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Indicators of severity and intensity of the working process at robotized farms in the Middle Ural

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***Abstract*—The scientific idea is that robotization of agricultural production results in a significant change in severity and intensity of the working process. Different sociological research methods were used to assess these changes. Robotization causes a transformation of the occupational pattern of workers at agricultural organizations. Workers with a high proportion of hand work (milkmaids, cattlemen) are replaced by specialists of mainly intellectual work (operators of robotic milking, technicians on robot servicing). In robotized organizations, the work severity is declined, and a gender and age pattern of workers is transformed. Also high job satisfaction should be noted at farms with robotics. Indicators of work intensity increase. At robotized farms one can notice often repeated signals and reports, numerous productive objects for simultaneous monitoring, monitoring the screens. There is an unfixed working period and a possibility to solve production tasks remotely, after working time. Increased emotional loads are associated with high responsibility for the result of one's own activities. The use of robotics in agricultural production increases the attractiveness and diversity of work operations, which attract young professionals in the industry.**

Keywords—labor performance, work severity, work intensity, robotics, agriculture.

I. INTRODUCTION

Currently, robotics and digital technologies are used in various areas of agricultural production. Thus, automatic milking systems (AMS) or milking robots are becoming increasingly popular as a milking technology; their use reduces labor costs [1], increases milk yields and improves milk quality [2]. Planting of vegetable crops is rather laborious operation that is usually done by hands. The use of a planting robot can reduce the labor intensity; it can improve the efficiency of seedling planting due to high accuracy with minimal human help [3]. A robot with a computer vision system distinguishes cultivated plants from weeds. While weeds are treated with individual drops of herbicide. This can reduce the use of herbicides significantly and apply herbicides that would otherwise harm the cultivated crops [4]. The use of a harvesting robot is quite effective when harvesting grapes [5] and planting crops [6].

The most important factor in the transformation of social and labor relations is the development of the means of production, the scientific and technological progress, and the improvement of machinery and technologies. At the same time, the efficiency of introducing and using robotic technologies in agriculture has not been studied well [7].

Robotization transforms significantly the nature of work in the industry, influences improvement of the working environment, reduces morbidity and industrial injuries, increases production efficiency based on a productivity growth, improves the quality of working life by doing dangerous, monotonous and tedious work by robots.

There are concerns that further introduction of robotics in agriculture may cause a decrease in employment [8, 9], and, consequently, worsen the living standards of population, which is especially important for rural areas. However, as the rural area is a rather diversified zone, it is impossible to identify employment at rural areas only with agricultural organizations. So, according to L.V. Bondarenko [10] only 26-28% of rural residents are employed in agriculture, the others work in different sectors: mining, a public sector, housing and communal services, education, medicine, etc.

On the one hand, having skills in working with robotics will increase the labor cost in the labor market. On the other hand, as there is a lack of job positions in the labor market, there is competition between agricultural organizations for a qualified young work force, and organizations that use innovative technologies including robotics will benefit.

Thus, the introduction of robotics does not exclude a human from performing working tasks in agriculture, but allows performing tasks at a new higher level. Further digitization of agriculture contributes to the formation of new forms of work activities, cooperation and exchange, as the Internet unites humans with machines and things [11]. Labor activity becomes transparent and controlled from the outside. Expansion of innovations and development of educational opportunities improve the quality of labor resources, which changes a profile of employees and the nature of requirements to them. The working process becomes more autonomous, mobile, and labor functions are associated with mastering numerous competencies. In Russia, the transformation of mass labor and employment is much slower, partially because

this issue is not studied well.

II. MATERIALS AND METHODS

A set of methods will be used to study the severity and intensity of labor relations in conditions of using robotics. In the process of research, primarily, it is necessary to minimize the influence of peripheral factors of the external and internal environment in which agricultural organizations operate. They include the breed of animals, the availability and quality of food supply, the difference in wage systems, etc. For this purpose, all organizations in the Middle Urals will be chosen which use in production both conventional technologies and robotics.

The nature of work and its other characteristics undergo a certain transformation. An assessment of the workplace of an operator at a robotized farm and a technician on servicing robotized equipment should be done through a comparison between the conventional and robotized farms.

The main indicators of severity of the working process include: physical dynamic load; the weigh of lifted and moved loadings; a total number of typical working movements; static load; a body working position; a degree of body bending; movements in space. The assessment of physical severity is influenced by all the above mentioned indicators. It should be noted that at first a class is determined for each measured indicator and recorded in a protocol; and the final assessment of work severity is done according to the greatest indicator.

Job satisfaction was studied on the basis of a survey of workers at robotized farms. Employees at conventional farms of the same agricultural organization can act as a control group.

The organizations were grouped in order to understand the characteristic of farmers engaged in digital transformation. In accordance with Russian legislation, organizations can be classified as large, medium or small, in terms of the size or scale of their activities, depending on the number of personnel and the revenues from product sales. From the total number of organizations involved in the study, by the number of personnel 54.5% of organizations can be considered as small businesses with 16-100 employees, 18.2% of organizations as medium businesses with 101-250 employees, 27.3 % as large enterprises with more than 250 employees. By revenue from sales of products 63.6% of organizations can be considered as microbusiness with revenues up to 120 million rubles, 36.4% as small businesses with 120-800 million rubles.

The study aims to determine the trends in changes in severity and intensity of work in the conditions of using robotics at livestock farms.

III. RESULTS. THE INDICATORS OF SEVERITY OF WORK AT ROBOTIZED FARMS

Currently, the agricultural organizations in the Middle Urals have a huge shortage of qualified personnel. In recent years there has been an increase of investments in the industry, new facilities are being built for the production and processing of agricultural products; and livestock-breeding complexes are being re-equipped with new machinery and technologies. However, the number of professionals who want to work in agriculture is decreasing. In addition, the age of workers in the industry is near the retirement one. So, a problem of staffing is one of the most acute in the system of reproduction processes in agriculture.

This problem can be solved with robotization of agriculture, introduction of modern robotics into the organizations of the industry. According to the Ministry of Agriculture and Food of the Sverdlovsk region, as of January 1, 2019, 37 milking robots and one feed leveling robot have been installed and are used (Fig. 1).

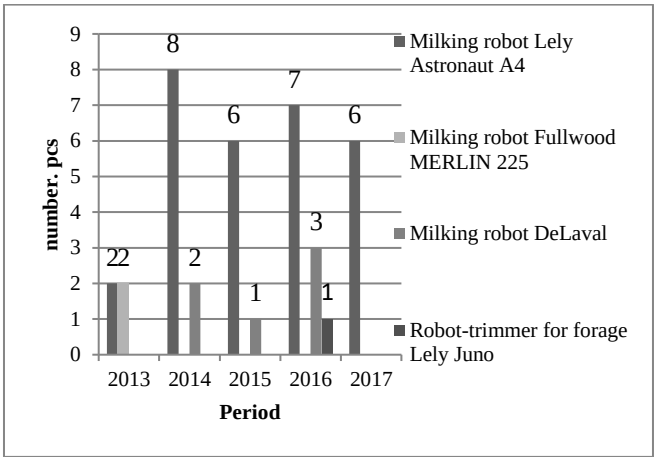

Fig. 1. Dynamics of introduction of robotics by brands in the Middle Urals

The figure shows that robotics for milking animals takes the largest share in the structure, while the Lely brand equipment makes up 78.9% of the total, which can be explained by of a wide service network of this manufacturer, and therefore farmers are willing to purchase it.

When robotization of agriculture, it is necessary to consider regional peculiarities and features of particular sectors of agricultural production. We can distinguish regional features of robotization, which may be associated with features of rural areas. These features include the level and conditions of socio-economic development, the urbanization level, the infrastructure development, the demographic situation, the competitiveness of the agricultural sector and its possibility to attract labor forces compared to other industries, etc.

However, the pace of introduction of agricultural robotics in Russia varies significantly by territories (Fig. 2).

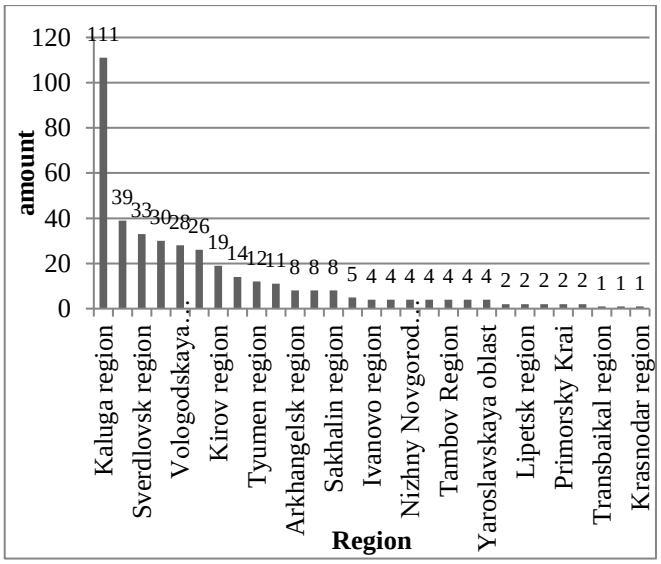

Fig. 2. Availability of robots at agricultural organizations by regions in RF by 1 January, 2017, units*.

[a.] According to Ministries and Administrations of agriculture except Ministry of Agriculture and Food Products of Republic of Tatarstan and Ministry of agriculture of the Perm territory

The data show that from 2006 to 2016, 393 units of robotics were introduced in the agricultural organizations of the Russian Federation [16]. The overwhelming majority of robotics used in agriculture in Russia is milking robots mainly by European manufacturers. The most famous manufacturers of this machinery are DeLaval (Sweden), Lely (Holland), Fullwood (United Kingdom), GEA FarmTechnologies (Germany), SAC (Denmark). Lely robot trimmer for forage is used in several regions. There are other types of robots of various applications, but they are not widely used in Russia.

As of the beginning of 2017, robotics is used in 28 regions of the RF, in 71 municipalities, on their territory 103 business entities operate. The most active robotization of rural areas is carried out in the Kaluga region due to the current state support. However, the significant differentiation of regions in terms of the use of robotics is not explained only with state support programs. Thus, in some regions, despite the availability of programs for modernization of this industry, robotization is not carried out or is carried out at extremely low pace.

At this stage of development of robotics in agriculture it is impossible to exclude humans from the production process. Robotic milking operators replace milkmaids. And, cattlemen, who level the feed on a feed table, are replaced with a technician on robot servicing, including a feed-leveling robot.

A robotic milking operator is a relatively new category of personnel at Russian farms. These specialists perform the functions of analyzing the data of reports in the system, carry out corrective operations, make replacements of consumables and small repairing of robotics, put data into the system, adjust the animals to a robot's milking box.

TABLE I. COMPARISON OF INDICATORS OF SEVERITY OF THE WORKING PROCESS AT DIFFERENT FARMS

Indicator	Conventional farm	Robotized farm
1. Physical dynamic load	Harmful physical work	Optimal (low physical activity)
2. The weigh of lifted and moved loadings by hands	Constant lifting and moving of heavy loadings with interchange with another operations	Total weight of loadings, moved during every hour of a working period
3. Typical working movements	Local movements, typically at a rapid pace	Working movements, typically at a slow pace
4. Typical working position	Periodical, being in an uncomfortable and/or fixed position up to 50% of a working period; being in a constrained position (on knees, on hunkers, etc.) up to 25% of a working period. Being in a standing position up to 80% of a working period	Free and comfortable position, possibility to change a body working position (sitting, standing). Being in a standing position up to 40% of a working period

Improvements in severity of working conditions, monotony, and periodicity of operations in the production process have a positive impact on attractiveness of labor in agriculture, especially for young people who in recent years leave rural areas. Currently, graduates of agricultural higher schools do not tend to work on their profession as working in the agrarian sector of the economy is characterized with severity, low attractiveness, monotony and does not provide opportunities for a personal and professional growth, does not contribute to mastering of new technologies. There is no doubt that the use of digital, intelligent technologies and robotics increases the attractiveness and diversity of labor, which can make young professionals be interested in working in the industry. The most important factors for job satisfaction are interest in work, a decrease in the number of monotonous and repetitive operations, an increase in comfort of working conditions, etc.

It should be noted that working with digital, intelligent and robotic technologies has an impact on lowering the average age. As a rule, robotics is operated on the basis of computer technologies, which is attractive for the younger personnel.

IV. THE INTENSITY OF THE WORKING PROCESS AT ROBOTIZED FARMS.

Work intensity is a characteristic of the working process, which reflects the stress on the central nervous system, sensory organs, and emotions of the worker. The assessment of work intensity of a professional group of workers is based on an analysis of work activity and its structure, which are studied by means of time-keeping observations in the dynamics of a working day for at least one week.

TABLE II. COMPARISON OF WORK INTENSITY OF THE WORKING PROCESS AT DIFFERENT FARMS

Indicator	Conventional farm	Robotized farm
1. Intellectual load	Performing simple operations without high intellectual load	Processing and analyzing of data, making decisions, high intellectual load
2. Sensory load	Sensory loads within the norm	Often repeated signals and reports. Numerous productive objects for simultaneous monitoring. Monitoring the screens
3. Emotional load	Possibility of conflict situations due to professional activities during a working period	High responsibility for a result of one's own activities. Medium error level
4. Monotony of loads	Long performing of simple productive and repetitive operations	Monitoring the production process
5. Working period	A «broken» working period, a fixed working and rest period	«Unfixed» working period. Possibility to solve production tasks remotely, after a working period
6. Work satisfaction	Low	High

A robotic milking operator mainly interacts with the operating system of a milking robot, processes all those signals that are generated by the herd management system. This control system performs an intellectual function and has a wide range of various reports about a status of animal health, the amount of milk production, and information on reproduction. The software in milking robotics constantly generates information in various reports. A robotic milking operator has a possibility to analyze the data from those reports and adapts operations.

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V. DISCUSSIONS

It can be noted that at the level of individual agricultural organizations, the link between innovations and the nature of labor transformation is almost always positive. This can be expressed in improvement of severity of work, monotony, and a periodicity of operations in working activities in agriculture, which have a positive impact on attractiveness of working in agriculture, especially for young personnel. At the industry level it is disputable; at the macro level the technological progress seems to be either a positive or a neutral factor.

A further increase in intensity of the use of digital technologies in agriculture can cause a significant transformation of the process of labor resources training. These changes include new occupations for employment, new types of employment, and the transformation of supply and demand for labor in regional and local labor markets. Transformation on labor spheres can occur mainly from a specialist of manual labor to a specialist of mental work. Further development of these processes will result in new specialists in agriculture – they are the NC programmer, the robotic systems operator, the operator of an automated control system used in agriculture of the future.

To bring forward the process of reproducing the potential of personnel in the conditions of further digitalization of the industry at the regional level, the following measures should be taken:

- to form a sectoral innovation system in the region, acting in accordance with the strategy of the country's scientific and technological development;
- to stimulate scientific, agricultural, educational institutions to conduct basic and applied research, in accordance with global trends in agricultural development;
- information and consulting work in the agricultural sector should be one of the development priorities;
- development of state support for agricultural organizations should contribute to the growth of their financial sustainability, increase of solvency and improve the capacity to introduce digital production technologies;
- personnel training should be aimed at developing competences in the field of advanced digital technologies;
- it is necessary to increase the state funding in research and development, in foundation of scientific and technical centers aimed at increasing the interaction of scientific, educational institutions and business entities, which will increase the efficiency of introducing digital technologies.

At the level of business entities, further digitalization will require additional competencies from personnel:

- engineers - should master the skills of exploitation, service, repair of robotics, Internet networks, etc.
- economists - should be able to determine the feasibility and calculate the economic efficiency of introduction of robotics, the Internet of things, artificial intelligence;
- technologists - should be able to identify areas requiring the introduction of digital technologies;
- zoo-engineers - should be able to operate robotics and other digital elements for zoo-technical keeping;

- veterinarians - should be able to use the data obtained by robotics for making management decisions about treating animals;
- managers - should be able to use information from various sensors, artificial intelligence networks for making management decisions based on verified data, to understand the digital technology market in order to choose an optimal option of this technology.

The use of various digital technologies necessitates improvement of personnel potential who are capable of mastering these technologies, that leads to a change in all phases of personnel reproduction in the industry.

VI. CONCLUSION

The results of the study allow making a conclusion that can be defined as the social effect of the use of robotics and digital technologies in agriculture. The social effect of the use of robotics in agriculture is a result of this activity, which leads to reduction of the proportion of heavy physical, monotonous work with frequently repeated operations, improvement of the material and cultural living standards for workers, decline in occupational morbidity and injuries at work, increase of free time and employee displacement for labor potential fulfillment in other industries.

There are widespread concerns about a possible increase in unemployment under the influence of agricultural robotization, but it has no sufficient reasons. The analysis shows that robotization changes the structure of employment but not its level. At the same time, at this stage of development of digital, intellectual technologies and robotics, it is impossible to exclude human work.

The results of this study can be used as recommendations to farmers on implementing robotization to decrease the severity of work and on attracting young employees in these conditions. It is also necessary to pay attention to increasing sensory loads associated with the use of robotics.

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REFERENCES

[1] E. Wauters, and E. Mathijs, “Socio-economic consequences of automatic milking on dairy farms,” Proceedings of the international symposium, Wageningen Academic Publishers, Wageningen, p. 526, 2004.
10.3920 / 978–90–8686–525–3.

[2] C. Tse; H.W. Barkema; T.J. DeVries; J. Rushen; and E.A. Pajor “Impact of automatic milking systems on dairy cattle producers' reports of milking labour management milk production and milk quality,” Animal. № 12 Issue: 12. pp. 2649-2656, 2018.
10.1017/S1751731118000654

[3] A. Khadatkar; S.M. Mathur; and B.B. “Gaikwad Automation in transplanting: a smart way of vegetable cultivation,” Current science. № 10. pp. 1884-1892, 2018.
10.18520/cs/v115/i10/1884-1892

[4] T. Utstumo; A. Brevik; J. Dorum; J. Netland; O. Overskeid; T.W. Berge; and J.T. Gravdahl. Robotic in-row weed control in vegetables. Computers and electronics in agriculture. № 154. pp. 36-45, 2018.
DOI: 10.1016/j.compag.2018.08.043

[5] L.F. Luo; Y.C. Tang; Q.H. Lu; X. Chen; P. Zhang; and X.J. Zou. “A vision methodology for harvesting robot to detect cutting points on peduncles of double overlapping grape clusters in a vineyard,” Computers in industry, № 99. pp. 130-139, 2018.
DOI: 10.1016/j.compind.2018.03.017

[6] B.Baron Sam, S.Balaji, and Anthuvan Jerald Majella, A., “Using mobile robots to act as surveillance in the crop field, *International”* Journal of Applied Engineering Research, № 10, Issue 6, pp. 15825-15832, 2015.

[7] A. Keisner, and J. Raffo, S. “Wunsch-Vincent Robotics: Breakthrough Technologies, Innovation, Intellectual Property,”. Foresight and STI Governance, № 10, issue 2, pp. 7–27. 2016.

[8] S.P. Zemtsov. “Robots and Potential Technological Unemployment in the Regions of Russia,” Study Experience and Preliminary Estimates, Economic issues, № 7, pp. 142-157, 2017.

[9] C.B. Frey and M.A. Osborne. “The Future of Employment: How Susceptible Are Jobs to Computerization,” Oxford Martin School. Programme on the Impacts of Future Technology. p. 38, 2013.

[10] L.V. Bondarenko. “The demographic situation in the countryside and prospects for the development of rural areas,” Economics of agricultural and processing enterprises. № 3. pp. 53-57, 2013.

[11] I.L.Sizova, and T.M.Khusyainov. “Labor and employment in the digital economy: problems of the Russian labor market,” Bulletin of St. Petersburg University. Sociology, № 4, pp. 376-396, 2017.
DOI: https://doi.org/10.21638/11701/spbu12.2017.401