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DETERMINATION OF THE FORCES, APPLYINGTO THE WORKING BODIES OF TILLING AND SEEDING MACHINES

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Abstract
The article presents data on the resistance of the working bodies of seeders and tillers, which are determined by dynamic researchmachine in general. Since, during operation, the working body makes a uniform rectilinear movement, and an arbitrary system of active soil resistance forces acting on the working body with supporting reactions on wheels is in equilibrium, we can use six static equations to determine the components, for knowing the basic reactions. Torque trolley small soil channel enables spatial dynamic research the working organs of the above machines, for example finding the value, direction and point of application of the resultant of soil resistance. Graphical - analytical method for calculating the parameters of the dynamic rotor components for determining soil resistance forces and moments at individual points proposed.

Keywords: small soil canal, dynamometer trolley,strain gauge rack; strain gage.

1. Introduction

The development of methodological and technical foundations of accelerated experimental research and testing of processes and working bodies of machines for cultivating agricultural crops on the basis of a small soil canal (SSC) equipped with a modern informational measurer systems (IMS) using a personal computer allows us to improve experimental research methods and significantly reduce their term.The assessment of the tool from the point of view of use in an economic environment is usually based on data on the resistance of the working bodies, depending on the depth, speed of processing and the width of the grip of the tillage or sowing working body. These resistances are determined by dynamometry of the tool as a whole [1].

M.N.Moskovsky et al. (2011) developed a methodology for studying the wear resistance of working bodies of tillage machines which are made from a material based on UHMWPE polymer. Since the soil is a heterogeneous medium, many phenomena in it proceed are unsteady, hence the component of random processes is significant. This presents for the working bodies and materials on the basis of which they are made special requirements [2].In addition, the working body, being in the soil, works in a potentially corrosive aggressive environment. The installation “Circular soil canal” was used, on which various types of soil conditions are modeled. The working body is mounted on the frame, buried in the soil, and then by the continuous movement of the soil circle relative to the working body with a given speed of movement, the soil cultivation process is simulated. The tests on the wear resistance of the samples revealed a significant increase in the wear resistance of parts made from UHMWPE-based material compared to metal products.

V.V.Myalo (2016) proposed a method for determining the agrotechnical indicators of a blade working body in the soil channel. To analyze the results of the planned full-factor experiment, laboratory experimental studies of the influence of the parameters of the blade working body on the quality indicators of processing were carried out in the soil channel. When testing the working body in the soil channel, the maximum processing depth reached 45-50 cm. In the soil channel, the most rational angle of attack of the blades of the working body was determined, the value of which was in the range 30 ... 40 ° [3].

F.F.Yarullin et al. (2014) presented the results of experimental studies of a rotary conical tillage working body in the soil channel. The methodology used made it possible to establish the functional dependences of the traction force and the rotation speed of the conical working body on the angles of attack and the inclination of the axis of rotation to the horizon and on the depth of tillage. As a result, rational values of the angles of attack and the inclination of the axis of rotation to the horizon were determined, providing minimum traction or maximum rotation speed of the working body [4].

P.A.Yemelyanov et al. (2013) developed and manufactured the construction of a mobile soil canal, which makes it possible to carry out research with any working bodies of agricultural machines on concrete real soils close to field studies. On the manufactured mobile soil canal, laboratory studies were carried out to seal the bulbs in the furrow with disk-type closing bodies. The determination of the economic efficiency of its use in comparison with the stationary soil canal showed that the use of the mobile soil canal will reduce the laboriousness of laboratory research by 60%, the annual labor savings in the operation of the mobile soil canal will be 346 people/year [5].

2. Methodology

To select a rational form of the working body, to compare two orseveral working bodies for their traction resistance, as well as for the calculation and design of agricultural machinery, there is a need to fully determine the forces acting to the working bodies, in the absence of any intermediate running gear between the working bodies and the dynamometer.At the Department of Ground Transportation Systems, of Tashkent State Technical University a traction trolley has been developed which can be successfully used for spatial dynamometry of the working bodies of tillage and sowing machines. Small soil canal is a laboratory complex consisting of a soil canal, traction trolley, trolley drive, adjustment mechanisms.The traction trolley (Fig. 1.) is equipped with a hitch mechanism, by means of which the investigated working bodies are installed on the trolley frame. A trolley driven by an electric motor moves along the soil channel, thereby simulating an agricultural aggregate. This makes it possible to carry out the necessary experiments in the laboratory conditions.

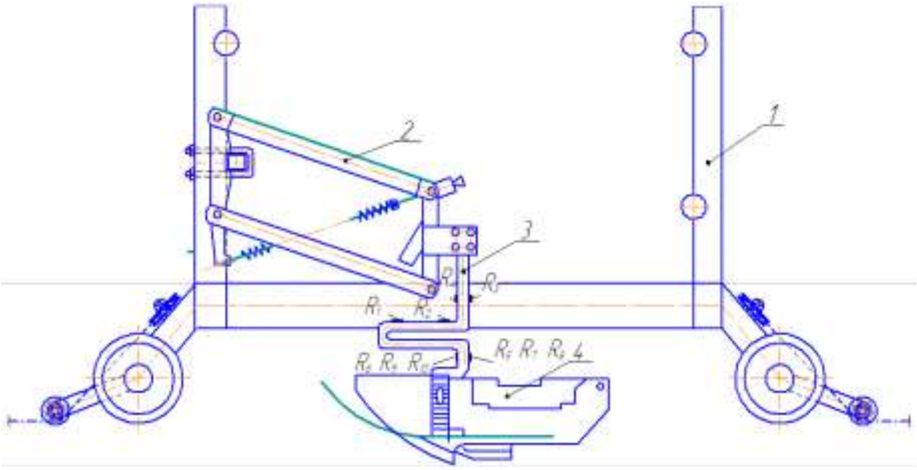

FIGURE 1. Dynamometer trolleydiagram:
1-trolley frame; 2- hitch mechanism;3- strain gauge rack;4-tensometric opener;
R_1, R_2, R_3, R_4, R_5, R_6, R_7, R_8, R_9, R_{10}- gages.

The study of the forces acting on the working body of a soil-cultivating or sowing agricultural machine makes it possible to develop a rational form of the working body and to spot the place and type of suspension it to the frame of the machine, as well as conduct force calculation. Accurate knowledge of the spatial change in the forces acting on the working body is necessary, for example, in order to determine the most favorable position of the control points of the mounted implements and in order to correctly select the regulation and installation mechanism for all possible load cases. The spatial effect of soil resistance on the working body can be determined using a dynamometric trolley [6].

Soil type is typical greysoil, soil structure clay - loamy pH 6.7; humus content 3,5%; on sowing soil moisture - 15.4% 19,5%, soil temperature - 27°…28° C [7].

3. Results and discussing

For example, we consider a methodology for studying the force loading of the fastening elements of cultivator ridges working bodies. The following power and linear parameters were adopted as criteria for determining the stress state of the fastening elements of cotton cultivator ridges working bodies:

1. Transverse - horizontal components of dynamic loads, causing a bending moment which acts on the rack of the working body in the transverse-horizontal plane of movement of the cultivator.
2. Longitudinal - horizontal components of dynamic loads, causing a bending moment which acts on the strut of the working body in the longitudinally horizontal plane of movement of the cultivator.
3. Transverse - horizontal components of dynamic loads, causing a bending moment which acts on the bar in the transverse - horizontal plane of movement of the cultivator.
4. The vertical components of dynamic loads, causing a bending moment which acts on the bar of the ridge in the vertical plane of movement of the cultivator.
5. Efforts arising at the point of contact of the holder bolt with the working body strut and contributing to the appearance of normal stresses.

6. The longitudinal components of dynamic loads acting on the working bodies, causing stretching of the links of the ridges in the longitudinal plane of movement of the cultivator.
7. Parameters of linear displacements $X_i$and Z_i of working bodies in the transverse - horizontal and vertical planes of movement of the cultivator relative to the tractor.
8. Parameters of linear displacements X_i^I and Z_i^I of working bodies in the transverse - horizontal and vertical planes of movement of the cultivator relative to the processed row spacing.

The practice of carry out experimental studies of the stress state of the fastening elements of the working bodies shows that the placement of strain gauges in arbitrarily selected places, even with a large number of them, does not allow to restore the full picture of the stress state. Therefore, the results of the processing of the experiment are closely related to the methods of placing sensors on the elements of the ridges of cultivators.As a result of the analysis, it was revealed that under operating conditions, the weakening of the fastening of the working bodies, leads to a decrease in agrotechnical indicators, in particular, the stability of the stroke along the depth and width of the row spacing is not maintained [3].

Spatial vibrations of the working bodies, arising on tractor oscillations and the difference in soil resistance, have a significant effect on the efficiency of fastening the working bodies. Therefore, to obtain and register vibrations and force loading of the fastening elements of the working bodies of cultivator ridges, the following strain gauge constructions should be installed on the experimental cultivator ridges:

1. Strain gauge racks of working bodies (Fig. 1.) with strain gauges 1; 2 which record the transverse forces arising from the action of longitudinal and transverse components of dynamic loads on the working bodies.
2. Strain gauge bars with strain gauges 3; 4 which register the transverse forces arising from the action on the working bodies of the vertical and transverse components of dynamic loads.
3. Strain gauge locks with a strain gauge 5 which registers the forces arising from the moment of tightening of the fastening bolt.
4. The tensometric fingers of the hinged joints of the lower links of the ridges with strain gauges 6, registering the longitudinal components of dynamic loads.
5. Strain gauge plates with strain gauges recording the movement of organs relative to the tractor in the transverse - horizontal $X_i$and vertical $Z_i$motion planes.
6. Strain gauges mounted on the ski with strain gauges that record the movements of the working bodies relative to the treated cotton rows between the transversal - horizontal $X_i$and vertical Z_i motion planes.

To determine the components, knowing the support reactions, you can use the six equations of statics [7]. From the course of theoretical mechanics it is known that an arbitrary system of forces can be reduced to the action of a dynamic screw. To solve this problem, you can use the grapho-analytical method for determining the magnitude and direction of the main vector, the position of the central axis in space and the point of its intersection with the surface of the working body, as well as the magnitude and direction of the main moment, its projection on the direction of the main vector.

We write six static equations to determine the desired quantities. The origin is taken at point C (cast point) (Fig. 2.).

$$
\begin{array}{ll}
\sum x = R_x - B_x - D_x = 0; & R_x = B_x + D_x \\
\sum y = R_y - U_y + E_y = 0; & R_y = U_y - E_y \\
\sum z = R_z + C_z - A_z = 0; & R_z = A_z - C_z \\
\sum M_x = M_x - E_y l_\varepsilon + U_y l_\varepsilon = 0; & M_x = E_y l_\varepsilon - U_y l_\varepsilon \\
\sum M_y = M_y - A_z l = 0; & M_y = A_z l \\
\sum M_z = M_z - B_x l_B + D_x l_B = 0; & M_z = B_x l_B - D_x l_B
\end{array}
$$

The reactions of the supports at points A, B, C, D, E and U are perceived by the respective load gauges and are recorded by the recording mechanism. The average reactions of the supports found during the processing of dynamometer diagrams are substituted into the above equations; the linear dimensions l, l_ε, l_B are determined by directly measuring them on a trolley.

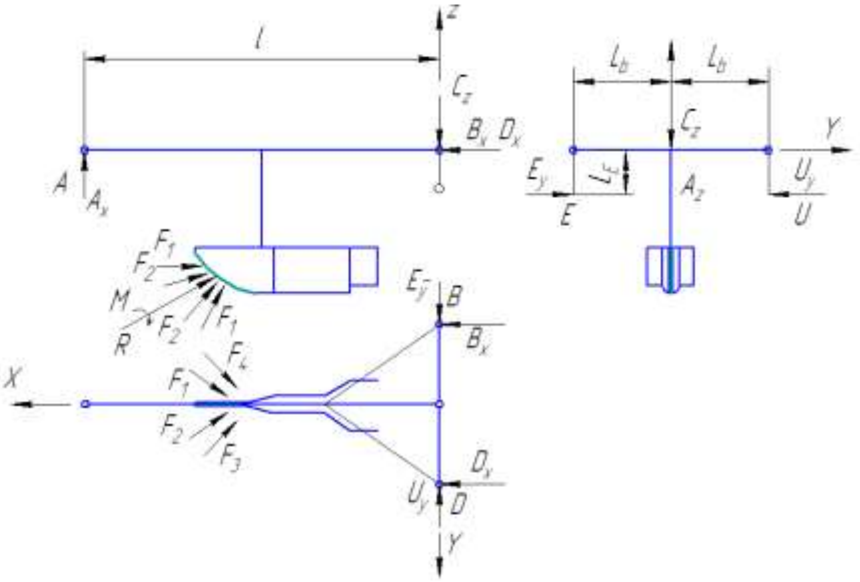

FIGURE2. The arrangement of strain gauges on the frame of the dynamometer trolley for spatial dynamometry of the sowing and tillage machines working bodies.

The magnitude of the main vector is determined by the formula: $R = \sqrt{x^2 + y^2 + z^2}$;
The direction of the main vector is determined by the direction cosines:

$$\cos(\overrightarrow{R,x}) = \frac{x}{R};\ \cos(\overrightarrow{R,x}) = \frac{U}{R};$$

The magnitude of the main moment is determined from the formula:

$$\cos(\overrightarrow{R,z}) = \frac{z}{R};$$

The direction of the vector of the main moment is determined by the direction cosines:

$$M = \sqrt{M_x^2 + M_y^2 + M_z^2};$$

The magnitude of the main moment and the direction cosines change with a change in the point of reduction of the soil resistance forces (point C). The magnitude and direction of the smallest moment does not depend on the choice of the point of reduction and is defined as:

$$M_0 = \frac{XM_x + YM_y + ZM_Z}{R};$$

The direction of the least moment coincides with the direction of the main vector and the least moment is obtained when projecting the main moment in the direction of the main vector. The quantities R and $M_0$are independent of the choice of one or another coordinate system and are called the static invariants of this system of forces. The line of action of the main vector and of the main moment projected onto it has a well-defined position for this system of forces. The central axis is located at a distance r from the point of reduction C, and the central axis is parallel to the main vector R.

$$Z = \frac{\sqrt{M^2 - M_Z}}{R};$$

The distance is laid on the perpendicular to the plane passing through the main vector and the main moment, in the direction in which the main vector R rotates counterclockwise relative to point C. To construct the perpendicular in the coordinate axes using the formulas of analytical geometry, direction cosines were found [] 8.After all quantities are determined analytically, a working body is constructed in the coordinate axes. The coordinate point C is taken for the origin and the working body is drawn in the position that he occupied during the experiment with respect to point C of the dynamometer trolley.

The components of the main vector R_x , R_y ,$R_z$and the main vector itself are constructed; components of the main moment M_x, M_y, $M_z$and the main moment M itself. The least moment $M_0$is plotted on the direction of the main vector R. A perpendicular line is being built. The value of r is plotted on the perpendicular. Through the obtained point, parallel to the direction of the main vector Rthe central axis line is drawn. The point of intersection of the central axis with the surface of the working body is found.

4. Conclusion

The preliminary studies carried out made it possible to determine some parameters of power loading and oscillations of the working bodies on the frame of the dynamometer trolley:

moments on the rack of the working body (strain gauges 1; 2)M_1 =26 N·m^2; M_2 =43N·m^2;

moments on the bar of the ridge (strain gauges 3; 4)M_3 =275 N m^2; M_2 =33 N m^2;

holder tightening force (strain gauge 5) P_5=20000 N;

traction force (strain gauge 6) P_6=1820 N.

Thus, the spatial effect of soil resistance on the working body can be determined using a dynamometer trolley. Since, during operation, the working body makes a uniform rectilinear movement, and an arbitrary system of active soil resistance forces acting on the working body with supporting reactions on wheels is in equilibrium, we can use six static equations to determine the components, knowing the basic reactions. It is known that an arbitrary system of forces can be reduced to the action of a dynamic screw; therefore, using the grapho-analytical method for calculating the parameters of a dynamic screw, one can construct a working body and find the intersection points of the central axis with its surface.

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