INFLUENCE OF THE TECHNOLOGY OF THE THROUGH STUDY OF AGRICULTURAL MACHINES ON THE AGROENGINEERS' READINESS FOR THE PROJECT ACTIVITY

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Abstract: *Here is presented the influence of pedagogical technology of the through study of agricultural machines on the formation of readiness for the future activities of future specialists in agroengineering. Here are analyzed the dynamics of development of professional competences from the first year of study, during the study of the discipline «Introduction to the specialty», and further on, educational practice, constructive and theoretical courses of agricultural machines, course design, industrial practices, etc. Here are given the examples of a set of basic text-based tasks in the discipline "Agricultural Machines", which deal with soil cultivation, the work of a cutting machine, a reel, a system for cleaning a combine harvester, etc. The factors emphasizing the quality of preparation of agroengineering specialists, development of the ability to perform design functions are highlighted. The issue of diagnostics and criteria of general amount of knowledge about the agricultural machines at the final stage of training is covered.*

KEYWORDS: *AGROENGINEER, PROJECT ACTIVITY, AGRICULTURAL MACHINES, COMPETENCIES, THROUGH STUDY, TECHNOLOGY PROJECT FUNCTIONS.*

1. Introduction

The basic educational discipline, which ensures the formation of professional competencies of agroengineering, is "Agricultural Machines" [1].

The purpose of studying the discipline is to provide students with in-depth knowledge of the structure, work and setting up of agricultural machines in accordance with specific conditions, as well as obtaining knowledge on the theory and calculation of technological processes and working machinery of machines, which is necessary for research aimed at improving existing and creating new high-performance machines.

According to the requirements of the higher education standard, the student must know:

- agrotechnical requirements for growing crops and conducting technological operations in crop production;
- the best achievements of science and production in the application of agricultural machinery in technological processes;
- purpose, structure, working processes and technological adjustment of machines;
- methods of substantiation and determination of the basic parameters, modes and indicators of the work of agricultural machines, machine aggregates and complexes;
- methods of assessing the quality of machines, their advantages and disadvantages;
- peculiarities of mechanization of plant growing processes in the conditions of a market economy;
- the main trends and trends of the development of individual groups of machinery and agricultural machinery in general;

should be able to:

- to set up machines for the given mode of operation, to work on them, to detect and eliminate malfunctions;
- independently master the constructions and working processes of new agricultural machines and technological complexes;
- perform technological, kinematic and energy calculations of machines and their working bodies and units.

Effective learning technology in higher education is breakthrough study of subjects, breakthrough of the project activity, breakthrough of the practical training and so on. As the influence of technology breakthrough study agricultural machines for forming readiness for project activities of the agroengineers is not properly investigated because it is an urgent scientific and technical and pedagogical problem, which is advisable to be addressed comprehensively and systematically. Thus, the main objective of these studies is a programming and scientific and methodical study of educational technology a breakthrough study of the specialty "Agroengineering" first (bachelor's) degree of higher education discipline "Farm machines" and examine its impact on the process of preparedness for design of future professionals from agroengineering according to real agricultural production conditions, which can sometimes be special, for example, bioenergetic crop sowing on sloping lands of variable steepness [2].

2. Prerequisites and means for solving the problem

Particular attention is paid to the breakthrough-art technology of training, independent work of students of agroengineering specialties in the scientific works by Bender I.M. [3]. Innovative pedagogical technology of breakthrough design significantly increases the requirements for coursework and graduate papers or projects, needs a lot of professional commitment and the ability to develop educational projects for the development of student project activities. The prediction of the effectiveness of the development of the breakthrough line design, the right choice of the scientific direction, the themes should be based on a person-oriented approach, which will maximally reveal the motivational-value, cognitive-understanding and activity-practical criteria of productive learning technology.

Breakthrough eliminates the simple repetition of the material passed. Therefore, at each stage of the process of studying agricultural machines at least 80% should be the latest for the student character, enrich him with new knowledge, expand and deepen professional competencies. Repetition of the studied material in auditorium is allowed, but no more than 20%. In extracurricular time as an independent work, students can, if necessary, devote more time to this, especially in view of the need for in-depth study of agricultural machines in foreign languages, which is necessary for them in the case of going abroad for practice or doing work there according to their specialty. The method of realization of the planned breakthrough program for studying agricultural machines involves consistent gradual growth of professional competencies at the expense of optimal use of all types of educational work with a comprehensive study of the content and amount of lectures, laboratory and practical classes, course design, training and production practices, independent work, etc.

The creative potential of the student is most revealed in the project activity of agricultural machines. In order to ensure efficient and high-quality implementation of the 3-year course work on agricultural machines, it is important to develop a scheme for the thematic introduction of non-core types of independent work of agricultural machinery basic discipline and related disciplines in course work. In order to provide a breakthrough course design in basic disciplines it is important to be able to allocate the content of the term paper or diploma project by sections, parts and fragments. An important and up-to-date is the development of a mechanism for the implementation and operation of the method of a breakthrough stage phased in development of professional competencies, including the project within one of the basic disciplines − "Agricultural machines".

3. Solution of the examined problem

Agricultural machines the students of specialty 208 − "Agroengineering" begin to study from the 1st year in the form of theoretical study within the discipline "Introduction to the specialty", as well as during the training practice on agricultural machines. To understand the content of training, structure, general provisions, etc. working programs have been developed.

In the work program of the academic discipline "Introduction to the specialty", developed at the department of agricultural machines of the Vinnitsa National Agrarian University, the description, structure, purpose and tasks of studying the discipline are presented, the competence of the specialist, from whom the student must learn in the process of study, is indicated. Within the framework of interdisciplinary relations, the discipline "Introduction to a specialty" is oriented practically to all disciplines that in one way or another form the general and professional competences, which include the formation of preparedness for the project activity of the agroengineer. These are the disciplines such as: Higher Mathematics, Theory of Machines and Mechanisms, Material Science and Technology of Structural Materials, Mechanics of Materials and Structures, Applied Mathematics, Fuel and lubrication and other operational materials, Machine parts and design bases, Tractors and cars, Agricultural machines, Tolerances, landing, interchangeability, Machinery and equipment for processing of agricultural products, Machines and equipment for livestock, Hoisting and transport vehicles, Machinery and equipment maintenance, Technical service of agrarian and industrial complex, Machinery use in crop production, Design of technological processes in crop production.

The purpose of the educational practice of agricultural machines on the first year, that is, at the initial stage of acquiring practical knowledge of students by the structure, the working process of agricultural machines and modern means of planting mechanization, is the formation of skills, professional competencies to substantiate the choice of the design of the working bodies of agricultural machines, their arranging for the personal participation of a trainee for optimal working conditions in accordance with the specific conditions of use of technical means of mechanization.

Basic study of agricultural machines is based on the developed program [4] of the discipline "Agricultural machines", compiled on the thematically generalized basis, taking into account the requirements of the educational and qualification characteristics of the bachelor's direction of preparation 6.100102 "Processes, machines and equipment of agro-industrial production". From each group of cars the basic ones are allocated. On their basis, the general structure, the design of the working bodies, the technological process of work and regulation, the theory and methods of calculating the parameters of machines, its evaluation by qualitative, energy and economic indicators are studied. The program includes a description of the discipline, its purpose, qualification requirements, interdisciplinary connections, forms of final control and means of diagnostics of success.

The final form of control measures is the exam. Means of diagnosing the success of training are used for the final examination of knowledge and are based on the technology of standardized test control. The approximate fragment of a set of basic text tasks on the discipline "Agricultural Machines" is given below [1].

Part 1. Construction, process and technological adjustment of agricultural machines.

Specify what has to be the ratio between the speed of the rope slats $V_{кол}$ and the speed of the forward movement of the combine harvester $V_{маш}$?

1. $V_{кол} > V_{маш}$;
2. $V_{кол} < V_{маш}$;
3. $V_{кол} = V_{маш}$;
4. All of these options are available.

Right answer: 1.

2. *Indicate which numerical positions in the figure indicate the components of the cleaning system of the combine harvester GHS-9-1 " Slavutych "*

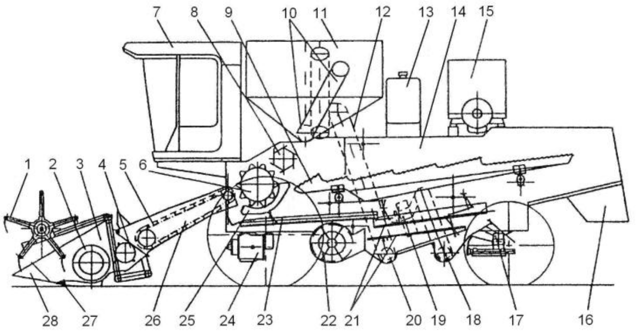

Fig. 1. *Combine harvester*

Right answer: 21, 22, 23.

Part 2. Fundamentals of the theory and calculation of agricultural machines.

1. At the expense of which factor is it possible to crumble grain from the ear during the work of the reel? (m – mass of grain; a – acceleration, g = 9,8 m/s²; ω – angular velocity; u – circular speed of the rope slab; R – radius of a rope)

1. $E = \dfrac{mu^2}{2}$;
2. $F = ma$;
3. $G = mg$;
4. $J = m\omega^2 R^2$.

Right answer: 1.

2. Correctly arrange indicators according to the scheme of rotational cutting apparatus

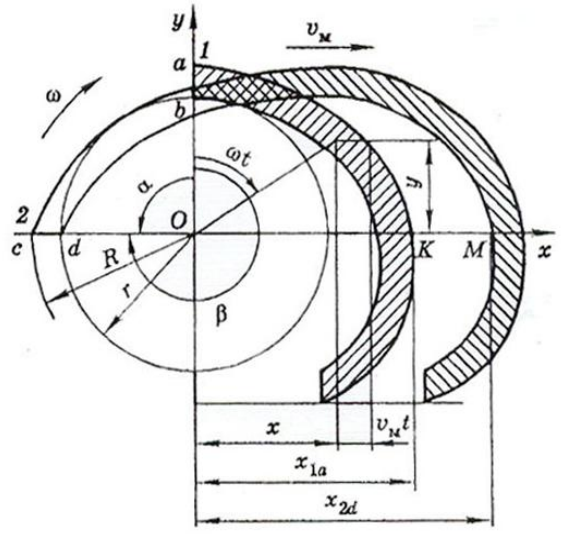

Fig. 2. *Scheme of rotational cutting machine operation*

1. Angle of knife turn	A) $R\omega \sin \omega t$
2. Knife length	B) $R\sin \omega t + V_M t$
3. Knife speed	C) $R - r$
4. Moving of the knife	D) KM
5. A possible fate	E) ωt

Right answer: 1 – E, 2 – C, 3 – A, 4 – B, 5 – D.

The constructive course of agricultural machines the students are gradually beginning to study at the 2nd year. In the methodological guidelines for carrying out laboratory work on agricultural machines for students of the specialty 208 "Agroengineering" is presented a structural diagram of the study of discipline, from which it is clear that, in general, the entire course is divided into 4 content blocks [5]. The substantive block 1, in particular, involves the study of machines for cultivating soil and sowing crops. There are also studying and reclamation machines [6]. Laboratory work is carried out on basic of the agricultural machines, laboratory plants, operating models simulating the working process. Basic machines are selected taking into account regional peculiarities of growing crops and the material base of the educational institution. In laboratory work students study the general structure, the process of machines, the design and functioning of the working bodies, the adjustment of machines in accordance with the production conditions, conduct laboratory studies. Active forms of laboratory work (disassembly, assembly, regulation, research of parameters and modes of operation of units and machines, use of computers, etc.) are provided.

For example, during the laboratory work on the topic "Plows", students are expanding their knowledge of the theoretical knowledge of plows, studying the design features of the plow to be investigated, the principle of its operation, checking the technical condition and the correctness of the plow assembly. Students prepare plow for work on the control platform. First, they check the completeness and technical condition of the plow, the reliability of all assembly units, the reliability of bolts and other connections, etc. In this case, special attention is paid to the state of plums, shelves, field boards, disk or blade knives. After that, they check the placement of the pre-plows and disk knife on the frame of the plow. The end edges of cases must be on the same line: they are checked with a tensed lace along the edges.

The design of the frame of the plow PLN-3-35 allows you to set the working width of the capture of 90 or 105 cm. To rebuild the plow to another width of the grab, the students dismantle from the frame the working bodies, the supporting wheel and the coupling device, turn the bar 180° (the front part is set back) and attach all removed assembly units to the frame.

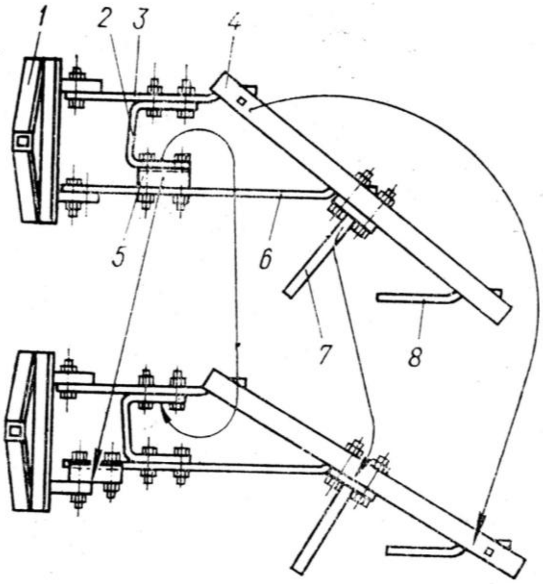

Fig. 3. *Plow rebuilding scheme PTH-3-35 to another width of capture:*
1 − lock autocuff; 2 – stud; 3, 6, 8 − frame frames; 4 − the main beam of the frame; 5 − gasket; 7 − console of a disk knife.

The depth of the plowing level on the plow is determined after mounting it to the tractor and moving it to the working position.

During the study of the 2nd module, students study and research machines for fertilizing and chemical protection of plants [7]. For example, when adjusting the spreaders of solid organic fertilizers of the type PRT-10 for a given norm of introduction they need to know the volume amount of fertilizer. The basis is a volumetric mass of 0.8 t/m^3. At a speed of 10 km/h, a working width of 5 ... 6 m and a volumetric mass of 0.8 t/m^3, the estimated fertilizer rate for devices with 13, 22 and 28 teeth installed on the conveyor drive shafts will be respectively 15, 30 and 45 t/ha. In the case of putting organic fertilizers with another volume mass, the mass is multiplied with the correctional factor.

In accordance with the table of the rates of introduction, given in the factory instructions, for the spreader OFS-6 it is set on the desired supply of a ratchet drive mechanism conveyor.

After the performed adjustments set the actual rate of fertilizer application. For this, the scooter is weighed on car scales. The body of the spreader is loaded with fertilizers and weighed again. By the difference in the readings of the weights determine the mass of fertilizers in the body. Activate a scheduled transmission that meets the specified norm, and spread fertilizer on the field until the body is completely drained. Measure the width of the spreading band and the length of the traversed path. The actual rate of fertilizer application Q, t/ha, is determined by the formula:

$$Q = \frac{G\,10^4}{BL},$$

where G − weight of fertilizer loaded in the body, t;
B − width of the spreading band, m;
L − length of the path of spreading, m.

If the actual rate of fertilizer application differs from the given by more than ± 10%, then the speed of movement of the aggregate or the speed of the feeder conveyor by changing the variable cutting devices or by changing the radius of the crank of the ratchet mechanism.

At the 3rd year of study in the 5th semester, students continue to study the constructive course of agricultural machines. Here they are studying harvesting equipment and machinery and equipment for post-harvest crop cultivation. For example, when studying the combine harvester GHS-9-1, they learn that a combine has a universal eccentric bucket, which, as the research shows, works well on erect and dead crops [8]. The basis of the rope is a tubular shaft, at the ends of which are welded screws. These screws are attached to sliding bearings, mounted on sliders. The crawlers are freely placed on holders. To the tubular shaft are welded flanges, which are attached discs with technical paddles. At the ends of these paddles 2 (Fig. 4), the hinges are attached to the pipes 3 with elastic finger-screws 4 (rake). On both sides of these pipes there are cranks 5, to which hinges are attached technical paddles 6 circles 7 eccentric mechanism. In the clip there are freely placed rollers 8, bars 13 which are freely and eccentrically mounted on a tubular shaft of a rope. The beam with the help of a lever 9 and a finger 11 is freely connected to a copier 12, which is fixedly attached to the holder 10 of the reel. The length of the *AB* crank 5 is equal to the eccentricity of the *VG* beam of 13 rollers, and the length of the beam 2 is the sum of the beam's length 6, the distance from the circles 7 to the shaft 1 and the eccentricity of the *VG*. That is, *AG* = *BV* = *BG* + *VH*. In this way a parallelogram mechanism of *ABVG* is formed. When rotation of a shaft 1 of a rotor with it revolve pipes 3 with cranks 5 (rake), which revolve around rollers 8 clamps 7 eccentric. As a result, a constant angle of tilt of elastic finger-screws is provided (Fig. 4, *b*). Depending on the position of the finger-screw 11 in the copier 12, the elastic screw-fingers may have forward deviation to 15° (fig. 4, *в*) and go back to 30° (fig. 4, *г*).

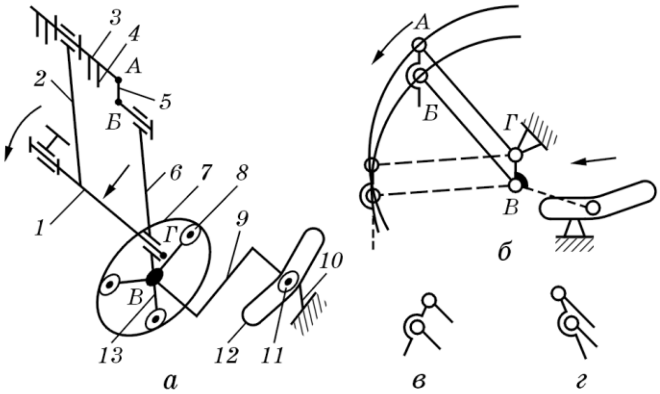

Fig 4. *Eccentric mechanism of the rotor:*

а – scheme; *б* − vertical position of screw-fingers ; *в* and *г* − screw-fingers tilt fitted respectively forward and backward; *1* − shaft of a rope; *2* and *6* – technical paddles; *3* – tube; *4* − elastic screw-finger; *5* – crank; *7* − clip of the eccentric; *8* – roller ; *9* – leash; *10* − hook holder; *11* – screw-finger; *12* – copier; *13* − roller bar.

The angle of the tilting of the fingers of the rake changes automatically when moving the shaft along the holders due to the special configuration of the copier. Depending on the height and condition of the grain, the position of the rope changes in its height and horizontally. Simultaneously with lifting or lowering the reel automatically moves horizontally (along the holders) with the help of a locked mechanism.

At the 3rd year of the 6th semester students study the theoretical course of agricultural machines, carry out course work, undergo industrial practice. So in lectures, for example, as for a reel, the students master the basics of theory and calculation. Namely, the theoretical analysis can be carried out using the following algorithm.

Radius of reel R:

$$R \le \frac{U \cdot l_{\max}}{3(U - V_м)}, м \qquad (1)$$

where U – knob speed of the reel, m/s , $U = \lambda \cdot V_м$;

l_{max} – maximum length of stem;

$V_м$ – translational speed of the machine, m/s.

Rotation frequency of a reel n:

$$n = \frac{30 \cdot \omega}{\pi}, об / хв, \qquad (2)$$

where ω – angular speed of a reel, c^{-1}, $\omega = \frac{U}{R}$.

Height of the reel H over the cutting unit:

$$H = l_{\max} - h + R\frac{V_м}{U}, м, \qquad (3)$$

where h – the height of the cutting device is above the field level, m (during theoretical studies, students choose h based on the results of studies of technological properties of a given culture).

Optimal removal of the reel relative to the cutting unit b:

$$b = R \cdot \sin\frac{\arcsin(1 - \frac{V_м^2}{U^2})}{2}. \qquad (4)$$

Degree of action of a reel on a bread mass η:

$$\eta = \frac{Z}{2\pi}[\arcsin\frac{1}{\lambda} + \sqrt{\lambda^2 - 1} - \frac{\pi}{2}], \qquad (5)$$

where Z − number of reel rods (selects the executor of calculations).

Dependence (5) is used in the case where the shaft of the propeller is located above the cutting unit (in one vertical surface).

During laboratory work on the theoretical course of agricultural machines students experimentally study kinematics and carry out energy calculations [9]. As for a reel, using analytical dependencies it is possible to determine the power on the drive of the reel $N_м$:

$$N_м = \eta \cdot \frac{m \cdot U^2}{2 \cdot 75} \cdot 0{,}736, кВт, \qquad (6)$$

where U – кnob speed of a reel, m/s;

η – the degree of action of the reel on the bread mass;

m –second mass supply of bread mass,

$$m = \frac{q}{g}, \frac{кг \cdot c}{м},$$

where g – acceleration of free fall, m/s^2;

q – feeding of the bread mass to the cutting unit per one second, kg/s,

$$q = Q \cdot B \cdot V_м \cdot 10^{-4}, кг / с,$$

where Q – yield of the bread mass, kg/ha;

B – width of the capture of the reaper, m;

$V_м$, –. translational speed of the machine m/s.

Development of general and specific competencies on the basics of design mechanization is an important factor in the improvement and modernization of the machines both in business and at the factory, enables efficient use of technical means of production and, in general, contributes to the further development of mechanization of agriculture. Therefore, for students of the specialty "Agroengineering", the typical and working plans and programs [1] is provided for the course work the discipline "Agricultural machines". Execution of course work will promote consolidation, deepening and generalization of students' knowledge both in this discipline and in other general technical disciplines. The peculiarity of this course work is that the student independently, on the basis of the revealed shortcomings in the process of performing the technological process, improves existing one or develops a new machine or instrument. To do this, he/she studies the accumulated historical experience of designing technical tools on the theme of course work. That is, the purpose of this course designed to improve the existing or develop a new, more advanced technical tool for the mechanization of plant growing. During its performance the students design types of working bodies, systems, mechanisms to drive and control, calculate basic dimensions of parts that are necessary to comply drawings of the technical documentation, explained and proofed shape, dimensions and aesthetic outlook of the sample, which should provide a reliable, high performance and smooth operation of the aggregate in general [10]. During the course work the student must show the ability to use computers, namely - during the modeling process, solving equations, the calculation and optimization, typing of the text, its explanatory notes, the performance of graphics work. It is believed that the course work done at a high level if it has the basic provisions of the methodology of scientific research in the field of mechanization of crop covers and applied questions of general and specific methods of raising and conducting theoretical, experimental research methods, algorithmic, mathematical modeling of functioning of means of agricultural production [11]. It is very positive to carry out some laboratory or field experimental research, the processing of the results obtained and their use in course work. The student should independently solve engineering problems, make technical decisions to implement knowledge up to the most, show the skills learned in lectures, at laboratory and practical classes [9] during their practice [4].

At the end of the 3rd year of study, students undergo industrial practice in using agricultural machines (3 weeks), as well as the operation of a machine-tractor park (4 weeks). Before leaving for practice, each student receives an individual task from the head of the practice, which involves in-depth study of individual issues that can be used for writing course and diploma projects. These questions may affect the technology of growing individual crops and types of aggregates that are used on the farm, evaluation of the quality of the implementation of technological operations in crop production, methods of harvesting of cultivated crops, modern technologies of quality control of agricultural machines, experience of rationalizers on the improvement of structures of mechanization facilities, studying the experience of introducing the latest technologies in the production of agricultural products [12, 13].

The tests of measuring the residual knowledge of agricultural machines [14] have been developed, which are intended to evaluate and determine the level of professional competence of the future agroengineering at the final stage of training. The tests in the discipline "Agricultural Machines" for the control of bachelor's knowledge of the direction 6.100102 "Processes, machines and equipment for agro-industrial production" consist of 3 parts in accordance with the typical discipline program [1].

Part 1 (Test tasks of less complexity) include 49 questions and are characterized by an assessment of knowledge on the purpose, characteristics and structure of agricultural machinery and machine components.

Part 2 (Test tasks of greater complexity) include 46 questions and are characterized by an assessment of knowledge of the structure, process of work and technological adjustment of agricultural machines and machine aggregates.

Part 3 (Practical tasks, calculations) include 51 questions and are characterized by an assessment of knowledge of the theory and calculation of agricultural machines.

4. Results and discussion

The educational discipline "Agricultural Machines" is one of the main disciplines of agroengineering training, which ensures their readiness for the project activity. As the theoretical analysis and experimental pedagogical research showed, the breakthrough technology of studying agricultural machines provides better results, which is confirmed by conducting control measures in the form of credits, examinations, as well as a breakthrough of residual knowledge, which was conducted 5 months after the main control. In the tests it is expedient to include questions with varying degrees of complexity of theoretical, computational and practical orientation that would affect the increase of soil fertility due to the introduction of organic and mineral fertilizers, timely and quality agricultural crop sowing, cropping operations, harvesting with minimum costs, and with the maximum profit. Therefore, economic indicators must be taken into account when developing and designing agricultural machinery and technology.

5. Conclusion

The theoretical and experimental studies carried out made it possible to clarify certain positions of the features of the influence of pedagogical technology of the breakthrough study of agricultural machines on the formation of readiness for the project activity of future agroengineers. In this direction, new scientific results were obtained, in particular, the theoretical basis for the software system of the educational disciplines "Introduction to the speciality" and "Agricultural machines", developed and tested working programs and practice diaries taking into account their relationship with the material of lectures, laboratory and practical classes, methods of course and diploma design. In the development of training programs and tests of knowledge control, project activities of future agroengineers were taken into account. The use of tests for the diagnosis of training significantly increases the objectivity of the assessment and reduces the time spent by the teacher and students to control knowledge by 2-4 times. The developed model of the innovative system of forming the readiness for the project activity of future agroengineers includes a diagnostic component of assessment and correction of learning outcomes using testing as a form of knowledge control.

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