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JUSTIFICATION OF THE PARAMETERS A REAR-MOUNTED LINKAGE WIDE SPAN TRACTOR (VEHICLE)

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Abstract *– To ensure the statically high universality, wide span tractors (vehicles) can (and undoubtedly should) be aggregated with various trailed, semi-mounted and mounted agricultural machines and implements. The sealing effect on the soil of their running systems in the fertile (agrotechnical) zone of the field, as well as the traction and coupling properties, stability and controllability of the movement of wide span vehicle is substantially determined by the scheme of their connection and the parameters of the rear-mounted linkage. The purpose of research is to increase the traction and traction properties, stability and controllability of the movement of wide span tractor (vehicle) and to reduce the sealing effect of running machinery systems on the soil in the fertile zone of the field, by justifying the parameters of their hinged devices and the scheme of attaching agricultural machines and implements to them. Theoretical studies, synthesis of structural schemes and parameters of a wide span tractor (vehicle) were carried out by simulating the conditions of its operation on a PC. The research methods are based on the basic principles of theoretical mechanics and tractor theory using the Mathcad package. As a physical object of research, a wide span vehicle design of the Tavria State Agrotechnological University (TSAU), Ukraine. A result of the conducted researches it was established that in addition to the angles of inclination of the rear-mounted linkage wide span tractor (vehicle), such design parameters as the distance from the hinged device to the center of resistance and the support wheel of the agricultural machine or implement have a significant effect on the redistribution of normal reactions on its front and rear wheels. With the purpose of almost completely eliminating the sealing effect on the soil of the running systems of machines in the fertile (agrotechnical) zone of the field, it is recommended to use regulators on wide span tractors (vehicles) to correct the normal vertical load on the support wheels of an agricultural machine or implement that work according to the principle of known traction tractors.*

Formulation of the problem. Recently, wide span vehicles (more often referred to as wide span tractors) have become increasingly popular in the world [1, 2]. The latter make it possible to realize technology of track, bridge and controlled traffic farming [3, 4]. And their development corresponds to the vector of scientific and technological progress directly in the trend of automation and robotization of agricultural production.

Owing to their quite high versatility, wide span tractors (vehicles) can (and undoubtedly should) be aggregated with various trailed, semi-mounted and mounted agricultural machines and implements. Due to the weight of the latter and tractive resistance, regardless of the way they are connected by means of an attachment, they can cause a significant redistribution of vertical loads on the wheels of the bridge tractor. The main problem is that if the agricultural machines and implements are not connected correctly, there may be no loading, but, conversely, unloading the steering and driving wheels of a wide span tractor (vehicle) with all the ensuing consequences. At the same time, the vertical load on the supporting wheels of the attached agricultural machines and tools placed, as a rule, in the agrotechnical (fertile) zone of the field can be substantially increased. Because of this, as a result of the excessive sealing effect of the running systems of machines on the soil, the entire effect of the controlled traffic farming can be reduced to zero. Therefore, the issue of studying the influence of the parameters of the rear-mounted linkage a wide span tractor (vehicle) and the scheme of attaching machines and implements to it on the nature of the change in the vertical loads on its wheels is urgent.

This work is devoted to studying the features of aggregation of wide span tractor (vehicle) with agricultural machines and implements.

Analysis of recent studies and publications. The existing world experience in the integration of wide span tractors (vehicles) has shown the possibility of using three-point rear-mounted linkage on them (Fig. 1). The study of the structural features of the latter when used on wide span tractors (vehicles) is practically not covered in the scientific literature. It is fairly well known that the angles of inclination of the central and lower links of its hinged mechanism exert a significant influence on the redistribution of normal reactions on the wheels of a traditional tractor. And the very nature of the redistribution of normal reactions on the tractor wheels is determined by the design parameters of its hinged mechanism and the agricultural machine or implements aggregated with it. For example, with the increase in the angle of inclination of the central traction of the front attachment of the arable unit, built according to the "push-pull" scheme based on the tractor of the HTZ series 120/160, vertical reactions on the front axle of the tractor increase, and in the rear – decrease [5]. The same picture is observed with an increase in the angle of inclination of the lower links. At the same time, these regularities are valid for the traditional layout of the machine-tractor unit, when the attachments with attached agricultural machines and implements are located outside the zone of the tractor's wheelbase. And, naturally, they are not suitable for analysis of the character of the change in vertical reactions on the wheels of wide span tractors (vehicles).

Also, taking into account the possibility of unification of the rear-mounted linkages of wide span tractors (vehicles) with traditional ones, the parameters of which are determined by the ISO 730:2009, it is necessary to establish the correspondence of sizes and requirements for a three-point rear-mounted linkage intended for connection of agricultural machinery and implements to the tractor. This ISO 730:2009 standard defines the various categories of three-point rear-mounted linkage that are used for various agricultural tractors.

a)

b)

Fig. 1 – The rear-mounted linkages of wide span tractor (vehicle) ASALift WS9600 (http://www.gartnertidende.dk) (a) and design of TSAU [6] (b)

It should also be noted that recently certain trends in improving the design of three-point rear-mounted linkage of tractors [7-12] have been outlined. But, the problem of studying the influence of the parameters of the rear-mounted linkages of a wide span tractors (vehicles) and the scheme of attaching machines and implements to it on the character of the change in the vertical loads on its wheels is not paid enough attention.

Statement of the objective and tasks of the study. The objective of the study is to increase the traction and traction properties, stability and controllability of the movement of wide span tractor (vehicle) and to reduce the sealing effect of running machinery systems on the soil in the fertile zone of the field, by justifying the parameters of their hinged devices and the scheme of attaching agricultural machines and implements to them.

To achieve the set objective, the following tasks were solved:

- to determine the influence of the angles of inclination of the traction devices a rear-mounted linkage of wide span tractor (vehicle) and its design parameters on the nature of the redistribution of normal reactions on the front, rear wheels and support wheels of the agricultural implement;

- to justify the optimal variant of adjusting a rear-mounted linkage of wide span tractor (vehicle) in order to increase its traction and coupling properties, stability and controllability of the movement;

- to propose a way to reduce the sealing effect of the running systems of machines on the soil in the fertile zone of the field.

Methods of research. Theoretical studies, synthesis of structural schemes and parameters of a wide span tractor (vehicle) were carried out by simulating the conditions of its operation on a PC. The research methods are based on the basic principles of theoretical mechanics and tractor theory using the Mathcad package. As a physical object of research, a wide span vehicle design of the Tavria State Agrotechnological University (TSAU), Ukraine.

The basic part of the study. To solve the problem, we formulate the equilibrium condition of the wide span vehicle in the longitudinal-vertical plane. To do this, consider it as a physical solid body that has a longitudinal plane of symmetry passing through the center of its masses. With the agricultural machine attached to it, we will present it in the calculation scheme in the form of a flat equivalent model (Fig. 2). The working bodies of aggregated agricultural machines and implements in the model are represented by the projection of one working organ in which the resultant (horizontal R_X and vertical R_Y components) are concentrated their traction resistance. The quantitative relationship between them, as is known, is determined by the type of the working organ itself. This equivalent working body is assembled with a wide span vehicle with the help of the central and lower links of its attachments. All support wheels that can have an aggregate agricultural machine or implement on the scheme are represented by one equivalent support wheel.

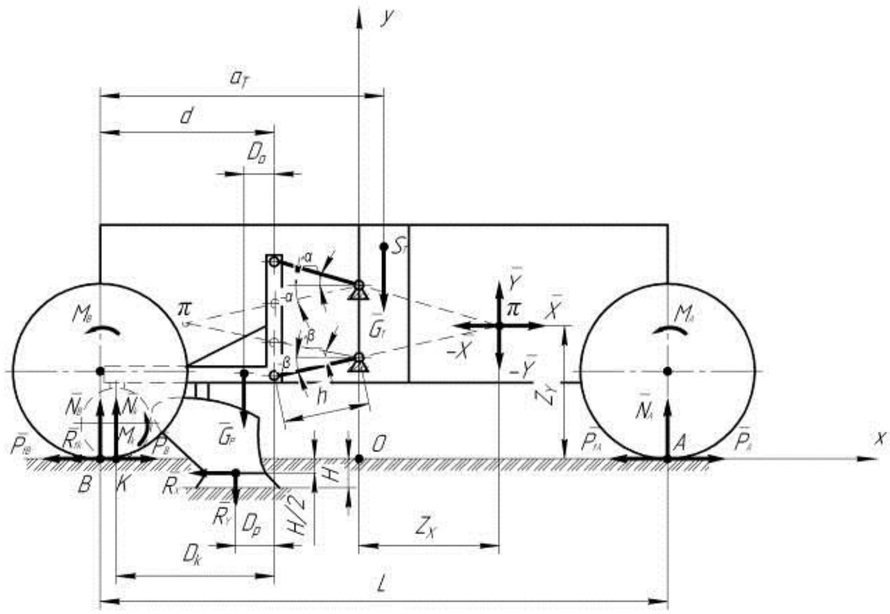

Fig. 2 – The scheme of forces and moments acting on the wide span vehicle in the longitudinal-vertical plane

In accordance with the generally accepted principle of replacing bonds by the forces of their reactions, the mutual influence of the vehicle and agricultural implements is expressed through the forces *X* and *Y*, which are concentrated in the instantaneous center of rotation of the attached device (point π, see Fig. 2). When considering the vehicle's equilibrium condition, we take the positive direction of the forces X and Y, and for the agricultural implement – the negative one.

The coordinates of the instantaneous center of rotation of rear-mounted linkage of the wide span vehicle (Z_X and Z_Y) (Fig. 2) are not constant in time during its movement. But since the trend of their oscillations is not very large, it practically does not affect the character of the redistribution of vertical loads on the front and rear wheels of the wide span vehicle, whereby they (coordinates) are taken constant.

Of the possible options for connecting machines and tools to a wide span vehicle, the angles of inclination of the central (α) and lower (β) links of its rear-mounted linkage can be either positive or negative, or equal to zero (Fig. 2).

Proceeding from the foregoing it follows that the rear-mounted linkage of the wide span vehicle, depending on the angles of inclination of its central and lower links, can have six variants of its adjustment:

$$\begin{aligned} &1)\,\alpha > 0, \beta < 0;\\ &2)\,\alpha < 0, \beta > 0;\\ &3)\,\alpha \le 0, \beta < 0, |\alpha| < |\beta|;\\ &4)\,\alpha > 0, \beta \ge 0, \alpha > \beta;\\ &5)\,\alpha < 0, \beta \le 0, |\alpha| > |\beta|;\\ &6)\,\alpha \ge 0, \beta > 0, \alpha < \beta. \end{aligned} \tag{1}$$

Depending on the angles α and β of the tilt, respectively, of the central and lower links of the rear-mounted linkage wide span vehicle, the coordinates of its instantaneous turning center (Z_X and Z_Y) can be expressed through its design parameters (Fig. 3).

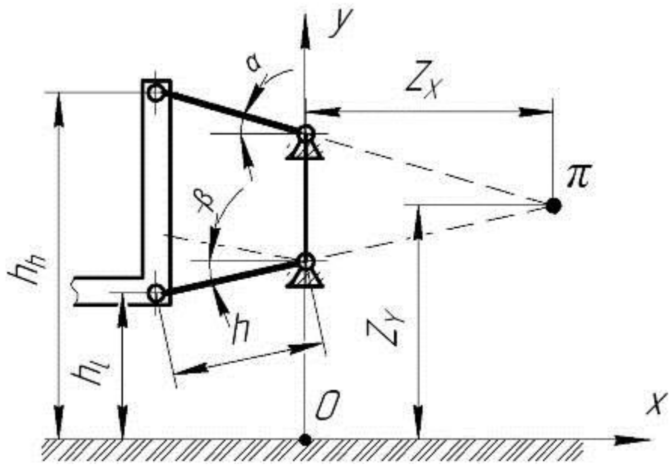

Fig. 3 – Scheme for determining the coordinates of the instantaneous center of rotation of the rear-mounted linkage wide span vehicle

The coordinates of the instantaneous center of rotation of the rear-mounted linkage in each of the variants (1) according to Fig. 3 can be defined as follows:

$$Z_{\tilde{O}} = \frac{h_h - h_l}{TAN(\alpha) - TAN(\beta)};$$
$$Z_Y = h_l - \frac{(h_h - h_l)TAN(\beta)}{TAN(\alpha) - TAN(\beta)}, \tag{2}$$

where: Z_X, Z_Y – longitudinal and lateral coordinates of the instantaneous center of rotation of the rear-mounted linkage wide span vehicle; h_h, h_l – are design parameters, the nature of which is clear from Fig. 4.

To calculate the two vertical reactions N_A and N_B on the front and rear wheels of the vehicle (see Fig. 2), it is sufficient to make up two systems of equations in which the sum of the projections of all forces in the vertical plane and the sum of their moments relative to, for example, point B:

$$\begin{cases} \sum\limits_{k=1}^{n} (F_k)_y = 0; \\ \sum\limits_{k=1}^{n} M_B(F_k) = 0, \end{cases} \tag{3}$$

where: $\sum\limits_{k=1}^{n} (F_k)_y$ – the sum of the k-th forces acting on the wide span vehicle in the vertical plane; $\sum\limits_{k=1}^{n} (F_k)_y$ – the sum of the moments of the k-th forces acting on the wide span vehicle relative to point B.

In accordance with the scheme of acting forces (see Fig. 2), we have:

$$\begin{cases} N_A + N_B - G_{\grave{O}} + Y = 0; \\ -N_A \cdot L + G_{\grave{O}} \cdot a_{\grave{O}} - M_A - M_B \pm Y(Z_X + hcos|\beta| + d) \pm X \cdot Z_Y = 0, \end{cases} \tag{4}$$

where: G_T, a_T – weight of the vehicle and the horizontal coordinate of its center of mass; M_A, M_B – moments of rolling resistance of the front and rear wheels of the vehicle, respectively; L – wheelbase of the vehicle; d – distance from the attached mechanism of the attached agricultural implement to the rear axle of the wide span vehicle; h – the length of the lower linkage of the rear-mounted linkage.

The choice of the sign «+» or «–» before the last two terms in the second equation of the system (4) depends on the position of the instantaneous center of rotation of the rear-mounted linkage (point π) relative to point B. So, if the moment formed by the reactions X and Y, hour, then the sign «+» is put, in the opposite case «–».

The moments of M_A and M_B can be expressed as follows:

$$M_A = (P_A - P_{fA}) r_A,$$
$$M_B = (P_B - P_{fB}) r_B, \quad (5)$$

where: P_{fA}, P_{fB} – tangential traction forces on the front and rear wheels of the vehicle, respectively; P_{fA}, P_{fB} – rolling resistance forces of the front and rear wheels of the vehicle, respectively; r_A, r_B – radii of the front and rear wheels of the vehicle.

In its turn:

$$P_A = \ N_A; \quad P_{fA} = f N_A;$$
$$P_{\hat{A}} = \ N_{\hat{A}}; \quad P_{f\hat{A}} = f N_{\hat{A}}, \quad (6)$$

where: f – coefficient of rolling resistance; φ – coefficient of traction of the wide span vehicle.

According to the system (4), the vertical reactions N_A and N_B, taking into account the expressions (5) and (6), after the corresponding transformations will be determined as follows:

$$\begin{cases} N_B = G_{\grave{O}} - Y - N_A, \\ N_A = \dfrac{G_{\grave{O}} \cdot a_{\grave{O}} - (G_{\grave{O}} - Y) \cdot r_{\hat{A}} (\varphi - f) \pm Y (Z_X + h cos|\beta| + d) \pm X \cdot Z_Y}{L - (\varphi - f) \cdot (r_{\hat{A}} - r_{\grave{A}})}. \end{cases} \quad (7)$$

To determine the two unknown reactions X and Y, as well as the unknown vertical reaction N_k on the support wheel of an equivalent agricultural implement, three independent equations of its equilibrium are sufficient:

$$\begin{cases} \sum\limits_{p=1}^{m} (F_p)_{\tilde{o}} = 0; \\ \sum\limits_{p=1}^{m} (F_p)_y = 0; \\ \sum\limits_{p=1}^{m} M_\pi (F_p) = 0, \end{cases} \quad (8)$$

where: $\sum\limits_{p=1}^{m} (F_p)_x$ – sum of the p-th forces acting on the agricultural implement in the horizontal plane; $\sum\limits_{p=1}^{m} (F_p)_y$ – sum of the p-th forces acting on the agricultural implement in the vertical plane; $\sum_{p=1}^{m} M_{\pi}(F_p)$ –sum of the moments of the *p*-th forces acting on the agricultural implement relative to the instantaneous center of rotation of the attachment (point π).

In accordance with the scheme of acting forces (see Fig. 2), we have:

$$\begin{cases} N_k - G_{Ð} - R_Y - Y = 0, \\ - P_{fk} - R_{\tilde{O}} + \tilde{O} = 0, \\ \pm G_P (D_0 + hcos|\beta| + Z_X) \pm R_Y (D_P + hcos|\beta| + Z_X) \pm N_k (D_k + hcos|\beta| + Z_X) \pm \\ \pm P_{fk} \cdot Z_Y \pm R_{\tilde{O}} (Z_Y + \acute{I}\ /2) - \grave{I}\ _k = 0, \end{cases} \tag{9}$$

where: H – depth of soil cultivation by the agricultural implement; G_P – weight of agricultural implements; R_X, R_Y –horizontal and vertical components of traction resistance of agricultural tools; P_{fk}, M_k – force and moment of rolling resistance of the supporting wheel of the agricultural implement; D_0, D_P, D_k – design parameters of the agricultural implements, the nature of which is clear from Fig. 3.

The sign «+» in the third equation of the system (9) is put in the case when the corresponding forces form a moment with respect to the point π, whose direction coincides with the direction of the clockwise direction, otherwise the sign «–» is put.

The force P_{fk} and the moment M_k of the rolling resistance of the support wheel of the agricultural implement can be determined as follows:

$$\begin{aligned} P_{fk} &= fN_k, \\ M_k &= fN_k r_k, \end{aligned} \tag{10}$$

where: r_k – radius of the support wheel of the agricultural implement.

From the system of equations (9), taking into account the expressions (10) after the corresponding transformations, we find:

$$\begin{cases} Y = N_{\hat{E}} - G_{\ddot{\imath}} - R_Z, \\ \tilde{O} = f \cdot N_{\hat{E}} + R_{\tilde{O}}, \\ N_{\hat{E}} = \dfrac{\pm G_{\ddot{\imath}} (D_0 + hcos|\beta| + Z_X) \pm R_Y (D_{\ddot{\imath}} + hcos|\beta| + Z_X) \pm R_{\tilde{O}} (Z_Y + \acute{I}\ /2)}{\pm (D_{\hat{E}} + hcos|\beta| + Z_X) \pm f \cdot Z_Y - f \cdot r_{\hat{e}}}. \end{cases} \tag{11}$$

The systems of equations (7) and (11) allow to determine the optimum values of both the inclination of the tilt of the rear-mounted linkage and other design parameters of the wide span vehicle from the position of the desired redistribution of normal reactions on its front and rear wheels. The analysis of these expressions shows that, in addition to the inclination angles of the rear-mounted linkage, a significant influence on the redistribution of normal reactions on the wheels of the wide span vehicle is provided by such design parameters as the distance from the attachment to the resistance center (D_P) and the support wheel (D_k) of the agricultural implement. It should be borne in mind that in real operating conditions, the point of application of the hook load can be shifted relative to the center of mass of the agricultural implement in one direction or another (for example, the assembly of a wide span vehicle with a technological capacity).

During the research, the inclination angles of the linkage (α and β) of the rear-mounted linkage ere changed from –20 degrees. up to 40 deg., that constructively such values can take place at the wide span vehicle, as it is clearly shown in Fig. 1. With regard to the distance from the rear-mounted linkage to the center of resistance and the support wheel of the agricultural implement, the considerations with respect to the methodology for selecting the values of these parameters follow from the analysis given below

The results of calculating the normal reactions on the front and rear wheels of the wide span vehicle TSAU and supporting wheels of its technological part are represented in relation to the load acting on them in the static position (without hook load at rest), that is, the degree of their redistribution will be:

$$\chi_i = \frac{100N_i}{N_{i\ st}}, \tag{12}$$

where: χ_i – degree of redistribution of normal reactions on the *i*-th wheel of the wide span vehicle and agricultural implements,%; N_i – redistributed normal reaction on the *i*-th wheel of the bridge tractor and agricultural implements; N_{ist} – load on the *i*-th wheel of a wide span vehicle and agricultural implement in a static position (without a hook load at rest).

Results and discussion. Analysis of the mathematical modeling data shows (Fig. 4 and 5) that the degree of redistribution of normal reactions on the front, rear wheels of the TGATU wide span vehicle TSAU and the support wheels of the agricultural implement essentially depends on the inclination angle α of the central traction of the rear-mounted linkage.

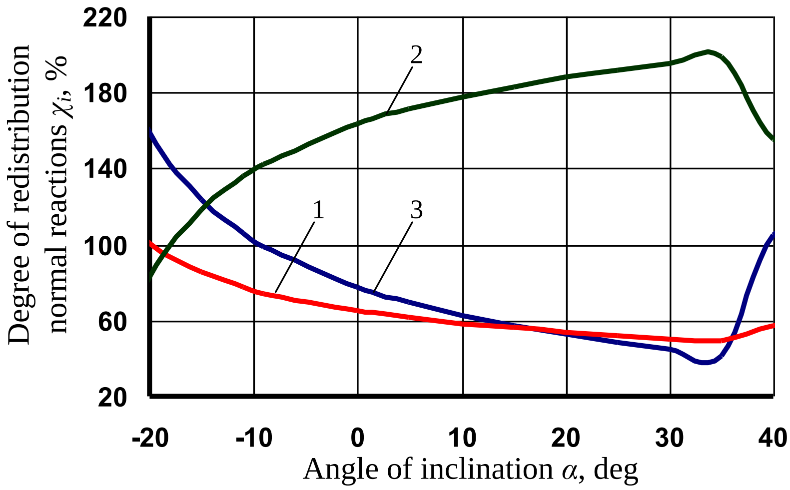

Fig. 4 – Degree of redistribution of normal reactions on the front (1), rear (2) wheels of the wide span vehicle TSAU and supporting wheels of the agricultural implement (3) from the inclination angle α of the central traction of the rear-mounted linkage with negative inclination of the lower links (β = –10 deg)

The analysis of Fig. 4 showed that with a negative angle of inclination of the central traction of α = –17 deg, the vertical load on the rear wheels (curve 2) of the wide span vehicle TSAU design corresponds to the value of the static position (χ_2=100%). At the same time, its front wheels (curve 1) are somewhat unloaded, which increased the load on the support wheel of the agricultural implement (curve 3). The increase in the vertical load on the supporting wheels of agricultural implements is highly undesirable, since they are usually located in the agrotechnical (fruitful) zone of the field. And, proceeding from the principles of bridge and controlled traffic farming, the sealing effect on the soil of the running systems of machines in the fertile zone of the field should be maximally excluded [4]. With an increase in the angle of inclination of the central traction α from –10 to 35 deg. the normal reaction on the support wheels of the agricultural implement tends to desirably decrease relative to its static position, reaching an unloading rate of up to 40%. But, the vertical load on the front wheels of the wide span vehicle is also undesirably reduced, almost doubling them. Unloading of the latter leads to a proportional increase in the vertical load on the rear wheels of the vehicle (curve 2).

With an increase in the angle of inclination of the central thrust of more than 35 deg., the reverse picture is observed (Fig. 4). Vertical load on the rear wheels of the wide span vehicle decreases, and on the front wheels increases, approaching, its static value. Such a result can be explained by a significant decrease in the horizontal coordinate Z_X of the instantaneous center of rotation of the rear-mounted linkage (point π), which caused a redistribution of the moments of the acting forces.

The foregoing analysis summarizes the following. At a negative angle β of the inclination of the lower links, the most suitable is the adjustment of the rear-mounted linkage wide span vehicle TSAU, in which the angle of inclination α of the upper link has a large positive value, reaching a level of 40 deg. In this case, the vertical load on its rear wheels is increased by an average of 1.5 times relative to its static state, and the normal reaction on the front wheels is reduced to 60%, which is permissible from the point of providing sufficient controllability of the movement of the vehicle under the kinematic method of its control. The normal reaction on the support wheel of the agricultural implement is, in this case, desirably reduced or practically equal to its static value.

But, it should be borne in mind that the adjustment of the three-link rear-mounted linkage with a large positive angle of inclination of the central rod (reaching 40 deg. and above) and a negative angle of inclination of the lower links is possible only after a detailed study of the kinematics of its operation, which may serve as a basis for further research.

It should also be noted that the location of the agricultural implement in the inter-wheel space of the wide span vehicle positively affects the provision of sufficient controllability of the latter under the kinematic method of its control. Since, in the considered range of the angle of inclination of the top linkage of the rear-mounted linkage, its front wheels are unloaded by no more than 50%. At the same time, the normal reaction to them can be reduced to 50% relative to its static position from the position of reducing the compaction effect on the soil by the support wheels of the agricultural implement.

With a positive value of the angle of inclination of the lower link of the rear-mounted linkage wide span vehicle TSAU, which is highly unlikely from the position of kinematics of the three-link rear-mounted linkage, and also the loading of the rear wheels, vertical reactions, depending on the angle of inclination of the upper link, are redistributed as follows (Fig. 5).

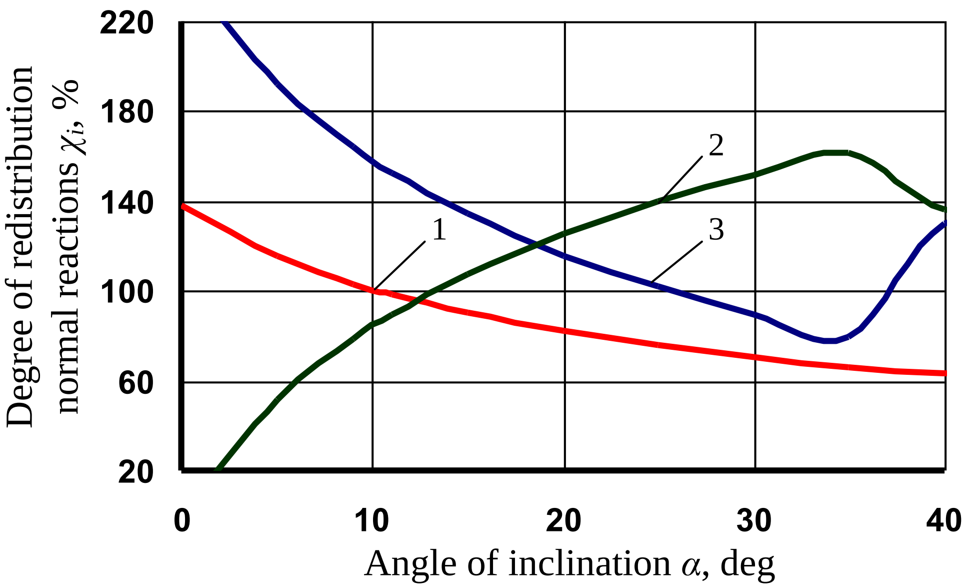

Fig. 5 – Degree of redistribution of normal reactions on the front (1), rear (2) wheels of the wide span vehicle TSAU and supporting wheels of the agricultural implement (3) from the inclination

angle α of the central traction of the rear-mounted linkage with a positive inclination of the lower links (β = 10 deg)

The analysis of Fig. 5 shows that, with a positive angle of inclination of the lower links of the rear-mounted linkage, unloading of the front wheels of the wide span vehicle TSAU occurs at an angle of inclination of the upper draft of more than 10 deg. At the same time, its rear wheels are appropriately loaded. At small positive angles of inclination of the central draft (less than 10 deg.), despite the increased load on the front wheels of the wide span vehicle, its rear wheels are almost completely unloaded. Part of the weight is then redistributed onto the support wheels of the agricultural implement.

As for the vertical load on the support wheel of the agricultural implement, it begins to decrease only at elevation angles higher than 25 deg. (Fig. 5). And, having overcome the mark of the angle of inclination of the last in 37 deg., the nature of the redistribution of this load begins to change. As a result, we have some decrease in the vertical load on the rear wheels of the wide span vehicle.

From the foregoing it follows that with a positive angle of inclination of the lower links of the rear-mounted linkage wide span vehicle TSAU is most desirable to adjust the upper thrust at angles of inclination from 25 to 35 deg. Since in this case we have a certain decrease in the sealing effect of the supporting wheels of the agricultural implement on the soil in the fertile zone of the field, the rear wheels load and the natural permissible reduction (up to 30%) of the vertical load on its front wheels.

In addition to what has been said, the analysis of Fig. 4 and 5 indicate that to exclude the negative sealing effect of the support wheels of agricultural machines and implements on the soil in the agrotechnical (fertile) zone of the field, if possible, then no more than 50%. In this situation, the additional use of the regulator to correct the normal load on the support wheels of the agricultural implement will make it possible to achieve an almost complete elimination of the compacting effect on the soil of the running systems of machines in the fertile zone of the field. The principle of operation of this regulator is similar to the widely known hydraulic traction traction amplifiers. The latter, as is known, form the force necessary to lift the hinged device with a mounted agricultural machine or implement. The position of the instantaneous turning center of the hinged mechanism remains unchanged. This condition is met when the amount of effort of lifting the agricultural implement does not exceed the value necessary for its penetration from the soil.

When using this regulator on a wide span vehicle, the degree of redistribution of normal reactions on its front and rear wheels will substantially depend on the horizontal coordinate of the center of mass (D_0) and the center of resistance of the agricultural implement (D_p). Using the expressions (4) and (7), the degree of redistribution of these reactions on the front and rear wheels of the wide span vehicle TSAU, depending on the change in the design parameters D_0 and D_p, will have the following form (Fig. 6).

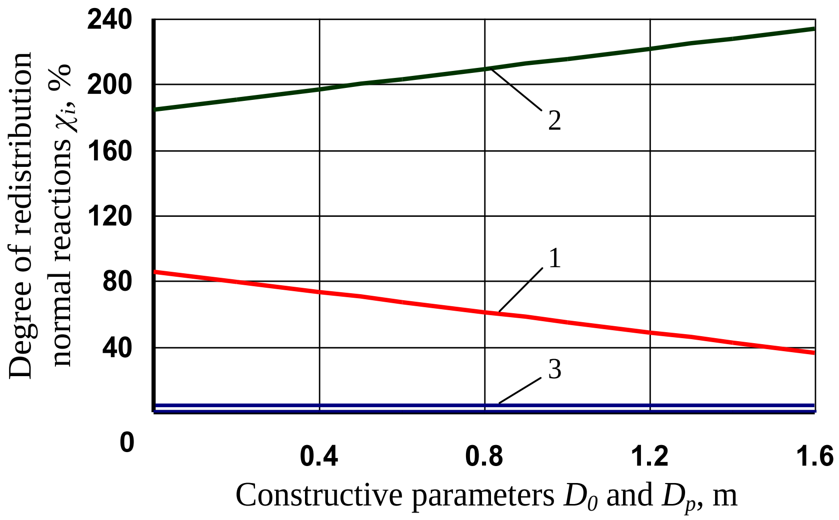

Fig. 6 – Degree of redistribution of normal reactions on the front (1), rear (2) wheels of the wide span vehicle TSAU using a regulator to adjust the normal load on the support wheels of the agricultural implement (3)

From the analysis of Fig. 6 it follows that the distance of the center of mass and the center of resistance of the agricultural machine or implement from the rear-mounted linkage wide span vehicle results in a natural increase in the load on its rear wheels, due to the weight of the attachment, and the reduction of the load on the front wheels. And with the increase in the absolute value of the design parameters D_0 and D_p to 1.6 m, the vertical load on the front wheels may drop to a critical level (20-40%), which is the possible loss of controllability of the wide span vehicle with its kinematic control.

At the same time, the constructively possible decrease in the values of these parameters positively affects the character of the redistribution of vertical loads on the wheels of the wide span vehicle. Since it almost doubles the load on the rear wheels and discharges the front wheels by no more than 50%. From the point of maximum realization of the traction-coupling properties of wide span tractors (vehicles) and so the absence of a sealing effect on the soil of the running systems of machines in the fertile zone of the field, the result obtained is the most desirable.

On the basis of the analysis presented above, it should be noted that in most possible options for setting up a bridge tractor rear-mounted linkage wide span vehicle we have unloading its front wheels. To increase and, consequently, maintain sufficient controllability of the wide span vehicle under the kinematic method of its control, it is advisable to place all possible technological capacities closer to the front axis of its wheels. Thus, increasing the vertical load on them by adding weight from the process container to the material.

Conclusion. As a result of the research, it has been established that apart from the inclination angles of the rear-mounted linkage wide span tractor (vehicle), such design parameters as the distance from the attachment to the center of resistance and the support wheel of the agricultural machine or implement have a significant effect on the redistribution of normal reactions on its front and rear wheels.

Adjustment of the three-link rear-mounted linkage wide span tractor (vehicle) with a large positive angle of inclination of the central rod (reaching 40 deg. and above) and a negative angle of inclination of the lower links is possible only after a detailed study of the kinematics of its operation, which may serve as the basis for further research.

With the purpose of almost completely eliminating the sealing effect on the soil of the running systems of machines in the fertile (agrotechnical) zone of the field, it is recommended to use regulators on wide span tractors (vehicles) to correct the normal vertical load on the support wheels of an agricultural machine or implement that work according to the principle of known traction tractors.

In most possible options for setting up a rear-mounted linkage wide span tractor (vehicle) we have unloading its front wheels. To increase and, consequently, maintain the residual controllability of the wide span tractor (vehicle) under the kinematic method of its control, it is expedient to place all possible technological capacities closer to the front axis of its wheels. Thus, increasing the vertical load on them by adding weight from the process container to the material.

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Аннотация

ОБОСНОВАНИЕ ПАРАМЕТРОВ НАВЕСНОГО МЕХАНИЗМА МОСТОВОГО ТРАКТОРА (ТРАНСПОРТНОГО СРЕДСТВА)

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Для обеспечения достаточно высокой универсальности мостовые тракторы могут (и, несомненно, должны) агрегатироваться с различными прицепными, полунавесными и навесными сельскохозяйственными машинами и орудиями. Уплотняющее воздействие на почву их ходовых систем в плодоносной (агротехнической) зоне поля, а также тягово-сцепные свойства, устойчивость и управляемость движения мостовых тракторов существенным образом определена схемой их присоединения и параметрами навесного устройства. Главная проблема состоит в том, что при неправильном присоединении сельскохозяйственных машин и орудий может иметь место не догрузка, а, наоборот, разгрузка управляющих и ведущих колес мостового трактора со всеми вытекающими отсюда последствиями. При этом вертикальная нагрузка на опорные колеса присоединенных сельскохозяйственных машин и орудий может быть существенно увеличена, что нивелирует весь эффект от колейной системы земледелия. Изучению особенностей агрегатирования мостовых тракторов с сельскохозяйственными машинами и орудиями посвящена данная работа. Целью исследований является повышение тягово-сцепных свойств, устойчивости и управляемости движения мостовых тракторов, путем обоснования параметров их навесных устройств и схемы присоединения к ним сельскохозяйственных машин и орудий. Теоретические исследования, синтез конструктивных схем и параметров мостового трактора осуществлялся путем моделирования на ПК условий его функционирования. В основу методов исследования положены основные принципы теоретической механики и теории трактора с использованием пакета Mathcad. В качестве физического объекта исследования выступало специализированное ширококолейное агросредство конструкции Таврического государственного агротехнологического университета (ТГАТУ), Украина. В результате проведенных исследований установлено, что кроме углов наклона тяг навесного устройства мостового трактора, существенное влияние на перераспределение нормальных реакций на его передних и задних колесах оказывают такие конструктивные параметры, как расстояние от навесного устройства до центра сопротивления и опорного колеса сельскохозяйственной машины или орудия. С целью практически полного исключения уплотняющего воздействия на почву ходовых систем машин в

плодоносной (агротехнической) зоне поля рекомендуется использовать на мостовых тракторах регуляторы для корректировки нормальной вертикальной нагрузки на опорных колесах сельскохозяйственной машины или орудия, работающих по принципу известных увеличителей сцепного веса традиционных тракторов.

Анотація

ОБҐРУНТУВАННЯ ПАРАМЕТРІВ НАВІСНОГО МЕХАНІЗМУ МОСТОВОГО ТРАКТОРА (ТРАНСПОРТНОГО ЗАСОБУ)

Кувачов В.П.

Для забезпечення достатньо високої універсальності мостові трактори можуть (і, безсумнівно, повинні) агрегатуватися з різними причіпними, напівнавісними і навісними сільськогосподарськими машинами і знаряддями. Ущільнююча дія на грунт їх ходових систем в плодоносній (агротехнічній) зоні поля, а також тягово-зчіпні властивості, стійкість і керованість руху мостових тракторів суттєво визначена схемою їх приєднання і параметрами навісного механізму. Головна проблема полягає в тому, що при неправильному приєднання сільськогосподарських машин і знарядь може мати місце не довантаження, а, навпаки, розвантаження керуючих і ведучих коліс мостового трактора з усіма наслідками, які звідси випливають. При цьому вертикальне навантаження на опорні колеса приєднаних до нього сільськогосподарських машин і знарядь може бути значно збільшено, що нівелює весь ефект від запровадження колійної системи землеробства. Вивченню особливостей агрегатування мостових тракторів з сільськогосподарськими машинами і знаряддями присвячена дана робота. Метою досліджень є підвищення тягово-зчіпних властивостей, стійкості і керованості руху мостових тракторів, шляхом обґрунтування параметрів їх навісних механізмів і схеми приєднання до них сільськогосподарських машин і знарядь. Теоретичні дослідження, синтез конструктивних схем і параметрів мостового трактора здійснювався шляхом моделювання на ПК умов його функціонування. В основу методів дослідження покладено основні принципи теоретичної механіки і теорії трактора з використанням пакета Mathcad. В якості фізичного об'єкта дослідження виступав спеціалізований ширококолійний агрозасіб конструкції Таврійського державного агротехнологічного університету (ТДАТУ), Україна. В результаті проведених досліджень встановлено, що крім кутів нахилу тяг навісного пристрою мостового трактора, суттєвий вплив на перерозподіл нормальних реакцій на його передніх і задніх колесах надають такі конструктивні параметри, як відстань від навісного механізму до центру опору і опорного колеса сільськогосподарської машини або знаряддя. З метою практично повного виключення ущільнюючого впливу на грунт ходових систем машин в плодоносній (агротехнічній) зоні поля рекомендується використовувати на мостових тракторах регулятори для коригування нормального вертикального навантаження на опорних колесах сільськогосподарської машини або знаряддя, які працюють за принципом відомих довантажувачів зчіпної ваги традиційних тракторів.