DEVELOPMENT OF INNOVATIONAL TECHNOLOGIES OF AGRICULTURAL MACHINES PROJECTING AND THEIR INFLUENCE ON THE FORMATION OF PROFESSIONAL COMPETENCIES OF AGRICULTURAL ENGINEER

Candidate of Technical Sciences, Associate Professor Viktor Pryshliak
Ukraine, Vinnytsia National Agricultural University
viktor.prishlyak@i.ua

Abstract: The development of innovative technologies of designing agricultural machines and their influence on the formation of professional competencies of agroengineer is presented. The course designing topics and stages of work implementation are highlighted, which states that during designing a review and analysis of existing structures of this type is performed, the mechanical and technological properties of agricultural materials with which the machine will work (soil, seeds, fertilizers, root crops, etc.) are determined, the agrotechnical requirements and technical requirements for the car are formed, the technological scheme of the design is substantiated and the principle of its work is described, the basic technological, kinematic, hydro or pneumatic mechanical parameters, the forces acting on the working bodies, traction resistance and power consumption are determined, calculations are made for the strength of the changed structural elements, the technical passport of the machine is drawn up, the technical and economic indicators are determined, the technological scheme is drawn up, the description is made and the formula of the invention is compiled according to the requirements of the patent documents. It is noted that the successful completion of the course work on agricultural machines involves interdisciplinary connections with other disciplines, for example, such as the mechanical and technological properties of agricultural materials, the basis of engineering methods for calculation of strength and rigidity, machine parts and design principles, agriculture, the basis intellectual property, the basis of scientific research, etc. An example of an approximate algorithm for calculating and designing an agricultural machine on the example of a grain seed drill is given. The factors emphasizing the quality of preparation of agroengineering specialists, development of capabilities for performing design functions are highlighted.

Keywords: agroengineer, project activity, design, agricultural machinery, competencies, cross study, technology, innovative technology.

1. Introduction

The educational discipline "Agricultural Machines" [1] is the basic in the structural-logical scheme of training specialists in specialty 208 − "Agroengineering".

Students learning the structure and principle of the operation of agricultural machines, adjust the optimal operating modes, the theoretical foundations of the technological processes of the working bodies, the method of designing and designing new and improving the existing structures, learning the discipline.

Total volume of educational discipline "Agricultural machines. Fundamentals of theory and calculation " is 162 hours, of which 108 hours. assigned to classroom work, and 54 − for self-study. In recent years, changing the number of hours in this discipline tends to reduce the number of class hours, while the time for self-employment is increasing.

Independent work consists in studying software material in the laboratory of the estimated course of agricultural machines, on the site of storage of equipment, in libraries, at the branches of the department.

Individual tasks of self-fulfillment include calculation, calculation and graphic work, and most importantly, it is course work (project).

The aim of the course work is the technological development of structures of agricultural machines or their units or the improvement of existing production processes for the cultivation and production of agricultural products or the improvement of operational and economic indicators. It is intended to consolidate the theoretical positions of the basic discipline "Agricultural Machines" by substantiating and calculating the processes that execute agricultural machines and the formation of students' ability to make optimal decisions on technological design of new and improvement of existing means of mechanization taking into account specific agrotechnical and relief conditions [2].

2. Prerequisites and means for solving the problem

During the design, the review and analysis of existing structures of this type are carried out, the mechanical and technological properties of the agricultural materials with which the machine will work (soil, seeds, fertilizers, root crops and others), the agrotechnical requirements and specifications for the machine, the technological scheme of construction and describes the principle of its work, calculates the main technological, kinematic, hydro (pneumatic) mechanical indicators, determines the forces acting on the working bodies, traction resistance and costs of power, calculations for the strength of the changed structural elements are presented, the technical passport of the machine is issued, the technical and economic indicators are determined, the technological scheme is drawn up, and the application for the invention is made in the best course projects.

For the purpose of rational use of time and the elimination of duplication of certain types of tasks, the designer develops and at the beginning of studying the discipline gives the student a plan for the implementation of course work.

Professor Bendera I.M. payed special attention to the project activity in the framework of independent work of students of agroengineering specialties in his scientific works. [3]. He believed that a successful project activity greatly increased the requirements for coursework and diploma theses or projects, needs a lot of professional commitment and the ability to develop educational science and technology projects.

3. Solution of the examined problem

Successful implementation of the course work on agricultural machines involves interdisciplinary connections with other disciplines, for example, such as the mechanical and technological properties of agricultural materials, the basis of engineering methods for calculating strength and rigidity, machine parts and design basics, agriculture, the fundamentals of intellectual property, the basis of scientific research, etc.

During the issuance of individual tasks for course design, account is taken of the agronomic requirements, the technical characteristics of the machines, the economic activity of the particular enterprise, the practical direction of the project activity of the future agroengineer.

When doing the course work adhere to the basic provisions of the algorithm for the development of a new agricultural machine [4].

Objects for course work can be as separate agricultural and reclamation machines [5, 6], assembly units that perform the basic operations of the technological process (plow case, milling drum, sowing section, cleaning of the combine, etc.), as well as schemes of technological lines from several machines that allow to completely or partially mechanize complex works. An example can be schemes of a grain harvesting combine, a grain-cleaning and drying complex, a potato sorting station.

Coursework contains an estimated explanatory note for 25-30 pages of handwritten text and graphic materials, the total volume of 3 sheets of A1 format.

The calculation and explanatory note should have: title page, task, content, annotation, introduction, review of literature on the theme of course work, justification of the design of the working body, agrotechnical requirements to the machine, specifications, calculations: technological, kinematic, hydraulic, energy, strength [7], technical passport of the machine, feasibility study, conclusions, list of used literary sources, applications. A list of literary sources can be found at the end of each section.

The graphic part must contain:

sheet 1 – technological, kinematic, hydraulic, pneumatic schemes;

sheet 2 – general view of the machine (node);

sheet 3 – detailing.

The content of the explanatory note and graphic materials can be adjusted depending on the type of machine, the presence of certain systems in it (for example: pneumatics or hydraulics).

Coursework is carried out on topics that are initiated by students and executives of their graduation projects

Course design is carried out through a cross-sectional scheme in which separate sections are performed as stand-alone descriptive, computational, graphic, calculation and graphic works of basic discipline and related, which are taught parallel in the same course.

The topic can be devoted to the development of the technological scheme of the machine in general, individual nodes, working bodies, machine complexes.

The reason for the choice of the topic may be the student's own experience, the experience of the manager of the diploma project, the data of the official publication "Systems of machines for the complex mechanization of agricultural production", the order of the basic agricultural enterprises or factories producing agricultural machinery. As a rule, these are plows, combined aggregates, disk harrows and devices, tine harrows, cultivators for solid and row soil cultivation, grain sowing machines, vegetable and special, potatoes and seedlings, mineral and organic fertilizer [8], sprayers, feeders, mowers, feeders, grain- ,tuber- and root combines, combine harvesters or attachments to combine harvesters [9] for the harvesting of technical crops, grain cleaning [10], drying, sorting machines, land reclamation machines, irrigation systems and installations, etc.

Choosing a topic [11], we can be guided by the following recommended directions of agricultural processes [12]. Recommended design directions:

1. Mechanization of agricultural operations, which are partially mechanized or executed manually: cutting down stairs (for example, sugar beets); picking berries; fruit harvesting; harvesting vegetables; sorting of agricultural products; packaging of agricultural products; harvesting of tubers (potatoes, Jerusalem artichoke); harvesting of root crops (carrots, table beets); control of pests and diseases of agricultural crops; storage of agricultural crops in natural conditions; storage of agricultural products by creating the necessary temperature-air conditions.
2. Modernization of existing cars by way of connection to the energy source: mobile (semi-mounted, mounted, self-propelled); stationary; mobile
3. Modernization of existing cars under different sources of driving of operating bodies: by running systems; by the power take-off shaft; by the hydrosystem of power take-off; by the autonomous hydro-propulsion station; by the autonomous power source mounted on the machine (internal combustion engine), and from unconventional energy sources (sun, wind).
4. Modernization of the drive of existing machines with the development or improvement: mechanical; hydraulic; pneumatic; electric; combined.
5. Use of new types of actions of working bodies on the object of cultivation: active action; vibration; passive action; electromagnetic action.
6. Increase productivity, outcome ability due to the change of: width of device; speed of movement; submission of material to the working bodies.

The wording of the topic should be made in the following:

1. Development of the design of the machine (node) for … .
2. Improvement of the design (the mark of the car for the purpose …).
3. Improvement of the site (name) of the machine (name) for the purpose ... .

Implementation of the course work is effective and rational considering the introduction of its main developments in the future graduation project, subject to the follow-up design scheme, in which the main sections of the work are performed as separate individual tasks from the basic discipline (agricultural machines) and other disciplines that are laid out in parallel.

To fulfill the theme of the course work as a precondition for future qualification work (diploma project), the head of the latter officially orders the course design course relevant topic.

For an example, consider the approximate algorithms for calculating and designing an agricultural machine on an example of a seeder.

At first, it is recommended to calculate the kinematics of the seed drill. Calculations of transmission ratios of the drive from the wheel to the shaft of the seeding machines of the seed drill are to be started from the definition of the overall gear ratio.

The total gear ratio of the drive from the support wheel of the drill to the shaft of seeding machines is determined by the formula [4]

$$i = \frac{10^{-3} \cdot \pi \cdot D_{\kappa} \cdot b \cdot Q}{q_0 \cdot (1-\varepsilon)}, \quad (1)$$

where D_{κ} – diameter of the support wheel (for a seeder SG-3,6 taking into account the tire deflection D_{κ} = 1,18 м cm);

b – width of row spacing (b =15 cm);

Q – seed rate (wheat – 150-250 kg/he; barley – 160-350 kg/he; pea – 200-400 kg/he);

ε – coefficient of grip of the support-drive wheel (ε =0,1);

q_0 – the quantity of sown seeds in grams for one reel, the value of which depends, in addition, on the type of seed and the value of the working length of the coil. Maximum coil length $L_{\kappa_{\max}}$ = 32 mm, but minimal – $L_{\kappa_{\min}} \geq 2c$, where c – maximum seed width, mm (wheat – c = 4 mm; barley – c = 5 mm, pea – c = 9 mm).

The sequence of finding the gear ratios follows

a) determine i_1 for the above formula, replacing

$$q_0 = 10^{-6} \cdot S_c \cdot \gamma \cdot L_{\kappa},$$

where
$$S_c = S \cdot z \cdot \mu + \frac{\pi \cdot d_{\kappa}\left(1 - e^{-b_0 \cdot c_1}\right)}{b_0};$$

at $Q = Q_{\min}$ and $L_{\kappa} = L_{\kappa \min}$;

where S – cross-sectional area of the coil chute, mm^2 (Fig. 1);

$$S = S_1 + S_2, \quad (2)$$

where
$$S_1 = 0,5r^2\left(\pi - \alpha_1 - \sin\left(180^0 - \alpha_1\right)\right);$$

$$\alpha_1 = 2(0,5\alpha + \beta); \quad (3)$$

$$S_2 = 0{,}125 \cdot d_к^2 (\alpha - sin\alpha);$$
$$\alpha = 2 arcsin(b_{жс} / d_к), \quad (4)$$

where r = 5,5 mm; β = 60°; $b_{жс}$ = 11 mm; z − number of chuts (z =12).

μ – coefficient of filling of grooves with seeds (for wheat and barley μ = 0,75; peas μ = 0,65);

$d_к$ – outer coil diameter: $d_к$ = 50 mm;

e – the basis of the natural logarithm;

c_1 – gap at the exit of the device between the coil and the bottom (c_1 = 2c);

b_0 – coefficient of proportionality (for wheat and barley b_0 = 0,32, peas b_0 = 0,18);

γ − bulk mass of the seed, g / dm^3 (for wheat γ = 750 g / dm^3, barley γ = 650 g / dm^3; peas γ =850 g / dm^3).

Then

$$i_1 = 10^3 \pi \cdot D_к \cdot b \cdot Q_{min} / S_c \cdot \gamma \cdot L_{к_{min}} \cdot (1-\varepsilon). \quad (5)$$

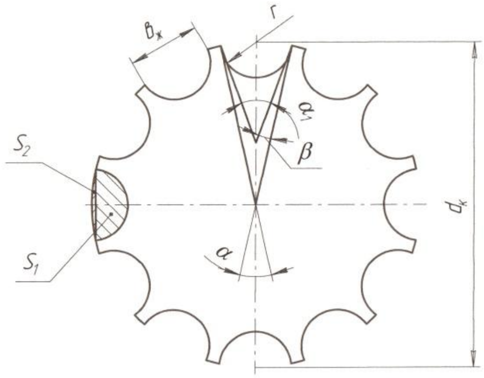

***Fig. 1.** Profile of a reel of a sowing machine [4]*

b) check the range of sowing rates for the value found i_1, taking $L_к = L_{к_{max}}$ = 32 mm.

$$Q_1 = \frac{10^{-3} \cdot i_1 \cdot S_c \cdot \gamma \cdot L_{к_{max}} \cdot (1-\varepsilon)}{\pi \cdot D_к \cdot b}. \quad (6)$$

If $Q_1 \geq Q_{max}$ a given value, then for sowing norms from Q_{min} to Q_{max} enough one value of the gear ratio i_1.

If so $Q_1 < Q_{max}$, the calculation must be continued.

c) determine the new value of the gear ratio i_2 at $Q = 0{,}9Q_1$ and $L_к = L_{к_{min}}$.

$$i_2 = 10^3 \pi \cdot D_к \cdot b \cdot (0{,}9Q_1) / S_c \cdot \gamma \cdot L_{к_{min}} (1-\varepsilon). \quad (7)$$

d) check the range of seed sowing rates for a new value found i_2, taking $L_к = L_{к_{max}}$.

$$Q_2 = \frac{10^{-3} \cdot i_2 \cdot S_c \cdot \gamma \cdot L_{max} \cdot (1-\varepsilon)}{\pi \cdot D_к \cdot b}. \quad (8)$$

It is necessary to $Q_2 \geq Q_{max}$ of the given value. Otherwise, the calculation should be continued until all the necessary ratios of the ratio have been obtained, which would ensure that the whole range of sowing norms is hanging from Q_{min} to Q_{max}.

Consequently, it is first necessary to determine the gear ratio for seeding wheat. Then check whether the required seeding standards for barley are found in the gear ratios for seeding wheat. If they are not enough, it is necessary to calculate the additional gear ratio for sowing of barley seeds.

In the same way, check and, if necessary, calculate additional gear ratios for sowing seeds of peas.

After determining the value of the transfer ratios, pick up the required number of tines z_j gears in the actuator (Figures 2 and 3), for example:

$$i_1 = z_1 \cdot z_3 ... z_j / z_2 \cdot z_4 ... z_{j+1}, \quad (9)$$

where z_j − the number of tines of an gears of the support and drive wheel of the drill. Similarly define for i_2, etc.

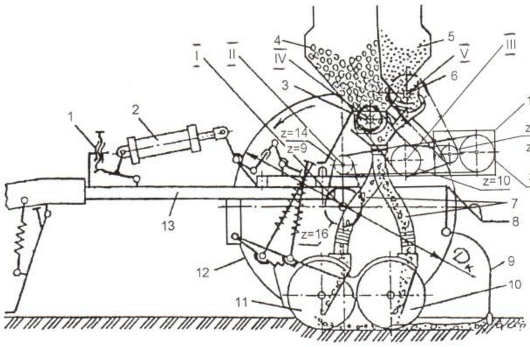

***Fig.2.** Scheme of seed drill for seeding and mineral fertilizers SG-3,6 [4]:*
1 – screw; 2 – hydraulic cylinder; 3 – reel machine for sowing seeds; 4 – seed box; 5 – box for mineral fertilizers;
6 – coil-rod device for fertilizing mineral fertilizers;
7 – seed pipelines; 8 –footboard; 9 –wraping tines;
10 –rear two-disc coulter; 11 – front two-disc coulter; 12 – support wheel; 13 – frame; 14 – gearboxes;
I – wheel axle; II – counter-drive shaft; III – intermediate shaft of counter-drive; IV – насіння shaft of devices for sowing seeds;
V – shaft of devices for sowing mineral fertilizers.

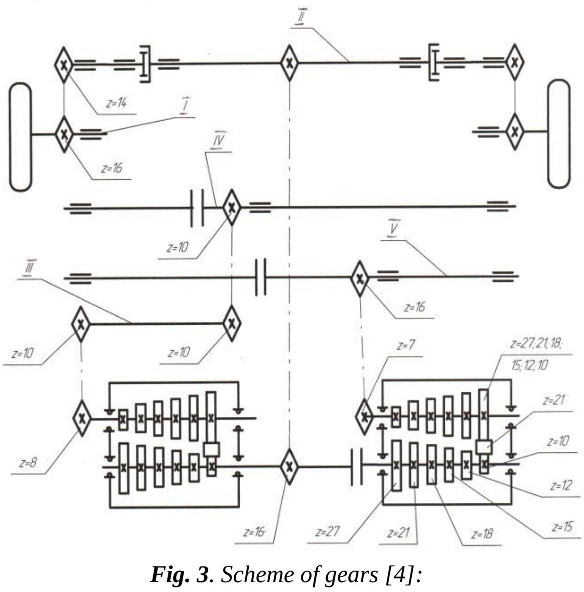

***Fig. 3**. Scheme of gears [4]:*
I – wheel axle; II, III – intermediate shafts of the counter-drive;
IV – shaft of machines for sowing seeds;
V – shaft of devices for mineral fertilizers

The algorithm of kinematic calculation of seeders of other technological schemes (propagating, combined, etc.) is the same. The difference is only in the original kinematic scheme of the drill, which, accordingly, makes changes in the calculations. Calculations of the seed drill can be expanded, for example, after conducting power and energy calculations.

4. Results and discussion

The educational discipline "Agricultural Machines" is one of the main disciplines of future agroengineer training, which ensures their readiness for the project activity. As shown by the results of theoretical analysis and experimental pedagogical research, the development of innovative technologies for designing agricultural machines increased the quality of training, provided a positive impact on the formation of professional competencies of agroengineering. Particularly effective cross-cutting technology for the study of agricultural machines - in general, and the development of project activities - in particular. The cross-design technology provides substantially better results, which is confirmed by conducting control measures in the form of credits, examinations, as well as a cut of residual knowledge, which was conducted 5 months after the main control. The tests should include issues with varying degrees of complexity of theoretical, computational and practical orientation that would include test questions from soil cultivating, reclamation, seeding machines, fertilizing machines, chemical plant protection, forage harvesting, grain harvesting, maize harvesting, beet harvesting and potato harvesting machinery, machinery for post-harvest cultivation of grain.

5. Conclusion

The conducted theoretical and experimental researches made it possible to specify some of the features of the influence of innovative pedagogical technology of designing 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 substantiation of the system of measures aimed at comprehensive project activity of future agroengineers was given. The algorithms of calculation of agricultural machines and their working bodies have been developed and tested. The given example of designing and construction of a grain drill gives an idea of the peculiarities of the design of technical means of agricultural production. Course methods and graduate design in the sequence and logic of the stages of designing machines are similar, and therefore successful course design is the key to a successful graduate project. In developing the topics of course projects should take into account the needs of agricultural production in improved mechanized technological processes, increased production efficiency.

6. References

1. Agricultural machinery. The program of study discipline for the preparation of applicants for the higher education "bachelor" in the directions 6.100102 "Processes, machines and equipment of agro-industrial production" in agrarian higher educational institutions / D.G. Voytyuk, L.V. Aniskevich, V.M. Martyshko et al. – Nemishaive: Agrarian Education, 2016. – 50 p.
2. Pryshliak Viktor. Investigation of machines for soil processing sowing bioenergetic crops under conditions of changeable relief / Viktor Pryshliak // Mechanization in agriculture: International scientific journal. – Sofia, Bulgaria: Scientific technical union of mechanical engineering Bulgarian association of mechanization in agriculture, Year LXIII, Issue 2/2017. – 82-86, ISSN web 2534-8450.
3. Bender I.M. Theory and methodology of organization of independent work of future specialists in mechanization of agriculture in higher educational institutions: diss. ... Doctor Ped. Sciences: 13.00.04 / Bendera Ivan Nikolaevich. – K., 2008. – 579 p.
4. Designing agricultural machines. Tutorial / I.M. Bendera, A.V. Rud, Ya.V. Koziy and others; ed. I.M. Bendery, A.V. Rudia, Ya.V. Kozia. – Kamyanets-Podilsky: FOP Sysin O.V., 2010. – 640 p.
5. Working program of agricultural machinery training for students of the 1st year students of the Faculty of Agricultural Mechanization, specialty 6.100102 "Processes, machines and equipment of agricultural production" of full-time education / V.M. Pryshliak, V.M. Yaropod, I.A. Babin, O.V. Kovalchuk. – Vinnytsya: Editorial and Publishing Department, VNAU, 2013. – 24 p.
6. Pryshlyak V.M. Agricultural machinery. Machines for cultivating soil and sowing crops: methodical guidelines for the implementation of laboratory work by students of the FMSG of the knowledge department 20 "Agrarian sciences and food", specialty 208 "Agroengineering" // V.M. Prishlyak, O.V. Kovalchuk, V.M. Jaropud. – Vinnytsya: RVV VNAU, 2018. – 92 p.
7. Machinery and equipment in agricultural land melioration: Textbook / G.M. Kaletnik, M.G. Chausov, M.M. Bondar, V.M. Pryshliak and others. – K.: Hi-Tech Press, 2011. – 488 p.
8. Pryshliak V.M. Agricultural machinery. Machines for fertilizing, plant protection and harvesting of forages: methodical instructions for the implementation of laboratory work by students of the FMSG of the knowledge department 20 "Agrarian Sciences and Food" specialty 208 "Agroengineering" // V.M. Pryshliak, O.V. Kovalchuk, V.M. Jaropud. – Vinnytsya: EPD VNAU, 2018. – 68 p.
9. Pogorelyts O.M. Machines for harvesting of grain crops. Electron. Tutor-manual Samovichitel / O.M. Pogorelyts, V.M. Pryshliak. – Vinnytsya: VNAU, 2015 – 432 p.
10. Sereda L.P. Laboratory practice on the Theoretical Course of Agricultural Machinery / L.P. Sereda, V.M. Pryshliak. – Vinnytsa: CC of VSAU, 2007. – 72 p.
11. Pryshliak V.M. Agricultural machines: calculation, designing. Methodical instructions for course work / V.M. Pryshliak, O.M. Pogorelyts. – Vinnytsya: VNAU, 2015. – 60 p.
12. Vasilenko P.M. Fundamentals of Scientific Research. Mechanization of agriculture / P.M. Vasilenko, L.V. Pohorily. – Kiev: Higher school, 1985. – 266 p.