

ORIGINAL PAPER
POWER SUPPLY OF FARM TRACTOR INDUSTRY IN RUSSIA

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Abstract. Determining the prospects for the development of the tractor fleet in Russia and its supplying with power units is an important task in establishing a technological foundation to effectively tackle the problems of agricultural production. Taking into consideration the indicator of power supply in agriculture in the world's economically developed countries, the authors consider the domestic needs in agricultural tractors and engines. As a result of the analysis, it is shown that the fleet of agricultural tractors is at a low level of about 200 thousand units, and it requires further serious development. To ensure effective agricultural production, it is necessary to balance the level of farm tractor availability in Russia with that of economically advanced countries. The indicator of 4 kW/ha was taken as a promising level of tractor availability, and the required number of tractors was determined. The analysis was carried out for the cultivation of arable land in Russia with an area of 80 million hectares as of 2020 and amounted to about 2.5 million units for the entire range of agricultural tractors taking into account their traction class. To cultivate all arable areas in Russia, which amounted to about 120 million hectares in 1990, a third more equipment will be required. To maintain the tractor fleet at this level, it is necessary to ensure an annual supply of at least 250 thousand units of various engines with a total capacity of at least 320 GW. This problem can be solved through increasing the production capacity of existing engine-building plants and designing new diesel engines for tractors of traction classes 0.6...1.4 with a capacity between 20 and 70 kW.

Key words: agriculture, power available per unit area, tractor fleet, diesel engine, production needs.

ORIGINAL PAPER

**EXPERIMENTAL STUDIES ON THE DEVELOPMENT
OF AN AUTOMATED SYSTEM FOR REGULATING
THE SOIL DENSITY USED IN A SEEDING MACHINE**

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Abstract. Research on the development of an automatic control system for the rolling-in working units is aimed at establishing the reliability and analytical relationships, determining the quality indicators of work in real conditions of the rolling-in working units of a seeding machine, and checking the patterns obtained in the field and identified theoretically. Research on the development of an automatic control system for the rolling implements was carried out when sowing dragee seeds of table beet of the Bordeaux variety with a seeding unit consisting of a Belarus-4235 tractor and a Monopil S 15/12 precision seeding machine. The system for automatic control of soil density includes the main hardware and software: actuators for maintaining and deepening the rolling working units, microcontrollers, motor drivers, a non-contact ultrasonic sensor, a power supply unit and a sensor for measuring soil density. The paper presents the results of a study to determine the soil density when sowing seeds of table beet, depending on the moisture content of the soil in the sowing layer. The authors describe research methodology, provide graphical relationships between changes in soil density and the depth of seeding, and comment on the main obtained statistical characteristics of the experiment. As a result of the study, structural, technological and functional diagrams of a rolling rink with an automatic control system using electronically controlled electric cylinders (linear actuators) have been developed. The optimal parameters of the linear drive of the press roller have been established: power - 50W, power supply - 12V, rod stroke - 200...600 mm, speed - 10...45 mm/s, load - 200...900 N. Experimental studies have shown the applicability of the presented system of the automatic control of soil density, which ensures the optimum density of the seedbed of 1.3...1.4 g / cm³. The described technique can be used to develop a soil density control system when sowing seeds of other vegetable crops.

Key words: press roller, sowing layer, table beet, onion, sowing machine, moisture, density, soil, multifactor experiment.

ORIGINAL PAPER

FEATURES OF USING A GROUND LASER PROFILER TO ASSESS THE QUALITY OF SOIL CULTIVATION ON AGRICULTURAL SLOPE LANDSCAPES

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Abstract. The authors analyze an extensive set of data for measuring the daily surface profile of the cultivated soil to assess its agrotechnical parameters. The research was carried out on a small agricultural catchment area of the Orininsky rural settlement, which is located in the Morgaushy district of the Chuvash Republic. Three agricultural fields were selected, ranging from 25 ha to 53 ha. The studied areas were cultivated in various ways: plowing with harrowing, disking the soil and winter plowing. The profiles of the studied elementary sections were measured using a developed ground-based circular laser profilometer. Data on the state of the profile were used to determine the main agrotechnical parameters – clumping, cloddiness, surface slope, and deviation of the travel trajectory of a machine and tractor unit from the line of equal height. A software tool for processing and analyzing data received from sensors has been developed. The results established that the deviation of the projection of the greatest elevation line changes (measured by the slope) from the travel trajectory of a unit with an angle of 62, a slope of 6.5, and in a quantitative size distribution soil aggregates of 1...4 inches in diameter prevail. The weighted average diameter of the clods was 3.99 cm. The research results have determined the use of recommend methods for stating the agrotechnical parameters of the daylight surface to evaluate the cultivated soil in accordance with agrotechnical requirements.

Key words: quality assessment, tillage, soil surface, laser profiler, circular scanning, agricultural landscape, slope lands.

ORIGINAL PAPER

CURRENTLY USED MECHANIZATION MEANS OF CHEMICAL PLANT PROTECTION IN RUSSIA

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Abstract. Mechanized processes of plant protection from pests, diseases and weeds are one of the main components of intensive technologies used for the cultivation of agricultural crops. The analysis shows that agricultural organizations are currently equipped with mechanization means of chemical plant protection by 8.7% of the scientifically grounded standard, recommended for our country. Therefore, the market for equipment for chemical plant protection in Russia is currently very attractive for product promotion and production development. At present, Russian enterprises manufacture sprayers, but the designing and manufacturing of new equipment for plant protection in most cases are carried out without taking into account the modern achievements of domestic and foreign science, international standards, technological and environmental requirements. Using the example of the European Union countries, the authors point out the need to improve Russian legislation in the field of plant protection and control of the technical condition of sprayers, as well as to develop regulatory documents and approve regulations that provide for constructive, technological and environmental requirements for plant protection equipment. As further development of the production of mechanization means of plant protection is observed, the priority should be the introduction and improvement of information systems and automation of technological processes and individual systems using modern domestic and foreign scientific solutions aimed at improving the quality of plant protection and reducing the impact of negative factors on the environment.

Key words: plant protection, chemical plant protection, sprayer, technical means for plant protection, technical regulations.

ORIGINAL PAPER

STRUCTURAL-AND-FUNCTIONAL MODELS FOR CONSTRUCTING DIGITAL TECHNOLOGICAL MODULES OF MODERN DAIRY FARMS

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Abstract. Establishing a standard series of digital automated robotic dairy farms of a new generation with different configurations and capacity (25-50-100...1200...2400 goals) implies their structural typing and modular building based on the methodology of finite element analysis and structural-functional models, including complete modular units. The author has developed structural and functional models for building digital technological modules and modular units of modern automated and robotic dairy farms of a new generation. Modular structural and functional units are proposed. They include passive accumulative and regulating modules of inanimate (material, technological) and animate biological flows (animals), active machine-technological modules for moving and transforming material technological and production flows to/from animals, information and analytical modules for rapid assessment of the quality of production flows, systems for receiving, transmitting, processing and storing information flows (signals) received from machine-technological modules (milking, feeding, manure removal, etc.) and from animal sensors. The author analyzed and obtained formalized structural and functional models of digital modular units: automated and robotic milking parlors, automated and robotic animal feeding systems, automated systems for differentiated microclimate provision, energy-saving aerobic and (or anaerobic) modules for manure processing as complete structures, including space-planning accumulative-regulating technological modules of the passive type and machine-technological modules of the active type to move and transform material technological flows, as well as carry out express diagnostics of their quality and storage of information flows. The implementation of the developed structural and functional models of digital technological modules and modular units will provide for designing new projects of digital automated and robotic dairy farms of a new generation with increased functionality and adaptive functions to be applied to biological objects.

Key words: structural-and-functional model, passive technological module, active machine-technological module, modular unit, local biotechnical system.

ORIGINAL PAPER

NON-CONTACT BODY CONDITION SCORE OF DAIRY COWS BASED ON TOF-TECHNOLOGY

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Abstract. The paper presents the results of applying the body condition score (BCS) least squares algorithm used to assess the body condition of dairy cows with a 3D ToF camera. The authors propose a method for collecting field data on the body condition of dairy cows in industrial milk production using a 3D ToF camera. The camera was installed at a height of 2200 mm from the floor at an angle of 5° towards the sacrum. Four areas of the body of 34 dairy cows were examined: the ischial tuberosities, the roundness of the maclugs, the sacral ligament, and the caudal ligament. Data were collected during milking. 136 images were processed. Digital data were processed in three types of images: in the RGB-D color spectrum, Point Cloud and binary. The assessment took into account five groups of fatness: 1 – lean; 2 – thin; 3 – well-fed; 4 – very well-fed; 5 – obese dairy cow. The resulting images were analyzed using software developed in the Matlab environment. The results of the algorithm were compared with the expert assessment of four specialists. According to the results of the BCS assessment of the algorithm, the fatness scores of groups 1 and 5 coincided with the opinion of experts with a probability of 73 and 67%, in groups 2, 3, 4 the coincidence was 61, 52 and 55%, respectively. The authors suppose that the inaccuracy in determining the fatness of groups 2, 3 and 4 is associated with their implicit differences. It is concluded that of all the BCS groups, the system more accurately determines the fatness of cows of groups 1 and 5, as well as from three image options (Point cloud 3D, RGB-D, binary) RGB-D most accurately determined the fatness of cows.

Key words: dairy farming, dairy cow, body condition score, BCS, ToF, 3D, non-contact body condition score.

TECHNICAL SERVICE IN AGRICULTURE

ORIGINAL PAPER

INTELLIGENT SYSTEM FOR DIAGNOSING THE PARAMETERS OF THE TECHNICAL CONDITION OF TRACTORS

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Abstract. Research aimed at the development and implementation of new digital methods and intelligent systems that allow improving the diagnostic process, increasing the reliability of determining the functional characteristics of agricultural tractors in an online mode is an important and relevant component of technologies and tools for servicing agricultural machinery. The paper presents the results on the justification and development of an intelligent system for diagnosing machines based on the interaction of a neural network. The advantage of this diagnostic system is the ability to maintain the working condition of agricultural machinery, in case the processes of diagnosis and analysis of the obtained data are automated. The use of an intelligent tractor

diagnostic system provides for the determination of not only the cause of failure by the controlled parameters, but also the efficiency evaluation of the machine as a whole. It is established that one of the ways to increase the efficiency of using agricultural machinery is the non-contact determination of the parameters of the technical condition of equipment through the modernization of the technology for monitoring the technical condition of machines and the quality of work on the basis of the introduction of modern intelligent and telemetric systems.

Key words: intelligent system, tractor, technical condition, diagnostics, neural network, online monitoring.

ORIGINAL PAPER

NORMALIZATION OF THE PERMISSIBLE ERROR AND THE CHOICE OF MEASUREMENT TOOLS FOR CONTROLLING DEVIATIONS IN THE SHAPE AND LOCATION OF SURFACES

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Abstract. The reliability of repaired engines is determined by many factors, among which the accuracy of the geometric parameters of engine parts plays an important role. Errors in the shape and location of the surfaces of parts cause additional acceleration of moving parts and reduce the accuracy of kinematic pairs. Violation of the movement kinematics of parts leads to a deterioration in the technical performance of the engine. In this regard, increasing the level of metrological control of shape deviation and surface location is one of the ways to improve the quality of engine repairs. Analysis of the measurement tools recommended in the reference literature has shown that they were chosen irrespective of the controlled values and without taking into account the type of measurement. The purpose of this study is to develop recommendations for improving metrological control of deviations in the shape and location of surfaces of parts during engine repairs. The paper provides theoretical grounds for choosing the criteria for selecting measuring instruments to control deviations in the shape and location of the surfaces of parts, taking into account the relevant formula. The result of indirect measurement and the measurement error (deviation of the shape and location of the surfaces of parts) are considered random values functionally related to the measured values (diameters of a part). The limits of permissible measurement errors and measurement tool errors are determined to control the deviation of the shape and location of the surfaces of new engine parts and parts subject to troubleshooting. The authors have carried out a comparative analysis of the obtained values with the error values of measuring instruments recommended in the reference literature. It has been established that most of the recommended measuring instruments have an error greater than the allowed measurement error. To reduce the risk of accepting parts that exceed the deviation norms relating to the shape and location of surfaces, it has been suggested using special criteria when selecting measuring instruments.

Key words: selection of measuring instrument, indirect measurements, measurement error, deviations of the shape and location of surfaces, engine repair, measurement quality, standardization of permissible error.

ORIGINAL PAPER

STUDY OF THE RESISTANCE OF TAPERS WHEN APPLYING METAL-CLADDING LUBRICANT-COOLING FLUIDS

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Abstract. The paper discusses the results of comparative tests of the period of tap resistance in various technological environments. The workpieces were processed in the medium of industrial oil I-30 with using a 10 and 20 percent solution of the metal-coating additive “Valena SV” in the same oil. The tests were performed on M10×1 taps made of high-speed steel of the R6M5 brand during the production of through threaded holes in samples made of steel of the Steel 40X brand. The cutting speed varied from 5.7 to 11.1 m/min at the rotary speed of the tool ranging between 180 and 355 rpm. Based on the experimental material, a regression model of the relationship between the relative wear resistance and the additive concentration, and cutting speed has been determined. The author has evaluated the model adequacy and the convergence of the experimental and calculated data. It has been found that at a cutting speed of 11.1 m/min and an additive concentration of 20%, the relative wear resistance of the taps increased by 3.1 times. The results obtained testify to the effectiveness of the composition and confirm the hypothesis of an increase in the wear resistance of the taps in the medium of metal-plating lubricating-and-cooling liquids.

Key words: metal-cladding additive, threading, taps, oil-based cutting fluids, durability period.

ORIGINAL PAPER

ANALYSING THE EFFECTIVENESS OF MODERN TECHNICAL SERVICE OF AGRICULTURAL MACHINERY

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Abstract. Taking into account the importance and necessity of establishing an effective repair and maintenance facilities for Russian farm industry, research was conducted on agricultural enterprises to analyze methods of organizing maintenance and repair, as well as technical and economic indicators of services that perform these types of activities in all regions of the country. The authors have determined quantitative composition of operating enterprises, the engineering staff, as well as a number of indicators characterizing their economic condition. It is noted that

currently farm enterprises dealing with the repair and maintenance facilities do not meet modern requirements. The equipment fleet is outdated and requires large amounts of maintenance and repair to maintain its operability. The repair and maintenance facilities cannot perform this task and need organizational and technical transformations that take into account the prospects for the transition of manufacturers to a new level of interaction with consumers in the medium term - the life cycle contract. The paper considers the methodology concerning the possibility of using the "Total Cost of Ownership" criterion in Russia, and the possibility of transition of agricultural machinery manufacturers to a life cycle contract. It is noted that the lack of information on the state of the farm repair and maintenance facilities makes it difficult to determine a criterion for the full cost of ownership and the subsequent transition manufacturers on a contract life cycle. The authors indicate that the efficiency of the repair and maintenance facilities of the industry can be increased by raising the production of domestic agricultural machinery in the medium term in 1.5...2 times, developing in the short term a regulatory and legal framework to include maintenance and repair services related to the leased equipment in the list of additional activities of leasing companies. Also the list of measures includes making vehicle repair contracts with manufacturers, providing state support for establishing service centers in leasing companies, and ensuring the availability of information on the cost of operation and maintenance for the entire period of the equipment use, as well as scientific support and training.

Key words: technical service, repair and maintenance facilities, agricultural machinery, maintenance and repair of machinery, total cost of ownership, inter-repair period, life cycle contract.

ORIGINAL PAPER

ASSESSING THE FEASIBILITY OF TECHNOLOGICAL EQUIPMENT FOR PROCESSING CYLINDER LINERS

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Abstract. The production of high-quality repaired engines is possible only with the right selection of technological equipment. The issues of the processing quality on honing machines rank first in the repair production, since the reliability of engines depends on the processing quality of cylinder liners. It is revealed that for a clear understanding of the feasibility of using old and choosing new technological equipment, it is necessary to evaluate it from the standpoint of an integral quality indicator. As a basic model for assessing the quality of technological equipment, use is made of the cost method. According to it, the cost index of quality as the value inverse to the integral indicator of product quality is formed for evaluating machines. It is determined by the value of the unit cost of processing one part calculated in cost form by groups of resource intensity indicators multiplied by the corresponding resource prices. Each cost group is the product of the resource price by its specific consumption in physical terms, resulting in a cost index of quality. For honing machines used for processing cylinder liners, a relationship was determined to analyze the cost index of quality. This index includes four basic elements – the indicators of material intensity,

labor intensity, energy intensity of machinery and the material intensity of the inputs used in the technological process. The evaluation of the quality of machines has revealed that purchasing new equipment is economically feasible as technical and economic level of new machines exceeds the base level due to increased productivity, reduced energy consumption and unit cost. It is most advisable to use the ROBBI SET150-L machine (Italy) from among the new ones, since its integral quality indicator is significantly higher than its analogues. From among the old ones, NAGEL VS8-50 (Germany) should be recommended, while domestic machines should be replaced due to their low efficiency.

Key words: technological equipment, material consumption, energy consumption, labor intensity, integral quality indicator, cost index of quality.

THEORY AND METHODOLOGY OF PROFESSIONAL EDUCATION

ORIGINAL PAPER

TEACHING CAPABILITIES OF ROBOTIC VR- CONSTRUCTORS IN THE TRAINING PROGRAMS OF AGRICULTURAL ENGINEERS FOR THE DOMESTIC FARM INDUSTRY

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Abstract. The paper discusses the didactic advantages and features of the use of such immersive technologies as “virtual constructor” in the practical training of BSc students (training area 35.03.04 “Agricultural Engineering”) for the domestic farm industry. VR-constructors are software products that fully emulate a virtual environment with a 360° view, the distinctive feature of which is to maximize the possibilities for interacting with virtual objects in terms of their study, movement and transformation of the object system. As applied to the training of agricultural engineers such systems of virtual objects can be represented by properly designed training mechanisms of engines, various irrigation systems in hydroponic installations or a specific soil profile with its individual horizons. The authors conducted analysis of scientific literature, reflecting the practice of the application of virtual reality technology to be used in the training of university students. The study has revealed the lack of precedents comprehensive introduction of VR technology as an effective learning tool in higher agricultural education in Russia and abroad. After conducting the experiment based on a number of expert assessment methods, two VR software products of the “VR-constructor” type were identified, which are recommended for implementation in course syllabi for BSc training in agricultural engineering in: “3D-card file of soil sections” and “VR-atlas of agricultural machinery”. The study of the teaching capabilities of these curricula has stated the need to change the traditional roles of the teacher and the student and the necessity for further scientifically-based introduction of university course syllabi of various levels to train more competitive and highly qualified personnel for the innovative agriculture of Russia.

Key words: VR-constructor, training of agricultural engineers, immersive technologies, virtual reality, educational robotics.