

FARM MACHINERY AND TECHNOLOGIES

**WATER SUPPLY OF PLANTS VIEWED FROM THE STANDPOINT OF THE BIOENERGY APPROACH**

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The most promising of the previously known approaches in the use of theories in the practice of water supply of plants is the approach based on the bioenergy theory of productivity. The paper contains a brief review of conventional approaches to the use of theories and discoveries in the practice of water supply of plants and methods of its evaluation. It is proposed to estimate the need of plants for water by the amount that should be spent on transpiration to reduce the plant leaf temperature to the optimum temperature for photosynthesis by evaporative cooling. It is shown that optical radiation, along with photosynthetic radiation, has other effects on plants (thermal, photoperiodic, photomorphogenic, etc.). The authors suggest identifying the transferability of indicators (criteria) describing the basic conditions of the external environment on thermodynamic basis. Thus, the research purpose is to justify the analytical dependence to take into account the influence of these factors on the water supply of plants. With the help of experimental measurements and calculations of evaporated water, two samples of water lost in evaporative cooling are obtained, which have the same characteristics. On the basis of the carried out researches, the analytical dependence of evaporated water at constant illumination is obtained in the form of a polynomial of the second degree. It is shown that when lighting is switched on, the evaporated water first decreases, and then the phase of active photosynthesis occurs, and the amount of evaporated water grows. It has been found that taking account of bioenergetic aspects, the plant should be provided with water at an average rate of 0.7 g/h, and with the onset of the active phase of photosynthesis, an hourly amendment should be made according to the obtained dependence.

**Key words:** water supply of plants, bioenergy theory of productivity, transpiration, temperature optimum of photosynthesis.

**DETERMINING DESIGN AND TECHNOLOGICAL PARAMETERS OF A DIGGING SHARE OF ROOT CROP AND ONION HARVESTERS**

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The quality of onion harvesting is determined by the work of a digging tool, as the design and technological parameters of the separating devices depend on the type and technological parameters of this tool. The authors have presented the research results aimed at determining the optimal technological parameters of a lifting plowshare for harvesting root crops and onion bulbs, depending on changes in the physical-and-mechanical properties of the material interacting with the considered working tool (the depth of digging and translational speed). The authors have determined the main design and technological parameters of the considered digging tool. They also have obtained a formula to determine the optimal curvature radius of the working surface of a lifting plowshare in polar coordinates, the differential equation of motion of the soil particle on the ploughshare surface for digging out root crops and onion bulbs, as well as the research results concerning the lifting plowshare design at the highest rate of soil particle lifting depending on the shape of its working surface. It has been established that a lifting plowshare with a working surface in the Archimedes spiral form is capable of ensuring the most qualitative process of extracting root crops and onion bulbs from the soil.

**Key words:** lifting plowshare, root crops, onion bulbs, design parameters, length, radius of curvature, speed of soil particles lifting.

## **IMPROVEMENT OF ROTARY MACHINE FOR RIDGE FORMING**

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The authors present the design of a twin-rotor machine for ridge bed forming in cultivation of vegetables technologies. The field tests of the machine prototypes carried out jointly by Federal Agroengineering Center VIM and Russian State Agrarian University – Moscow Timiryazev Agricultural Academy have shown that this design does not always loosen the topsoil in accordance with the agronomic requirements for ridge formation. A mathematical model has been developed to enable computer calculations of the rational parameters of the machine's working parts – tiller rotor diameters and speeds. Computer simulations have been performed to calculate the machine's kinematic parameters – feed to the cutter and the degree of crumbling (the thickness of soil cut off by the tiller rotors), as well as energy indicators – soil resistance forces acting on the rotors, driving torques, as well as the power transmitted through the tractor's power takeoff shaft. The considered mathematical model of the machine operation takes into account various soil conditions. Recommendations have been worked out to improve the machine design by driving the rear tiller rotor from the hydraulic motor. According to analytical studies, in order to improve the quality of tillage and reduce energy costs, it is necessary to smoothly change the rear rotor speed in the range between 150 and 200 min<sup>-1</sup>. The upgraded machine will provide high-quality tillage at the depth of up to 12 cm with grinding of crop residues and mulching the field surface with teeth of the rear tiller rotor for planting potato and Jerusalem artichoke in the system of elite seed production, and cutting the ridges in the cultivation of carrot, lettuce and other vegetables in the open ground in all climatic zones of Russia.

**Key words:** rotary tillage, ridge cultivator, vegetable growing.

## **ENERGY CONSIDERATIONS FOR A METHOD OF ASSESSING THE VIABILITY OF SEEDS**

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Methods for determining the viability of biological objects are based on the identification of differences in the response of objects to the effects of external environmental parameters. To analyze the existing methods for determining the viability of seeds and providing prerequisites for the development of a rapid method for estimating this indicator, use was made of the fundamentals of the analysis of material-energy transformations of material systems in the course of biotechnological processes occurring in them. The most general approach to the analysis of biotechnological processes occurring during storage and subsequent cyclic activation is the regularities of multivariate energy transformations, i.e. this is actually a thermodynamic approach. On this basis, the grain biosystem was compared with the following systems: an isolated system; an energy conservative system; a dynamically stationary system; and a dynamically quasi-stationary system. The authors have formalized energy conditions, in which biosystems jump into other qualitative states under the influence of external factors. The viability of the examined grain is determined according to the form of the transient process.

**Key words:** thermodynamics, viability of seeds, methods of assessing the viability of seeds, effects on biosystem, biosystem response to impacts, dissipators.

## **DAIRY EQUIPMENT CLEANING BY OZONATION**

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The development of technology and means of cleaning milking equipment allowing to minimize the use of synthetic surfactants and other chemicals, is an urgent task in view of solving problems of improving milk quality. Ozonation is a promising eco-friendly method of water treatment, allowing to effectively combat a large number of different pollutants of artificial and natural origin with simultaneous disinfection of water. To study the possibility of using ozonation in the technology of cleaning milking equipment with water of different hardness, the following modern detergents were taken: ЦМС-5 (patented by RSAU-MTAA), МИГ-МД (Russia, Penza), Chlorcept D (USA), Dayrial (France). The authors propose a method for cleaning the surface of stainless steel 08X10HT1 from milk residues by ozonizing the washing solution. In laboratory conditions, they experimentally determined the relationships between the cleaning coefficients and the hardness of water. In cleaning with ozonated solutions at a concentration of 0.5% and a temperature of 40...70°C in soft water (hardness Ж = 1...3°), all the studied detergents showed high cleaning efficiency (the cleaning coefficient of more than 90%). In water of medium hardness (Ж = 6±1°), the cleaning coefficients demonstrated the following values: ЦМС –5 (ozonized solution) – 93%; МИГ-МД – 89%; Dayrial – 90%; and Chlorcept D – 90%. In hard water (Ж = 12°) under the same conditions, the cleaning coefficients featured the following values: ЦМС-5 (ozonized solution) – 92%; МИГ-МД – 83%;

Dayryal – 87%; and Chlorcept D – 84%. In very hard water ( $\text{Ж} = 15^\circ$ ), the following results were obtained: ЦМС-5 (ozonized solution) –  $k = 91\%$ ; МИГ-МД –  $k = 79\%$ ; Dayryal –  $k = 85\%$ ; and Chlorcept D –  $k = 80\%$ . Basing on the conducted research, the authors propose the following cleaning modes for the ЦМС-5 detergent using ozonation: washing solution concentration – 5 g/l; temperature –  $40^\circ\text{C}$ ; cleaning time – 10-15 minutes; water hardness – up to 15 mg-eq/l.

**Key words:** cleaning effectiveness, dairy milking equipment, ozonation, alkali detergents.

## **USE OF RECLAMATION TECHNOLOGIES TO REDUCE THE INTAKE OF RADIO NUCLIDES INTO PLANTS ON CONTAMINATED AGRICULTURAL LANDS**

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The paper includes an assessment of the scope of agricultural land pollution with radionuclides caused by the Chernobyl accident, the classification of land by the degree of contamination with radionuclides Cesium (Cs) –137 and Strontium (Sr) –90. The paper describes the most common technologies for reducing the level of radionuclide intake by agricultural produce and provides the introduction rates for lime and mineral fertilizers on contaminated fields in the Bryansk region. The authors consider the descending -order sequence of grain crop according to their Cs-137 transfer coefficients. The paper also presents the assessment results of the contamination state of land in the Bryansk region 25 years after the accident. The problems of secondary local soil pollution caused by wind and water erosion are analyzed. A number of new technical solutions aimed at binding Cs-137 to the absorbing material, withdrawing it beyond the limits of the root layer (topsoil), as well as methods of extracting it from the soil, are also described in the paper, in particular, sowing perennial grasses with subsequent delivery of hay to special storage facilities; claying of the contaminated topsoil with its subsequent movement to a location deeper than the main mass of absorbing plant roots. The authors give account of several sorbents used for the removal of Cs-137 radionuclides. The technology of transferring Cs-137 to the sorbent by evaporation and drip irrigation is described. In addition, a possibility of flushing Sr-90 beyond the topsoil layer with the subsequent formation of slightly soluble salt is considered. The offered technical solutions provide for the decreased content of radionuclides in farm produce and the elimination of the localized pockets of radionuclide accumulation.

**Key words:** radioactive contamination, fertilizer doses for radioactive contamination, claying, drip irrigation, sorbents, flushing soil from Sr-90 extract.

## **TECHNICAL SERVICE IN AGRICULTURE**

### **INCREASING THE DURABILITY OF PLOUGHSHARES WITH WEAR RESISTANT HARDFACING**

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The authors have carried out an analysis of various materials used for obtaining high-strength wear-resistant coatings of the cutting edges of ploughshares. When choosing the method of hardening of agricultural working elements, it is necessary to take into account the maximum possible thickness of the hardened layer, the penetration and adhesion of the hard alloy to the base metal, process performance and the "price-quality" criterion. Steel grade 30XГCA has shown the best "price-quality" properties as compared with those produced by the domestic metallurgical enterprises. Domestic reinforcing materials in the form of powders, electrodes, wires generally correspond in hardness and wear resistance to foreign analogues, however, it is necessary to take into account that in the strength of their adhesion to the base metal, adhesive properties, chipping and delamination of fragments of the reinforcing layer under shock loads they are 1.5...2.5 times lower in performance. The paper describes the design of the new ploughshare consisting of a blade and a facemounted chisel. The material for the ploughshare is 30XГCA steel grade. The reinforcing material is ФБХ-6-2 with 35% WC, the hardening method is plasma surfacing with a thickness of 0.5...4.5 mm. The results of field tests have shown the advantage of experimental ploughshares with a chisel overlap in resource by 2.5...4 times, in strength by 3...5 times compared with conventional ploughshares.

**Key words:** ploughshare, wear, hardfacing, durability.

## **DEVELOPMENT OF CONTROL SHEET FORM TO ASSESS INTERNAL LOSSES OF FARM MACHINERY REPAIR PROCEDURES**

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The paper deals with the issues of quality assurance in small-scale engineering and repair production. The analysis of machining processes in engineering and repair production should include the monitoring of internal and external defects in pre-defined categories, which are systematized in the form of tables. The aim of this study is to use checklists for assessing the repair quality. To detect internal faults occurring in technical processing of machine parts it is proposed to use a checklist with additional graphs to estimate of the number of faults and the amount of loss across the whole range of defects. The offered form of a checklist shows that internal losses, which can be estimated in the processing of shafts, include those from irreparable fault, reparable fault, and reduced production cost due to poor quality. The authors emphasize that the information obtained should be recorded for all types of products, and it is necessary to compile reports for different periods of time, to study the dynamics of the analyzed indicators. Basing on the analysis of the number of defects and losses, corrective and preventive measures to reduce their occurrence rate should be developed. Thus, the use of quality control tools should be integrated into the identification of processes, the assessment of costs and losses and their recording into reporting forms. The reporting system should contain information on losses from the faults, the cost of preventing defects and control costs. Analysis of the aggregate information on the costs of quality will lead to a reduction in losses from the faults and increase the functioning effect of the quality management system at mechanical engineering and repair enterprises.

**Key words:** quality, control, checklist, reparable fault, irreparable fault, internal losses.

## **DEVELOPMENT OF DEVICE FOR FIXING DISK DRILL BOOT IN A LATHE WHEN HARDENING**

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Drop of operating costs for maintenance in operating state of the equipment is possible by rational restoration and hardening of details of farm vehicles, on the basis of development of the original industrial equipment, for example, for disk working bodies. The critical review of devices for fixation of details of various forms and appointment is executed. Their main shortcoming – impossibility of strong fixing in the lathe and fixations of details like “disk” with accuracy guarantee is revealed at their processing and also complexity of design of devices that affects labor input of performance of work. For the purpose of elimination of shortcomings, adaptation on mode of fixing of disk of soshnik in the lathe when hardening by means of the left and right mandrels is developed. The design has the following sizes: outer diameter of mandrels – 45 mm, threaded connection – M16, the size of “turnkey” hexagonal face nuts – 24, the total length of adaptation assembled – 258 mm, the right mandrel has length of 50 mm, the left mandrel supplied with the pressing face surface – with a diameter of 60 mm. Common effort of tightening of threaded connection – 200 N. At the same time the minimum safety factor on fatigue strength of design is equal to 16; equivalent normal tension in body of adaptation does not exceed 3.5 MPa; safety factor on fatigue strength of disk is equal to 2.637; conveyance of working edge of disk makes 1.034 mm. Analytical calculation in the automated workplace program complex APM Win Machine has confirmed that when processing disk strength and ruggedness of design of adaptation are assembled provided. Approbation of installation of adaptation on the lathe with imitation of processing has confirmed operability of technical solution.

**Key words:** seeder, disc coulter, mandrel, fixing, hardening.

### **ECONOMY AND ORGANIZATION OF AGRICULTURAL ENGINEERING SYSTEMS**

## **INFLUENCE OF INVESTMENTS ON THE REPRODUCTION OF MACHINE-TRACTOR FLEET IN AGRICULTURE**

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Investment plays a central role in ensuring the efficiency of an economic system and the whole social reproduction sphere, since it directly affects the possibility of economic growth in the long term. The main type of agriculture investments in Russia is the investment in fixed capital. The grouping of regions by the size of investments has shown that the differences between the groups in the coefficient of renewal for tractors is 0.9%, and for combines 1.7%, which means that the higher the size of investments is, the greater the opportunities for the renewal of agricultural machinery are. The author has taken the coefficient of renewal and disposal of tractors as one of the indicators reflecting the process of the equipment reproduction and calculated the impact of the amount of investments and the amount of workload per one tractor on the change of these coefficients in relation to the reproduction of tractors. Studies have shown that the higher the investments are, the more the upgrade process

exceeds the disposal process of tractors. With a high level of investment and workload per one tractor, a decrease in the disposal is achieved due to the ongoing measures for the repair and maintenance of agricultural machinery.

**Key words:** investments, agricultural machinery, coefficients of renewal, retirement and intensive renewal, grouping.

## POWER SUPPLY AND AUTOMATION OF AGRICULTURAL PRODUCTION

### REDUCING ENERGY CONSUMPTION OF TELEMETRIC FARM SYSTEMS

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To obtain information on the state of automated control facilities, it is expedient to use the centralized principle of data collection, in which information from multiple sensors is transmitted via wireless communication channels. The sensors are equipped with receiving and transmitting devices that require electrical energy for their power supply. In order to reduce energy consumption, it is proposed to carry out a step-by-step data transfer, in which each element of the telemetry system is both a source of information and a relay information from neighboring elements. The paper shows that with an increase in the number of “receive-transmit” steps, the amount of energy consumed exponentially decreases. Due to the functioning algorithm of the coordinator and the router, the considered system is capable of self-organizing and self-recovering. If any elements of the network fail, as well as in the case of a change in the spatial location of these elements, the system, without an operator’s intervention, determines a new signal transmission path and assigns it to each element through the service channel. In order to increase energy saving and communication efficiency, it is proposed to supplement the sensor connection algorithm with their alternate switching. In this case, at each time point, only one sensor is connected to the information processing point along the shortest path through a limited number of working network elements. To ensure energy savings, the remaining elements are “in a sleep mode”. The author note that the sensor’s sampling frequency should comply with two alternative requirements: the prevention of information loss during a rapid change in the state of the control object and the necessity not to recognize any information as reliable if it is received before the transients in the communication line are completed. Basing on the ratio assessment of the useful signal levels in the receiving antenna and noise, as well as taking into account the distortions in the restoration and discretization of information, the authors have derived formulas for determining the desired frequency.

**Key words:** telemetry systems, sensors, radio communication, power consumption, reception and transmission of information, ZigBee-technology, alternate connection, network element.

## TO THE MEMORY OF THE SCIENTIST

### VASILY N. BOLTINSKIY – ACADEMICIAN OF VASKHNIL (THE USSR ACADEMY OF AGRICULTURAL SCIENCES)

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The paper outlines the life and career of Vasily N. Boltinskiy, full member and Vice-President of the Academy of Agricultural Sciences, Hero of Socialist Labor, laureate of the Stalin and State Prizes, Honored Worker of Science and Technology. He was a disciple and a scientific companion of Academician Vasilii P. Goryachkin, the founder of agricultural mechanics. Vasily Boltinskiy belongs to the second generation of scientists and specialists who made a significant contribution to the development of the domestic branches of the tractor industry and farm mechanization. V.N. Boltinskiy conducted and summarized test results of more than 25 models of imported and domestic tractors. His recommendations were widely used in the practice of design organizations developing domestic agricultural machinery, as they most fully complied with the soil and climatic conditions of the country. A significant cycle of his works aimed at improving the fuel efficiency of tractor engines. His monograph “Operation of a tractor engine under an unsteady load” (1949) opened a new stage in the development of the tractor theory allowing to reveal the dynamics of steady and unsteady traction processes. This provided additional opportunities for raising the technical level of tractors. Along with the membership in the state scientific commissions, V.N. Boltinskiy carried out scientific supervision and coordination of state-funded research and development activities aimed at solving the problem of “Increasing the working speeds of machine-tractor units.” The offered solution to that problem led to an increase in the productivity of machine-tractor units by 1.5 ... 2 times. In parallel with his research work, V.N. Boltinskiy was actively engaged in teaching, for 20 years he headed the “Tractors and Automobiles” Department. Under his leadership, a curriculum was designed for the “Construction and Calculation of Tractors and Automobiles” course (1934) for the training of engineering personnel. His textbook “Automotive and Tractor engines” (1935), run into seven editions, was translated into Chinese, Bulgarian, Korean and Romanian. Practically all students of technical universities of the corresponding training profile were familiar with his textbooks. He prepared 40 PhDs and Doctors of Science.

**Key words:** V.N. Boltinskiy, tractor, engine, governor, agricultural machine, unsteady load, increased speeds.