

ORIGINAL PAPER

**CONCEPTUAL GROUNDS FOR THE CONSTRUCTION OF A REGIONAL
MULTIFUNCTIONAL SERVICE CENTER FOR DAIRY LIVESTOCK**

MIKHAIL N. EROKHIN, Member of the Russian Academy of Sciences, DSc (Eng), Professor¹
er.mihn@mail.ru, <https://orcid.org/0000-0001-6573-0950>

*ALEKSEI S. DOROKHOV, Corresponding Member of the Russian Academy of Sciences, DSc (Eng),
Professor²*

dorokhov.vim@yandex.ru, <https://orcid.org/0000-0002-4758-3843>

VLADIMIR V. KIRSANOV, DSc (Eng), Chief Research Engineer²
kirvv2014@mail.ru

EKATERINA L. CHEPURINA, PhD (Eng), Associate Professor¹
chepurina@rgau-msha.ru

¹ Russian State Agrarian University – Moscow Timiryazev Agricultural Academy; 127550, Russian
Federation, Moscow,

Timiryazevskaya Str., 49

² Federal Scientific Agroengineering Center VIM; 109428, Russian Federation, Moscow, 1st Institutskiy
Proezd Str., 5

Abstract. The paper outlines the main problems related to the technical service of machines and equipment used in dairy farming. The authors analyze the companies that provide their services to dairy farms of various sizes and forms of ownership, ranging from personal subsidiary farms to agricultural holdings. The main disadvantages of technical service of small and medium farms are shown, namely: large number and disunity of individual equipment suppliers; lack of incoming control of products and materials being in contact with milk; inconsistency in a number of cases of the proposed technical and technological solutions and equipment operation modes with the international requirements and other regulatory documents; impossibility of providing qualified consulting, technical, financial, legal and economic support to agricultural producers. The authors propose a structural and logistic model of a regional multifunctional service center for the livestock breeding industry, providing comprehensive technological, technical and operational services related to consulting, training, choosing the best available technologies and appropriate sets of machines. The multifunctional service center is expected to unite the disparate efforts of regional service companies and dealers, improve the quality of services provided to commodity producers, and raise the level of production on small and medium-size farms.

Key words: multifunctional service center, dairy farming, structural and logistic model, consulting, design, logistics.

ORIGINAL PAPER

**METHODOLOGY FOR OPTIMIZING THE PARAMETERS
OF MACHINE FEEDING OF CATTLE**

VLADIMIR V. KIRSANOV, DSc (Eng), Chief Research Engineer
kirvv2014@mail.ru

DMITRIY YU. PAVKIN, PhD (Eng), Senior Research Engineer
dimqaqa@mail.ru

EVGENY A. NIKITIN, Junior Research Engineer
evgeniy.nicks@yandex.ru

IGOR M. DOVLATOV, Junior Research Engineer

Federal Scientific Agroengineering Center VIM; 109428, Russian Federation, Moscow, 1st Institutskiy
Proezd Str., 5

Abstract. The authors propose a methodology for determining technological parameters for the machine implementation of the preparation and distribution of feed mixture at cattle breeding facilities. The

proposed methodology can be used to determine the optimal ratio parameters of the number of technical means for preparing a feed mixture and the number of operations performed for feeding cattle with multi-component feed mixtures. It was developed taking into account livestock breeding requirements and standards. The authors present an analysis that takes into account the European, Russian and American experience of the technology of organizing cattle feeding. This methodology applies to facilities (a farm) practicing year-round keeping of animals, where a concrete feed table is mounted in the same plane with the passage for technical equipment: a tractor, an aggregated or self-propelled mixer dispenser, as well as an auxiliary technical means – a feed pusher or its substitute attachments on the tractor. The feed mixture is dispensed on both sides. Taking into account the strategy of organizing the technological process of cattle feeding, the proposed method allows determining the optimal construction parameters of livestock facilities at the design stage, as well as the number and productivity of the machines used.

Key words: assessment of technological efficiency, cattle feeding, livestock breeding.

ORIGINAL PAPER

INCREASING THE ESTIMATION EFFICIENCY OF THE FUNCTIONAL CHARACTERISTICS OF GRAIN HARVESTERS

VYACHESLAV F. FEDORENKO, Deputy Director, DSc (Eng), Member of the Russian Academy of Sciences¹

vim@vim.ru

VITALY E. TARKIVSKIY, Head of the Laboratory, DSc (Eng)²

Tarkivskiy@yandex.ru

NIKOLAY V. TRUBITSYN, Head of the Metrological Support Sector, PhD (Eng)²

trubicin@yandex.ru

EVGENIY S. VORONIN, Research Engineer²

KDbyScience@mail.ru

¹ Federal Scientific Agroengineering Center VIM; 109428, Russian Federation, Moscow, 1st Institutskiy Proezd Str., 5

² Novokubansk Branch of Federal State Budgetary Scientific Institution “Rosinformagrotech” (KubNIITiM); 352243, Russian Federation, Novokubansk, Krasnaya Str., 15

Abstract. When assessing the functional characteristics of combine harvesters, one of the most important indicators to be determined is grain loss occurring in the threshing-and-separating unit. In compliance with GOST 28301-2015 “Combine harvesters. Test methods”, it should not exceed 1.5%. The existing methods of its determination and estimation are laborious and require specialized frames of samplers manually placed in the grain in front of the combine or the use of strip samplers. Moreover, technologies for grain harvesting with chopping and spreading straw require the use of an automated system for placing sample frames. The authors present an automatic device for placing sampling frames under the threshing-and-separating unit of a grain harvester during its operation. The proposed design five sampling frames with a size of 1500×650 mm both in manual and automatic modes with a predetermined interval. The device provides for better labor safety of testers, reduces the complexity of testing by 10...15%, and improves the accuracy of the agrotechnical and operational-technological assessment of grain harvesters.

Key words: combine harvester, agrotechnical assessment, grain loss, threshing and separating unit, sampler.

ORIGINAL PAPER

METHODOLOGICAL APPROACHES TO ASSESSING THE TECHNOLOGICAL NEED FOR FARM TRACTORS

ALEKSANDR V. LAVROV, PhD (Eng), Key Research Engineer

VALERIYA A. ZUBINA, PhD (Eng), Junior Research Engineer

lera_zubina@mail.ru

Abstract. Mechanized technology of crop production is a sequence of impacts on soil, seeds, plants and fertilizers strictly specified in time and space. These requirements can be satisfied only in case certain technical support is provided, which is a regulatory technological need. In this regard, it is necessary to develop methods for assessing the demand for crop production equipment using the coefficients for converting physical units of equipment into reference units. The characteristic of reference conditions is presented when determining the performance of machine-tractor units. Tractors TE-120 and TE-150 (conditional brands) were taken as reference machines. The first one corresponds to the modern technical level, which allows making calculations until 2025. The second reference sample can be used in calculations after 2025. The main technical characteristics of tractors are given. The paper presents methods for assessing the technological demand for tractors in agricultural enterprises, agrozones, federal districts, republics, regions and the country as a whole. The authors analyze the block diagram of the development standards for the demand and determine the technologically required size of the machine and tractor fleet in Russia. They show that each agricultural enterprise can determine how much equipment it should purchase to complete the entire amount of work in the agricultural period using conditional (reference) coefficients. For regions, federal districts and the country as a whole, specialists can not only estimate the number of equipment, but also predict the future demand for technological means. The use of conditional (reference) coefficients allows assessing the existing availability of the necessary machines and agricultural tractors in the regions and the country and determining the estimated demand and the number of various-sized equipment to be purchased to provide technical support for all modern and future technologies.

Key words: technological need for equipment, machine and tractor fleet, agricultural production, the amount of required equipment, agricultural enterprises, reference tractor output, conventional reference hectare.

ORIGINAL PAPER

DEVELOPMENT PROSPECTS FOR METHODS AND TECHNICAL MEANS OF FARM CROP PROTECTION

ALEKSEI S. DOROKHOV, DSc (Eng), Corresponding Member of the Russian Academy of Sciences
dorokhov.vim@yandex.ru

IVAN A. STAROSTIN, PhD (Eng)

ALEKSANDR V. ESCHIN, PhD (Eng), Senior Research Engineer
vim@vim.ru

Federal Scientific Agroengineering Center VIM, 109428, Russian Federation, Moscow, 1st Institutskiy Proezd Str., bld 5

Abstract. Modern intensive highly productive agricultural production should be based on a combination of various types of plant protection measures – quarantine, agrotechnical, chemical, breeding, biological, mechanical and physical methods, taking into account the balance between their efficiency, minimal negative impact on the environment and economic feasibility. The paper discusses the advantages and disadvantages of the listed methods. The chemical method of plant protection, despite its shortcomings, is one of the most widely used productive and effective methods. The negative effect of the chemical method can be significantly reduced by tightening the requirements for the safety of using pesticides for the environment and human health, ensuring targeted application of the product directly to the treated object, increasing the quality of application and reducing the loss of working fluid, using products with a narrower range of action and short decomposition time. The authors stress that in order to achieve maximum efficiency of chemical treatment, sprayer nozzles must provide a monodisperse spray and, at the same time, be able to adjust the size of monodisperse aerosol droplets in the range from 10 to 150 microns. Technical means for plant protection should be equipped with means that allow eliminating or minimizing the working fluid drift as a result of wind exposure and evaporation, and ensuring the forced deposition of aerosol droplets on the treated objects to reduce the loss of working fluid.

Key words: plant protection, integrated plant protection, plant protection measures, plant protection methods, pesticides, sprayers, sprayer nozzles, targeted application of pesticides, environmental pollution, intensive agricultural production.

ORIGINAL PAPER

WAYS TO IMPROVE THE QUALITY OF COMBING WHEN HARVESTING SOYBEANS

VLADIMIR A. SAKHAROV, Senior Research Engineer

sakharov.v.a@mail.ru, <https://orcid.org/0000-0003-3471-301X>

ALEKSEI A. KUVSHINOV, Research Engineer, PhD (Eng)

pzrk_igla1992@mail.ru, <https://orcid.org/0000-0002-6332-5406>

All-Russian Scientific Research Institute of Soybean Growing; 675027, 19, Ignatievskoe Ave., Blagoveshchensk, Amur Region, Russian Federation

Abstract. The use of combing headers for soy harvesting is a promising direction for improving the harvesting process. The method of combing standing crops will reduce the harvest time by increasing working speed, improve the product quality by reducing grain crushing, and minimize the anthropogenic impact of harvesters on the soil because of their reduced number and weight of their working units as compared to harvesters with conventional threshing-and-separating units. This modification will provide livestock industry with cheap feed resulting from grain-soybean heap processing. The purpose of the study was to design and improve technical means for harvesting soybeans with the method of combing. Research was conducted on the “Lazurnaya” soybean variety. The results of soybean weighing and the composition of the grain-soybean heap are presented. The obtained experimental data show a decrease in the loss from the non-combed fraction at increased combing drum speed and reduced ground speed, but this is accompanied by significantly increased loss of soybeans. To improve the quality of soybean harvesting using the combing method, promising solutions for the modernization of the combing headers are considered: installation of an additional beater, which will prevent unwinding of the uncombed parts of the soybean stalks on the drum and their subsequent breaking off; integration of a sieve into a combing header design to reduce the amount of impurities; the use of hinges to attach the comb to the drum and the stopper, which help prevent accidental contact of the comb with the field surface.

Key words: soybeans, harvesting, comb, combing header, grain-soybean heap.

ORIGINAL PAPER

EVALUATION OF THE EFFECTIVENESS OF THE MALTESE MECHANISM IN THE DRIVE OF A ROTARY TILLER

MIKHAIL I. BELOV, DSc (Eng), Professor

B-Mikhael@yandex.ru, <https://orcid.org/0000-0001-9907-8825>

OLEG M. MELNIKOV, Senior Lecturer

ommelnikov@mail.ru, <https://orcid.org/0000-0003-3202-8799>

Russian State Agrarian University – Moscow Timiryazev Agricultural Academy; 127550, Russian Federation, Moscow, Timiryazevskaya Str., 49

Abstract. The study focuses on a model of the KFG-3.6 rotary tiller with the Maltese-cross mechanism in the horizontal-axis rotary tiller drive. The continuous-rotation Maltese mechanism of external hooking allows reducing the knife speed when the knife penetrates into the soil. This kind of tillage minimizes erosion of the soil in dry areas. The study purpose is to determine the rational number of fingers, cross-wheel slots and knives on one side of the flange, providing a predetermined quality of soil tillage. It has been established that the Maltese-cross mechanism including a three-finger carrier gear and a cross with six slots is preferable among all the existing options.

Key words: rotary tiller, L-shaped knife, Maltese-cross mechanism, soil tillage quality.

ORIGINAL PAPER

EXPERIMENTAL AND ANALYTICAL TECHNIQUE FOR DETERMINING THE ANGLE OF LATERAL STATIC STABILITY OF MACHINES WITH BALANCED SUSPENSION OF THE STEERING WHEEL AXLE

SERGEY V. SCHIGOLEV, PhD (Eng), Senior Lecturer

sergeysch127@mail.ru

SERGEY G. LOMAKIN, PhD (Eng), Associate Professor

Russian State Agrarian University – Moscow Timiryazev Agricultural Academy; 127550, Russian Federation, Moscow, st. Timiryazevskaya, 49

Abstract. The criterion to determine the stability of self-propelled agricultural machines is the angle of lateral static stability. The authors analyzed methods for determining the angle of lateral static stability of self-propelled wheeled vehicles used during the state tests. The analysis revealed a significant deviation in the obtained results depending on the experimental and analytical methods used. Based on their analysis, it was determined that such a discrepancy in the results can be explained by a significant simplification of the calculation scheme used in the experimental-analytical method, instead of the tire deformation taken into account. The authors propose a method for determining the angle of lateral static stability for wheeled vehicles equipped with a balanced suspension of a steering axle. Moreover, the paper presents additional measurements and established relationships to take into account the effect of both the suspension, and tire deformation on the considered angle. To determine the angle of the lateral static stability of the machine, taking into account the influence of the balance suspension of the steering axle and the tire deformation, the authors propose to use a graphical method. Using this method reduces the labor intensity and increases the information value of the analysis, showing the significance of each factor affecting the angle. The paper shows the expediency of using the proposed technique, which makes it possible to significantly reduce the deviation of the calculated and experimental values of the lateral static stability angle.

Key words: tipping axle, lateral stability, steering wheel balancer axle, tire stiffness.

ORIGINAL PAPER

SELECTION OF MATERIALS USED FOR MANUFACTURING DIAPHRAGMS OF DIAPHRAGM-PISTON PUMPS IN AGGRESSIVE ENVIRONMENT

ALEKSEI S. SVIRIDOV, Junior Research Engineer

sviridov.vim@ya.ru

RAISA A. ALEKHINA, Engineer

rioraya9@gmail.com

Federal Scientific Agroengineering Center VIM; 109428, Russian Federation Moscow, 1st Institutsky Proezd Str., 5

Abstract. Wear of the diaphragm-piston pump may occur due to a reduction in the cross-section of the suction circuit (caused by an unsuitable pipe diameter, a dirty filter, pumping of high-viscosity liquids, etc.), the use of very aggressive chemicals, high operating temperature, abrasive particles, and high pressure in the pneumatic line. The paper considers various types of materials used for the manufacture of diaphragm piston pumps: rubbers, thermoplastic elastomers, thermoplastics and thermoset materials. The physical and mechanical, technological and operational characteristics of materials and the corresponding requirements for chemical resistance, temperature range of operation and abrasiveness were taken into account using an example of soybean cultivation. It was found that the optimal material that meets the above criteria is cast polyurethane. It has high physical and mechanical characteristics, a wide range of hardness (from 30 A to 90 B by Shore), low shrinkage, which implies long-term use of the material. Polyurethane products are manufactured by free casting, in which the liquid polymer composition is cured in a form that does not require complex and expensive injection molding rigs, unlike thermoplastics and elastomers. Injection polyurethane has sufficient chemical resistance in contact with the pump's working fluids and features wear resistance when pumping abrasive media. Therefore it is suitable for working in the climatic conditions of the Central region of Russia, and is also affordable, cheap and technologically advanced.

Key words: diaphragm, piston diaphragm pump, soybeans, polymers, polyurethane, fertilizers, chemical resistance.

ORIGINAL PAPER

TECHNICAL RE-EQUIPMENT OF AGRICULTURE IN THE CONTEXT OF DIGITALIZATION

VLADIMIR T. VODYANNIKOV, DSc (Econ), Professor¹

vvt-5210@yandex.ru

ASSIA K. SUBAEVA, PhD (Econ), Associate Professor²

subaeva.ak@mail.ru, <https://orcid.org/0000-0001-6237-807>

¹ Russian State Agrarian University – Moscow Timiryazev Agricultural Academy; 127550, Russian Federation, Moscow, st. Timiryazevskaya, 49

² Kazan State Agrarian University; 420015, Russian Federation, Kazan, st. K. Marx, 65

Abstract. The main trends in technical upgrading in the modern world include the transition to a digital economy, aimed at reducing costs through the use of computer technology in the management, repair and regulation of machinery, the use of IT technology to improve the quality and efficiency of the applied technologies. The paper presents the author's vision of technical re-equipment and the transition to digital agriculture. The purpose and objective of the study was to develop directions for technical re-equipment of agriculture with digital technologies and to form a plan for the implementation of digital solutions. In order to identify the main barriers to technical re-equipment of agriculture under the conditions of digitalization, the authors have conducted a survey, observation and polling of agricultural producers of the Volga Federal District. It has been established that the application of new innovative solutions in Russian agricultural enterprises will require a long time due to the problems in financial, economic, technological and psychological readiness of agricultural producers. The research has resulted in an algorithm developed by the authors for technical re-equipment of agriculture with digital technologies, which will allow managers and specialists of agriculture to use it as a basis in the digitalization of the technological capabilities of the agribusiness industry.

Key words: technical re-equipment, digital technologies, digital economy, problems of farm industry digitalization.

ORIGINAL PAPER

ECONOMIC RATIONALE FOR INNOVATIVE ENGINEERING SOLUTIONS IN LIVESTOCK BREEDING

NATALYA V. SERGEEVA, PhD (Econ), Associate Professor

sergeewanv78@mail.ru

Russian State Agrarian University – Moscow Timiryazev Agricultural Academy; 127550, Russian Federation, Moscow, st. Timiryazevskaya, 49

Abstract. Under the stable system of livestock keeping, the productivity of farm animals directly depends on the nutritional value of the feed and the maintenance of certain air, temperature and humidity parameters of the breeding facilities. Based on methods of comparison and prediction of the technical and economic performance of a small livestock farm, simple cost-effective engineering solutions – light mode and microclimate regulation – are recommended. The economic activity analysis of the “Volna” farm enterprise in the Bryansk region for 2017-2019 showed a reduction in the productivity of dairy livestock and high growth rates of the cost of milk. Measures are proposed to maintain the microclimate in a cowshed for 110 heads using HB LED lamps and a system of ventilation curtains “PM-Kit” controlled by an automated Farm Management Support system. This information platform allows monitoring and analyzing many processes associated with animal care, helps quickly make engineering and organizational-and-economic decisions. The author offers an economic rationale for technical solutions to ensure stable lighting and air exchange of the cowshed. The new technical solutions will require about 1.2 million rubles of one-time investment, will increase the average annual productivity of cows by 7.3%, and reduce the cost of 1 kg of milk by 4.6%. The total economic effect, taking into account the regulatory efficiency of capital investments,

will be approximately 800 thousand rubles for one farm. The author proves the feasibility of the selected technical solutions for a small-size livestock farm.

Key words: innovative solutions, microclimate, led lights, ventilation curtains, automated systems, economic effect.

THEORY AND METHODOLOGY OF PROFESSIONAL EDUCATION

ORIGINAL PAPER

ORGANIZATION OF PRACTICAL TRAINING OF POLYTECHNIC COLLEGE STUDENTS

LIUDMILA I. NAZAROVA, PhD (Ed), Associate Professor

nazarova@inbox.ru, <https://orcid.org/0000-0001-5698-6284>

SVETLANA A. GRYAZEVA, postgraduate student (Ed)

griazneva.svetl@yandex.ru

Russian State Agrarian University – Moscow Timiryazev Agricultural Academy; 127550, Russian Federation, Moscow, Timiryazevskaya Str., 49

Abstract. The paper deals with the organization of practical training of students in educational institutions of secondary professional education. Practical training is a form of organizing educational activities within the syllabus implying that students perform certain types of work related to future professional activities. It aims at forming, consolidating, developing practical skills and competencies according to the corresponding syllabus. The authors analyzed the normative documentation regulating the practical training of students. The paper shows the role of dual education in the development of professional competencies of college graduates, and reveals the features of network interaction in the study process between the educational organization and partner enterprises. The key component of practical training is industrial internships aimed at consolidating and deepening the knowledge acquired by students, as well as acquiring the necessary practical abilities and skills. Networking opens up many opportunities for mutually beneficial cooperation between educational organizations and partner enterprises. The authors analyzed the experience of network interaction of Polytechnic College No. 8 named after the Double Hero of the Soviet Union I.F. Pavlov and a number of enterprises in Moscow and the Moscow region, cooperating on the basis of agreements on network education. Along with taking practical internships at industrial enterprises, college students take part in the “Professional Internships” project. The high level of practical training is evidenced by the results of professional skills competitions according to WorldSkills standards and the Abilympics championship. According to the Center for Assistance to Employment of Graduates, 76.7% of graduates of 2020 were employed in Moscow, of which 55.6% were employed by partner enterprises.

Key words: practical training, polytechnic college, networking, dual training, industrial practices, professional internships.