothesis.

The equipment for cutting soils with a spatially oriented knife 1 itself is attached to the movable trolley 3 of the test bench through the eyelets 2, which ensures its movement (Fig. 13).

Figure 14 shows the placement of the electric motor 1, worm 2 and bevel 3 gears on the flange of the working body, this placement was designed to move the motor and gears away from the working area, the hopper with the test material, and to easily connect the motor control wires. Also, this arrangement should have less impact on the strain gauges placed in the trolley. However, the disadvantage of this arrangement is that the mass is moved further away from the eyelets, which creates an overturning moment and affects the fine-tuning of the spatially oriented knife.

To solve the problem with the skewing of the working body due to the misalignment of the motor and gears, we made a side stop 1 (Fig. 15), which rests on the eyelet, thereby compensating for the deviations created by the mass on the other arm of the working body.

Next, we designed a spatially orientated knife (Fig. 16), observing all the parameters used in the calculations of the cutting forces.

For the model of the spatially oriented knife, we chose a dihedral knife with side cutting surfaces inclined at 45° and cutting edges φ (corresponding to the angle of rotation of the knife in the plan γ), also at 45°, because Professor V.M. Smirnov experimentally proved that it is advisable to give the cutting tool of earthmoving machines a cutting angle φ of no more than 35-40° and a rotation angle γ of no more than 30-45° for the most productive cutting of soil.

Also, a slot is designed in the knife mount through which the knife is fixed to the transmission with a screw nut, the second task of the slot is to adjust the cutting depth, since the working body itself is quite voluminous and its lowering can lead to the fact that during the experimental study it can hit the hopper with the test material, which is unacceptable.

The next step was to conduct a computer simulation of the load of the working body in accordance with the working hypothesis. In which, in accordance with the ratio of the speed of movement of the blade and the movement of the spatially oriented knife, the geometric interaction with the working environment changes, the supports of which are given in Table 1 and their physical characteristics are given in Table 2. The cutting force was calculated and plotted in a graph (Fig. 17).

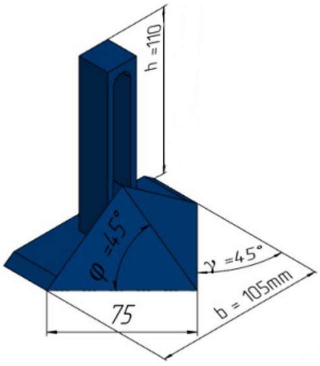

Fig. 16. 3D model of a spatially orientated knife

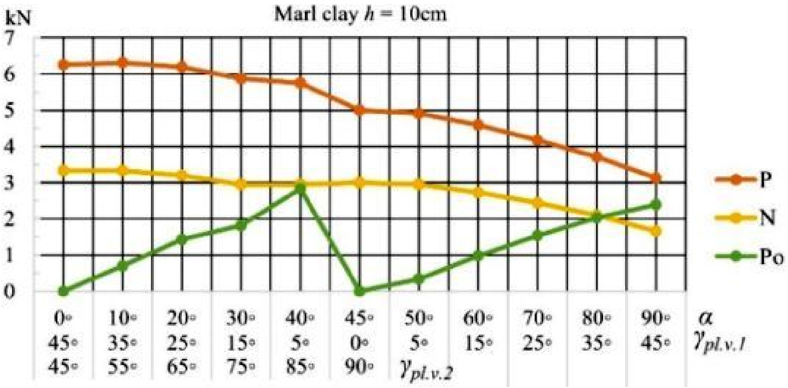

Fig. 17. Cutting forces in marl clay at working depth

Table 1

Specific soil resistances

Soil	m_f, MPa	m_s, MPa	$m_{s.c}$, кN/m
Paraffin	0,05	0,008	1,26
Marl clay	0,3	0,021	0,4
Loam	0,15	0,013	1,42
Argillite	0,25	0,024	5,47

Table 2

Physical characteristics of soils

Soil	Dimensional characteristics of the destruction zone		
	μ	k_s	γ
Paraffin	23°	*0,6*	60°
Marl clay	14°	0,8	30°
Loam	18°	0,85	40°
Argillite	16°	0,9	30°

To conduct computer modelling, first, materials were selected (Table 3) from which a model of a spatially oriented knife and lugs will be made, then a load was applied to the knife faces (Fig. 18) corresponding to the maximum cutting force shown in the graph (Fig. 17), which is 6500 N (Table 5).

Information about the material used and its physical properties are listed in Table 4, then a finite element mesh was created by software (Fig. 19) and the parameters of the breakdown were listed in Table 6.

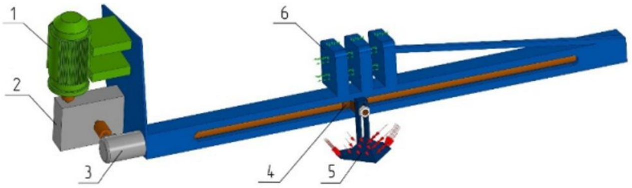

Fig. 18. Visualisation of applying loads to the edges of a spatially orientated knife

Next, we determined the inertial characteristics of the model (Table 7) and the reactions in the supports (Table 8).

Having all the above parameters, the stress equivalents (Fig. 20, Table 9), the sum of linear displacement (Fig. 21, Table 10), the yield strength factor (Fig. 22, Table 11), the tensile strength factor (Fig. 23, Table 12), and the loss of stability factor (Table 13) were determined and visualized using computer modelling.

The natural frequencies were also calculated (Table 14) to understand the stability and strength of the modelled structure of the working body.

Table 3

Detailing

№	Title of detail
1	Electric motor
2	Worm gearbox
3	Bevel gear
4	Gear screw-nut
5	Spatially orientated knife
6	Eyelet

Table 4

Information about the material

Yield strength [N/mm^2]	235
Modulus of elasticity [N/mm^2]	200000
Poisson's ratio	0,3
Density [kg/mm^3]	0,000008
Temperature coefficient of linear expansion [1/°C]	0,000012
Heat conductivity [Vt/(°C mm)]	0,055
Compressive strength [N/mm^2]	410
Tensile strength (Temporary resistance) [N/mm^2]	410
Tensile endurance limit [N/mm^2]	209
Torsional endurance limit [N/mm^2]	139

Table 5

Information about the load

Title	Selected objects	Load parameters
Pressure 1	Edge: 1	Value: 6500 H
Pressure 2	Edge: 2	Value: 6500 H

Table 6

Finite element mesh parameters and breakdown results

Title	Value
Element type	10-node tetrahedra
Maximum length of the element side [mm]	100
Maximum thickening factor on the surface	1,2
Dilution coefficient in volume	1,5
Number of finite elements	11378
Number of nodes	23321

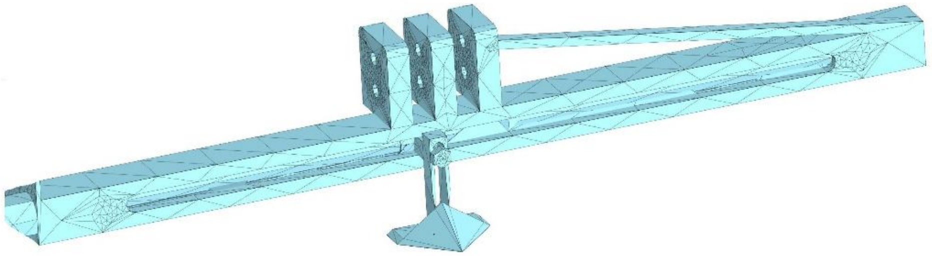

Fig. 19. Visualisation of finite element mesh

Table 7

Inertial characteristics of the model

Title	Value
Model weight [kg]	39,23
Centre of mass of the model [mm]	(-577,45; -32198; 1733,38)
Moments of inertia of the model relative to the centre of mass [kg·mm^2]	(4884881,07; 316829,721601; 4731127,025)
Reactive moment relative to the centre of mass [N·mm]	(-263315,26; 860409,55; -706540,76)
Total reaction of the supports [N]	(-2860,67; 3309,138546; 4679,83)
Absolute value of the reaction [H]	6405,832467
Absolute torque value [N·mm]	1144045,17

Table 8

Reactions in the supports

Rx [N]	**Ry [N]**	**Rz [N]**
-2860,67	3309,13	4679,83

Table 9

Equivalent stress

Title	Type	Minimum value	Maximum value
Equivalent stress	SVM [H/mm^2]	0,000009	2244,03

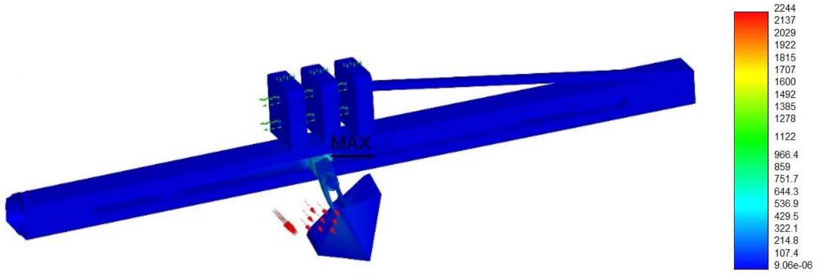

Fig. 20. Visualisation of equivalent stress

Table 10

Total linear displacement

Title	Type	Minimum value	Maximum value
Total linear displacement	USUM [mm]	0 mm	1,297595 mm

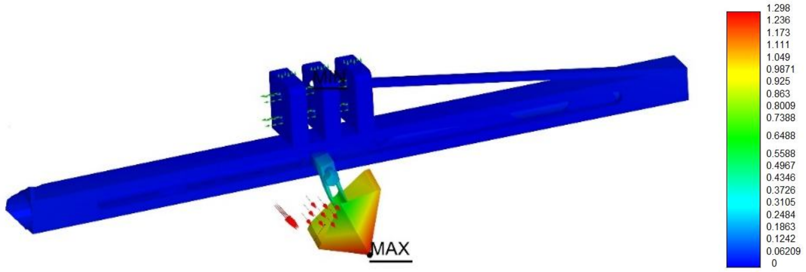

Fig. 21. Visualisation of the total linear displacement

Table 11

Yield strength safety coefficient

Title	Type	Minimum value	Maximum value
Yield strength safety coefficient	SVM	0,32	10

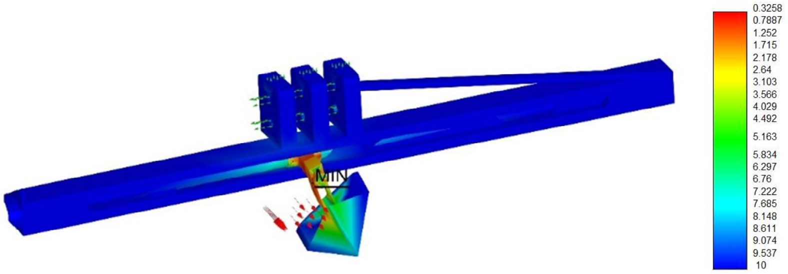

Fig. 22. Visualisation of the yield strength stock

Table 12

Tensile strength safety coefficient

Title	Type	Minimum value	Maximum value
Tensile strength safety coefficient	SVM	0,56	10

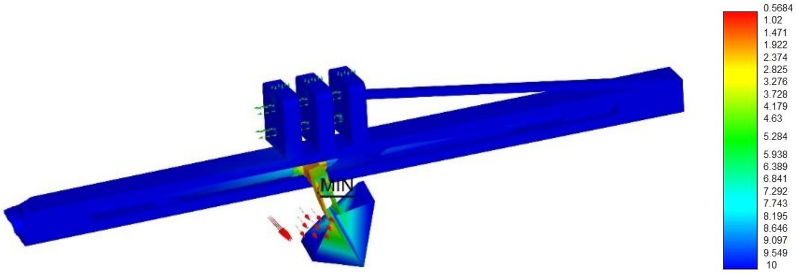

Fig. 23. Visualisation of the margin of safety

Table 13

Results of the stability calculation

№	Loss of stability margin coefficient
1	0,000305

Table 14

Results of the natural frequency calculation

№	Frequency [rad/s]	Frequency [Hz]	Period [s]	m.m. X [%]	s.m.m. X [%]	m.m. Y [%]	s.m.m. Y [%]	m.m. Z [%]	s.m.m. Z [%]
1	295,1379	46,9726	0,0212	28,9390	28,9403	0,3811	0,3815	10,0909	10.0913
2	306,7136	48,8149	0,0204	11,7948	40,7351	9,6298	10,0113	17,4117	27.5030
3	688,3180	109,5492	0,0091	0,0005	40,7356	3,2663	13,2776	10,8196	38.3226
4	710,2159	113,0343	0,0088	4,7029	45,4386	5,04439	18,3220	5,7934	44.1161
5	861,8333	137,1650	0,0072	0,9766	46,4153	3,6766	21,9987	6,6415	50.7576
6	978,8034	155,7814	0,0064	13,6691	60,0844	0,0152	22,0139	0,5400	51.2977
7	1253,7486	199,5402	0,0050	0,0120	60,0964	0,2617	22,2756	0,1607	51.4584
8	1522,4199	242,3006	0,0041	0,7444	60,8409	0,0140	22,2897	13,4852	64.9436
9	2052,6683	326,6923	0,0030	5,1584	65,9993	8,2485	30,5382	0,0001	64.9438

5. Conclusions

The creation of a 3D model of the test rig makes it possible to understand the scale and procedure for creating a real reduced-scale model of a spatially oriented bulldozer blade and the displacement mechanism, and this makes it possible to easily rebuild it in a CAD program, which speeds up the creation of a real test rig.

Also, the creation of a reduced-scale model was carried out in accordance with the similarity coefficients and the computer analysis of the loads makes it clear that the experimental working body has the correct parameterization, which is expressed in the safety factors for yield strength and strength, and the safety factor for loss of stability.

Another advantage of computer modelling is the ability to conduct many computer analyses with different input parameters, which further reduces the possibility of error between the mathematical model and experimental data, as it provides a larger sample of data.

For the real experiment, the working body and the movement mechanism in the test bench will be controlled by two separate frequency converters, which should provide precise control over the complex movement of the spatially oriented knife in accordance with the working hypothesis.

In the future, by conducting real experiments on the created test bench, it is expected to confirm the working hypothesis, the results of the mathematical model presented in the previous articles and the computer modelling described in this paper.

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РОЗРОБКА ОБЛАДНАННЯ ТА КОМП'ЮТЕРНЕ ВИПРОБУВАННЯ ДЛЯ РІЗАННЯ ҐРУНТІВ ПРОСТОРОВО ОРІЄНТОВАНИМИ НОЖАМИ ВІДВАЛУ БУЛЬДОЗЕРА

У статті використано підходи до створення та комп'ютерного випробування моделі експериментальної установки для різання ґрунту просторово-орієнтованими робочими органами землерийних машин, що використовуються на будівельних майданчиках. На сьогодні існує потреба в ефективному виконанні будівельних робіт, пов'язаних з експлуатацією будівельної техніки з відвальним обладнанням. Це, в свою чергу, ставить завдання визначення продуктивності механізованих земляних робіт в різних робочих середовищах. Основним способом механічної розробки ґрунтів є різання. Основними геометричними умовами є положення кромки ріжучого клину відносно напрямку різання і поверхні масиву, контур ріжучої кромки, контур і кількість робочих поверхонь ріжучого клину, кількість так званих бічних поверхонь різання і так званих заблокованих поверхонь різання. Особливістю процесу копання є те, що його силові та енергетичні показники залежать від кінематичних умов і геометричних параметрів - товщини, ширини і площі зрізу, а також від кутів орієнтації робочого органу в просторі. Створення такої комп'ютерної моделі експериментальної установки обумовлено необхідністю постійного вдосконалення існуючого обладнання та створення нового з урахуванням існуючих потреб. Модель експериментальної установки створена відповідно до робочої гіпотези, де рух просторово-орієнтованого ножа відбувається перпендикулярно до руху відвального обладнання, при різних співвідношеннях швидкості руху відвалу та переміщення ножа, що створює просторову взаємодію з робочим середовищем, та відхилення прикладання повного зусилля різання на кут α. Відповідно до робочої гіпотези в залежності від плану руху просторово-орієнтованого ножа змінюється його геометрична взаємодія з робочим середовищем і відповідно змінюється сила різання. Необхідність створення більш продуктивної та ефективної землерийної техніки вимагає застосування сучасних конструктивних рішень. Використовуючи розрахунки різання ґрунтів просторово-орієнтованими землерийними робочими органами у вигляді двогранного ножа відвального обладнання, проведено комп'ютерне дослідження еквівалентів напруження, суми лінійного переміщення, коефіцієнт запасу по межі текучості, коефіцієнт запасу по межі міцності, та коефіцієнт запасу втрати стійкості. Результати узагальнено у вигляді табличних даних та графічного відображення.

Ключові слова: параметризація, комп'ютерне випробування, бульдозерний відвал, сила різання, просторова орієнтація, кут повороту в плані, випробувальний стенд, парафін.

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Стаття присвячена розробці та комп'ютерному тестуванню моделі експериментальної установки для різання ґрунту просторово-орієнтованими робочими органами землерийних машин, що використовуються на будівельних майданчиках.
Табл. 14. Іл. 23. Бібліог. 17 назв.

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Maksymiuk Yu.V., Rashkivskyi V.P., Prystailo M.O., Fedyshyn. B.M. **Development and computer testing of equipment for cutting soils with spatially oriented knives of a bulldozer blade** // Strength of Materials and Theory of Structures: Scientific-and-technical collected articles – Kyiv: KNUBA, 2024. – Issue 113. – P. 285-296.
The paper is devoted to the design and computer testing of a model of an experimental setup for cutting soil with spatially oriented working bodies of earthmoving machines used on construction sites.
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