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FIELD TESTS OF AN AUTONOMOUS FIELD ROBOT FOR WIDE-ROW CULTIVATION

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Abstract: *In Industrial Institute of Agriculture Engineering (Poznań, Poland), together with the Institute of Vehicle of Warsaw Technical University and firm Promar Poznań action have been taken to design autonomous field robot for sowing and cultivation of crops. Designed robot is to be autonomous device. It will automatically perform the sowing, weeding and selective spraying plant crops such as sugar beet or maize. The robot will work in various terrain and weather conditions. It will move on the dirt roads and on cultivated fields, and therefore it will have to overcome mud, sand, puddles and avoid obstacles such as ruts, bumps in the road and stones. The achievement of this objective required the development of a suitable chassis, system of autonomous control in terms of driving and realization of agronomic processes.*
KEYWORDS*: FIELD TESTS, AUTONOMOUS ROBOT*

1. Introduction

Care for the natural environment and health benefits of crops and the growing interest of consumers in tasty food encourage farmers to look for ecological agricultural production technologies. The threat to the environment and the quality of agricultural produce is primarily the excessive use of herbicides. The need to maintain high yields and low production costs requires alternative methods of plant protection against excessive weed infestation. A simple and effective method of destroying weeds is their mechanical removal. It should be remembered that weeds are competition for arable crops and the longer they occur in the plantation, the greater the losses they cause in the crop. Manual weeding e.g. on large plantations sugar beets, due to the high cost of labor and the problem of employing a sufficient number of employees to perform the work at the required time, effectively discourages growers from ecological farming.

For mechanical removal of weeds hoes with tools passive, active or a combination of them are used These machines are aggregated with an agricultural tractor and can be equipped with automatic guidance systems for working elements. Usually, they allow you to remove weeds only from inter-row surfaces. More advanced cultivars, called intelligent ones, locate desired plants using GPS signals (using knowledge of the position of sown seeds) or image processing systems. These are solutions in the testing phase, with limited use. Problems occur with obtaining the required accuracy of the location based on the GPS system, especially since the sowing and weeding operations are performed in separate operations often by various tool carriers. Location systems based on image analysis are unreliable with big weed infestation, which may occur, for example, at delayed emergence, as well as due to bad weather conditions that prevent entry of the tractor on the subsoil at the required time. The solution to these and similar problems can be find by application of a common tool carrier in the form of an autonomous field robot. Its construction (power demand, stability, maneuverability, way of hanging the tools) should be adapted to various field treatments. An important requirement is also that it is a light machine, with good traction properties, causing low soil degradation and capable of performing operations in difficult terrain conditions (Fig. 1).

The introduction to the widespread use in agriculture, horticulture and forest nurseries of autonomous field robots may be a breakthrough in the current approach to large-scale crops, where this type of production could not do without the use of herbicides. The possibility of using autonomous field robots will increase the availability of organic food products and should lower their prices.

2. The concept of the designed robot

At the Industrial Institute of Agricultural Engineering in Poznań, in cooperation with the Institute of Vehicles of the Faculty of Automobiles and Working Machines of the Warsaw University of Technology and with PROMAR Sp. z o.o. (*private limited companies*). An attempt was made to develop an autonomous field robot for sowing and cultivating plants.

Three types of systems implemented in this type of machines can be distinguished: driver assistants, automatic control and autonomous, unmanned machines. The last type assumes the possibility of working without an operator (possible supervision). A device with these features must meet a number of requirements and perform several basic work modes, such as: task initiation (mission), task calibration, path planning, track tracking, observing and waiting, avoiding obstacles, detecting mission errors / interrupting missions, ending missions. Some of these tasks are deterministic (e.g. planning and tracking the path), while the part is completely reactionary (avoiding obstacles). The essence of the implementation of individual modes is the appropriate algorithm, while the key information for him is the appropriate measurement.

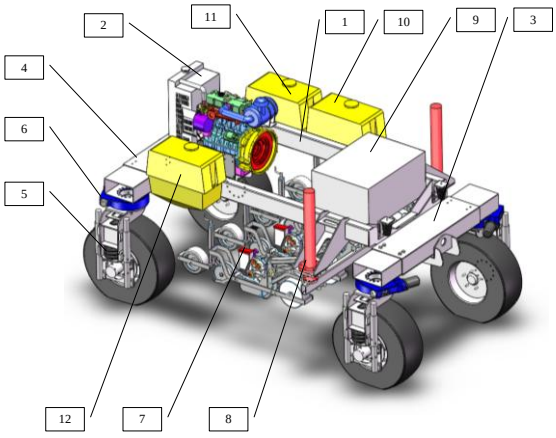


Fig.1. *Geometric structure of the initial robot model*
1 - supporting frame of the traveling platform; 2 - diesel engine; 3, 4 - suspension axle beams; 5 - running wheel assembly; 6 - turntable; 7 - tools (point seeder / active cultivator / sprayer); 8 - system of lifting the tools; 9 - oil tank; 10 - fuel tank, 11, 12 - sprayer tanks

The robot conception used in the project assumes building a device with the highest level of autonomy. The robot will automatically perform sowing, weeding and selective spraying of crop plants such

as sugar beets or corn. The robot will operate in various field and weather conditions. It will move across field roads and arable fields, so it will have to overcome mud, sand, puddles and avoid obstacles such as ruts, road unevenness and stones. Achieving this assumption required the development of an appropriate chassis, control system and algorithms of autonomous control in the field of traction and execution of agro-technical processes.

It was assumed that the robot will have a modular construction [1]:

- carrier

  The basic module is a stand-alone carrier cooperating with specialized modules. The carrier will be 4 wheeled vehicle, able to work remotely and autonomous. The drive wheels provide hydraulic motors and planetary gears. This way of transfer of power will get the high ground clearance of the machine (free space for tools) and independent suspension - important when working in difficult terrain. In addition, the speed differentiation of individual wheels and their appropriate setting will result in high maneuverability.

- sprayer

  Sprayer will be able to realize during the sowing or weeding dosage of liquid fertilizer or other liquid preparations of plant protection. The application will be executed surfactants (for plants or soil), or to the soil (of the depth below the surface of soil) in a continuous or selective based on the optical identification and location of objects.

– seeder

  For precision seeding seeder will be applied with the seed position recording system in the field.

- hoe

  The main working unit will be active hoe robot for precise control of weeds in both the inter-rows and row crops.

Particularly noteworthy is a comprehensive approach to the mechanization of wide row crops, including the use of a common autonomous tool carrier for the execution of sowing procedures and the mechanical destruction of weeds, assisted if necessary by the selective use of liquid plant protection products and fertilizers.

Essential part of robot is its control system [2]. The main sensor system is based on a specialized GPS receiver that provides position information with an accuracy of less than 100 mm. This system is mainly used to guide the robot along a designated path, and also (in cooperation with the vision system) for precise sowing - accurate seed location information will be used to build seed maps that will be used as auxiliary information for precise weeding and spraying. The view from the front camera will be used to increase the accuracy of the robot positioning. This will allow you to improve the path accuracy of the robot relative to the rows of plants. The vision system will also be used to detect stationary objects (Fig. 2). At the same time, the second vision unit will also be used to acquire images from the camera directly in front of the active hoe and sprayer. Additional information from acceleration sensors and encoders embedded in the wheels will also be used for navigation purposes. To determine the angular acceleration, the IMU (Inerial Measurement Unit) will be required. This will enable:

- correction of the robot's trajectory,
- precise work of an active hoe,
- position adjustment and precise dosing of fertilizers or plant protection products by the sprayer.

The diagram of the robot drive control system is shown in Fig. 3.

3. Field research of the robot's test model

After the test model of the mechanical structure of the robot was built, tests of its motion properties were carried out. The robot was then equipped with executive elements, including tools for performing agrotechnical works [3], but algorithms of autonomous control were not yet launched. The robot was controlled manually using a special panel and manipulators (Fig. 4). Status of the robot was visible on a special interface (Fig. 5).

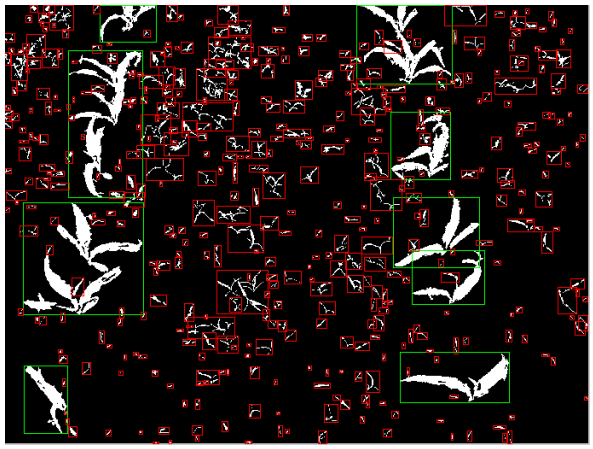


Fig. 2. *Tests of the system distinguishing crop plants from weeds*

In order to check the correctness of selected solutions and introduce any corrections:

A) Operating loads occurring under different operating conditions of the robot have been determined.

B) The hydraulic robot system has been tested. Pressure was measured in selected elements of the hydraulic system, including hydraulic motors driving individual wheels, during maneuvers in various operating conditions of the robot work.

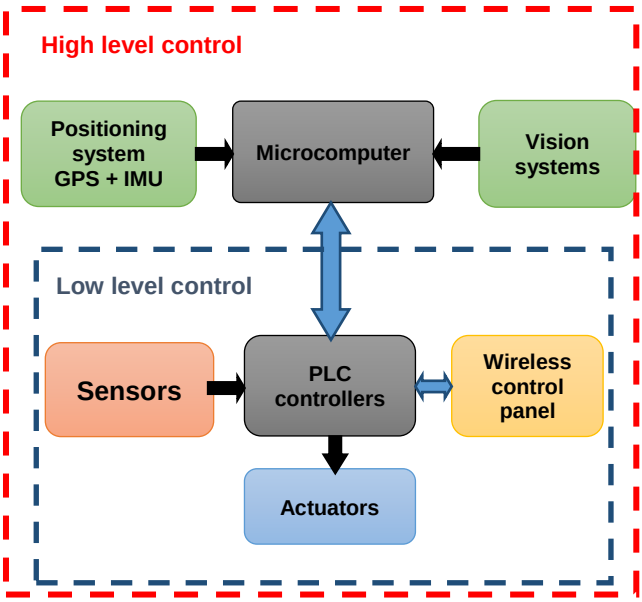


Fig. 3*. Diagram of robot driving control system*



Fig. 4. *The panel used for manual robot control during field tests*

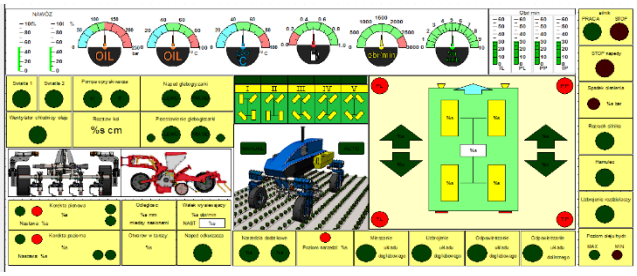


Fig. 5. *User interface used during robot tests*

C) Field tests of the robot's driving properties have been carried out (stability and drivability and the possibility of overcoming obstacles). The way of moving the vehicle with various configuration of driving wheels and for various configuration of the cornering method was checked.

D) Driveability of the field robot's work in terms of communication range, machine reaction and control quality has been checked. The correctness of the wheel control algorithms and the force with which the wheels of the field robot's platform interact on the ground have been checked.

E) Limit situations were determined for the robot's control system under various operating conditions (various types of ground and different speeds) in the range of obstacles, turns and turns (Fig. 6). During the tests on various types of ground (cultivated field and non-arable field), maneuvers of the running gear were tested for different speed settings. The possibility of moving during difficult conditions was also tested, where the robot's wheels went deep enough to prevent normal operation.

F) Introductory laboratory and field tests of the work of the tool modules were carried out. The sowing, weeding and spraying processes were tested.

4. Sample results and discussion

This section presents sample results obtained during robot field tests.

The figure 7 shows the behavior of the control system and the actuation system when robot is starting off. The characteristics show the start-up of the vehicle along with the gradual increase of the speed to the maximum and next rapid shutdown of the drives.



Fig.6. *Field tests of the robot in various operating conditions (various types of ground and different speeds)*

At start-up, you can see incorrect supply of current signal to feed pumps (A). This behavior was caused by deliberate tuning of the controllers in the controller for research purposes. The drive pump (hydraulic motors) on right side received working setting about 2 s faster. Due to the initiation of start only one of the parties, the pressure in the engines increased dramatically (B). After starting the second pump, the pressure dropped and began to stabilize at a set level. At increasing the speed to the maximum, pressure remained at a similar level. Interesting is the period when the vehicle moved at maximum speed and encountered harder working conditions, which caused rapid pressure jumps and speed reducing (11:03:40 - 11:03:45). The last fragment of the diagram shows the braking of the machine. After switching off the settings, the pressure on the pumps and motors increases temporarily due to the closing of the valves.

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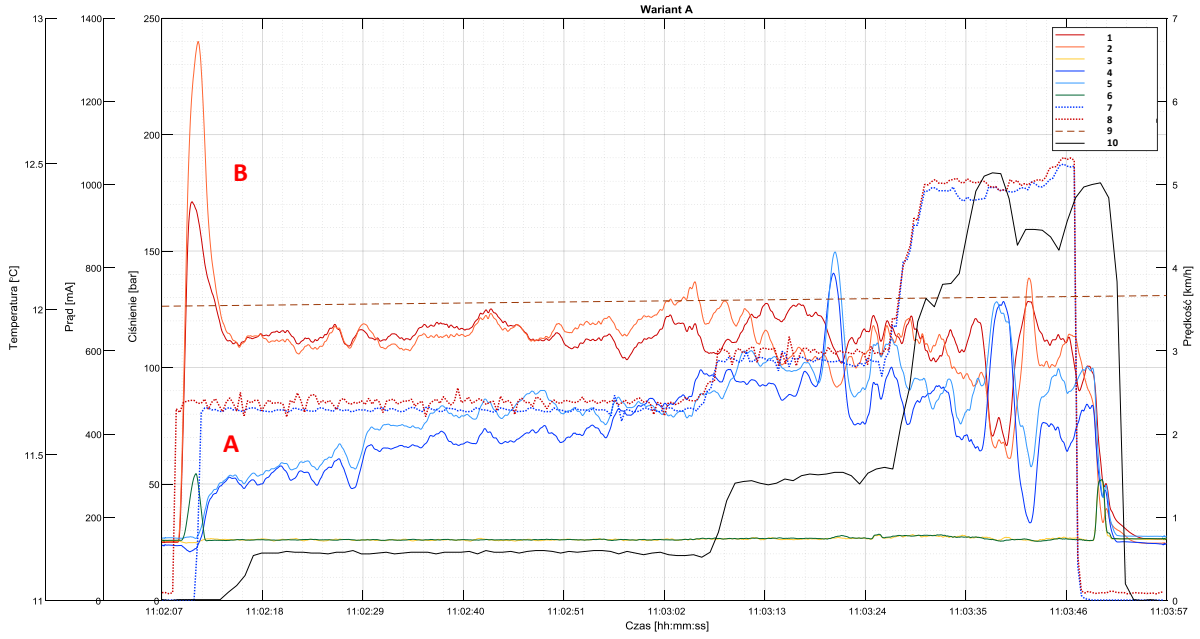


Fig. 7. *The working parameters of the robot during acceleration in a straight line*

1 - pressure in the right front wheel motor [bar]; 2 - pressure in the right rear wheel motor [bar]; 3 - pressure on the right side motor output; 4 - pressure in the left rear wheel motor [bar]; 5 - pressure in the left front wheel motor [bar]; 6 - pressure on the left side motor output [bar]; 7 - left wheels drive current [mA]; 8 - right wheels drive current [mA]; 9 – temperature [°C]; 10 – robot velocity km h^{-1}*]*

5. Conclusions

The carried out research allowed to remove defects occurring in the robot's structure, e.g. rebuilt the cover of the hoe working in inter-rows, in order to enable proper copying of the area. Also there was modified the hydraulic system, in which there was a harmful difference of pressure on both sides of the robot.

The general course of the tests, however, confirmed the correctness of the adopted structural solutions in the area covered by the tests.

Currently, the next cycle of research on robot work in the autonomous mode is being conducted. The subject of the research and tests are primarily robot control algorithms in the field of intelligent control of working tools and independent moving of the robot through the field.

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EVALUATION OF THE HORIZONTAL AND VERTICAL FORCE OF REVERSIBLE MOLDBOARD PLOW IN SILTY LOAM SOIL.

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Abstract: The aim of the study was to evaluate the horizontal and vertical force of reversible moldboard plow at various operation depth and speed. A complete randomized block design was used with three replications, the first treatment was tillage depth with three levels 15, 20 25 cm and the second treatment was the forward speed with two levels 3.9, 6.3 km·h^{-1}. The result showed that both forces were increased as increased of tillage depth and speed, however, the operation depth was more effective than speed, on the other hand, the horizontal force was more affected than vertical force by increasing both of depth and speed.

KEY WORDS: *VERTICAL, HORIZONTAL FORCE, MOLDBOARD PLOW, TILLAGE*

1. Introduction

Tillage is a process that is created suitable soil conditions for seed germination and crop growth (Al-Suhaibani and Ghaly, 2010). Primary tillage in many cases is important for successful crop establishment, pest and weed control (Nielsen., et al 2017). It is the base operation in the agriculture and its energy represents a considerable part of the energy utilized in crop production (Askari& Khalifahamzehghasem, 2013). The most common implement in the world for plowing is a moldboard plow, ranging from the simplest type for animal traction, up to the highly advanced, large plows for tractors (Celik et al., 2007). It is widely used as a primary tillage tool(Mari et al., 2014). It was stated that draft force of moldboard plow was about 2.14 and 1.8 times as much as the chisel plow and disk harrow respectively (Askari &Khalifahamzehghasem, 2013). The amount of force required to pull or push the implement through the soil is called horizontal or draft force (Godwin, 2007).while the Vertical force of implement is assisting or preventing the penetration into the soil (Manuwa et el., 2012). Forward speed and tillage depth have considerable effect on the horizontal and vertical force. The vertical force increased with the increase in the tillage depth, this effect occurred due to the fact that at higher depths a greater soil volume is considered (Ibrahmi et el., 2014; Manuwa, 2009). It is clearly that tillage forces varied according to the shape of the tools, forward speed and depth of plowing (Godwin & Dogherty, 2007). The relationships between draft and speed showed that with increasing forward speed, draft increased (Safari & Gazor, 2014; Rosa & Wulfsohn, 2008). For the moldboard plow, when forward speed increased from 1.5 to 3 km·h^{-1}, the draft requirement increased from 9 to 10 kN and was not doubled. This increment occurred for all plows. In the sense of doubling the forward speed, the draft requirement increased but was not doubled (ASABE Standards, 2009). Also the ploughing depth has a greater effect on the horizontal force than on the vertical force (Al-Suhaibani & Ghaly, 2013).The objective of this study was to estimate the horizontal and vertical force of reversible moldboard plough in silty loam at different tillage forward speed and depth using new three hitch point (frame).

2. Materials and method

2.1 Treatments and Experimental Design

The trial was conducted at Czeslawice field in Lublin province (Poland) which belong to the farm of the University of Life Science in Lublin at a latitude of N51° 18' 23'', N51° 13' 27', the soil texture was classified as a silt loam.

A complete randomized block design was used with three replications, the first treatment was tillage depth with three levels 15, 20, and 25 cm, the second treatment was the forward speed with two levels 3.9, 6.3 km·h^{-1}

Statistical software (Statistica ver. 13.1) was used for the statistical analysis of the results obtained. A two–way analysis of variance (ANOVA) with interaction was performed assuming 0.05 as the level of significance

2.2. Forces measurements

The three–point hitch dynamometer (Figure 5) was built in the form of an inverted U–shape and calibrated at the same company (Industrial Institute of Agricultural Engineering, Poznan, Poland). It was designed and fabricated to be used for measuring the horizontal and vertical force of the soil engaged tools. It was placed between the tractor and the implement. The force sensing elements comprise five extended transducers. Moreover, the data acquisition system consists of a program data logger and serial cable. A notebook computer was also used for the monitoring and processing of data in the system.



Fig.1. *Three hitch dynamometer (frame)*

3. Result and discussion

3.1. Effect of tillage depth on the horizontal and vertical force

The results (Figure 2) indicated that change of tillage depth of plow was effective on the both horizontal and vertical force ($p < 0.05$).

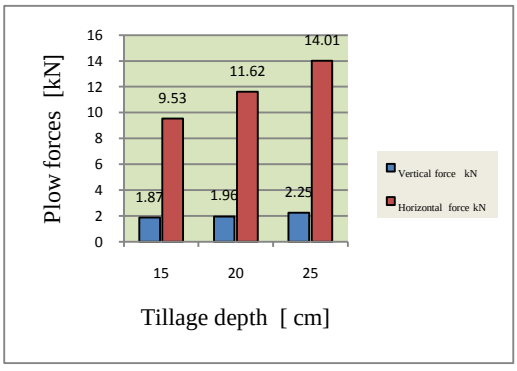


Fig. 2. *Effect of tillage depth on the horizontal and vertical force*

The maximum horizontal and vertical force (14.01 and 2.25 kN) occurred at tillage depth of 25 cm, while the minimum values (9.53 and 1.87) occurred at tillage depth of 15 cm. The forces increased with the operational depth of the plow was probably due to the greater depth of plow penetration, therefore, the larger surface area and greater soil resistance which requires more force to cut the soil and turn it over during plowing operation, this agreed with the findings of Deshpande et al. (2015)

3.2. Effect of forward speed on the horizontal and vertical force

The results (Figure 2) indicated that forward speed of plow was effective on the both horizontal and vertical force. The maximum horizontal and vertical force were occurred at forward speed 6.3 km·h^{-1}, and minimum values occurred at forward speed of 3.9 km·h^{-1}. these were agreed with finding of Manuwa (2009) who confirmed that horizontal force increased as forward speed increased, this is mainly due to the acceleration of the soil, which in turn, increased the reaction at the interface of tools, therefore, the higher sliding resistance

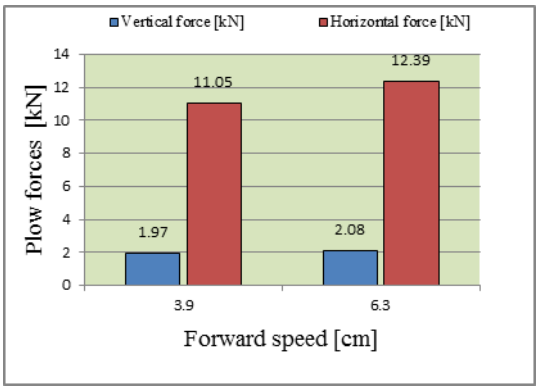


Fig 3. *Effect of forward speed on the horizontal and vertical force*

3.3. Effect of interaction of tillage depth forward speed on the horizontal and vertical force

The results (Figure 4) indicated that the interaction of change tillage depth and forward speed of moldboard plow was effective on the horizontal and vertical force the effect was significant at ($p < 0.05$). The highest horizontal and vertical force were obtained by forward speed of 6.3 km.h^{-1} and tillage depth of 25 cm, while the minimum values were obtained by forward speed of 3.9 km. h^{-1} and tillage depth of 15 cm.

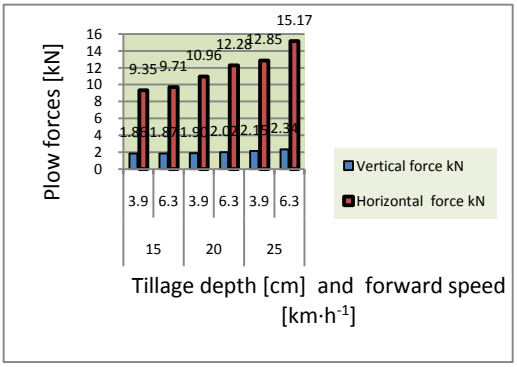


Fig 4. *The interaction effect of tillage depth forward speed on the horizontal and vertical force*

4. Conclusions

The horizontal and vertical forces of reversible moldboard plow are increased as forward speed and working depth increased. The effect of plowing depth was higher on the forces than effect of plowing speed. Moreover, the increasing in the horizontal force was higher than the increasing in vertical force.

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CONTEMPORARY TRENDS IN THE IMPROVEMENT OF BEET TOP REMOVING MECHANISMS AND MACHINES

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Abstract: *There are considered contemporary trends in the improvement of the technological process for the preparation of sugar beet roots for digging out and directions of the development of the designs of the working tools for the removal of the tops. Analysis of contemporary machines has been carried out according to the indicators of their quality, energy consumption and efficiency of the technological process. Tasks have been determined for creating new working tools. It is noted that at the current stage of development of the beet top removing machines the efficiency and quality problems of the top separation process are solved by increasing the number of operations, which is an energy-consuming, material-intensive and costly way to improve the technological process and the working tools. And, as a consequence, it is necessary to look for technical solutions, technologically allowing operations required only for the preparation of the root crops to be harvested. Therefore, further research should be conducted in the direction of creating a working tool that combines good tracing of the heads by cleaners with low-energy intensity of the cutting tools.*
KEYWORDS: ROOT CROP, HEAD OF THE ROOT CROP, ROOT, SEPARATION OF ROOTS, WORKING TOOL.

1. Introduction

Increased pollution of the heap of root crops with the green mass by 1% reduces the yield of sucrose by 0.1%, and, when storing the root crops in open heaps (в каратах) with the top content of about 4%, the daily sugar losses are, on average, 0.012% [1]. For mechanised harvesting of sugar beet roots crops, there is a wide range of sugar beet harvesters and beet harvesting complexes that have both advantages and disadvantages. Especially these shortcomings are present in the preparation process of the root crops for digging, which includes the operations of separating the tops from root crops and removing it from the area of action of the digging tools or attaching to the haulm properties which do not affect the technological process of digging and separating the heap of root crops from impurities. The working tools for separation of the tops perform satisfactorily the technological process at relatively lower speeds in comparison with the digging tools.

Analysis of a number of designs of the working tools for the removal of the tops has been made in considerable detail in the works by L.V.Pogorelov, V.M.Bulgakov, M.V.Tatyanko, R.B.Gevko, V.Ya.Martinenko, N.M.Helemendik, etc., yet creation of efficient working tools that would be characterised by small energy intensity, high efficiency and simplicity of design remains an actual production and scientific task.

The most complete overview of the designs, technological schemes and working tools for the removal of the tops is given in work [1]. There is the history of creation and development of designs considered, the quality indicators of the technological process performed by the main working tools are analyzed, but there are no indicators of energy intensity.

In [2], a classification of the working tools for the separation of the tops is presented. In [3, 4, 5, 6] there is analysis of various technological schemes for the separation of the tops, the results of comparative tests of machines from the West European firms Holmer, Ropa, Kleine, Matrot, Grimme, TIM-Thyregood.

It should be noted that the assessment of the quality indicators of the top separation process according to the European standard is a visual assessment and therefore it is impossible to estimate the mass content of the tops in the root crop heap left behind different machines. The drive power is given only for individual machines.

The purpose of the work is to analyse contemporary technologies and technical means for removing sugar beet tops and to identify the most promising designs and directions for their improvement.

2. Results and discussion

Let us trace the main trends in the development of the working tools for the top removal using as an example modern sugar beet harvesters and top-separating modules of the leading domestic and foreign manufacturers. As a result of analysis, it has been established that the following operations can be carried out at the present stage when the top is removed [1,3,4,5,6]:

- cutting of the main mass of the tops on the root crop which is growing;
- removal of the basic mass of the tops by shock interactions (defoliation);
- disintegration of the tops and their distribution in rows or inter-rows;
- transportation of the tops to the vehicle or to the harvested field;
- partial disintegration of the plant residues in the inter-row spaces;
- cutting the root crop heads with the residues of leaves which remained after cutting the bulk of the tops;
- cleaning of the root crop heads from the residues of the foliage.

In order to analyse various technological schemes of contemporary machines and to determine the current trends in the development of the designs, we classify the technological process of preparing root crops for digging according to the above-mentioned operations (Fig. 1).

Cutting of the basic mass of the tops can be carried out with tracing of the root crop heads or without their tracing at a fixed height relative to the soil surface. In this case the following mechanisms are predominately used: rotors with a horizontal, vertical or inclined at an angle to the horizon axes of rotation.

Removal of the tops by shock interactions takes place with the help of rotors having flexible elements - defoliators.

The distribution of the tops in the inter-row spacing occurs simultaneously with the cutting and disintegration processes, by applying guiding surfaces in the housing of the cutting rotor. There is also known a practice of pushing the plant residues into the inter-row soil.

For transportation of the tops, augers, rod conveyors or a set of vertical augers are predominantly used.

Removal of the plant residues from the inter-row zone is carried out using the fan effect at rotary drums with a horizontal axis of rotation.

Cleansing of the root crop heads from the top residues is effected by rotors with flexible cleaning tools. The most common of these are blade cleaners.

Table 1. *Analysis of technological schemes and working tools of the machines made by the world's leading companies for the top removal*

No.	Stages of top removal	The top removal operations / a design used for the execution of this technological operation							
		BM-6B [1]	Kleine SF10, Moreau, Matrot, Holmer, Gilles [1,6,12,10,14]	Ropa Euro-Tiger V8-3 [6]	Grimme Maxtron 620 [13]	Ropa, Holmer, Gilles [5,10,13]	WIC, Grimme BM 330, Aloway Industries [7,3,8]	Garford Victor, MGSh6 (TKZ) [1]	WIC (Amity Technology) [9]
1	Removal of the basic mass of the tops	Cutting with tracing	Cutting without tracing						Top removal by shock interactions
		Active knife	Horizontal cutting rotor					Active knife with vertical shaft	Rotor with flexible blades
2	Elimination of the influence of the basic mass of the tops	Transportation of the tops into the vehicle or the harvested field	Disintegration and transportation to the harvested field	Disintegration and distribution in inter-rows	Disintegration and distribution in inter-rows with compaction	Disintegration and distribution in inter-rows and rows		Transportation to the harvested field	Disintegration and distribution in inter-rows and rows
		Rod elevators	Horizontal auger	Horizontal cutting rotor and guiding surfaces	Horizontal cutting rotor and rollers for pressing the tops into the soil	Horizontal cutting rotor		Vertical auger working tools	Horizontal rotor defoliator
3	Removal of the top residues	Primary cleaning of the root crop heads	Primary cutting of the heads with tracing					Primary cleaning	Primary cleaning with primary cutting
		Blade cleaner of the root crop heads	Passive knife			Passive knife	Passive or active knife	Primary cleaner with a hard surface	Two horizontal rotors-defoliators. Active knife or passive knife.
4	Elimination of the influence of the top residues	Transportation of residues to the harvested field	—	—	—	—	Disintegration and distribution in inter-rows	Disintegration and distribution in rows and inter-rows	Disintegration and distribution in inter-rows
		Blade cleaner of the root crop heads					Rotor from working tools sectionally, arranged above the rows	Primary cleaner with a hard surface	Rotor from working tools sectionally, arranged above the rows
5	Separation of the tops on the digging-separating working tools	Separation of individual particles of the bound and loose tops from the heap	Partial removal of the bound and detachment of the free disintegrated tops						
Required power, kW		44 - full power	—	—	—	—	75…90	24.7 (drive power)	75…90
Working speed, $m \cdot s^{-1}$		up to 1.5	up to 1.8					—	up to 1.8

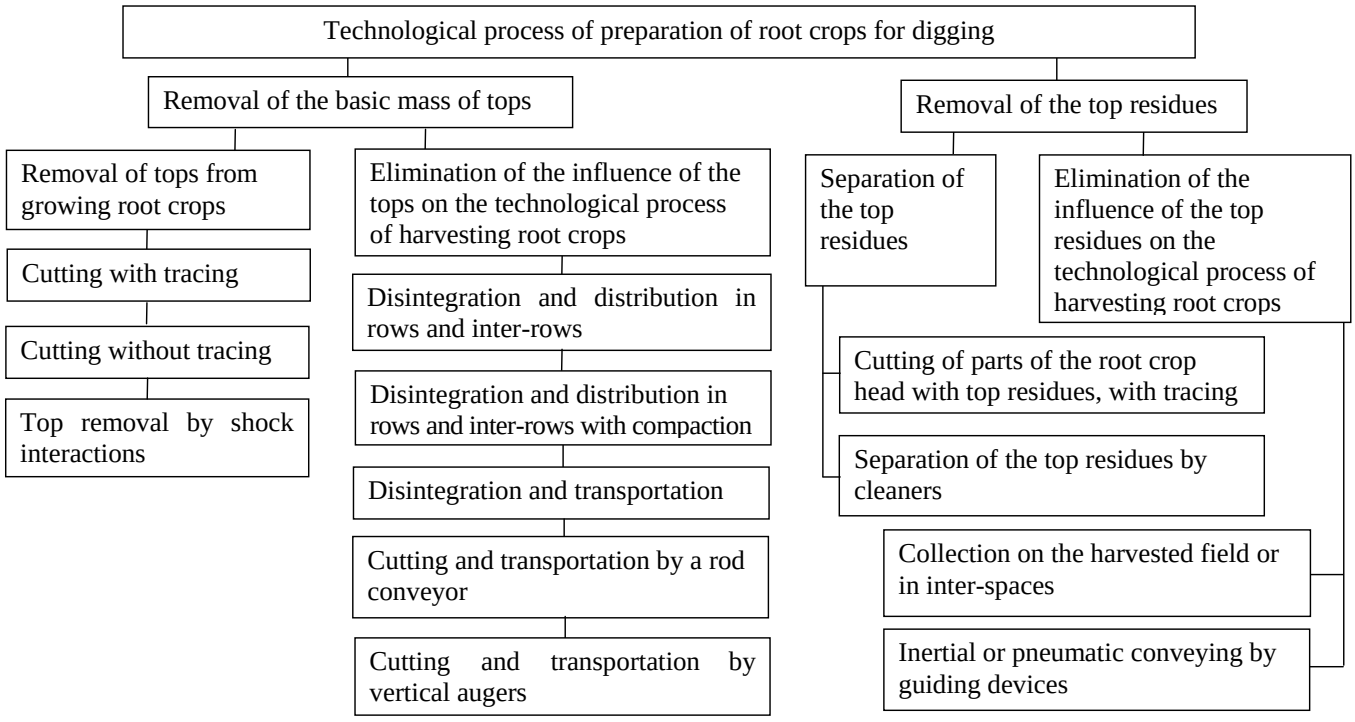


Fig.1. *– Classification of the technological process of the root crop preparation for digging*

On the basis of this classification let us analyse application of the aforementioned operations of the top removal in technological schemes of machines of the world's leading firms (Table 1). Also, we will display with the help of which constructions of working bodies these operations are implemented. We will also show by means of what designs of the working tools these operations are implemented.

Table 1 clearly manifests the tendency of the leading world's firms Holmer, Ropa, Kleine, Moreau et al. (Table 1) to apply cutting of the tops without using a tracer by means of a rotor with a horizontal axis of rotation, and using a tracer when cutting the root crop heads with passive cutters (Fig. 2). In individual combine harvesters a slightly modified technological scheme for the top removal is used. Instead of arcuate knives on the rotary top cutter drum, knives of various shapes are used, which allow the tops to be disintegrated and left in rows and inter-rows. In addition, the top is disintegrated to such a degree that it does not affect the work of the digging and separating tools of the root crop harvesting machines.

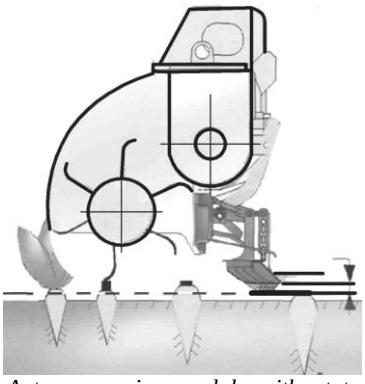
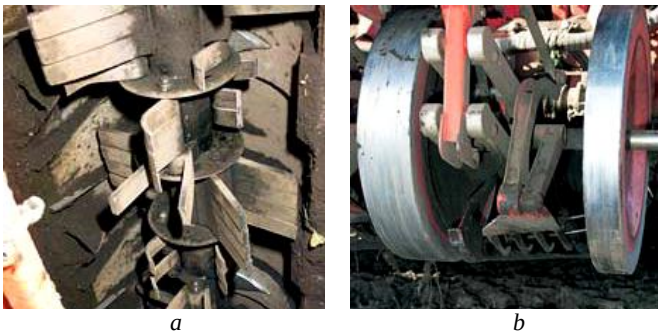


Fig. 2. – *A top removing module without tracing and with passive tracing for primary cutting of the root crop heads*

An original technical solution for the top separation was used by the firm Grimme in its Maxtron 620 combine harvester [3]. In it, the tops are cut only above the rows of sectionally arranged arc-shaped knives (Fig. 3a). On the shaft of the rotary top cutter, in the inter-row region, there are placed polyurethane beaters which are by 30 mm longer than the knives. Due to the suction effect, created by the long beaters, the plant residues are selected from the row region and fed into the region of the knifes for disintegration. By means of the guiding flaps, located on the housing, the shredded tops are distributed in the inter-rows and pressed into the soil by steel rollers (Fig. 3b).



a *b*

Fig. 3. – Peculiarities of the Maxtron 620 combine harvester: *a* – the working tools for the top separation; *b* - rollers for pressing the disintegrated tops into the ground

The next operation is primary cutting of the root crop heads with tracing, using passive primary cutters. Remote regulation of the cutting height is carried out by hydraulic cylinders, the top cutter having no supporting wheels. In order to control and automatically maintain the given cut-off height of the rotary top cutter, sensor signals are used from the primary cutter of the root crop heads.

Using the Harford Victor combine harvester (Fig. 4) as an example, it is possible to consider implementation of this technological scheme with the help of fundamentally different working tools. Cutting of the tops also occurs without tracing by means of active knives with vertical-auger transporting tools, but cleaning the root crop heads from the top residues takes place by active-type cleaners with a rigid parabolic surface.

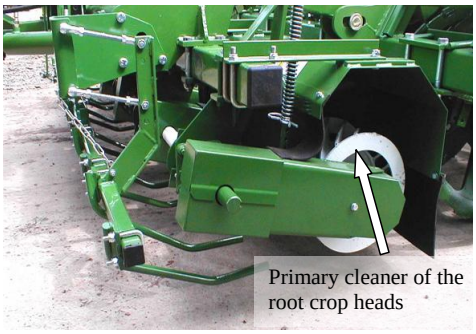


Fig. 4. – *Cleaning device of the combine harvester Garford Victor*

Grimme also puts out Rootster 604 trailed root crop harvesters. They work in a complex with the BM 330/300 top-harvesting machine. In this machine the technological process of separating the tops takes place in three stages (Fig. 5).

At first, the tops are cut off by a rotary top cutter with metal arc-shaped knives. The knives are arranged on the rotor shaft along a helical line (Fig. 6a). The next operation is cleaning of the root crop heads from the residues of the uncut tops by two shafts that rotate in opposite directions.

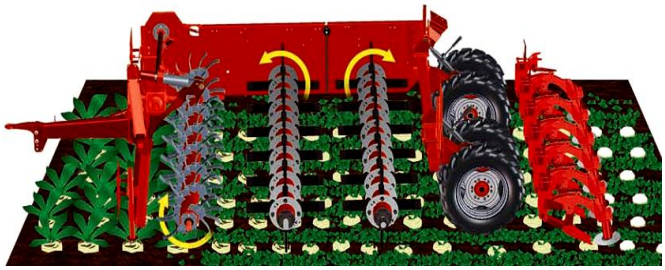
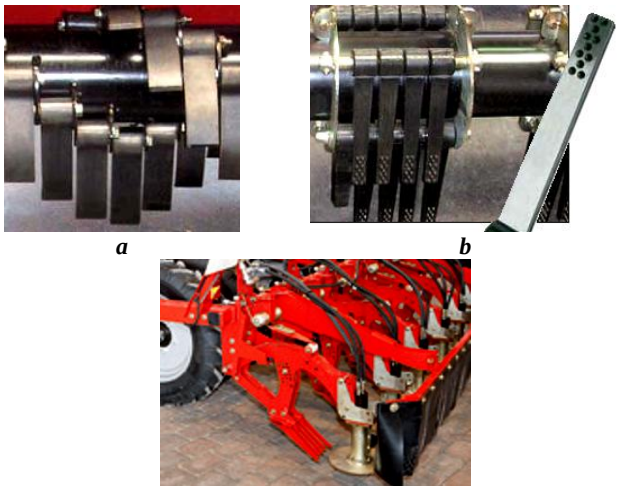


Fig. 5. *– A flow chart of the Grimme BM 330 top-harvesting machine*

On the shafts there are pivotally fixed polyurethane beaters (Fig. 6b). After cleaning the root crops are additionally cut. The cutting-off apparatus, which is used here for primary cutting of the root crop heads (Figure 6c) consists of a comb-shaped tracer and an active disk knife.



a ***b***

c

Fig. 6. *– The working tools of the top harvesting machine BM 330: a – a rotary top cutter; b - counter-rotating polyurethane beaters on the shafts; c – a primary cutter of the active type with tracing*

The WIT top harvesting machine from the Amity Technology (Fig. 7) [7] has an original design of the working parts. Instead of the traditional rotary top cutter a three-shaft beater-disintegrator (defoliation) is used in it. The working tools (beaters) are made from rubber of high mechanical strength. The working part of the beaters contains metal inserts, which increases the impact force of the beaters when they come into contact with the tops. Due to the high intensity of the action of the beaters the tops are crushed into small-size particles and sprayed into the inter-rows without adversely affecting the operation of the root crop harvesting machine.

The final completion of the top cutting process of the root crops is carried out by passive primary cutting knives moving above each of the rows and having an individual system for tracing the height of the root crop heads.

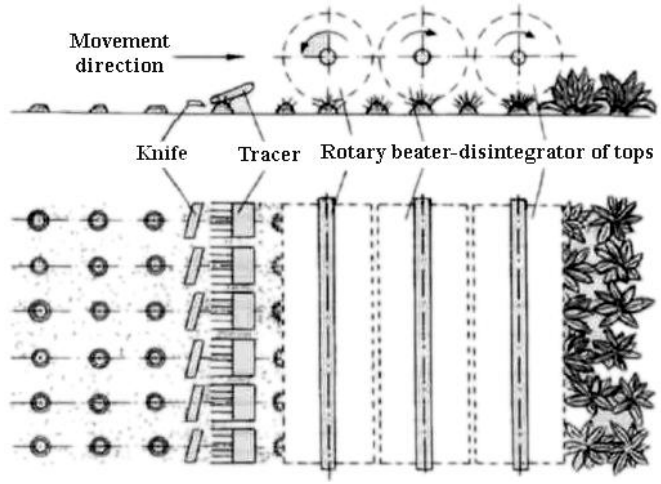


Fig. 7. *– A flow chart of the WIC top harvesting machine from the Amity Technology*

Analysing Table 1, we can draw a conclusion that the basic mass of the tops are removed:

- by cutting the tops without tracing, with primary cutting of the root crop heads with tracing (Fig. 8);
- by cutting the tops with tracing and cleaning the root crop heads from the top residues (Fig. 9);
- by shock interactions (Fig.10).

The technological scheme (Fig.8) is characterised by the complexity of the structures that are used, high metal intensity, and high energy costs due to the use of rotors with a horizontal and vertical arrangement of the rotation axis.

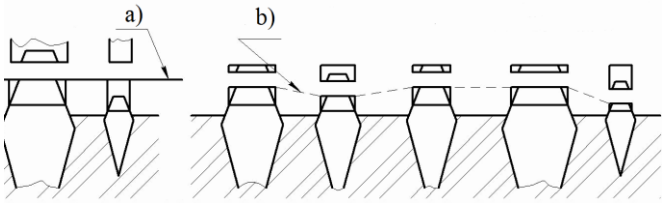


Fig. 8. *A technological scheme of separation of the tops by cutting without a tracer (a); by primary cutting of the top residues from the heads with tracing (b)*

Due to the application of cutting without tracing, the quality of the top removal in this technological scheme is insufficient, and it is possible that the sugar-bearing mass in the removed tops exceeds the agrotechnical requirements. The forward speed in this scheme is not greater than 1.8 $m \cdot s^{-1}$ since the working tools for the passive primary cutting of the root crop heads knock them out and form bevelled surfaces when the speed increases. It should also be noted that irregularities of the soil cause oscillations of the machine. In combination with varying heights of the root crop heads relative to the soil, this significantly affects the location of the cutting plane relative to each head of the root crop, which will lead to different thickness of the layer of the tops of the tops on the root crop heads (Fig. 8), worsening the tracing conditions, and, accordingly, lowering the cutting quality. Due to the increased thickness of the head, the quantity of the top residues on the root crops will diminish, yet the loss of the saccharіferous mass will increase.

According to the results of independent tests [6], the number of root crops with a height of the tops higher than 2 cm was on average 2% for the machines of this technological scheme, there were 26.6% of the high-cut root crops, 7.5% of the low-cut root crops, but satisfactorily cut root crops - 60.1% %. Such statistics indicate the losses of the saccharіferous mass and a significant amount of tops left on the root crops. These results are given for an average working speed of the machines 6 km / h. This is a small speed of movement, and its choice is determined by a desire to achieve a quality of the passive primary cutters as satisfactory as possible. The digging tools can work at a much higher speed. Therefore the use of the passive primary cutters in this flow chart allows reduction of the residues of tops on the root crops after cutting without tracing by a rotary top cutting apparatus, yet the efficiency of the harvesting process of the root crops remains at a low level.

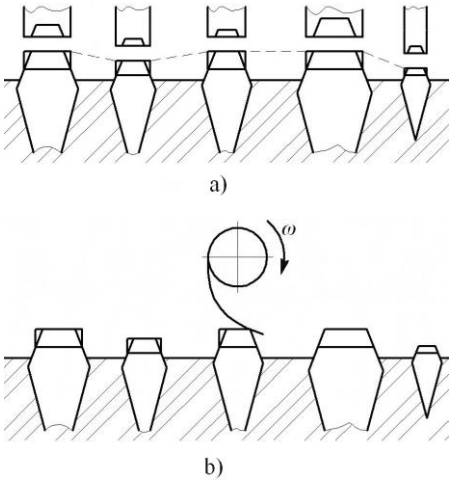


Fig. 9. *– A technological scheme for the separation of the tops by cutting with tracing (a) and primary cleaning of the root crop heads by cleaners (b)*

Thanks to cutting without tracing by means of a rotor with a vertical axis of rotation combined with an active-type cleaner (Garford Victor Harvester), the requirements for the separation quality of the tops can be more satisfied; however there may be root crops, damaged and kicked out of the soil. Considering that the required drive power of such an MGSH-6 machine is 24.7 kW, a considerable amount of energy is wasted for cutting and transportation of the tops using a set of vertical augers.

A combination of cutting without tracing with a primary cutting of the root crop heads by means of active-type cutting apparatus of a small mass (Grimme BM 330 machine) provides a possibility for higher quality separation of the tops at working speeds up to 1.8 $m \cdot s^{-1}$, but the required power is 75 ... 90 kW. A characteristic feature of this design is an individual hydraulic drive for each knife, which made it possible to reduce the weight of the top cutter apparatus. But such a drive is rather expensive, which will definitely be reflected on the total cost of the machine.

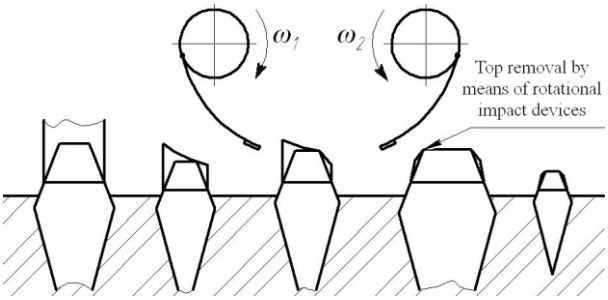


Fig. 10. *– A technological scheme of the top separation of the tops by shock interactions*

The technological scheme of cutting with tracing and primary cleaning of the root crop heads by a cleaner (BM-6B) is also characterised by the complexity of the design and the metal intensity through the need to use the tracing device in combination with the cutting tool. The quality of the top removal in such a technological scheme is much better; however, this time the forward speed of the machine is not high - up to 1.5 $m \cdot s^{-1}$. This is due to the fact that at higher speeds in the links of the tracing mechanism and in the cutting tool there arise inertial forces, and tracing of the heads deteriorates. The total power required to ensure the technological process is 44 kW.

Removal of the tops by shock interactions (separate models of the WIC machines) is characterised by significant energy losses due to additional disintegration of the tops and by the need to use three shafts with different directions of rotation. In this case the tops are disintegrated and distributed on the uncollected field. When the working speed is increased above 1.8 $m \cdot s^{-1}$, the quality of the top removal remains low. In order to carry out such a process, the required power is 75 ... 90 kW.

3. Conclusions

1. At the present stage of development of the top harvesting machinery the problems of efficiency and quality of the top separation process are solved by increasing the number of operations, which is an energy-consuming, material-intensive and costly way to improve the technological process and the working tools.

2. It is advised to carry out further research in the direction of creating a working tool that combines good tracing of the heads by cleaners with low-energy intensity of the cutting tools.

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THE JUSTIFICATION FOR COLTER SPREADER CONFICURATION SELECTED FOR BROADCAST SEEDING AND MINERAL FERTILIZER APPLICATION

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Abstract: *The aim of this work the graphical regularities of the fertilizer pellets outflow through a flattened cone have been considered in an effort to justify the configuration of universal colter spreader which would provide even distribution of the grass and grain seeds, and mineral fertilizer pellets within the soil. It has been determined that to achieve the granular materials' uniform outflow in the direction transverse to travel speed over the colter spreader surface its elliptical cross-section is required. To this effect the section plane should be directed perpendicular to travel speed, cross over all cone generators at an angle between it and central axis of the latter other than* $\pi/2$.
Keywords: *colter, broadcast seeding, mineral fertilizers, spreader, grass sowing, fertilizer applicator.*

Research analysis shows that broadcast subsoil seeding method creates the most vavorable conditions for growth and development of cultivated crops [1, 2, 3]. This is due to more even distribution of seeds over the field than that in the row seeding method [4, 5]. Thus, at broadcast seeding method the yield capacity of corn crops and grass at an average increases by 10…30% if compared with close-drilling and row seeding methods [6, 7, 8].

At broadcast seeding the best quality is assured by the seeding machines equipped with tine colters having spreaders for broadcast subsoil seeding which evenly distribute the seeds throughout all field area [9,10]. Passive spreader of various configurations is the most common and simple in design. However, such spreaders are characterized by highly irregular distribution of seeds and fertilizer pellets by the grasp width [11,12]. Vibrating spreaders create low irregularity of the seed distribution but their design is more complicated.

It is known from analysis of various methods of positional application of fertilizers in the soil that in order to minimize the fertilizer absorption by soil and to create conditions for the plants' better access to them in risky agriculture environment of North Kazakhstan the using screen method for local application of the main fertilizer dose for grain crops to 10…15cm depth of permanent moisture.

To implement the said technology various distribution devices and attachments are aplied. However, the existing distribution devices for internal soil application of mineral fertilizers equipped with passive spreaders do not provide the required (up to 15%) regularity of solid fertilizers screening [13].

In connection therewith, the work aimed to improve the regular distribution of various crop seeds and fertilizer pellets over the field area by means of improving the universal spreader design in under-tine space is of great topicality and practical significance.

Goal of research is to justify the configuration of universal cone – colter spreader providing even distribution of grass seeds, grain crops and mineral fertilizer pellets within the soil.

Research objective:

- research of regularities of fertilizer pellet outflow through the flattened cone.

Materials and methods of research.

According to *operational hypothesis* we have suggested, *in order to achieve the even band distribution of fertilizers the impact is required to stabilize the law of mineral fertilizer distribution at outlet from the colter shank and in under-tine space of the colter* [14].

If using the technical solution [15], which consists in that at the cone surface cutting off in directions transverse to movement, in parallel to the cone generator, the bottomscatterer edge has the parabolic curve shape and oval shape in the plan (in this case the material traces 1^1-2^1, 2^1-3^1, 3^1-4^1 may be equal, figure 1), then it is possible to provide even distribution of the fertilizer pellets across the width of colter.

To realize the suggested hypothesis, for subsoil application of fertilizers the new colter design has been developed. The structure consists of fertilizer funnel shank to which the duck-foot tine or tine point is connected (at grass seeding). In the base of fertilizer funnel shank the spreader cone is fixed.

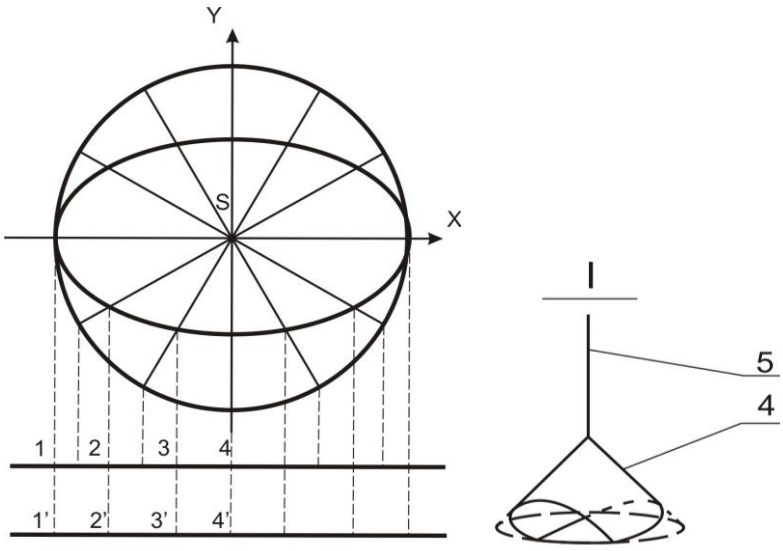


Figure 1 *– Cone scatterer, top view*

Essential prerequisite to achieve the even fertilizer pellets flowing down from cone is their falling into top part of the flattened cone. The spreader cone purpose consists in even distribution of materials in transverse direction of under-tine space.

Research results and their analysis. Figure 2 represents the scatterer cone with *S* vertex and *S-1, S-2,…,S-12* generators. Three projections, namely: front, horizontal and profile are shown in the figure. If the travel speed direction υ is taken by *Ox* axis then in profile projection the $S''' - 7''' - 1'''$ scatterer cone moves towards us, the lookers. Flowing down the cone generator the fertilizer particles fall into the $1''', 2''', \ldots, 6''', 7'''$. points. In the figure the fertilizer traces are shown by dash-dotted lines. As it is seen from the figure, the interval between the application traces are not equal and have the sizes of δ_1, δ_2 u δ_3, though the fertilizers were delivered to the scatterer cone by equal angular spacing δ^o.

The task is to make equal the unequal intervals δ_i between the traces of fertilizer particles drilling. For this purpose, we divide the cone scatterer base diameter *D* into six parts with equal intervals Δ. The project traces of fertilizer particles drilling are reconstructed through the obtained 1, 2, …7 points. For differentiation they are drawn by dash lines. Let us determine the points of obtained drilling traces intersection with corresponding generators in the profile projection:

$$\begin{aligned} &Сл.1 \cap S'''1''' = L_1'''; && Сл.5 \cap S'''5''' = L_5'''; \\ &Сл.2 \cap S'''2''' = L_2'''; && Сл.6 \cap S'''65 = L_6'''; \\ &Сл.3 \cap S'''3''' = L_3'''; && Сл.7 \cap S'''76 = L_7'''. \\ &Сл.4 \cap S'''4''' = L_4'''; \end{aligned} \qquad (1)$$

Through the obtained points connecting by smooth lines we obtain the profile projection of unknown curve $L_1''', L_2''', \ldots, L_7'''$, which can provide regular outflow of the fertilizer particles over the scatterer cone surface in the transverse direction *z*. However, its form and the way to obtain it remain unknown.

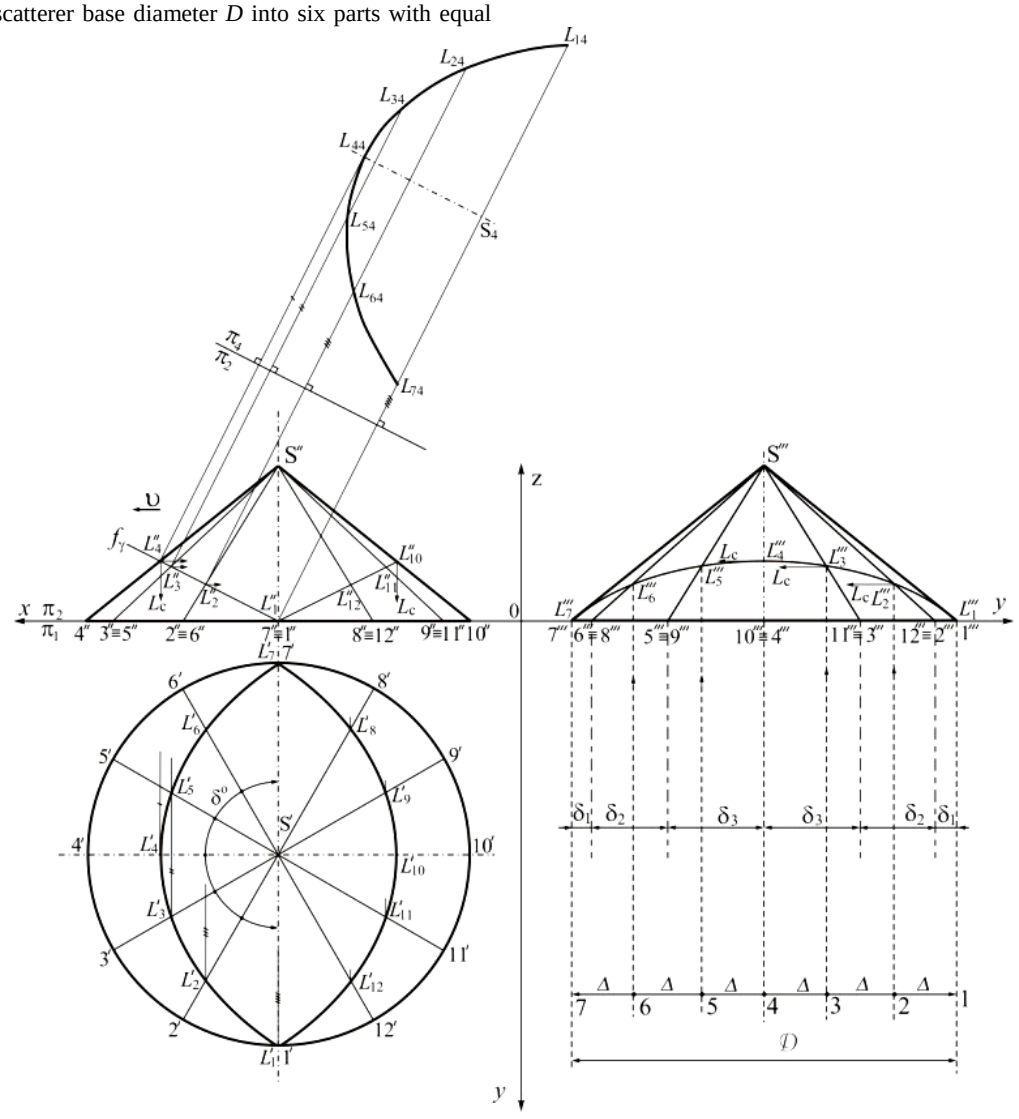


Figure 2 *– To rationale for the spreader cone configuration*

To determine the form of, and way of obtaining the desired curve let us project the $L_1''', L_2''', \ldots,$ points, as well as L_4''', point located at the curve peak to corresponding generators of front projection. As it is seen from the figure, L_1'' remains in $1''$ point. In the cone backside L_7'' coincides with it. The remained points are determined at connection line (*Ls*) intersections with corresponding generators:

$$\Pi c L_2''' \cap S''2'' = L_2'';$$
$$\Pi c L_3''' \cap S''3'' = L_3''. \qquad (2)$$

Having $L_1'' - L_2'' - L_3''$ connected we obtain a straight line. It goes without saying that this line constitutes a front trace of frontally projecting plane γ, on which the desired curve is located. Further we determine:

$$f_\gamma \cap S''4'' = L_4''.$$

Back projection gives a point at the peak of desired curve:

$$\Pi c L_4'' \cap S'''4''' = L_4'''.$$

Cone is the surface symmetric with respect to its central axis. Therefore, the L''_{10}, L''_{11} and L''_{12} are determined according to symmetry law.

Horizontal projection of the desired line points is determined by means of the found front projections to corresponding cone generators on horizontal plane of the projection:

$$\Pi c L_2'' \cap S'2' = L_2';$$
$$\Pi c L_3'' \cap S'3' = L_3'. \qquad (3)$$
$$\ldots\ldots\ldots\ldots\ldots\ldots$$

However, the obtained projection does not give the comprehensive idea of the curve nature since it consists of two branches, at that, each branch is not represented in full.

To determine the natural form of desired curve let us use the descriptive geometry methods for projection transformation, particularly, the method of projection plane replacement. For this purpose, let us replace π_1 plane of initial system by π_4 plane of the new system. At that, the replacing plane should be parallel to γ plane, as the desired curve lies on it:

$$(L_1, -L_2, -\ldots)\frac{\pi_2}{\pi_1}\quad\frac{\pi_2}{\pi_4}(L_{14}, -L_{24} - \ldots) \parallel \pi_4. \qquad (4)$$

Based on the provision that coordinates in the replacing plane should be equal to coordinates in replaced plane, we determine the points L_{14}, L_{24}, L_{34} and L_{44}. The desired figure is symmetric with respect to $S'4'$ generator. That is why the points L_{54}, L_{64} and L_{74} are determined according to the symmetry law.

Upon the obtained points connecting by smooth lines one may note that the desired curve constitutes a half of ellipse the major axis of which is equal to $b = L_{14} - L_{74}$, and minor axis is equal to $a = 2L_{44} - S_4$.

To confirm the reached conclusion let us consider the α cone with *S* vertex and rotation axis *i*. Some γ - plane intersects all its generators but is not perpendicular to the cone axis. Thus:

$$\gamma \cap \alpha = l,$$

some curve line is obtained, figure 3.

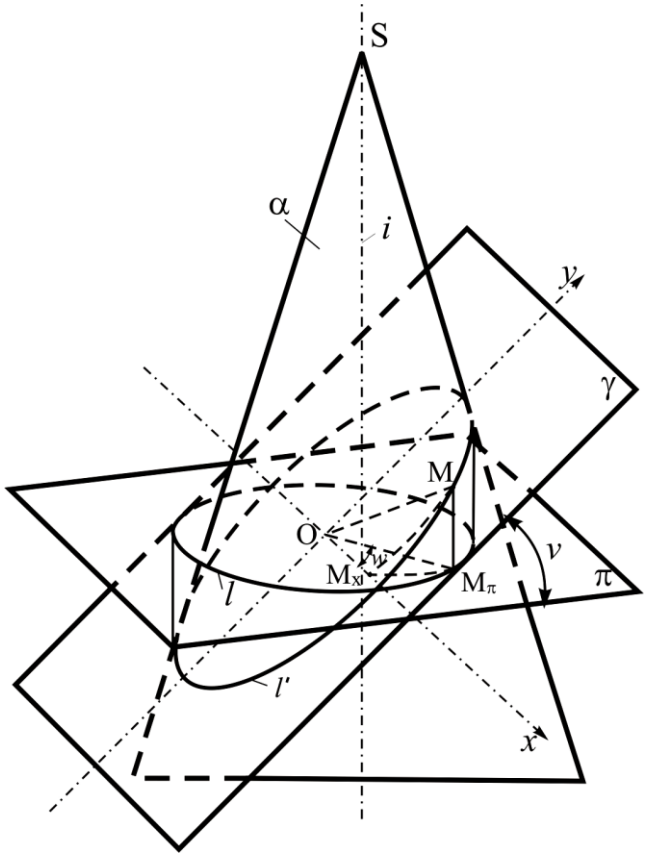


Figure 3 *– To rationale for the spreader cone configuration*

Let us project all pints of *l* curve to π plane which is perpendicular to *i* axis of the cone. For example, the *M* point is projected to M_π point.

The given cone is circular, therefore, on the π plane the circle l' of radius a will be obtained. Its value is equal to the radius of cone on the plane π .

Let us draw through the center of circle l the coordinate axis oy in the γ plane and axis ox perpendicular to it. M point coordinates on these axes are equal to:

$$x = OMx;$$
$$y = MMx. \qquad (5)$$

We take following notations:

ν – acute angle between the planes γ and π ;

w – angle between radius of circle $a = OM_\pi$ and *Ox* axis;

Mx – point *M* projection to *Ox* axis.

Let us determine the *M* point coordinates via *w* parameter.

From the triangle OM_xM_π :

$$\frac{OM_x}{OM_\pi} = \cos w; \qquad OM_x = a\cos w. \qquad (6)$$

From the triangle M_xMM_π :

$$\frac{M_xM_\pi}{M_xM} = \cos\nu; \qquad M_xM = \frac{M_xM_\pi}{\cos\nu}. \qquad (7)$$

From the triangle M_xOM_π :

$$\frac{M_xM_\pi}{OM_\pi} = \sin w; \qquad M_xM_\pi = a\sin w. \qquad (8)$$

Substitute (8) into (7):

$$M_xM = \frac{a\sin w}{\cos\nu}. \qquad (9)$$

In (9) take notation

$$\frac{a}{\cos\nu} = b; \qquad M_xM = b\sin w. \qquad (10)$$

From (6) and (10) with due regard to (5) we obtain:

$$x = a\cos w;$$
$$y = b\sin w. \qquad (11)$$

So, we have obtained parametric equation of ellipse. Therefore, the line l' constitutes the ellipse, as was to be proved. Minor axis of ellipse is equal to a , and major axis is equal to *b*; and it is protruded in direction of axis *y*.

Conclusions and proposals for production.

To obtain the regular outflow of the mineral fertilizer pellets and other granulized materials over the surface of spreader cone of experimental colter in direction transverse to the travel speed its elliptical cross-section is required. To this effect the section plane should be directed perpendicular to travel speed, cross over all cone generators at an angle between it and central axis of the latter other than $\pi/2$.

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INFLUENCE OF DISEL COMPOSITE FUEL ON THE BASIS OF RICINIC OIL ON INDICATORS OF THE TRACTOR DIESEL OPERATION

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Timeliness: *The relevance of the matter is confirmed by numerous researches of the alternate engine fuel, in particular, from the renewable sources of raw materials (biomass) studied in various regions of the Russian Federation and abroad.*

For obtaining diesel composite fuel as raw materials are attractive oil crops which are not used in the food industry, for example, carthamus, false flax, colza, winter cress, crambe and castor-oil plant.

At the moment the need for the ricinic oil used in military, chemical, machine-building, radio-electronic, printing, paint and varnish, medical, cosmetic and other industries in the Russian Federation grows. As a result of processing of a castor-oil plant fruits by cold press in residual meal or pod there are about 10% of oil which is possible for allocating by processing of meal on technology of extraction with receiving technical ricinic oil with a possibility of application as raw materials for receiving paint and varnish, lubricants and diesel composite fuel.

However viscosity of ricinic oil is 10 times more, than at diesel gas oil therefore it is necessary to apply in mix with low-viscosity components. As additive to ricinic oil can be used mineral oil fuel and bioethanol due to which mixture viscosity considerably decreases, cloud point and crystallizations temperature decreases. [8]

As diesel composite fuel is investigated mixture of ricinic oil (RicO), and summer diesel gas oil according to National State Standard 305-2013. On the basis of the carried-out calculation are defined indexes of a working cycle, dependences on concentration of components of blenderized fuel are shown.

On the basis of the calculation, are determined the working cycle indexes, are shown the dependences on the concentration of the components of the composite fuel. Based on the results of the calculation, the obtained indicators were compared with diesel gas oil.

KEY WORDS: *RICINIC OIL, CASTOR OIL, DIESEL COMPOSITE FUEL, DIESEL, INTERNAL COMBUSTION ENGINE, MIXTURES, POWER, ECONOMY, ALTERNATIVE FUEL, BIOMASS.*

1. INTRODUCTION

One of the main ways of development of agricultural and timber production is the partial transfer to alternative fuels from biomass. This is confirmed by the Decree of the President of the Russian Federation of July 7, 2011 No. 899 on priority areas for the development of science, technology and technics in the Russian Federation. The development of alternative energy and the use of biomass are also taken into account by many international studies and scenarios for the development of energy and industry in general.

According to the innovative scenario for the development of world energy until 2050 as a result of the change in the structure of the global fleet of vehicles, as well as the introduction of strict restrictions on emissions of toxic substances, renewable energy and alternative fuels will develop significantly. [2]

An innovative scenario involves overcoming the crisis of the industrial phase (in its postindustrial or non-industrial form) and the crisis of relations with the environment on the basis of the transition to a new phase of development of the society, economy and energy. [2]

As a consequence of this, the energy sources obtained from biomass will receive a great development already in modern times, they can be applied to the vehicles and tractors without significant upgrades of the existing ICE.

For this reason, is being carried out large-scale international scientific research to diversify energy supply sources that will solve the problem of replacing petroleum fuels, significantly expand the resource base for obtaining motor fuels, facilitate the solution of fuel supply issues for vehicles and fixed installations remote from large settlements, can be achieved reduction of production costs. [3,4]

Biodiesel, methane and diesel composite fuel are preferred as alternative energy sources for automotive vehicles in this period.

Biodiesel as a fuel type has a disadvantage expressed by a low temperature of turbidity and crystallization as a result of which it cannot be applied in northern regions where the ambient temperature reaches over -30 ° C. This type of alternative fuel is more applicable in countries with a warm climate and having smaller reserves of petroleum raw materials than the Russian Federation, such as Brazil, India, Vietnam. [2,6]

Gas-diesel is installed on KamAZ-65115, Scania G340 and NefAZ-5299 buses. But as a result of the insufficient level of gasification of the territory of the Russian Federation, and especially in the rural areas, it is impossible to use methane as an alternative source of energy for tractors in agricultural enterprises and logging enterprises that are remote from the gas pipeline.

Among the preferred types of biofuel applicable to agriculture and forestry is the multicomponent diesel composite fuel produced from the mixing of petroleum diesel fuel and plant oil. [13]

The most studied source of plant raw materials is rape. However, the use of oils from other oilseeds deserves attention. Today, there is a growing need in the Russian Federation for ricin oil in military, chemical, machine-building, radio electronic, printing, paint, medical, cosmetic and other industries. In connection with the current policy on import phase-out and oil demand in the Russian Federation, since the main share of ricinic oil on the market is produced in India. It can be considered that technical ricinic oil is a promising competitor to other plant oils, investigated as components of diesel composite fuel. [14,15,16]

Castor oil plant belongs to the genus of perennial plants of the family of euphorbia. This genus is represented by one species - castor beetle (Ricinus communis), which is subdivided into several subspecies.

In tropical and subtropical countries, castor oil is grown as a perennial or annual culture, in areas with a temperate climate - only as an annual one.

In crop rotation, castor oil plant is placed after winter wheat, winter barley, maize and leguminous plants. The castor oil plant itself is a good precursor for spring cereals.

The cultivar of castor oil plant Khortitskaya 1 is mid-season, plants of medium height, weakly-violet, laid a dense brush at 8-10 knots. Bole height is 50-70 cm. Khortitskaya 1 is highly resistant to fusarium, adapted for mechanized harvesting. Oil content of seeds is 51-52%. The yield is 1.2-1.5 t / ha. [17]

As a result of processing of the castor oil plant fruit by cold pressing, only 10% of the oil remains in the residual meal, which can be recovered by processing the meal using the technology of extraction or processing of fruits by hot pressing to obtain a technical ricinic oil with the possibility of using it as raw material for the production of paintwork materials and diesel composite fuel.

2. *ESTIMATE INDICATORS OF TRACTOR DIESEL ENGINE WORK*

To use diesel composite fuel on the basis of ricinic oil, it is necessary to analyze the influence of the constituent components on the economic, power-cycle characteristics of the diesel engine.

Calculation of the D-240 engine was carried out by the methods of Prokopenko R.M., Khorosh A.I., Bashirova R.M. [9,10,11] using three fuel mixtures: RicO + DO, respectively (mixture 1, mixture 2, mixture 3). The results of the studies are presented in Table No. 2.

Is determined the content of the basic substances included in the composition of ricinic oil by the method of Egazaryants C.B, and is calculated the elementary composition of the mixture, which is determined by the content of C, H, O by the formula Mendeleyev D.I. The results of the studies are presented in Table No. 1 [12].

***Table No. 1** - Elementary composition of mixtures.*

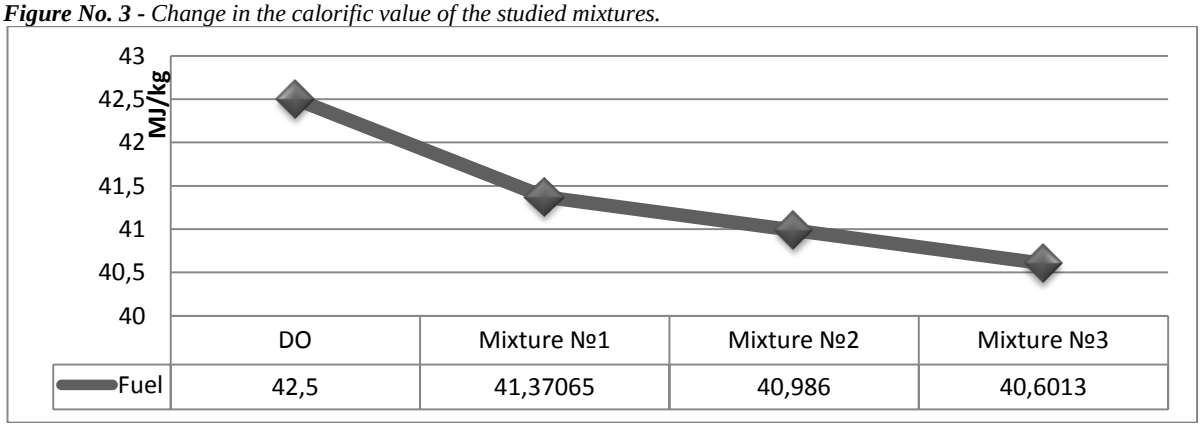
№	Indexes	DO	Mixture 1	Mixture 2	Mixture 3
1.	Carbon C	0,870	0,8495151	0,8426868	0,8358585
2.	Hydrogen H	0,126	0,1239453	0,1232604	0,1225755
3.	Oxygen O	0,004	0,0265396	0,0340528	0,041566

From the obtained data it is possible to single out the primary feature of diesel composite fuel based on ricinic oil, the oxygen content increases which favorably affects the completeness of combustion of the mixture.

***Table No. 2** - Indicators of the working cycle of a diesel engine using mixtures of different concentrations.*

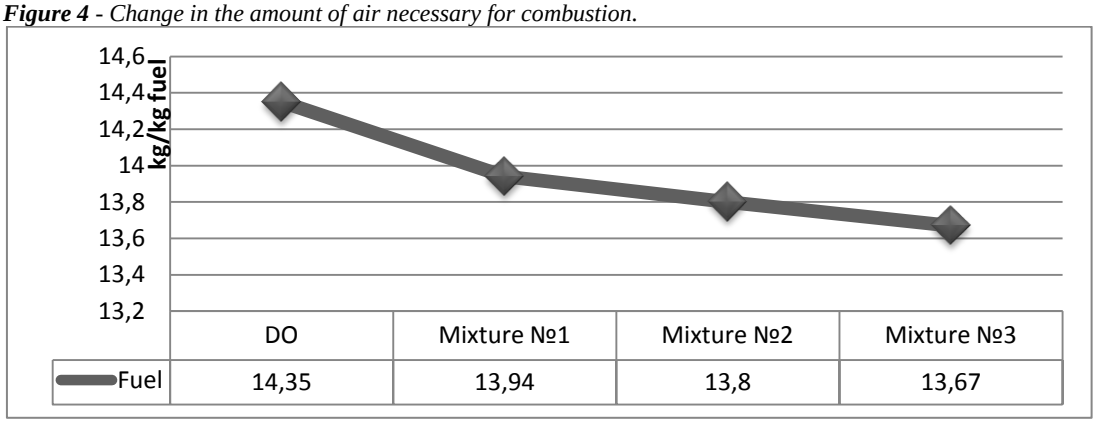
№	Indexes	DO	Mixture 1	Mixture 2	Mixture 3
1	2	3	4	5	6
4.	Heat of fuel combustion, MJ / kg	42,5	41,37065	40,986	40,6013
5.	Theoretical amount of air, kg \ kg of fuel	14.35	13,94	13,80	13,67
6.	Heat of combustion of a inflammable mixture MJ / kg	1.8874	1.8882	1.88876	1.8880
7.	Coefficient of molecular change	1,041	1,04283771	1,04334192	1,043856
8.	Combustion temperature, ^{0}K	2158,0	2168,5	2168	2167,5
9.	Mean effective pressure, MPa	0.7233	0.709635	0.71	0,71035
10.	Effective efficiency	0.363	0,351645	0,3517	0,35174
11.	Effective specific fuel consumption, g \ kW	233,3	247,46	249,74	252,08
12.	Effective power, kW	63,0	61,80	61,83	61,86
13.	Power change,%	-	-1,91	-1,86	-1,81
14.	Change in specific fuel consumption,%	-	+6,07	+7,048	+ 8,05

***Figure No. 3** - Change in the calorific value of the studied mixtures.*



When analyzing the calculations, it is noticed the decrease in the heat of combustion the test mixtures by 2.6% in comparison with diesel fuel. With a change in the oil fraction by 5%, the heat value of combustion changes by an average of 0.93%.

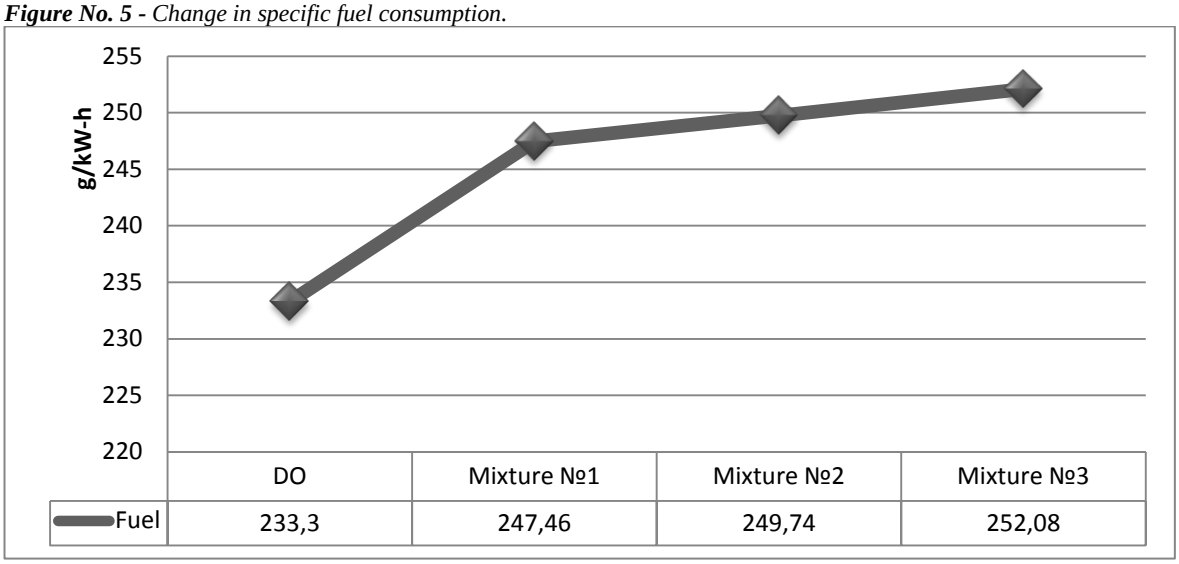
***Figure 4** - Change in the amount of air necessary for combustion.*



When using mixtures based on ricinic oil, is reduced the required amount of air for combustion of the mixture: according to calculations in comparison with diesel fuel, it decreases by 2.86%, with the required amount of air decreasing as the concentration of oil in the mixture increases. This is due to the high oxygen content according to the elemental composition of $C_3H_5O_3$ ($C_{18}H_{33}O_3$) ricinic oil compared to diesel fuel.

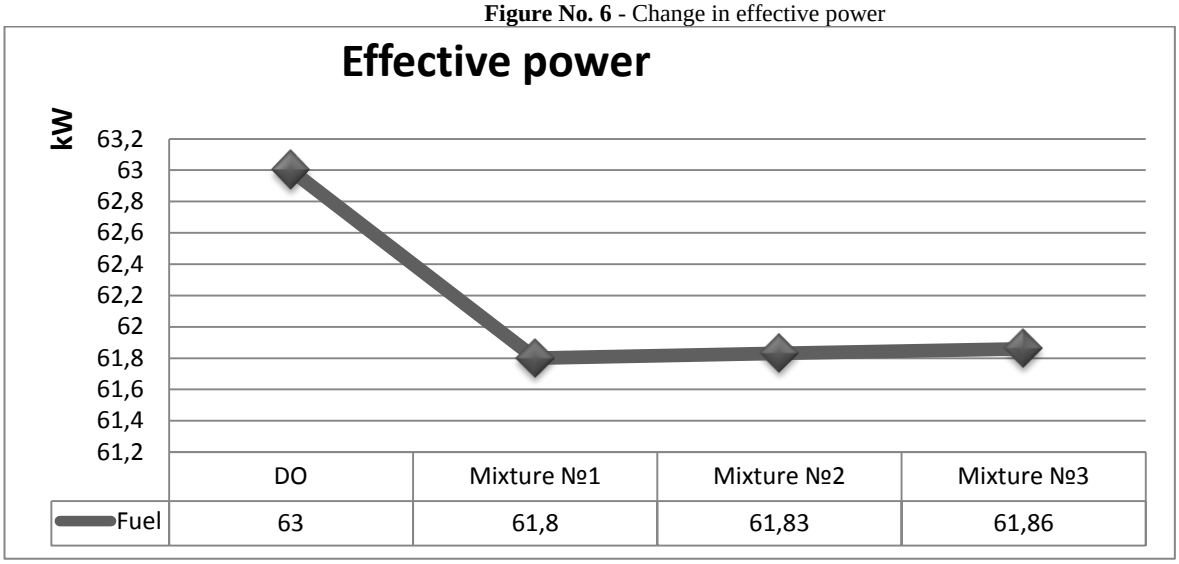
It was found that the heat of combustion of the combustible mixture is relatively small changed, which is associated with a decrease in the number of moles of combustion products. [5.8]

Figure No. 5 *- Change in specific fuel consumption.*



Specific fuel consumption is significantly increased by 6.07% in comparison with diesel fuel, and is revealed regularity: with an increase in the oil concentration for every 5%, the consumption increases by 2.3 g / kWh.

Figure No. 6 - Change in effective power



There is a slight decrease in power compared to the operation of the engine on diesel fuel mixture: an average of 1.86-1.91%, depending on the concentrations of the used components.

3. CAN BE DONE THE FOLLOWING CONCLUSIONS ON THE BASIS OF THE CONDUCTED STUDIES:

1. The required amount of air for combustion of the mixture decreases as increases the concentration of oil in the mixture.

2. There is slight decrease in the power of engine D-240 at 1.86-1.91% when working on diesel composite fuel based on ricinic oil compared to diesel fuel.

3. The economy of the engine deteriorates by 6.07% in comparison with diesel fuel or by an average of 2.3 g / kWh, with an increase in the proportion of oil in the mixture by 5%.

4. CONCLUSION.

Thus, diesel composite fuel based on ricinic oil has the ability to be used on diesel internal combustion engines, according to the calculations, it has similar indicators with mixtures based on rapeseed, mustard, soybean oil.

These studies will be of interest to companies engaged in the production and processing of castor oil in order to reduce fuel costs. But it makes sense to reduce the share of the oil base and increase the environmental friendliness of the ICE to conduct research on the addition of bioethanol.

5. CONFLICT OF INTERESTS.

The author confirms that the presented data do not contain a conflict of interest.

6. GRATITUDES.

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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 "*

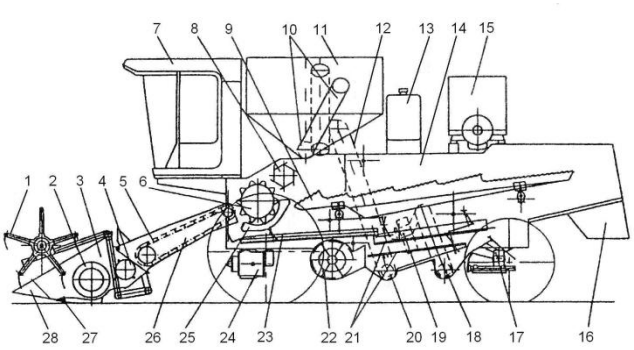


Fig. 1. *Combine harvester*

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/s^2; 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

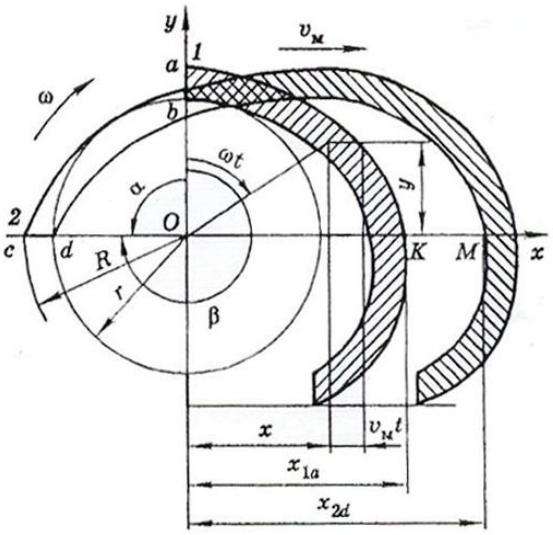


Fig. 2. *Scheme of rotational cutting machine operation*

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.

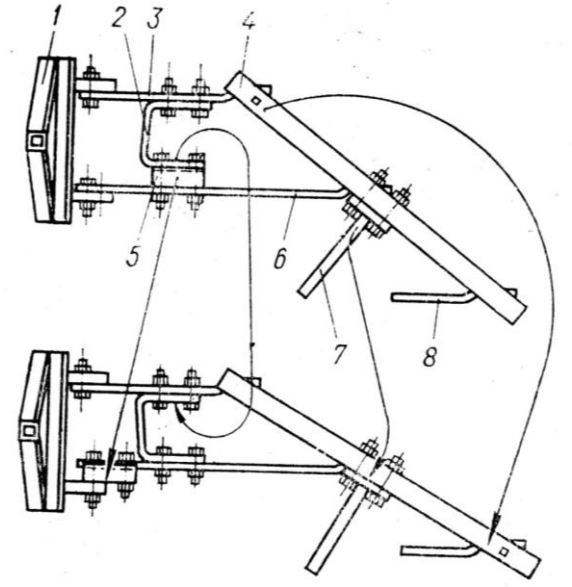


Fig. 3. *Plow rebuilding scheme PTH-3-35 to another width of capture:*
1 − lock autocuff; 2 – stud; 3, 6, 8 − frame frames; 4 − the main beam of the frame; 5 − gasket; 7 − console of a disk knife.

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*).

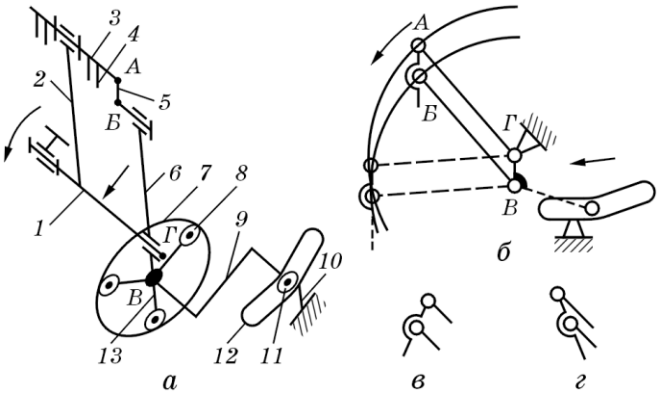


Fig 4. *Eccentric mechanism of the rotor:*

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*:

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

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*:

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

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

Height of the reel H over the cutting unit:

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

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*:

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

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

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

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 $N_{м:}$

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

where *U* – knob 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,

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

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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Healthy soils and advantages of the cover crops

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Abstract: *Cover crops (green manure) brings not only immediate advantages like slowing erosion, suppressing weed growth, improving soil structure, increasing nutrients and water content and hindering some pests but also long term ones like decreasing erosion, air pollution, investment in mineral fertilizers and herbicides and increasing microbiological activity. The paper gives examples of good practices both for whole and row-crop grains. It also suggest a useful crop rotation for a period of five years.*

Keywords: COVER CROPS, IMPROVING SOIL HEATH, REDUCING EXPENSES, CROP ROTATION

1. Introduction

Increasing energy costs will have a profound effect on the economy in the forthcoming years, but at the moment it is hard to predict how fast the energy cost in agriculture will grow. The economy of green (cover) crops is rooted in the dynamics of nitrogen, i.e. how much nitrogen (N) is saved by the farmers as a consequence from its production by the green crops, what the costs, respectively fuel savings, etc.

In general, green crops bring a lot of benefits to the farmers [1,2]. Their main advantages are: delaying the erosion processes, improving soil structure, suppression of weeds, improving availability of nutrients and humidity, aiding pest control. At the same time, they can reduce costs, increase profits and even provide new income sources. The dividends on the investments in cover crops are enjoyed in the course of many years because their advantages grow in the long run.

The farmers should recognise the long term contribution of cover crops to the whole farm structure more and more often. Some of the most successful farmers are those who have seen the benefits and have committed to using cover crops, which work for them. For this purpose they reorganise their systems for soil treatment, in order to adapt better to the needs of the plants.

It is good to remember that every farm has unique structure and needs. There is no simple recipe for achieving the goals of the farmers. Tools for selecting and managing the best crops are sought and found.

2. The benefits of green crops

Green crops can increase the profit even during the first year. They can improve the overall state of the arable land and the whole farm. Moreover, effects that improve the soil accumulate over the years. Additionally, they lead to effects, which can hardly be determined purely financially such as reducing atmosphere pollution, erosion, weeds and pests [3,4,5,6].

Identifying these advantages can help everybody, who wishes to make long term decisions for his/her whole farm. In general, green crops have two main dimensions – ecological and economic.

By using green crops, producers protect their soil resources from erosion, facilitate the fight against weeds, and improve the circulation of nutrients and other useful activities. These considerable benefits differ in different locations and seasons, but at least two or three of them usually manifest themselves with any cover crop, for example:

- Reducing costs for mineral fertilisers. Fertiliser costs are reduced by adding nitrogen to crops, which accumulate it in the soil. Bean crops convert nitrogen from the atmosphere into nitrogen in the soil, which can be used by the plants. Crops grown in the field after bean crops can absorb from 30 to 60 percent of nitrogen (N), produced by them. It is with this percentage that fertilising with mineral nitrogen can be reduced. The value of bean crop nitrogen (N) is the easiest benefit for covering the costs, which can be estimated from both agronomical and economic point of view. This natural introduction into preserving fertility could justify using the cover crop;
- Reducing the need for applying herbicides and other pesticides. Cover crops suppress the development of weeds and reduce harms from diseases, pests and nematodes. Many of the cover crops have an effective impact on weeds by reducing their accessibility to water and nutrients. They provide residue or growing leaf mass, which blocks light, changes the light wave frequency and the surface soil temperature. They are a source of root exudates or compounds, which provide natural herbicide effect.
- Increasing microbiological activity. Through green crops, useful microbial life is ensured, which discourages pathogen microorganisms. For many soil diseases there is unsaturated soil environment. The natural development of useful pests and parasitoids is encouraged, which leads to reducing pest damage below economic thresholds. Compounds are produced, which reduce the nematode population. The development of useful nematodes is encouraged.
- Increasing yields and improving the quality of the production through improving soil health;

Preventing soil erosion; Cover crops improve soil through accelerating the infiltration of excess surface water. The structure of the mulled and degraded soil. Organic substances are synthesised, which encourage the useful microbial life. The circulation of nutrients is increased.

- Preserving moisture in the soil
- Helping to protect the farmers' personal health.

3. Basic principles in selecting green crops

Green (cover) crops provide many advantages but they cannot make wonders if their selection is not proper. The main points to be taken into consideration in their selection are:

- Identifying the current state of soil resources through carrying out the relevant analyses;
- Identifying the best time and place for covering the soil.

Sometimes it is obvious where and when cover crops should be used. The analyses can show that a field where corn will be grown needs nitrogen while the vineyard, which is usually on sloped terrains, needs erosion reduction activities or weed control.

For some purpose like long term soil conservation and improving its structure, it is necessary to apply the proper rotation table (see Fig. 1).

Vetch increases corn yieldy, for no-till grown corn, which is more than enough to cover the costs for its application. Besides, vetch can reduce the economic risk and will usually be more profitable than no-till grown corn after winter wheat.

Red clover, sown in a mix with oaths and vetch, can replace applying mineral nitrogen from 32 to 51 kg N/ha. A study in the USA shows that with two-year crop rotation the average corn yield is over 1.6 tonnes/hectare

Winter peas in combination with vetch and clover, can provide 80 to 100% of the subsequent needs of nitrogen for potato crops, as seen in a study in the North western part of the Atlantic.

Crop/ Field		Year				
		I	*II*	*III*	*IV*	*V*
Wheat	*1*	Wheat + green crop	Sunflower + strip tilling	Barley + green crop	Rapeseed + green crop	Corn + Strip tilling
Corn	*2*	Corn + Strip tilling	Wheat + green crop	Sunflower + strip tilling	Barley + green crop	Rapeseed + green crop
Barley	*3*	Rapeseed + green crop	Corn + Strip tilling	Wheat + green crop	Sunflower + strip tilling	Barley + green crop
Sunflower	*4*	Barley + green crop	Rapeseed + green crop	Corn + Strip tilling	Wheat + green crop	Sunflower + strip tilling
Rapeseed	*5*	Sunflower + strip tilling	Barley + green crop	Rapeseed + green crop	Corn + Strip tilling	Wheat + green crop
Crop/Field						

Fig. 1. *Crop rotation in using green crops*

Cereal-grain crops or grasses are especially good at extracting residue nutrients – especially of nitrogen N from the soil after harvesting. A large part of N is contained in plant residues and self-planters. The grain from the losses plus the plant residues can absorb a considerable part of the nitrogen up to three months after they have entered the soil. This finding can be used for applying cover crops before growing corn, reducing the total nitrogen loss, without causing loss of yield. This fact is confirmed by computer modelling done by USDA-ARS.

When needed, the crop rotation selected can be accompanied by information about rainfall, the periods of last spring and first autumn frosts, as well as other useful information.

One basic principle when using green crops is to look for and cover all periods when the soil is without plant cover and is subject to the effects of weather without any protection. In the case of the crop rotation suggested – 60% of the fields are covered by green crops and 40% undergo strip tilling, where 50 % of the soil surface is covered by plants.

When possible, other kinds of key information is added such as the quantity of rainfall, periods without frost and periods of peak load on labour and material resources.

In general, in each field should be sought free periods, when there are good conditions for creating cover crops.



Fig. 2. *Soil surface with strip tilling*

4. Examples of common niches in some systems for agricultural production

4.1. Winter niche

In many regions, winter crop sowing should finish at least six weeks before temperatures fall and soil freezes. Winter grain crops, rye in particular, are an exception and can be sown a bit later.

Green crops can be sown as second crops immediately after the main (summer) crop is harvested, when the weather is still suitable. In the cooler regions green crops that are tolerant to shading until the main crop has been harvested can be used. Small seed plants like clover do not need much moisture to germinate and they can sprout with small gaps through the remaining plant residues. The larger seeds need a few days of moisture in order to germinate.

When changing the crop rotation ratio with the so called “market oriented crops”, in the beginning of the season, the vigorous growth of the green crops can cause water stress, increase the risk of diseases, caused by lower air circulation in the soil or create new risks of pest attacks. In this case, changing sowing standards and times is recommended. In this way, green crops are “kept” in their development until the moment, when the main crop goes into a technical maturity stage, i.e. the leaves and the stem begin turning yellow. From that moment on the exposure to sunshine starts improving and the green crop continues its development without being affected by the yields of the main crop.

4.2. Summer niche

Many of the crop rotations implemented involve the opportunities and challenges of the crops grown. When two types of crops are grown in the same field and year, there should be an interval of three to eight weeks between the early sown/planted and the late sown/planted crops. Fast developing spring crops require erosion control, weed control, control of organic matter (humus) as well as nitrogen (N). For this purpose, the self-sown plants from the previous crop + fodder peas can be used. In this case it is most convenient to apply strip tilling of the soil for green crops.



Fig. 3. *Strip tilling of the soil for green crops - front view*



Fig. 4. *Strip tilling of the soil for green crops - back view*

Mulching with green crops can facilitate some soil treatments. Bringing the plants down to the soil surface regulates water evaporation, and, respectively, soil's humidity.

White clover can be a good choice when growing sweet corn and tomatoes. Perennial rye grass and other less aggressive grasses can be used for bean crops, tomatoes and other vegetables.

5. Unused benefits

The hedge is one benefit that is not used enough when cultivating agricultural crops. It can replace fences successfully and has a number of advantages such as:

- Suppressing weeds;
- Providing a favourable habitat for regulating biological equilibrium;

It is not possible to use plants yielding fruit, nuts, etc., for building a hedge. For this purpose it is necessary to apply appropriate pruning;

6. Key moments when applying green crops

To manage green crops effectively, it is necessary to answer a few questions:

- How will green crops be planted?
- What will the weather be like at the time of their planting?
- What will the temperature and humidity of the soil be at that time?
- How vital other crops will be in combination with green crops?
- Should the green crop develop more slowly than the main one or be high and grow vigorously?
- At what temperature intervals will it develop?
- Will the low winter temperatures destroy it?
- How will the green crop be destroyed?
- Is there a back-up plan if the green crop creates unforeseen situations such as going out of schedule of cultivation?
- Are there material and labour resources available?

7. Practical tips when choosing the appropriate green crop

After determining the time and place for using the green crops, it is necessary to identify the specific requirements.

7.1. First example

Situation: An orchard located over a sloped terrain.
Needs: Plant cover to reduce soil erosion.
Requirements:

- Introducing nutrients and organic matter, attracting useful organisms;
- Repelling rodents, nematodes or other pests;
- Not using any of the available water and the nutrients in the soil at periods critical for the development of the orchard plants;
- Not creating much nitrogen in the soil, and thus stimulating growth of trees or prevent their hardening during the winter period;
- Being easy to maintain;
- Being available all year round or planted annually;
- Being low-growing and needing minimal attention and care;
- Releasing some nutrients during the year but not too many;
- Having a root system, which enhances the root system of the main crop.

Suggestion: Combination of bean crop – peas + spring wheat or spring barley. Taking the green crop down to the soil surface as a mulching layer.

7.2. Second example

Situation: Wheat to be cultivated before corn. Insufficient rainfall after harvesting the wheat – up to 40 mm.
Needs: Winter cover for soil protection, which can supply nitrogen (N) for corn without losses in the next spring.
Requirements:

- Destroying the green culture before planting the main one, so that the former does not hamper the development of the latter;
- Leaving plant residues on the soil surface, so that they can reduce water evaporation from the soil;
- Leaving enough nitrogen in the soil so that there is no need for introducing additional mineral nitrogen during vegetation;

Suggestions:

- Vetch is good in the northeast, Midwest and partly in the south regions. Mixing it with rye or another grain crop improves its potential for controlling weeds and keeping the moisture.
- Red clover could be an appropriate choice.
- Forage peas could be used alone or in combination with another crop like self-sown wheat, which is a predecessor in this case.
- A very good effect is obtained when using a combination of forage peas + self-sown predecessor + additional introduction of microorganisms to the soil



Fig. 5. *Corn with green crop between the rows*



Fig. 6. *Strip tilling of the soil after wheat*

8. Conclusion

Using green crops has both short-term and long-term benefits for the soil, for the environment as well as for the farmers' expenses. It is important, however, to follow the main principles when choosing an appropriate green crop with the main goal being to provide a constant surface cover of the soil regardless if it is with alive plants of crop residue. It is also important to take into account the previous crop and the biological specifics of the current one in order to find the best possible match between it and the chosen green crop.

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THE USE OF GEOINFORMATION SYSTEMS IN THE DEVELOPMENT OF A FEASIBILITY STUDY FOR SMALL HYDROPOWER PLANTS FOR AGRO-INDUSTRIAL COMPLEXES IN KAZAKHSTAN

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***Abstract**: It shows the urgency of the task of creating a methodological and program base that supports the adoption of pre-project solutions in the placement and justification of the parameters of prospective small hydro power plants in Kazakhstan. The questions of application of the data of geoinformation systems using SRTM DEM and ASTER GDEM in the making of a digital relief model are considered. Moreover, showed the using this application for preparation of the feasibility study for the construction of small hydro power stations. A brief overview of the used geoinformation systems tools is given. The deviation of proposed methods for making topographic maps was studied using the example of calculating the volume of the reservoir on the Baskan river in the Almaty region.*

KEYWORDS: SMALL HYDROPOWER PLANT; AGRO-INDUSTRIAL COMPLEX (AIC); WATER-ENERGY POTENTIAL; GEOINFORMATION SYSTEMS; FEASIBILITY STUDY, WATER RESERVOIR.

1. Introduction

Currently, the dependence of the agricultural sector on hydrocarbon fuel limits the ability to meet the demand for food in the region and in the country as a whole. For agricultural producers there is another serious problem related to the reliability of supply of electricity.

Kazakhstan's national electricity system is characterized by uneven concentration of generating capacity in the North and location of energy-deficient areas in the South, which combined with a large territory of the Republic led to long power lines. In Kazakhstan, many rural settlements do not have access to centralized electricity because of their remoteness or power lines that have reached their end of life. A large length of the distribution grid leads to a significant loss of 20-30% of electricity, in consequence of this there is a rise in the cost of electricity supply, as a result of which the supply of electricity to small energy consumers becomes a loss-making process. All of the above leads to the economic inexpediency of the construction or restoration of dilapidated long power lines.

The prospects and relevance of the use of renewable energy resources for the supply of remote rural consumers are noted today by both domestic and foreign experts in the field of electricity and heat supply. The energy strategy of Kazakhstan for the period up to 2020 provides for the replacement of 20 million tons of conventional fuel of traditional energy sources by renewable energy sources. The main priorities for the transition to a "green economy" facing the Republic of Kazakhstan are [1]: improving the efficiency of the use of resources (water, land, biological, etc.) and their management; improving national security, including water.

In accordance with the Concept of all sectoral and regional Programs must be reviewed for compliance with the principles of "green economy", which includes: increasing resource productivity: resource productivity (defined as GDP per unit of water, land, energy resources, unit of greenhouse gas emissions, etc.) should become the central economic indicator since this parameter evaluates the country's ability to create value by minimizing the load on the environment.

Another important problem for agricultural producers is a reliable irrigation system with the possibility of regulating the irrigation regime of crops throughout the season. The Eastern and Southern regions of Kazakhstan are rich in small rivers without sufficient irrigation systems. There are also a number of problems associated with the poor technical condition of existing reservoirs of water and irrigation value, insufficient automation of processes in monitoring and accounting of hydropower and water resources of the country. And therefore, the widespread use of renewable energy sources and information systems in agro-industrial complexes (AIC) is one of the ways to reduce the cost of final agricultural products.

One of the solutions may be the use of dam small hydropower plants (SHP) with a reservoir using undeveloped hydro potential of small rivers of Kazakhstan, which has strategic importance for AIC as a source of reliable electricity and a water reservoir for irrigation of various crops. SHP has several advantages compared to large hydro: lower absolute capital costs, shorter investment cycle and a shorter period of commissioning; environmental impact of less global. The construction of SHP is a whole complex for solving various issues.

2. Preconditions and means for resolving the problem

In the design of SHP, naturally there is a problem of choosing the optimal parameters of the project. The main requirements for the small hydropower project are contained in [2], section 5.1.3 "Scientific justification of hydropower facilities at the stage of investment justification»:

1) selection of the location of the hydropower facility;
2) determination of the energy parameters of the object (head, capacity, taking into account the work in the power system, the preliminary parameters of the reservoir);
3) preliminary justification of the layout of the elements of the hydroelectric system, taking into account the hydroelectric parameters and environmental consequences;
4) justification of the type and quantity of hydropower equipment.

This paper considers the solution of the problem associated with the definition of the preliminary energy parameters of the reservoir. For the design of SHP with a reservoir on small rivers requires the analysis of the terrain, water regime of the river, landscape features of the area to take into account all geographical, economic and social indicators and requires financial and time costs. Traditional methods require the consideration of a large number of physical, geographical and socio-economic factors and require the consideration of human and time resources. For this, it is necessary to provide field geodetic expeditions to area and engage in topographic work for the water-energy potential (WEP) of each proposed basin for the reservoir, which requires time and finance. Topographers use various means, but recently more often use gps-receivers, to obtain a base point from which further surveying of the terrain takes place. For more accurate results, gps-receivers require clear, rain-free weather and a time-based signal from a large number of satellites that will be located above the area at the time of shooting.

For preliminary feasibility studies, in particular, small finances are spent and made in a short time, which create inconvenience. Thus, the actual task is to create a mathematical model that uses the existing base of the Kazakhstan WEP with the possibility of making adjustments based on the results of new studies, conducting an equilateral analysis in the feasibility study of the construction of SHP in Kazakhstan. The mathematical model should analyze the different layout of the hydroelectric power station taking into account the choice of electromechanical, hydraulic equipment and facilities, and their technical parameters. One of the blocks should simulate the operation mode of the reservoir taking into account its parameters.

As described above, topographical data are needed to determine the parameters of the reservoir, which can be obtained using geoinformation systems (GIS). The main advantage of GIS is

currently available to all databases on space earth sensing. This information is constantly updated and updated with adjustments. With the help of a digital elevation model and climate information, it is possible to perform hydrological calculations, try different variants of hydroelectric power station location. The construction of a three-dimensional terrain model on the matrix of heights does not require a long preliminary preparation of materials. In a simple description for mathematical and cartographic modeling of the surface of the repeating relief form, a set of point elements containing information about the spatial position (x, y, z) of the object is needed; in some cases (the use of photogrammetric methods of construction), the initial data can serve as a pair of images forming a stereo pair, etc. [3]. Further processing is carried out using GIS tools.

The review of modern software based on GIS systems for solving problems of finding WEP is presented in [4]. The described works were carried out in different countries and, in general, were optimized and took into account the peculiarities of only those regions in which they were modeled. Also, one example of the use of comprehensive analysis in GIS systems to determine the optimal location for SHP is the work, which results are described in the report [5]. Different factors such as proximity to power lines, supply facilities, roads, and environmental impacts were taken into account in the choice of location. The disadvantage of this work lies in the fact that there is only a diversion hydropower plant. In the next work [6], the above-described factors were also taken into account in the modeling of a SHP, but the reservoir was already taken into account. Engineering and economic-social factors affecting the location of small hydropower plants were considered in [7]. The above works are based on paid software products and require manual entry or update of databases to enter information for the new region.

Currently existing paid software automates the necessary calculations for the analysis of WEP of rivers, but does not allow for a comprehensive analysis with a feasibility study, the lack of a database of rivers of Kazakhstan deprives the possibility of mathematical modeling of the modes of operation of Kazakhstan small hydropower plants.

3. Analysis of the deviation of GIS survey results

The known open databases on space probing, for example, are:

ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) GDEM data base. Is a joint product of NASA and the Ministry of economy, trade and industry of Japan (METI), ASTER has a very good 30-meter coverage all over the world [8].

SRTM (Shuttle Radar Topography Mission) DEM database international mission to obtain digital elevation model (DEM) data for the Earth's territory. Filming of the area was made in February 2000 from the space Shuttle using a radar interferometric camera and two radar sensors SIR-C and X-SAR installed on board the ship [9]. It has a resolution of both 90 and 30 meters of land cover.

According to estimates Karwel and Ewiak [10] SRTM matrix has error, which averages to the plains of 2.9 m and 5.4 m for hilly terrain, a significant portion of the data includes systematic error. The Russian company "RAKURS" [11] also conducted research on the accuracy of the matrix SRTM and ASTER, in order to clarify the possibilities of its use in the manufacture of digital orthophotos, which resulted in its own data on the systematic errors of this matrix, which led to the accounting of systematic errors increases the accuracy of the matrix SRTM and ASTER.

Experimental studies of the accuracy of topographic GIS data, namely SRTM DEM version 3 and ASTER GDEM version 2, were carried out by comparison with the results obtained by traditional topographic survey.

As an object for study was chosen village Ekiasha on the Baskan river in Almaty region. Near the village of Ekiasha there are agricultural fields, for which a reservoir for irrigation and a small hydroelectric power station is designed. It was calculated that the optimal solution for the dam will be a earthfill dam with a height of 50 meters and a construction tunnel with a length of 400 meters as a pressure water pipe after construction. The location of the SHP is planned to be installed after the dam. This comprehensive solution covers the needs of the local population in electricity and water supply for agriculture.

To obtain the WEP of the reservoir, it is necessary to calculate the volume of water in the reservoir and its dependence on the height. On the basis of this dependence, the calculation of the modes of operation of a SHP.

According to SRTM DEM and ASTER GDEM, the heights to the given points were obtained, and with their help, high-altitude contours for the reservoir on the Baskan river were created. Each contours are closed by the body of the proposed dam and give the surface area. The volume of the reservoir is calculated by successively summing the volumes of individual layers enclosed between two adjacent contours. The total volume of the reservoir V is equal to [12]:

$$V = \sum_{1}^{n} \Delta V_{(i-(i+1))} = \sum_{1}^{n} \frac{1}{2}(F_i + F_{i+1})\Delta h_{(i-(i+1))}, \quad (1)$$

where F_i and F_{i+1} – the surface areas at two adjacent levels H_i and H_{i+1};

$\Delta h_{(1-2)}$ - the height of the layer of water between the levels H_i and H_{i+1}

n - the number of layers.

Figure 1 shows an example of the work done on the Baskan river, a digital model of the reservoir relief was simulated based on the SRTM version 3 matrix.

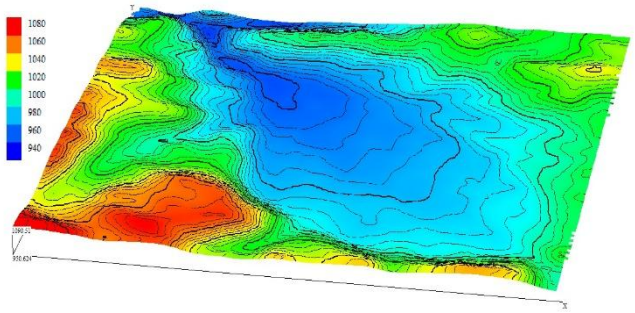


Figure-1 *DEM of the reservoir*

Figure 2 shows a comparison of the curves of dependence on the height to the volume of water in the reservoir obtained using SRTM DEM, ASTER GDEM and base. The base here is the data obtained from the field topographic works in the area.

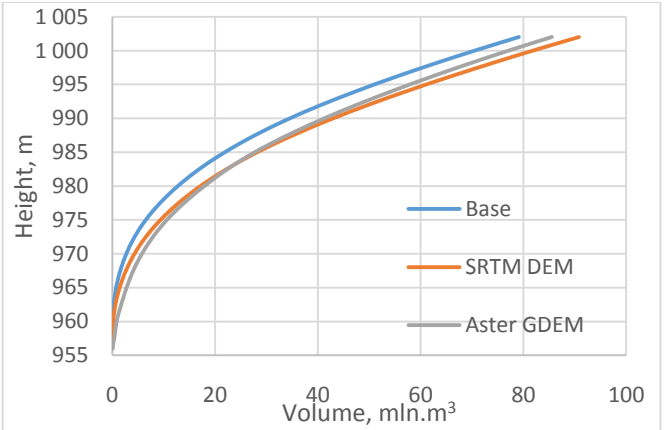


Figure 2. *Curves of dependence from height on volume*

The deviation of SRTM data from the field topographic survey on the surface area at the level of 1002 meters is 4.08%, and the total volume of water at 12.84%. Deviation of the ASTER data with field topographic survey in the area of the mirror at the level of 1002 meters is equal to 1.89%, and the total water volume by

7.47%. Studies have shown [13] that the model of satellite data SRTM and ASTER has deviations at which the dependence of positive and negative deviations from the coverage of the territory by tree and shrub vegetation is observed, namely: the main percentage of negative deviations is located in the forests, which indicates a poor-quality correction of DEM for the height of the tree cover. At the same time, in open areas DEM has positive deviations of 3 − 4 meters. The previously described systematic error in the SRTM data was found when comparing all altitude levels and was equal to an average of 2 meters. Which corresponds to the local vegetation as in this area growing shrubs growth of 1-2 meters.

Figure 3 shows the dependence curves with a systematic error of 2 meters. What led to the following changes: SRTM deviations decreased in the mirror area to 0.06%, and the volume of water to 3.33%; ASTER deviations decreased to 0.13%, and the volume of water to 2.35%. It was also found that the area of small mirrors had a higher error rate even with the adjustment. At a height of 970 meters, the area of the small mirror had deviations of 9.17% and the volume of water by 7.41%. The area of small mirrors is closer to the gorge and has a hillier terrain, which increases the accuracy of satellite imagery as described earlier.

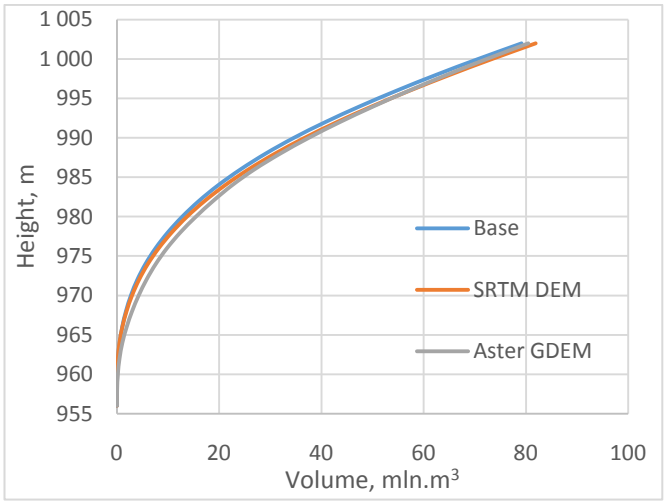


Figure-3. *Curves of dependence from height on volume (corrected)*

Further work should include a comparison of SRTM DEM and ASTER GDEM in the Eastern regions to identify more accurate matrices for each defined area. And to collect in one single database the water-energy cadaster and hydrological yearbooks of Kazakhstan to address the regulation of small hydroelectric power during the year given the full-flowing and low-water years.

5. Conclusion

Analysis of data from satellite surveys of SRTM DEM and ASTER GDEM showed the possibility of using GIS in the forecast of water-energy potential of rivers for small hydropower plants. A comparative analysis of the results of determining the volume of the reservoir using satellite data and topographic survey results on the example of the reservoir on the Baskan river in the Almaty region showed a satisfactory proportion of differences. The source and level of deviation, the value and methods of adjustment to improve the accuracy of indicators is determined. The resulting accuracy after the adjustment is within the limits of error at the stage of preliminary feasibility study.

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RENEWABLE ENERGY STORAGE METHODS

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Absctract: : *Renewable energy has been demanding in recent years and work on it has increased, but it does not have the potential to meet the required energy level. Energy can only meet high demand when it is used more efficiently and when correct conversions are made. The correct and economical use of energy can only be achieved by storing energy. There are many problems such as the situations where the resources are present and insufficient, the unbalance of the production consumption and the supply demand balance are prevented by storing energy. There are many ways of storing energy. When we examine these under 4 headings; electrical energy storage, mechanical energy storage, thermal energy storage and chemical energy storage.*

Keywords: RENEWABLE ENERGY, ENERGY STORAGE, FOSSİL FUEL

1.Introduction

Energy is an indispensable requirement of mankind as a sign of economic and social development. Rapidly increasing industry and population, and the desire to live in the city are increasing energy consumption. Fossil energy sources and reserves have gradually decreased while the need for electricity has increased. Heavily used fossil fuels have caused many demage to the environment, such as global warming, ozone depletion, acid rain. It is known that in the coming years fossil fuels will meet the needs of today's energy needs and will have a final reserve. In recent years, people have turned to Renewable energy sources. Since Renewable energy sources are sustainable the use of Renewable energy has been increasing in recent years. Being harmless to the environment and being an unlimited source of energy has made it possible for Renewable energy source of energy source to be indispensable when energy is now available. Considering the state of renewable energy in Turkey it is seen rather as having a high potential.

At the end of industrial activities, atmospheric emissions of about 20 billion tons of carbon dioxide, 100 million tons of sulfur compounds, 2 million tons of lead and other toxic chemical compounds are released. Global warming is one of the most talked-about topics in recent times by people from all walks of life. Global warming's impact on the earth's crust, as we all know, results in warming of our earth, diminution of the thickness of the glaciers, increase in sea level, heavy precipitation and drought. As a result of these effects, some regions of the world are flooded and settlements will be flooded, and in some regions water wars between people will occur due to drought. Since renewable energy sources are sustainable, the use of renewable energy has been increasing in recent years. Being harmless to the environment and being an unlimited source of energy has made it possible to make renewable energy source indispensable when it is getting energy. Renewable energy sources come up against many areas of the public. As the use of energy is mentioned, the fields of use are also very broad.

Energy recovery from renewable energy sources is not sufficient to cope with increased energy demand. The work done in recent years has been increasing, and as a result of these studies it has become clear that energy should be used more efficiently. Renewable energy sources are being utilized in every way, but the ever-increasing population, industrialization and energy need are increasing day by day. Energy is only used when it is used efficiently and when the correct transformations are made.

Despite the increased work on renewable energy today, much of the energy is still met by fossil fuels. And the huge use of conventional energy consumes reserves quickly. The unbalance of the production consumption balance, the supply demand balance, the saving of energy and the storage of the energy (Turan, 2016).

2.Renewable Energy

The first oil crisis that broke out in 1973 led to the understanding of the world of energy as a whole. After the oil crisis, countries have begun to look for energy sources and renewable energy sources have become important. By 2000, the speed of energy search increased and renewable energy sources started to be used more. Renewable energy can be defined as an energy that takes its natural self-renewing power from nature. Although the potential and the potential of renewable energy sources are very high, when we look at the energy consumed in the world, the first place is oil, followed by coal and natural gas. The increase in demand for energy also affects the external dependency in the same way. Turkey has been using underground and aboveground resources and continuing until the end of the year outside energy needs were met. Meeting the energy requirement in this way creates big problems in paying the import energy bill. These emerging problems are raising the risk of energy security. In the name of renewing energy, this work has been increasing in recent years in order to overcome this risk and to end the dependence on foreign countries (Onal and Yarbay, 2010).

Yenilenebilir enerjide gelişmelerin artması için yasal düzenlenmelerin güncellenmesi ve hidroelektrik dışında diğer kaynaklar içinde teşviklerin artması gerekmektedir (WWF, 2011).

Source	Installed power potential
Hydraulic	47.497 MW/Year 164.000 GWh/Year
Wind	48.000 MW/Year
Geothermal	Electricity 610 MW/Year Heat 31.500 MW/Year
Biomass	Electricity 2,6 Mtep Heat 6 Mtep
Sun	56.000 MW/Year 380.000 GWh/Year

Turkey share of electricity production from renewable energy generally provided from hydroelectric. Hydroelectricity covers 98 percent of renewable energy share in our country. Energy is a developmental indicator for countries.
electricity from renewable energy to Turkey is planned to be an important part of the production must rise above the 30 percent global vision and should take appropriate steps in.

2.1.Renewable Energy Source

Solar Energy

Solar energy is explained by the radiation generated by the helium transformation of hydrogen gas in the solar core. Solar energy is mainly based on the position on Earth's surface, the date, and the time within the day. These factors can determine the maximum level of radiation. Height from sea level, water vapor in the atmosphere, or other factors such as pollutants and cloud cover reduce the maximum possible level of radiation. Work on utilizing solar energy has gained momentum, especially since the 1970s, and solar energy systems have advanced technologically. Costs have fallen and are considered to be an environmentally clean energy source (Onal and Yarbay, 2010).

One of the most widespread renewable energy sources on the planet is solar energy. Solar energy is used in many applications. The most interesting ones are low cost solar furnaces, water and space heaters, photovoltaic batteries.

Wind Power

The effect of forces that are caused by different warming and cooling on the earth is called the wind movement. The basic source of the wind is the sun. Winds are formed as a result of physical events created by different temperature distributions (Akınsal, 2009).
Wind is the most economical of today's renewable energy technologies. Although it is economical among renewable energy sources, it is not at the level that meets the energy need. However, current high energy areas increase the possibility of competing with demand.

Hydraulic Energy

Hydraulic energy is a type of energy provided by the conversion of the potential energy of water into kinetic energy. When the water falls from the upper levels to the lower levels, an energy is generated. This ensures that the resulting energy returns the turbines and produces electrical energy. The hydraulic potential depends on the precipitation regime.

Hydropower plants that utilize hydraulic energy to generate electricity have been established. Hydroelectric power plants have the lowest operating costs, the longest operating life and the highest yields when compared to other types of production(Özkaya, 2016).

Geothermal Energy

It is derived from the geo which means earth and the thermal words which means heat. Geothermal can be defined as hot water, steam and gas, with various chemical content, brought to the heat by the accumulated heat at the deep points of the earth's crust. Geothermal energy refers to the energy obtained from geothermal sources or from the direct or indirect routes that they generate. Geothermal energy is a new, renewable, sustainable, inexhaustible, inexpensive, reliable, environmentally friendly, domestic and green primary energy source. Hot dry irregular rocks with no fluid in them are among the geothermal energy sources.

Hydrogen Energy

Hydrogen is an energy system that can be locally produced, transported everywhere easily and safely, with little energy loss during transport, warmed by means of transportation, and benefited from every area, from industrial to kitchens. Hydrogen is a fuel suitable for direct use in internal combustion engines as well as flameless combustion on catalytic surfaces. However, development in the world is fuel-pile technology, where hydrogen is used as fuel.

Wave Energy

Renewable energies of sea origin; sea wave energy, tidal energy, sea temperature gradient energy, sea salinity gradient energy, sea current energy and sea surface evaporation energy. It is not possible to convert sea temperature gradient energy, sea salinity gradient energy, sea current energy and sea surface evaporation energy economically to electrical energy when considering the contribution of environmental factors and turbines together. The wave energy, which is defined as a recurrent source of natural energy, can be expressed as the great power that emerges between the Archimedes principle and gravity. On the assumption that energy consumption will increase significantly in the coming centuries all over the world, countries that are conscious of the damages they have caused to collective and environmental impacts of traditional energy-harvesting methods currently in use have opened the energy sectors to major renewals and developments and have seen renewable energy as the most appropriate solution (Mert, 2012).

Tidal Energy

The tidal energy is called the motion of the waves in the seas with the moon's gravitational force. The tidal phenomenon is the result of the interaction between the moon, the sun, and the centrifugal forces of the Earth's gravitational forces. With the tide, the fluctuations in the seas reach very high levels. With these waves, tidal energy comes to the water. It is possible to generate electricity from the seas with the tidal energy. Tidal energy is one of the types of wave energy.

Biomass Energy

Biomass refers to matter produced from living organisms in a very broad sense. For example, wood, agricultural wastes (straw, corn cobs, cotton wastes etc.), city sewage wastes, industrial organic wastes (black liquor in paper industry, sugar industry pulp)
Traditionally biomass is already known as an energy source for several thousand years. For example, the heat energy obtained by direct burning of wood is already used in cooking and heating. The modern use of biomass in the 21st century involves the conversion of fuel intensity to increased fuel intensity.

3.Renewable Energy Storage Methods

Renewable energy has been demanding in recent years and work on it has increased, but it does not have the potential to meet the required energy level. Energy can only meet high demand when it is used more efficiently and when correct conversions are made. The correct and economical use of energy can only be achieved by storing energy. There are many problems such as the situations where the resources are present and insufficient, the unbalance of the production consumption and the supply demand balance are prevented by storing energy. There are many ways of storing energy. When we examine these under 4 headings; electrical energy storage, mechanical energy storage, thermal energy storage and chemical energy storage.

Electrical Energy Storage (Lithium-Ion Batteries, Nickel-Cadmium Batteries,Lead-Acid Batteries, Nickel Metal Hydride Batteries, Ultra Capacitors)
Mechanical Energy Storage (Pump Stored Hydroelectric Systems, Compressed Air Storage Electrical Systems, Flywheel)
Thermal Energy Storage (Thermal Energy Storage on the Akifer, Energy Storage in Underground Waters)
Chemical Energy Storage (Storage in Hydrogen Metal Hydrate)

3.1 Electrical Energy Storage

Lithium-Ion Batteries

Some kind of refillable pills.
It has storage efficiency close to 100%.
Phones, music players, for example.



As the industrial use of energy is at the forefront, the investment made in lithium ion pile is getting stronger and importance given to new developments is increasing day by day. For this reason, the general characteristics of the currently used batteries are being altered, aiming to produce higher-yielding batteries, and the work done is becoming more and more powerful. Lithium is the lightest metal that can swim in hydrocarbon oil (Akın, 2015).

Lead-Acid Batteries

It has a reloadable feature. Its performance decreases at high and low temperatures. They have low energies.

Examples of uses include solar panels and wind turbines.



Lead-acid batteries are an old and widespread technology used in many applications. Lead-acid batteries use lead in the negatively charged electrode, lead dioxide (PbO2) in the positively charged electrode, and sulfuric acid (H2SO4) as the electrolyte. This battery technology has significant advantages such as high discharge current, low self-discharge, lack of memory effect and cheapness. However, this battery has low nominal voltage and energy density. Also when they are not used battery life is decreasing.

Nickel-Cadmium Batteries

High energy densities have long cycle life. The only problem is that the recycling of cadmium is difficult.

Examples of drills, hand tools.



Nickel Metal Hydride Batteries

Storage capacity is very high. However, these batteries can not be used at full capacity if they are charged before fully discharged. They can be used in cameras and toys.

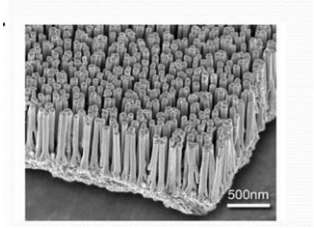


Nickel metal hydride battery technology has been developed as an alternative to the disadvantages of nickel cadmium batteries. Metal hydrate is used instead of cadmium electrode. Nickel metal hydrate batteries have higher energy density while the nominal voltage values are equal. Nickel metal hydride batteries, however, have a higher self-discharge rate than nickel cadmium batteries and lower reliability in case of overcharging (Kükrer, 2010).

Ultra Capacitors

Electrochemical consists of many electrons on a double layer structure. Electrodes increase surface area and capacitance.

They can be used on electric vehicles.

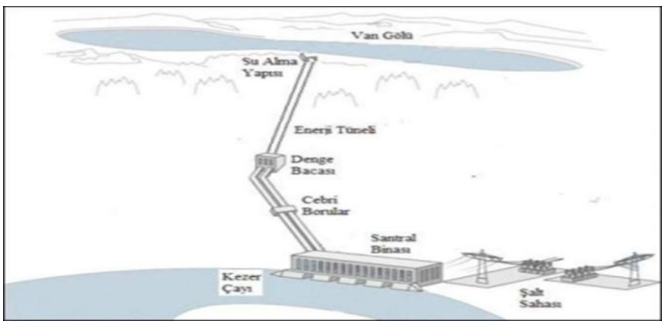




3.2 Mechanical Energy Storage

Pump Stored Hydroelectric Systems

It is a system that also poles in a pool of water at high times when the power demand is low. Electric energy is stored as potential energy in the water.



Compressed Air Storage Electrical Systems

The compressors installed next to the energy generating structures compress the air and send the big caves underground and store them there.

If necessary, the energy generated in the cave is transferred to the generators.

Flywheel

The flywheel system stores its energy with the inertia provided by the rotor rotating at high speed.
They can be used in hybrid systems

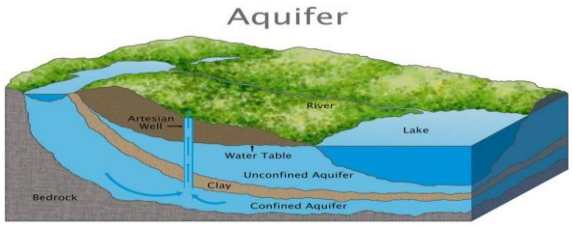


3.3 Thermal Energy Storage

Thermal Energy Storage on the Akifer

Storing warmed groundwater by feedback in the aquifer is the end result.

Houses are a good way to heat schools.



Energy Storage in Underground Waters

The pipes are placed underground by drilling and the energy is stored by passing the fluid.

Utilizing pipelines, energy is utilized.

3.4 Chemical Energy Storage

Storage in Hydrogen Metal Hydrate

It is based on the principle of using alloys capable of absorbing and retaining large amounts of hydrogen.



Hydrogen can be converted to electricity with a high efficiency in fuel cells. Another fuel used in fuel tanks is methanol, which is cheaper, easier to store, and occupies less volume than liquid hydrogen for today. Methanol can be used directly in fuel tanks. Because of the slow oxidation reaction of methanol, the fuel efficiency of these fuel cells is low today. Methanol oxidation is the fastest way to prepare cheap electrode material with catalytic surface (Solmaz, 2009).

Table 2. Comparison of characteristics of large-scale energy storage systems

STORAGE METHOD	FLYWHEEL	HYDROELECTRICS TORAGE	PRESSURIZED AIR STORAGE	SUPER CAPACITOR
INVESTMENT COST/MW	25.000.000 $	7.000 $	2.000 $	28.000.000 $
WEIGHT/MWH	3.000 kg	-	2.5 kg	10.000 kg
YIELD	0.93	0.8	0.85	0.95
MAINTENANCE COST	4 $	4 $	3 $	5 $
CAPACITY	750 kWh	22.000 kWh	2.400 kWh	0.5 kWh
ECONOMIC LIFE	20 Years	40 Years	30 Years	40 Years

4.Results

The definition of storage in electricity production has a wide range of samples from compressed air, molten salts, pumped plants to chemical pills. In fact, electrical storage or battery systems are older than electrical systems. The history of batteries from electrical storage systems dates back to the early 1800s. In this article, the storage systems that are covered by electrical storage are battery systems. Despite warehouse stocks in all known commodity markets, the non-storage of electricity is regarded as the norm, and the electric storage systems are evaluated within new technology or future predictions. The most important reason why electricity storage is costly is that electricity requires an electric field. Since the electric field can not be stored like light, the conditions that make up the electric field are being tried to be reconstructed. At the point we come to today, the use of electricity in all types of energy, increasing renewable production and falling costs and electricity storage are all on the agenda. Electricity storage is not an energy source that starts from scratch. Lap of cell phones, electricity and power management are already an important part of consumer products. If electricity storage is not economical, looking at cell phones and lap-tops is enough to disprove this thesis. Because in our daily lives, storage systems have a very important place. More battery life is an important parameter of everyday "online" life. Because the capacity and efficiency of the battery life / electrical storage system provides great comfort.

The search for alternative energy is under way in conditions that global warming and the use of fossil energy resources are in the process of being exhausted. As the need for the use of environmentally friendly energy sources increases, research activities on new energy sources are increasing day by day. The advantages of using clean energy sources are complete independence from any energy source, security against natural disasters,

the diversification of the energy source and the elimination of central energy production. With the widespread use of alternative energy sources, a more varied worldview will dominate everyday life. Unlimited and irresponsible energy consumption will take the place of conscious, respectful to the environment and energy use to meet the needs.

Our country is more fortunate than many countries in terms of sunshine durations throughout the year. This allows for the generation of electricity using solar energy in Turkey. Turkey, in order to evaluate the potential of this great solar energy to give importance to scientific studies on this subject and budget allocation is required. First, it can be started by attaching importance to micro dimension. Houses and other organizations should be encouraged to use solar energy to obtain hot water. Considering the duration of the sunshine of the Mediterranean region, large-scale projects, especially the Mediterranean region, should be prepared.

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EVAPOTRANSPIRATION AND BIOPHYSICAL COEFFICIENTS OF LONG-FRUIT CUCUMBERS GROWN IN PLASTIC GREENHOUSES IN DRIP IRRIGATION CONDITIONS

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Summary: *The evapotranspiration of Gergana long-fruit cucumbers was established in four years of field experimentation with drip irrigation, grown in greenhouse conditions on chromic luvisol soil in the Sofia region. Different irrigation regimes have been tested - from full satisfaction of the daily needs of the culture from water to irrigation with 20% and 40% reduced water application rates.*
The total evapotranspiration values for the study period were determined.
For the needs of practice and design, the ten-day values of the biophysical coefficient Z are calculated, which depends on the biological characteristics of the crop and the weather factors. On the basis of the established relationship between evapotranspiration and evaporation, the values of the coefficient of crop in unheated plastic greenhouses are calculated as the average for the cucumber vegetation curve Ki = 1.46.
KEY WORDS: *EVAPOTRANSPIRATION, EVAPORATION, BIOPHYSICAL COEFFICIENTS, CUCUMBERS, IRRIGATION RATE, DRIP IRRIGATION, BIOPHYSICAL COEFFICIENTS.*

The optimization of the irrigation regime is one of the most important factors for the efficient use of water to obtain sustainable yields from agricultural crops. This is related to the knowledge of its elements and, above all, to evapotranspiration (ET). According to (Lamm, 1977), the major part of the water consumption of greenhouse vegetable crops is evapotranspiration, the values of which are proportional to relative humidity in the range of 60-100% of MOP.

Little and insufficient are the studies to establish the evapotranspiration of vegetable cultures grown in greenhouse conditions. In the cultivation of pepper in drip irrigation in unheated greenhouses in the Sofia region, the ET reached 668 mm (Kireva, 1989) and in the region of Plovdiv up to 554 mm (Basitov, 2006). For greenhouse tomatoes, ET reached 373 mm (Abobamera, 1992).

The aim of the research is to determine the size of the evapotranspiration and the values of the biophysical coefficients of long cucumbers grown under greenhouse conditions with drip irrigation in the Sofia field.

Materials and method

To establish the evapotranspiration of long-fruit cucumbers during the period 2002-2004 a field experiment was conducted in plastic unheated greenhouses at the experimental field of the Pushkarov Institute in Chelopechene, Sofia

The following irrigation options have been tested:

- Option 1 irrigation with 100% water application rate
- Option 2 irrigation option with 80% water application rate
- Option 3 irrigation with 60% water application rate

The size of the water application rate is calculated using the formula by (Frecman and Garzoli, 1980). To monitor the dynamics of soil moisture soil samples were taken in variant 2 (100% w.a.r.) at a depth of 0-50 cm over 10 cm, which were processed by the weight-thermostatic method. On the basis of data on soil moisture dynamics during the vegetation period, the irrigation water drainage carried out has established the evapotranspiration (ET) of long-lasting cucumbers in ten days and in general for the vegetation period. On this basis the values of the biophysical coefficients z and $k_б$ are calculated. The relationship between crop's evapotranspiration and meteorological factors - air temperature and daylight hours for every ten days in% during the year. The limit values of the individual elements of the irrigation regime of long-lasting cucumbers are established experimentally.

The values of the biophysical coefficients z and $k_б$ needed to determine the evapotranspiration (Delibaltov, Hristov, Tsonev, 1969) and (Blanney, Criddle, 1962) were calculated using the formulas:

$$ET = Z.\sum t,$$

$$Z = \frac{ET}{\sum t}$$

Where: ET is evaprtransporation in mm;

$\sum t$ – the 10 - day sum of the average daily air temperatures in °C;

Z – the biophysical factor determined for each crop according to the final temperature sum of the period.

$$ET = K_b.p.\frac{45,7.t+813}{100} \quad (1)$$

Where: $K_b = \frac{ET}{p.\frac{45,7.t+813}{100}}$ is the biophysical coefficient; (2)

p – the length of daylight hours for each ten-day period in% during the year;

t - the average ten-day air temperature in ° C during the period considered.

Coefficient of the crop – Ki (3)

$$Ki = \frac{ET}{Eo},$$

Where: Eo is the evaporation of a free water surface (evaporation) in a "A" evaporator in mm.

The soil of the experimental field of the Pushkarov Institute is a chromic luvisol, slightly sandy clayey in the ore layer, formed on the base of an old diluvia cone of filler materials. It is poorly loaded with nitrogen, on average with phosphorus and well with potassium. Average for the layer 0 - 60 cm the following water-physical properties: WHC = 22.1%; wilting point - 12.3% on the weight of absolutely dry soil; volume weight at WHC - 1.47 g / cm3. For the soil layer 0 - 100 cm, these indicators have the following values: WHC- 21,8%; wilting point - 12.3%; bulk density - 1.50 cm3. Irrigation was carried out using a droplet-type drip plant.

Results and discussions

For the period of the surveys during the growing season of the crop (April-July), 21 irrigations were conducted with an average water application rate of 183 m3 / ha and an irrigation rate of 3742 m3 / ha were submitted. (Table 1)

The intensity of ET influences directly the length of the between-irrigation period, and hence the number of irrigations and the size of the irrigation rate. The main part of the water consumption of long-grain cucumbers grown under greenhouse conditions is the evapotranspiration which does not differ significantly from the irrigation norms and varies in years depending on the meteorological situation and the applied irrigation regime.

Table 1: *Number of irrigation, irrigation and irrigation norms by variant of long-lasting cucumbers averaged during the survey period*

variants	2002-2004 average		
	Number of irrigations	Water application rate /mm/	irrigation rate /mm/
100% M	20	18,3	366
80% M	20	14,6	292
60% M	20	11,5	230

Highest values of evapotranspiration reached 253 mm during the dry 2004, and in the remaining years it ranges from 217 to 253 mm (Table 2). On average, over the survey period, the size of the total ET for the long-fruit cucumber growing season is 231 mm.

In the experimental years, the average daily values of the evapotranspiration range from 0.5 to 5.5 mm with two minima - at the beginning and end of the vegetation and a maximum - in July, which reaches 5.5 mm (Table 2).

In the initial phase of crop's development, the average daily values of the evapotranspiration are lower, due to the smaller size of the plants, which consume small amounts of water, a large part of the soil surface is detected, the impact of the meteorological factors is low. The magnitude of evapotranspiration during this period is mainly determined by soil humidity and near-ground air temperature. The physical evaporation of the soil prevails. The intense increase in ET, which begins in the first and second quarters of June, is associated with an intensive growth phase and reaches a mean daily value of 3.8 to 4.6 mm. Its maximum for the three years is in the first and second tenth of July and reaches 5.5 mm. At the end of the long-fruit cucumber's vegetation, with decreasing the pressure of the meteorological factors, the medium-term ET decreases and in the first ten days of August it reaches 3.7 mm (Table 2).

The values of average daily evapotranspiration (100% water application rate) varied from 0.2 to 6.5 mm in the different years, with the highest values in the dry 2004. The course of its variations during the growing season follows the development of culture and changes in meteorological factors. (Table 2).

In order to meet the needs of multilingual practice in several countries, methods and formulas have been developed to determine evapotranspiration by computational pathway.

For the calculation of the evapotranspiration of these formulas, experimental determination of the biophysical coefficients is necessary. They reflect the specifics of water consumption depending on the biological requirements of the crop, the stage of development, the manifestations of the meteorological factors

The calculated ten-day values of the biophysical coefficients based on the experimental definition of the evapotranspiration and the daily sums of the average daily air temperature (for the coefficient z, calculated by the formula by Delebaltov, Hristov, Tsonev) and the air temperature and the daily hours for every ten days in% during the year. (for k_p coefficient according to the formula of Blanney, Criddle) are presented in (Table 3). Changes in the values of these coefficients follow changes in the evapotranspiration during the growing period of the culture.

The values of biophysical coefficients represent an objective basis for determining the design irrigation regime and predicting the irrigation time of the crop.

The values of the biophysical z factor of the culture range from 0.04 to 0.26 and the coefficient kb - from 0.36 to 0.89, respectively, meanwhile for the study period. (Table 2)

Table 2: *Evapotranspiration and evaporation from free water surface of long-fruit cucumbers 2002-2004*

	Average daily evapotranspiration (ET) mm					Average daily transpiration from a free water surface (Eo) mm			
Months	Ten days	2002 mm	2003 mm	2004 mm	Average mm	2002 mm	2003 mm	2004 mm	Average mm
May	II	0,4	0,5	1,0	0,5	-	2,0	2,2	2,2
	III	1,8	2,0	2,0	2,1	2,5	2,0	2,0	2,2
June	I	4,2	3,1	4,0	3,8	2,4	2,5	2,2	2,3
	II	4,7	3,8	5,0	4,6	2,7	2,9	2,3	2,6
	III	4,8	4,6	5,5	5,2	2,7	3,0	2,7	2,8
July	I	5,4	5,40	5,3	5,3	3,2	3,0	3,6	3,3
	II	5,3	5,8	4,7	5,4	3,5	2,0	2,2	2,8
	III	4,1	6,5	4,2	4,7	2,9	2,8	3,0	2,9
August	I	3,6	5,1	3,9	4,4	2,8	2,5	3,5	2,9
Total		3,9	4,1	4,0	4,0	2,9	2,7	2,6	2,7
Total		223	253	217	231	232	240	238	237

When growing crops in drip irrigation facilities where plants almost daily need to recover water, the problem of forecasting the amount of water required is of paramount importance. One of the most applicable ET connections is that of the evaporation of a free water surface (EO), established by a "A" evaporator, since it is considered to be integrated with all the weather factors that influence it (Goldberg, 1976, Rey, R. 1979). The results obtained on average for the three experimental years indicate that the total growing season of the crop Eo is 237 mm and reaches the highest daily average values in the second and third day of July 2.7 mm, (Table 3). The

average daily values of the evapotranspiration are higher than those of the evaporation, with the largest differences occurring during the period of mass fertilization of the crop in the months of June-July, when the pressure of the climatic factors is greatest.

The Ki coefficient, which reflects the relationship between evapotranspiration and evaporation from free water in open areas. According to Alpev's theory, it is approximately equal to a unit for the growing season of the crop.

Determination of the dependence between Eo, determined by A-type evaporator, and ET of the cultures can be judged for the daily dimensions of ET of the culture and from there to predict the terms and sizes of the forthcoming harvests. (Cristiansen, 1976).

Greenhouse-field studies found that this ratio averaged over the vegetation period amounted to 1.46 on average over the three experimental years. The Ki coefficient varies in ten-days from 0.4 to 1.9 and reaches the highest values in the second ten-day period of July - the period of the highest stress of the meteorological factors and the highest ET. Establishing a correlation between ET and Eco under greenhouse conditions allows for a more accurate use of class A evaporator data. (Table 3)

Table 3: *Biophysical coefficients for three trial years*

Months	Ten days	evapotranspiration /ET/, mm	evaporation Eo, mm	Z	Kb	Coefficient of the crop $Ki = \frac{ET}{Eo}$
May	II	0,5	2,2	0,04	0,36	0,2
	III	2,1	2,2	0,12	0,39	1,0
June	I	3,8	2,3	022	0,69	1,7
	II	4,6	2,6	0,23	0,84	1,8
	III	5,2	2,8	0,26	0,87	1,8
July	I	5,3	3,3	0,24	0,88	1,7
	II	5,4	2,8	0,25	0,89	1,9
	III	4,7	2,9	0,20	0,73	1,7
August	I	3,7	2,9	0,19	0,66	1,3
Total		4,0	2,7	0,18	0,69	1,46

Conclusions

1. The total amount of evapotranspiration of long-fruit cucumbers is established. Highest values reached in the dry year of 2004 -253 mm, and in the remaining years it ranges from 217 to 253 mm
2. Established average daily values of evapotranspiration range from 0.5 to 5.5 mm with two minima - at the beginning and end of vegetation and a maximum of - in July and August, reaching up to 5.4 mm
3. For the needs of the practice and the design are calculated also the ten-day values of the biophysical coefficients (Z and k), which depend on the biological characteristics of the culture and the meteorological factors.
4. On the basis of the relationship between evapotranspiration and evaporation, the values of the coefficient of the crop in unheated plastic greenhouses are calculated.
5. Establishing a correlation between ET and Eo under greenhouse conditions allows for a higher degree of reliability when using data from a "A" evaporator.

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