

Digitalization and use of artificial intelligence technologies in technical modernization of the agro-industrial complex

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Abstract. The article presents the prospects of digitalization and use of artificial intelligence technologies in the technical modernization of the agro-industrial complex (AIC). In order to improve the efficiency of agricultural industry, including the productivity and quality of products in such sectors as crop production, livestock, processing of agricultural products, a transition to innovative technologies is required. Their use in agricultural production makes it possible to significantly competitiveness of the agricultural sector of the economy of the Russian Federation. To do this, the technical modernization of the agro-industrial complex, which provides for the renewal of its base with domestic agricultural machinery is required. In modern machines, a large number of electronic systems with various sensors are involved. They allow to control the operation of various units, including the internal combustion engine, transmission, work tools and other mechanisms. The use of such systems makes it possible to reduce the cost of maintenance and use of equipment, to monitor the modes of operation and technical condition of equipment around the clock, to conduct repair and maintenance activities as required. The current global trend is the use of remote machine diagnostics systems. They allow service centers and emergency support to diagnose a vehicle at a distance, reducing downtime. In recent years, there has been a trend towards digital solutions in machine maintenance. 3D technologies are promising for repair of agricultural machinery, including restoration and hardening of parts. They can be used to measure the geometric dimensions and determine the physical and mechanical properties of part faces of agricultural machines during the incoming inspection of spare parts and fault detection of parts, by scanning them. The introduction of digital technologies and artificial intelligence in the repair practice will reduce the duration of repair and maintenance actions during the technical service of agricultural machinery and significantly reduce the cost of their implementation.

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1 Introduction

To ensure the sustainable development of agriculture, it is necessary to develop and implement new equipment and technologies that increase labor productivity, energy efficiency, resource saving and reduce environmental pollution. For example, studies are currently underway to replace fuels, oils, and various preservative materials of petroleum origin with alternatives, including those based on vegetable oils [1,2]. The technical modernization of the agro-industrial complex also includes large-scale digitalization and the use of artificial intelligence technologies. The implementation of the departmental project “Digital Agriculture” [3] will contribute to the implementation of digital solutions in the production processes of the country's agro-industrial complex. Intellectualization of agricultural processes and machinery are becoming a key resource for improving the efficiency and competitiveness of domestic agriculture. At present, the agro-industrial complex is already using systems of parallel driving of agricultural machines, telemetry and monitoring of tractors and combine harvesters, the introduction of precision agriculture technology, the use of the Internet of things, drones, robotic devices. The trend in foreign countries is now the use of remote (distant) machine monitoring systems. Such systems allow to reduce operating costs for the maintenance and use of agricultural machinery, to carry out round-the-clock monitoring of operating modes and the technical condition of machines, to carry out repair and maintenance actions to maintain their operability according to the need [4,5]. In the technical service of agricultural machinery, such digital solutions as “smart spare parts warehouse”, “smart oil warehouse”, etc. are already used. The most developing area of “digital” production is the use of 3-D technologies, which are called additive technologies. They are promising in repair of agricultural machinery, for example, in manufacture of spare parts and recovery of parts [6]. The introduction into practice of digital solutions for technical service will reduce downtime and costs for the maintenance and operation of equipment, as well as increase the coefficient of technical readiness of population of machines [7].

The article goal is to summarize domestic and foreign developments in the use of digital technology and artificial intelligence in the technical modernization of the agro-industrial complex.

2 Materials and methods

Publications in periodicals and websites, other open sources, as well as information resources of the Federal State Funded Research Institution “Rosinformagrotech”, including factual and documentary databases, were used for the analysis. Much attention is paid to the summary and comparative analysis of foreign technologies presented at various annual exhibitions, including international. To do this, open information resources, developments of domestic and foreign manufacturers of agricultural machinery, including those awarded at the International Agro-Industrial Exhibitions AGROSALON (Moscow, Russia), Agritechnika (Hannover, Germany), SIMA (Paris, France), Golden Autumn (Moscow, Russia) and others were analyzed.

3 Results and discussion

It was found that the use of electronic units and on-board computers is increasing in the designs of machines produced by major domestic and foreign manufacturers. In accordance with a given program, they control the operation of diesel engine; hydraulic drive transmission; work tools and other units. At present, parallel driving systems, telemetry and monitoring of agricultural machinery are already becoming widespread in agriculture,

precision agriculture technologies are being introduced, the Internet of things, drones, robotic devices, and mobile applications are being used [8]. One of the areas of digitalization and use of artificial intelligence technologies in technical modernization of the agro-industrial complex is the introduction of telemetry systems and monitoring of indicators of efficiency of use of agricultural machinery into engineering practice [9,10,11,12,13]. These systems allow to reduce the cost of maintenance and use of equipment, constantly monitor the modes and regulations of machine operation, monitor their technical condition, carry out maintenance and repair operations as required. The largest domestic and foreign manufacturers of agricultural machinery and equipment, including “Claas”, “John Deere”, “Rostselmash” use various telemetry and monitoring systems . It was found that TELEMATICS, AGCOMMAND, JDLINK, AFS Connect, and others were the most widely used systems. The presence of such systems on combine harvesters can significantly reduce the harvesting period, the cost of fuel and lubricants, increase productivity of harvesting complexes, as well as the utilization rate of working time [4]. Of the Russian developments, the most common are the systems of Rostselmash PJSC(AGROTRONIC), the companies Farvater, Autograph, ANTOR GC (ANTOR Monitor Master). The systems of the company Farvater monitor the technical condition of the machines in real time. Their use reduces the cost of maintenance and operation of equipment by up to 30%. Modern telematics systems operate using satellite navigation systems, cellular communications, computer technology, and digital maps. It is shown that remote fuel consumption control systems have found the greatest application, which can reduce fuel costs on farms. Electronic control systems for road construction machines control the hydraulic system, engine and other units. In recent years, the trend of digital solutions in machine maintenance is the use of computer diagnostics systems. With the help of such diagnostic systems (scanners), it is possible to minimize the area of fault finding and determine the nature of these defects without resorting to time-consuming operations. The analysis of advanced solutions in the field of technical service demonstrated the development of technologies for remote (distant) machinery diagnosis. Such technology allows to provide remote support to the customer via the Internet, without going directly to the machine. Using this information, maintenance schedules, order spare parts in time, based on the actual results of diagnostics can also be planned. Remote Diagnostics systems allow to perform diagnostics of agricultural equipment at a distance, which can reduce its broken time [4]. The characteristics of some remote equipment monitoring systems are given in the table below.

Table 1. Characteristics of some remote equipment monitoring systems

Ser. No.	System name	Developer	Purpose, effectiveness
1	Telematics	Claas companies	Use GPS satellites to determine the location of cars. More than 200 different parameters about GPS-coordinates, time and nature of work and technical parameters of the machines are transmitted via mobile communication to a single server. As a result of the system implementation, the operational reliability of agricultural machinery is increased, and organization of planning for their maintenance and repair is improved.
2	AGCOMMA ND	AGCO Corporation	Designed for managing the fleet of cars in farms. The system allows to assess up to 25 key machine parameters in real time and compare the effectiveness of their use in performance of agricultural works.
3	AFS Connect	Case IH company	Designed for remote diagnostics of machines. The use of the system can significantly reduce downtime of agricultural equipment during various operations, such as harvesting.

Table 1. Continued

4	JDLink	JohnDeere company	Designed to manage the fleet of machines used on farms. The system operation allows the staff to make decisions on the efficient use of fuel, optimizes the use of population of machines, as well as remotely diagnose them. Installing the system on machines saves time on maintenance work, allows to monitor the operation of machines directly from the office and from anywhere with Internet access or from a cell phone.
5	RemoteDiagnostics	Scania company	Designed for remote diagnostics of machines. The use of the system allows service centers and emergency support to perform diagnostic operations to identify machine faults at a distance, which reduces downtime and increases productivity in agricultural operations.
6	Auto GRAPH	Auto GRAPH	Designed for remote control of machine fuel consumption. The use of the system allows to save fuel consumed when using agricultural machinery.
7	AGROTRO NIC	Rostselmash company	Designed for remote monitoring of fuel consumption, unauthorized unloading of products from harvesting machines, machine downtime. Allows to maximize the use of machine power, reduce the maintenance duration, analyze technological processes, improve planning and logistics, reduce the cost of maintaining the population of machines and improve the performance indicators of agricultural work.
8	Can-Way, Line-Way	Farvater company	Designed for remote diagnostics and monitoring of the equipment operation efficiency in all operating modes. Allows to remotely diagnose machine assemblies, including internal combustion engines, predict preventive routine maintenance and repair work to prevent sudden equipment failures.

An important area of digitalization and the use of artificial intelligence technologies in technical modernization of the agro-industrial complex is the repair of agricultural machinery. Technologies based on 3D scanning are promising for the specified sphere of engineering and technical system of AIC, including for production facilities on parts restoration [14,15,16]. To implement them, various laser scanners, mainly laser scanners, are currently developed and used in the world. They allow to carry out non-contact measurements of geometric and physical and mechanical parameters of parts and are effective in the incoming inspection of spare parts and fault detection of assembly units during the repair of agricultural machines. Compared to contact measuring tools, 3D scanning is more accurate and productive. The specified method reduces the duration of measurements, reduces the subjectivity level of assessing the technical condition of part, reduces the process complexity by 30%. In the technological preparation of repair production in the absence of documentation for worn parts, reverse engineering is effective. The developing area of “digital” manufacture is the use of 3D printing technologies for polymer and metal parts. Various printers are developed and used to implement such technologies, mainly by foreign manufacturers SLA, FDM and PoLyJet, Russian ones, such as the Composer 3D printer and printers by “Lasers and Apparatura” and others [6,17]. As the analysis of foreign information resources showed, the use of additive coating technologies and 3D scanning of worn-out ones is effective. With this technology, a 3D scanner is used to determine the wear on the part surface, and it is restored on a 3D printer. Spot coating significantly reduces material consumption [6]. The use of digital solutions in the design of repair-engineering equipment makes it possible to reduce the duration of operations. Robotics systems are used in machine repair technologies. They are most widely used in painting machines and restoring and strengthening parts [18, 19]. In the technical service of agricultural machinery, such digital solutions as “smart spare parts warehouse”, “smart oil warehouse” are already used. The use of intelligent spare parts storage systems allows to reduce the time required to complete orders. The use of digital complexes of oil warehouses and gas stations allows to manage the

process of filling fuel without an operator, to move from paper to electronic accounting of fuel consumption, to control the amount of fuel in tanks. The developed software allows to identify and prevent fuel leaks, vent valve failures, spontaneous fuel combustion [20].

4 Conclusions

1. To improve the efficiency of agricultural industry, including the productivity and quality of products in such sectors as crop production, livestock, processing of agricultural products, a transition to innovative. This requires technical modernization of the agro-industrial complex, which includes the renewal of its base with domestic agricultural machinery, large-scale digitalization and the use of artificial intelligence.
2. In modern machines, a large number of electronic systems with various sensors are involved. They allow to control the operation of various units, including the internal combustion engine, transmission, work tools and other mechanisms. The installation of such systems on agricultural machinery allows to reduce the cost of maintenance charges, to continuously monitor the modes of operation and technical condition of machinery, carry out maintenance and repair as required.
3. One of the areas of digitalization and use of artificial intelligence technologies in technical modernization of the agro-industrial complex is the introduction of telemetry systems and monitoring of indicators of efficiency of use of agricultural machinery into engineering practice. The use of such systems on combine harvesters will reduce the duration of harvesting and its losses.
4. In recent years, the trend of digital solutions in machine maintenance is the use of computer and remote diagnostics systems. With their help, it is possible to minimize the area of fault finding and determine the nature of these defects without resorting to time-consuming operations, as well as to perform diagnostics of agricultural machines at a distance, which reduces their downtime.
5. An important area of digitalization and the use of artificial intelligence technologies in technical modernization of the agro-industrial complex is the repair of agricultural machinery. For this area of engineering and technical system of the agro-industrial complex, technologies based on 3D scanning are promising. To implement them, various laser scanners, mainly laser scanners, are currently developed and used in the world. They allow to carry out non-contact measurements of geometric and physical and mechanical parameters of parts and are effective in the incoming inspection of spare parts and fault detection of assembly units during the repair of agricultural machines.
6. The use of digital solutions in the design of repair-engineering equipment makes it possible to reduce the duration of operations. Robotics systems are used in machine repair technologies. They are most widely used in painting machines, restoring and strengthening parts.
7. In the technical service of agricultural machinery, such digital solutions as “smart spare parts warehouse”, “smart oil warehouse” are already used. Their use allows to significantly speed up the execution of orders for shipment of spare parts, control the amount of fuel in tanks.

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