Robotization in the production of dairy, meat and fish products

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Abstract. In the current conditions of a market economy, for the more complete automation of technological processes for the production of meat, dairy and fish products, and especially when frequent changes in the product range (assortment) are needed, the use of robots and robotic flexible technologies is extremely important. The possibilities of using robots and flexible robotic systems for more complete automation of technological processes for the production of meat, dairy and fish products are considered. The main directions of the development of technological progress in the mechanization and automation of animal husbandry and their impact on improving process technology, the use of digitally controlled technologies, increasing labor productivity, reducing costs, improving product quality, and protecting the environment are outlined. It is noted that one of the important areas of technological progress in the modern period is the comprehensive modernization of existing facilities.

Today, in pursuit of an increase in turnover, machinery manufacturers have begun to flood the market with many «smart» devices: from smartphones, glasses, and watches to complex sensor systems, robots and machine tools. While software developers began to release a significant number of platforms and programs that allow you to connect to all these «smart» devices and connect them together. That is, it can be stated that the moment has come when the accumulated theoretical research has become possible to put into practice. The era of intelligent machines began in our daily lives, but technology can also be actively developed in the manufacturing sector. There has been a trend that intelligent machines are transforming all the ways we operate. Machine learning and artificial intelligence will soon become part of our daily lives. This is pretty obvious. Giants such as Amazon, Alphabet, Facebook, and Microsoft have already made smart machines part of their systems.

Over the coming years, along with nano- and information and communication technologies, a significant expansion of the use of biotechnology is projected. In a number of leading countries of the world, these areas are already central to the development of their national economies and the development of development strategies.

So, without a doubt, the active introduction of these areas in the future will not only ensure the sustainable socio-economic development of the economies of many countries of the world but will also influence the solution of many global problems of our time [1].

The main element of the robotization of livestock processing enterprises is a fundamentally new type of machines that simulate human actions in a wide variety of labor processes. Namely, the so-called
industrial robots, being, in fact, a multi-purpose automated machine, fully meet the modern requirements of flexibly resizable production (which is extremely important in the conditions of fierce competition) and the need to automate auxiliary processes (operations), most of which are still still performed using manual labor. As you know, it is not possible to automate auxiliary production operations by traditional methods of classical automation. But a combination of well-known, seemingly self-developing scientific areas (the elemental base of automation - sensors, computer technology, computer science and mechanical manipulators) made it possible to obtain a new quality - a robot that is quite capable of solving automation problems of both basic and auxiliary technological operations 2[5].

The largest players in the agricultural robotics market are DeLaval (Sweden), Fullwood (UK), Lely (Netherlands) and GEA Farm Technologies (Germany). According to researchers from the robotics market, agricultural robotics occupies 39% of the entire European robot market. Agricultural robotics is developing at a very high pace in the Netherlands, which generally do not belong to the market leaders in this technology. The country occupies the strongest positions in the niche of agricultural robotics. Lely, the largest Dutch manufacturer of robotics, is the world leader in robotic milking systems. В настоящее время самым распространенным робототехническим продуктом можно назвать доильную робототехнику.

In December 2002, there were 1,754 milking robots in the world, and after 5 years there were 8190 of them, in 2010 - more than 16 thousand. Moreover, in Germany and France in 2010, 30% of all milking equipment was robots, in Denmark - 50%, the Netherlands - 57%. According to experts, the milking robotics market will be 28,600 robots per year by 2018 [3].

In the modern agro-industrial complex, robotic tools are widely used. Dairy farm robots are specialized equipment designed for automatic milking of cows, diagnostics and feeding of animals. With the introduction of robots, the advantage in the volume of milk production is growing, which is achieved through the competent planning of the milking system [4].

As international experience shows, the financial costs associated with the creation of such systems are quickly covered by a multiple increase in labor productivity, and the flexibility of rapidly redeployed production lines for the production of a new range of products. The following classes of robotic systems are distinguished: manipulation, mobile, information and information management [1].

The basis of the manipulation (and any other type of robots) is, as a rule, a multi-link manipulator with controlled drives and working bodies for each degree of mobility. The working bodies may vary in design (multiple grips, technological equipment, etc.). The basis of the manipulation (and any other type of robots) is, as a rule, a multi-link manipulator with controlled drives and working bodies for each degree of mobility. The working bodies can vary in design (multiple grips, technological equipment and the like) [3].

Manipulation robots mounted on a platform with moving devices in space belong to the class of mobile robotic systems. When constructing them, various principles of movement are used (wheelied, walking, caterpillar, floating, flying, and so on). For example, in the agro-industrial complex, self-propelled agricultural units (tractors) equipped with manipulators for spraying pesticides in orchards, vineyards (for pest control and others) can be used as mobile robots [2].

The largest share falls on the class of handling robots. The classification of manipulation robots is shown in figure 1[3].

Information and information management robotic systems are a complex of primary information-converting measuring equipment (sensor devices - automation sensors) combined with automated systems for collecting, processing, storing and presenting information, which is then used for control purposes.

Manipulation robots are divided into:

- manual, multi-link (exoskeleton and articulated balance), associated with the movements of the arms and legs of a person. They are used mainly when performing loading and unloading operations;
• remotely controlled, which are mainly used when working in extreme conditions (high radiation, explosive hazards, low temperatures, high pressures, when conducting research underwater, in space, etc.);
• automatically operating (robotic production lines, sections, robotic complexes).

In turn, automatically operating manipulation robots are also divided into the following varieties:

• rigidly built-in (in fact, they can be attributed to robots only conditionally). They are, as it were, the zero generation of robots. They do not have tunable control programs, and by their specificity they are, in the final analysis, converters and amplifiers of human muscular movements (mechanical arms, hereinafter referred to as autooperators);
• software robots are equipped with control systems that operate in accordance with a previously developed program, as well as controlled drives of the working bodies for each degree of manipulator mobility. The successful operation of such robots is possible only with a constant external environment, which creates certain difficulties in its ordering;
• adaptive robots - robots with adaptation systems that allow the robot to adapt to unpredictable changes in the environment (the software robot does not recognize these changes and can, for example, continue to carry out work on moving goods, despite their absence);
• intellectual robots are the third generation of robots, the development of which is still ongoing. They are equipped with sophisticated sensory systems, technical vision and microprocessor control systems. Such robots can navigate in a changing environment, recognize images, perform logically expedient operations, find optimal solutions to complex problems according to given criteria and offer them to a dispatcher operator or decision-maker [8].

Currently, livestock farms and complexes, enterprises for the processing and production of meat, dairy and fish products are equipped with robotic equipment. For example, automated pig farms and complexes [4] are successfully operating.

At meat processing plants, robots are widely used for cutting and cutting meat carcasses, considering variations in their geometric dimensions, loading, unloading and transport robots, stacker robots serving automated warehouses of finished products, warehouses for spare parts of technological equipment.
The leader in the use of robots for meat processing, with the widest assortment and with a unique level of robotization in the Russian Federation, and, apparently, in Europe, is the «Miratorg» meat processing enterprise located in the Belgorod region. The company has robotic processes of slaughter, cutting with preliminary scanning of carcasses using a laser device, the processes of pumping blood and cutting into half carcasses, primary meat processing.

Manipulating robots themselves pick up boxes of meat from the deboning conveyor and transport it to the warehouse by conveyor, where the products are automatically sorted and then transported to the processing and packaging lines at the request of personnel. And the boxes, after their automatic washing and processing, go to the warehouse of clean containers.

In addition, with the use of robots, the thickness of bacon is determined, the proportion of lean meat, the calorie content of the output raw materials, which completely eliminates the influence of the so-called «human factor» and significantly reduce the time for receiving pigs. They are also completely robotic: the packaging line for finished products, which excluded the presence of service personnel in storage facilities, the line to produce sausages [4].

The introduction of robotics has increased the throughput of the enterprise up to 420 heads per hour, and more than 2 million pigs per year. The plant actively uses not only domestic but also foreign experience. So, for example, equipment of the United States of America was installed on the packaging line, refrigeration equipment was supplied by Denmark. Certain types of technological equipment were purchased in Germany. But all this equipment is linked into a flexible robotic production by our domestic developers and it works smoothly [1].

In the wake of the leader, robotic means are actively being introduced at the Cherkizovsky meat processing enterprise with the «lean production» program, which has been operating since 2014, at the «Agropromcooperation» enterprise and others.

Milking robots, in particular, the Swedish company De Laval, were widely used. As you know, the first milking robot was created at the University of Oregon (USA). Its further development is a modular robot, consisting of several interconnected milking boxes. One such robot is designed to service 60-70 cows with a very high annual productivity (10-12 thousand kg of milk).

The robot carries out all the necessary procedures for preparing the udder, independently connects and disconnects the teat cups and washes them, separately siphons the first trickles of milk, tests the milk for diseases and only after the positive result of the sanitary control sends the milk to the cooling tank. And for the successful completion of all necessary technological operations, it is equipped with a laser scanner, touch sensors, an optical guidance system, ultrasonic devices, an automatic milk quality control system and a number of other auxiliary devices.

In modern Russian dairies, robotization covers milk intake lines, determining its calorie content and other physical and chemical indicators, filling, packaging, palletizing lines (pallet robots), as well as varieties of climatic equipment. The main supplier of such equipment is the open joint-stock company «Rosagroleasing».

The most important factor for breeding beef cattle breeding is the correct choice of breeds. For this, it is necessary to obtain objective data on animals, hematological, biochemical parameters of blood conduct immunogenetic studies, obtaining objective data [6].

At fish processing enterprises, auto operators, robotic technological modules for unloading blocks of frozen fish raw materials, their subsequent cutting and loading into a defroster, robots for grouping cans in packages, robots for packaging finished products (for example, automatic palletizing machines) and much more are widely used [7].

It can be assumed that the pace of robotization of such industries will undoubtedly increase in the future, due to competition between them, since this trend is due to the following main advantages of robotic systems:

- the ability to produce products on the same equipment in arbitrarily small and medium batches. At the same time, the indicators of cost and labor productivity will be almost the same as in mass production;
the ability to reduce the number of staff by about 80-90% and organize, in principle, virtually uninhabited production;
relatively quick cost recovery.

It should be noted that the robotization of such industries is a complex task that requires, first of all, solving the issues of sharing modern technological equipment with robots, creating single centers for group control of robots that simultaneously perform various technological operations in a single enterprise. All this, in turn, requires a radical revision of the technological policy at the state level, the creation and implementation of new flexible production systems, flexible automated production, focused on the production of multi-assortment products with the possibility of varying it both in terms of nomenclature and quantitative indicators.

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