# Features of calculation of agricultural machines trailed devices in pedagogical technologies of training agricultural engineers for innovative design activities

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***Summary.*** *The scientific-technical and pedagogical-methodological model of preparation of future specialists in agroengineering for innovative project activity on the basis of studying of agricultural machines on modern technologies of training, deepening of scientific activity of students based on features of calculation of trailers which are used in machine-tractor units has been developed. An equivalent calculation scheme of a technical system consisting of a wheeled tractor as an energy propulsion and a trailer is given. Such theoretical-calculative material is used in institutions of higher education of general and professional competencies of future specialists of agro-industrial production. It is noted that the preparation of future agricultural engineers for innovative project activities is carried out in accordance with industry standards and the Law of Ukraine "On Higher Education". The influence of end-to-end project training on students' readiness to perform scientific and practical tasks has been studied. The condition under which there will be no overloading of front wheels of the machine from its working bodies is substantiated, and ecologically admissible pressure on the ground will remain the same.*

***Keywords:*** *CALCULATION, TRAILERS, MACHINE, TECHNOLOGIES, PREPARATION, PROJECT ACTIVITY*

***Introduction***.

For agricultural engineering, as for other industries, it is important that the achievements of science are quickly implemented in the educational process and production. Development in a single integrated system of science and educational process provides the best result. The Law of Ukraine on Higher Education [1] states that the educational process is an innovative, intellectual, creative activity of research and teaching staff, students, manufacturers and other groups of people who have concern to the field.

The training of future agricultural engineers is based on the formation of their professional competencies, which provide to solve various problems of production activities. The object of activity of agricultural engineers are the processes associated with the efficient operation of agricultural machinery and mechanized technologies [2]. The educational process of students majoring in "Agroengineering" is aimed at training professionals capable of solving professional specialized tasks and applications related to the use of agricultural machinery in mechanized technologies of production, storage and transportation of agricultural products and etc.

The basic training discipline for future agricultural engineers is "Agricultural Machinery". Studying it, students gain knowledge on the structure and principle of operation of machines, adjusting them to optimal modes of operation. Students also study the theoretical foundations of machines, algorithms for calculating and designing new ones, as well as improving existing machine designs [3]. In addition to classroom classes, the study of the discipline involves independent performance of course work by students. The purpose of the course project is to develop the design of agricultural machinery or its components or to improve existing machinery to ensure the implementation of mechanized production processes for growing crops.

The main scientific directions of student papers of agro-engineering direction are the increase of productivity of units, expansion of their universality, possibilities of combination of power means with other tools and maintenance of effective management, decrease in power indicators of performance of technological processes, improvement of traffic safety, etc.

Practical, scientific and educational activities show that the problematic issues of the calculation of trailers of agricultural machinery in pedagogical technologies for preparing agricultural engineers for innovative design activities are still insufficiently studied and require further fundamental theoretical and experimental research, scientific substantiation and generalizations.

***Prerequisites and means for solving the problem*.**

For a long time, scientific and pedagogical workers were mainly engaged in the study and improvement of the working bodies of agricultural machines, the processes of interaction of the running system with the soil and traction properties of machines. Regarding the design of trailer devices of agricultural machines, as well as in-depth application of algorithms for calculating such trailer technical systems in pedagogical technologies for training agricultural engineers for innovative design activities, these issues are insufficiently studied.

The scientific article [4] presents the main components of the formation of integrated, general and professional competencies of an agricultural engineer as a specialist. In general, an innovative training system is a system combined into physical-mathematical, general technical and special blocks and general and professional competencies, which must have a bachelor's degree in the specialization 208 "Agroengineering".

An innovative system of scientific and methodological developments that influence the formation of special professional competencies of an agricultural engineer is presented in the article [5]. The basic basis of this system are textbooks, manuals, monographs, curricula and other didactic materials. Improved pedagogical technology of teaching, which is based on the thorough, gradual development of the readiness of the future specialist for project activities. This pedagogical learning technology provides a comprehensive, integrated formation of professional competencies of agricultural engineers in accordance with the Laws of Ukraine and educational standards [1, 2]. The scientific activity of students is based on the development and modernization of agricultural machinery which has great importance for the training of agricultural engineers.

Questions of the theory of project preparation were studied by Bryukhanova N.O. [6], Kolesnikova I.A., Gorchakova-Sibirskaya M.P. [7], Nichkalo N.G, Zyazyun I.A., Goncharenko S.U. [8] and others. The theory, methods and practice of project training of agricultural engineers were studied and researched by Bender I.M. [3, 9, 10, 11], Duganets V.I. [12], Pryshliak V.M. [4, 5, 13, 14, 15] and others. Also, the work of O. Kovalenko, D. Chernylevsky, P. Yakovyshyn is devoted to the improvement of methods of training for future engineers, and the method of development of future agricultural engineers is reflected in scientific researches of I. Butsyk, A. Demin, O. Dzhedzhul, P. Luzan, V. Mank, S. Pastushenko, V. Yaroshenko. Transformation of independent educational activity into readiness for professional self-development by means of technologies of personality-oriented learning is reflected in the monograph Bondar M.M., Zhuravskaya L.M., Ostapenko E.O., Pryshliak V.M., Kutsenko A.G. [15].

***Solution of the examined problem.***

The theory and practice of project training of future agricultural engineers involves large-scale application of the scientific component in the educational process during classes, independent work of students look at the article [5]. Scientifically substantiated thoroughness, consistency and gradual formation of professional competencies involves increasing the quality of training and development of competitive technology. In addition to the fact that students take part in research processes, conferences, project

and model mechanization during their studies, they are engaged in course design in the 3rd year, and in the master's degree (5th - 6th years of studies) - conduct research and design scientific work. During the performance of the above-mentioned types of work, students mainly calculate, design and research the working bodies of agricultural machinery. There are also works in which auxiliary, but at the same time very important units, mechanisms or systems of machines are designed and researched. This also includes the theory, calculation, design and construction of trailers of the agricultural machinery.

The theory and practice of project training of future agricultural engineers involves large-scale application of the scientific component in the educational process during classes, independent work of students, article [5]. Scientifically substantiated thoroughness, consistency and gradual formation of professional competencies involves increasing the quality of training and development of competitive technology. In addition, when operating agricultural units with trailers under certain operating conditions, undesirable phenomena may occur due to the redistribution of loads on the supporting elements of the machine due to changing conditions of traction on the front wheels of the machine through its trailer. Therefore, when designing trailed and semi-trailed agricultural machines, special attention should be paid to the correct choice of parameters of the connecting elements of the machine to the tractor. To solve this problem, it is necessary to solve some specific design problems to determine the optimal parameters of the connecting elements of the trailer [3].

The work must be performed according to the initial data (diagrams of the wheel travel of the machine, its longitudinal base, the coordinate of the center of gravity of the machine, etc.), taken from an individual task for a course work in the discipline "Agricultural Machinery". Calculations must be made on two schemes of the wheel movement.

First, using the original data of only one column of the variant table (Table 1) and one of the schemes of wheel movement, determine the possibility of balancing the additional loads on the front wheels of the machine from the action of its working bodies due to the vertical traction component on the tractor hook. the presence of the angle of the trailer to the horizon. This angle of the trailer is determined by the formula:

$$\psi = arctg\left[\left(gQ_{м}a - n_2 G_2 L + R\sum в\right)/ XP_x\right], \quad (1)$$

where $g$ – acceleration of gravity, m / s$^2$;

$Q_{м}$ – machine weight, kg;

$n_2$ – the number of front wheels (according to the scheme);

$G_2$ – radial load on the front wheel, H;

$L$ – longitudinal base of the machine, m;

$R$ – total load from working bodies, N / cm;

$\sum в$ – the sum of the shoulders of the load $R$ depending on the number of rows of working bodies on the machine, m;

$X$ – horizontal coordinate of the hinge of the car trailer, m;

$P_x$ – tractor traction force, N.

Provided there are two rows of working bodies on the machine $\sum в = \left(в_1 + в_2\right)$,

where $в_1$, $в_2$, – shoulder application of load $R$, respectively, on one and the second row of working bodies.

$\sum в = в_1$, when only one row of working bodies on the machine is used.

Shoulder load application

$$в_{1,2} = \sqrt{h_0^2 + m^2}\, sin\left(\beta + \alpha\right), \quad (2)$$

where $h_0$, $m$ – respectively, the vertical and horizontal coordinates of the point of application of the load vector $R$ to the working bodies, m (Fig. 1);

$\alpha$ – the angle of inclination of the vector $R$, deg:

$$\beta = arctg\left(h_0 / m\right). \quad (3)$$

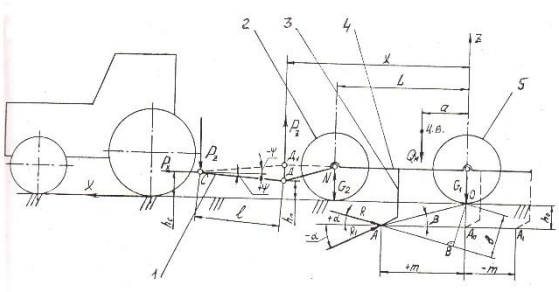

Fig. 1. Calculation scheme of the unit with a trailer:

1 – trailer; 2 – front wheels; 3 – working bodies; 4 – machine frame; 5 – rear wheels of the car; *С, Д* – trailer hinges

After obtaining the angle $\psi$ by formula (1) it is necessary using the formula

$$\psi_n = \arcsin\left(\left(h_c - h_n\right)/ l\right), \quad (4)$$

pick up the following values $h_n$ and $l$, in order to $\psi_n = \psi$,

where $h_c$ – height of trailer bracket placement, m (table 1);

$h_n$ – height of placement of the hinge of the trailer of the machine, m. (minimum value $h_n$ = 0,3 m.)

$l$ – railer length, m ($l_{min}$ = 0,8 м).

Table 1

Geometric and power characteristics of the trailer

| Indicator | The value of the indicator by options | | | | | |
|---|---|---|---|---|---|---|
| Traction force of the tractor $P_x$, *kH* | 1, 2, 3, | | 4, 5, 6, | | 7, 8, 9, 0 | |
| | 12 | 25 | 13,5 | 26 | 15,5 | 28 |
| $X$, м | 2,2 | 2,4 | 2,3 | 2,5 | 2,4 | 2,6 |
| $h_c$, м | 0,45 | 0,5 | 0,4 | 0,45 | 0,5 | 0,45 |
| $R$, kH | 6 | 19 | 7 | 20 | 7,5 | 22 |
| $h_0$, м | 0,05 | 0,08 | 0,06 | 0,1 | 0,07 | 0,12 |
| $m$, м | +0,2 | 0 та -0,4 | 0 та +0,3 | -0,3 | 0 та +0,5 | -0,2 |
| $\alpha$, grad | +20 | -20 | +30 | -15 | +25 | -10 |

If it is possible to obtain equality when, $\psi_n = \psi$, this means that with the selected $l$ and $h_n$ there will be no overload of the front wheels of the machine from its working bodies, the environmentally friendly pressure on the ground will be maintained. And if this equality cannot be obtained, it is necessary to choose the values of the length $l$ of the trailer and the height $h_n$ of the trailer hinge, which allow to obtain the maximum allowable value of the angle $\psi_n$ of the trailer to the horizon. Then you need to determine what the minimum load can be provided on the front wheels of the machine, using the formula

$$N = \left(gQ_{м}a - P_x X tg\psi_n + R\sum в\right)/ L. \quad (5)$$

Then it is necessary to compare it with environmentally friendly loads on the selected tires of the wheels taking into account the condition

$$N \le z G_{д}, \quad (6)$$

where $z$ – the number of tires on all front wheels of the machine;

$G_{д}$ – permissible load on the tire of the front wheel, which provides environmentally friendly pressure on the ground, N.

If condition (6) is not met, recommendations should be made in the conclusions regarding the need to replace or supplement the number of tires on the front wheels of the machine to meet environmental requirements or to obtain new values for the trailer ($l$ and $h_n$).

After using the data of one column of the variant table in the calculations, it is necessary to perform calculations according to the data of the second column for the same wheel scheme. Moreover, it should be assumed that the design of the trailer is already calculated, i.e. the values of $l$ and $h_n$ are selected, therefore, the angle $\psi_n$ of the trailer is known, and therefore it is necessary by formulae (5 and 6) only to check changes in load on the front wheels ( the second column of table 1) and fulfill the appropriate conclusions.

Thus, as a result of scientific research, an algorithm for calculating the trailer device has been developed, which provides aggregation of agricultural machines in variable production conditions. The use of the developed method of calculating trailers in the educational process will help to improve the quality of formation of design competencies of future agricultural engineers.

***Results and discussion*.**

The developed innovative system of scientific and methodical training of future specialists is based on a thorough, gradual growth of knowledge, skills and abilities of future agricultural engineers. Course design and master's work provide a qualitative growth of project competencies of graduates. The developed method of calculation of trailers is effective both for the design of new machine-tractor units and for the formation of design competencies of future agricultural engineers.

***Conclusion.***

The results of the research give grounds to conclude that the process of formation of professional competencies of future specialists in agricultural engineering is effective with the use of end-to-end innovative learning technologies. The developed algorithm for calculating trailers is effective both for the development of the latest technical means of agricultural mechanization and for a quality educational process.

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