JUSTIFICATION OF KINEMATIC PARAMETERS OF COUPLING FOR WIDE-SPAN ROW-CROP UNIT

Prof. Eng. Volodymyr Bulgakov[1] PhD., DrSc., Prof. Ladislav Nozdrovicky [2], Assis. prof. Eng. Vitaliy Movchan[3] PhD., Eng. Yevhen Ihnatiev[3] PhD.

[1]National University of Life and Environmental Sciences of Ukraine, 15, Heroyiv Oborony Str., Kyiv, 03041, Ukraine;
[2]Slovak University of Agriculture in Nitra, Trieda Andreja Hlinku 2, 949 76 Nitra, Slovak Republic;
[3]Tavria State Agrotechnological University, 18, Khmelnytsky av., Melitopol, 72312, Zaporizhia region, Ukraine;
E-mail:vbugakov@meta.ua, yevhen.ihnatiev@tsatu.edu.ua

Abstract: *Effective use of the KhTZ-160 tractor is possible, with the specified width, combining the implementation of the main technological process with an additional, i.e. sowing with cultivation. Shows the results of calculations of the transverse displacements of the working bodies as a function of their placement along the width of unit and along its length relative to the transverse geometric axis that passes through the kinematic the center of the tractor without taking into account the curvature of the trajectory of tractor and possible changes in the position of kinematic center along the unit. The largest values of the transverse displacements of the working bodies, which are placed at a distance of 2.6 m, i.e. at the machine which is attached to the rear hinged system of the tractor, reach 14.5 cm at maximum angles of rotation of the unit (3 degrees). The smallest transverse movements of the working bodies are observed when placed on a geometric axis that passes through the axis of the rear wheels (less than 1 cm). The lateral movements of working bodies of 18-row wide-coverage row-crop unit depending on the tractor turning angle and their placement in the unit are considered. Kinematic parameters and coupling scheme are recommended.*

KEY WORDS: UNIT, TRACTOR, COUPLING, WORKING BODIES, PLACEMENT, ANGLE, DEVIATION, SCHEME.

1. Introduction

The tractor KhTZ-160 in its performance indicators refers to the tractors of traction class 3. The undercarriage system of this wheeled tractor allows it to be used for growing row crops with a row spacing of 70 cm.

The possibility of using this tractor for growing row crops (maize, sunflower) proved by research [1], but the working width of such units is equal to 8.4 m (with a 12-row scheme). Effective use of the KhTZ-160 tractor is possible, with the specified width, combining the implementation of the main technological process with an additional, i.e. sowing with cultivation (the presence of front hinged system allows you to complete such unit) [3].

According to the traction properties, this tractor is able to provide a work with three SUPN-6 seeders (or three KRN-4.2A cultivators). Creating three-machine units is possible only if there is a special coupling, which would ensure the location of extreme machines in optimal position according to criterion of movement straightness of working bodies. The placement of three working machines in the trailed machine-tractor unit (MTU) according to the traditional scheme, i.e. with rank placement, it is possible only under the condition that only sowing is performed, and inter-row cultivation of tilled crops is not performed. The use of row-crop cultivators in the three-machine version of MTU according to the rank scheme does not allow to accurately copy of the unit movement, respectively, with direction of crop rows that is being processed [4, 5].

2. Preconditions and means for resolving the problem

Based on research [2] and extensive verification of farm producers, the use of wide-span three-machine MTU is possible only when using class 3 caterpillar tractors, provided that working bodiess of side machines are located in the zone of transverse geometrical axis that passes through the kinematic center of the tractor. Therefore, for creating of such units, we have proposed to use only the semi-mounted SN-75M coupling with some modernization.

3. Results and discussion

In a wheeled tractor KhTZ-160, in contrast to a caterpillar tractor, the kinematic center is located in the area around the geometric axis of the rear wheels and this coupling does not allow for optimal placement of the side machines. Therefore, there was a need to develop a semi-mounted coupling for an KhTZ-160 tractor that would ensure optimal placement of side machines in row crop units that could be used in sowing and inter-row processing of row crops (mainly maize and sunflower). The performance of three-machine units is much more than two-machine, which is especially important when sowing a given culture (because the field is sown in one or two days).

At these technological operations there are special requirements for the straightness of the movement of the MTU and the damage to plants in the rows of the crop that is being processed [6-8]. This is explained by the fact that reliability of damage to plants of a crop that is processed depends on the rows straightness and movement of the working bodies of cultivators during inter-row processing. The main statistical indicators, as is known, are the standard deviation of the working bodies from a given direction of movement and the placement of plants in a row. The values of these indicators depend on the angular deviations of tractor from the given direction of movement and on the characteristics of tractor's trajectory curvature. According to our previous studies, the transverse displacements of the working bodies, with some assumptions, are expressed [2]:

$$\sigma_{po} = K_2 \sqrt{\left[\frac{K_1(1-\cos\alpha)}{\grave{a}\cdot\sigma_\rho}\right]^2 + \left[L\cdot\sin\alpha \pm B(1-\cos\alpha)\right]^2}, \quad (1)$$

where σ_α, σ_ρ – root mean square values of the angular deviations of tractor and the radius of curvature of its trajectory; B, L – parameters that characterize placement of working body on the width and length of the unit; K_1, K_2 – correction factor and the coefficient of "conditional stiffness" of the entire system of the unit; a – coefficient of proportionality, which takes into account the proportion of standard deviation and for the normal distribution is taken 0.63.

Considering that in this case, we consider only the coupling parameters that affect the deviation from the direction of movement, Table 1 shows the results of calculations of the transverse displacements of the working bodies as a function of their placement along the width of unit and along its length relative to the transverse geometric axis that passes through the kinematic the center of the tractor without taking into account the curvature of the trajectory of tractor and possible changes in the position of kinematic center along the unit.

The results of calculations of the values of the transverse displacements of the working bodies are presented in the graphs (Fig. 1-3). Previous studies have revealed that lateral deviations of the working bodies from the direction of movement to the outside and towards the center of the unit are different, therefore on the graphs in fig. 1-3 shows only external transverse movement of working bodies, as more significant).

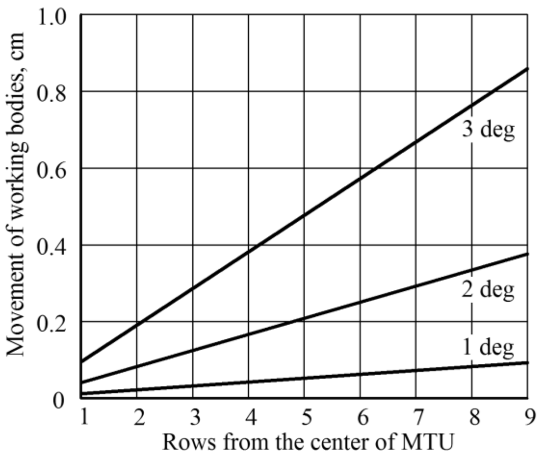

Fig.1. *Transverse movement of the working bodies at L = 0 and turning angle of MTU 1, 2 and 3 degrees*

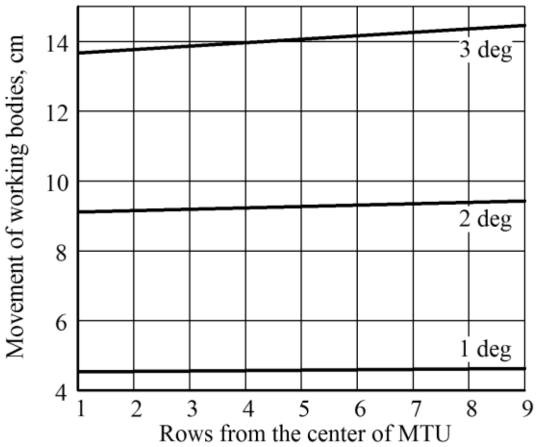

Fig.2. *Transverse movement of the working bodies at L = 260 cm and turning angle of MTU 1, 2 and 3 degrees*

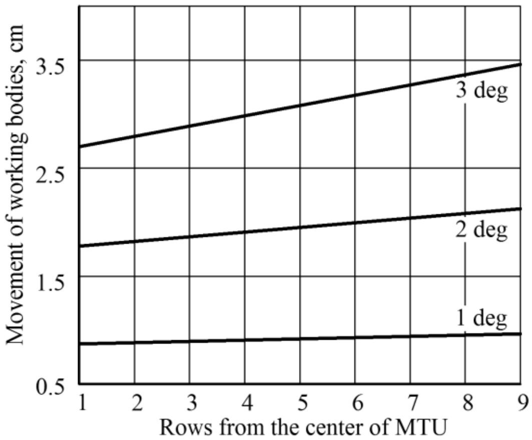

Fig.3. *Transverse movement of the working bodies at L = 50 cm and turning angle of MTU 1, 2 and 3 degrees*

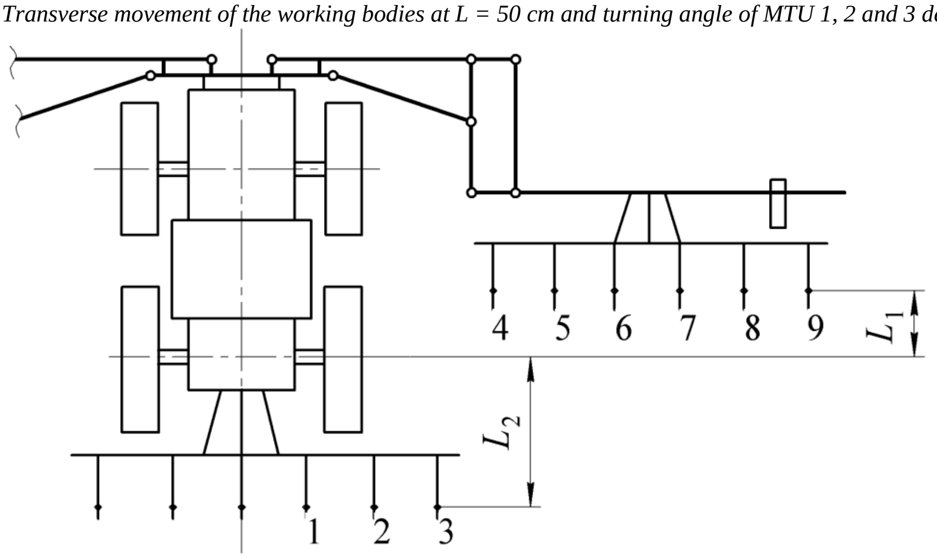

Fig.4. *The simplified scheme of the unit with an experimental coupling ZPN-18*

4. Conclusions

1) The largest values of the transverse displacements of the working bodies, which are placed at a distance of 2.6 m, i.e. at the machine which is attached to the rear hinged system of the tractor, reach 14.5 cm at maximum angles of rotation of the unit (3 degrees), fig. 2

2) The smallest transverse movements of the working bodies are observed when placed on a geometric axis that passes through the axis of the rear wheels (less than 1 cm).

3) The lateral movement of the working bodies when placed at a distance of 50 cm from the transverse geometric axis of the rear wheels of the tractor is insignificant and fully meets the agro demands.

4) The transverse movements of the working bodies increase with their distance from the longitudinal geometric axis of the unit, especially with significant angular deviations of the MTU.

When developing the actual design of the proposed coupling, minor deviations can be allowed with respect to the placement of the side machines along the unit in order to reduce the forces on the longitudinal links and some articulated joints. But the deviation of the placement of side machines from optimal position, in our opinion, is not allowed more than 50 cm. In this case, if the kinematic center of the unit will move slightly in longitudinal direction and transverse movements of working bodies will be minimal.

Based on the above requirements, the following coupling scheme is proposed. Fig.4.

5. References

1. Chorna T.S. Coupling device for energy means / Works of Tavria State Agrotechnological University. – Issue.8., Vol.1. – Melitopol: TDATU, 2008, P. 144-147 (in Ukrainian).

2. Zhigan V.Yu. Improvement of wide-range sowing and tilled units / AIC, Achievement of Science and Technology, No. 5, 1991 (in Russian).

3. Bulgakov V. Theoretical investigation of aggregation of top removal machine frontally mounted on wheeled tractor / V. Bulgakov, V. Adamchuk, S. Ivanovs, Y. Ihnatiev // "Engineering for rural development". Proceedings, Vol.16, May 24-26, 2017. Jelgava. – p.p. 273–280.

4. Bulgakov V. Theory of vibrations of sugar beet leaf harvester front-mounted on universal tractor / V. Bulgakov, V. Adamchuk, L. Nozdrovicky, Ye. Ihnatiev // Acta Technologica Agriculturae. – 2017. – Issue 4. – pp. 96 – 103.

5. Ihnatiev Ye. Theoretical substantiation of topping parameters without sugar beet head copying // IV International scientific Congress "Agricultural machinery". – Varna. – Issue 18 (181). Vol. 1, 22-25 june 2016. – P. 55 – 58.

6. Bulgakov V. Mathematical model of complex movement of a material point on a surface of agricultural machine working body / V. Bulgakov, V. Adamchuk, L. Nozdrovicky, V. Krocko, M. Korenko, V. Kyurchev, Ye. Ihnatiev // V International scientific Congress "Agricultural machinery". – Varna. – Issue 19 (205). Vol. 1, 21-24 june 2017. – pp. 64 – 71.

7. Adamchuk V. Laboratory and field equipment workingout and the results of experimental studies of pre-harvesting sugar beet field conditions / V. Adamchuk, V. Bulgakov, M. Korenko, Ye. Ihnatiev et al. // Mechanization in agriculture. – Sofia, 2016. – Issue 1. – pp. 3-5.

8. Bulgakov V. Theoretical determination of cutting force of the sugar beet tops from root crop head / V. Bulgakov , M. Boris , Ye., Ihnatiev H. Beloev // International scientific conference "Conserving soils and water". – Burgas. 31.08-3.09. 2016. p.p. 68-70.