Research of robotics and automation of construction processes in Russia

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Abstract. An important role in the construction industry is played by the robotics of individual processes in construction. However, despite a wide range of scientific and design developments in the field of construction, the level of automation and robotization processes remains quite low. This is due to the need to systematize the performed research and development, to carry out complex research and development activities. The paper presents data on the technological prerequisites for robotization of construction processes in Russia. The factors hindering the use of industrial robots in Russia are identified. The distinctive parameters and characteristics of robots in the construction of unique buildings and structures are considered. The main tasks for robotization of technological processes at construction enterprises are formulated. The analysis of the levels injuries at construction sites is carried out. The possibility of introducing robotic technology in the construction of unique buildings with complex technical features is considered. As a result of the research carried out, the scientific problem of analysis and synthesis specialized robots for the construction of unique buildings and structures has been considered. The solution to this problem is important, since it contributes to the development of highly effective means of complex mechanization and automation of construction processes that increase the productivity and quality of installation, finishing and plastering works, reduce their labor intensity, free people from harmful and dangerous working conditions.

1. Introduction

Construction is one of the leading spheres of human activity. The variety of ongoing construction projects and construction processes is increasing every day.

Construction processes are characterized by increased complexity and danger. The success of any construction project is determined by three indicators: cost, quality, timing.

To improve the quality of indicators in construction, it is necessary to improve construction production with the help of progressive and innovative technologies. Robotization technology accelerates construction processes, improves the quality and safety of work performed, and also has prerequisites for reducing the proportion of manual labor.

2. Materials and methods

The goal of research consists in analyzing and assessing the effectiveness of using robotic technology in construction and the possibility of its implementation in Russia.

Since the mid-80s of the 20th century, the tasks of robotization and automation of construction work have become relevant to scientists and specialists from research and construction organizations, such as...
the Massachusetts Institute of Technology, Munich University of Technology, Moscow State University of Civil Engineering and other scientific organizations. In this study, we have analyzed scientific developments to solve the problem of automation and robotization of construction processes [1–12]. However, despite a wide range of scientific and design developments in the field of construction robotics, the level of automation and robotization of construction operations remains rather low. It is required to systematize the performed research and development, to carry out complex research and development activities.

3. Research and analysis of technological prerequisites for the robotization of construction processes in Russia

Analyzing the technological features of production in the construction industry and taking into account the extensive experience of robotization at enterprises, we have formulated the following main tasks of robotization processes at construction enterprises:

- development of methods for analyzing the technology of production building products and materials, conducting on their basis a survey of enterprises and drawing up standard comprehensive scientific substantiated plans for creating certain types of technological processes;
- determination of priority technological operations and implementation of industrial manipulators and robots on them;
- development of special manipulators and robots for the construction industry;
- carrying out work on the unification and typification of robotics equipment for construction industry enterprises;
- development technological equipment for robotization of operations in the construction industry;
- carrying out work to improve technological processes and individual operations, taking into account the requirements of automation and robotization for effective implementation;
- creation and implementation of robotic systems, sections and lines, development of standard layout elements for various production processes;
- preparation of new industries for the introduction of flexible technologies and the creation of production systems (lines, sections and workshops) on their basis;
- solution of technical and organizational aspects of operation at enterprises of the construction industry.

Analysis of the main types of construction processes shows that individual construction processes can be automated using robotics. Automation and robotization will reduce the workload on builders engaged in manual labor in the construction of unique buildings and structures. Industrial robots allow a more rational use of labor resources and provide important social and economic benefits. The increase in labor productivity is also facilitated by an increase in the quality of work and a decrease in rejects in the production of building materials and products due to the elimination of individual and subjective factors. The scale of the construction industry and its dependence on manual labor create economic potential for automation and robotization of construction processes.

It is important to note that the price of housing in Russia does not depend on the cost of labor. The introduction of robots will not solve the problem of rising house prices. However, today some cutting-edge manufacturing enterprises are beginning to consider the frequent use of technological robots.

We have identified factors constraining the use of industrial robots in Russia: a) the lack of Russian enterprises' own experience in using robots, methodological materials of the technical and economic complex of robotic technologies; b) lack of qualified specialists able to ensure the operation of robots; c) a limited number of specialists capable of designing robotic areas for the implementation of robots and their technological training during construction.
4. Distinctive parameters and characteristics of robots in construction

Technological progress in the development of robots was aimed at improving control systems. The first generation industrial robots were programmable. The second generation of robots is equipped with sensor systems and a vision function. The third generation of robots has intelligent control.

Small dimensions and weight characteristics of robotic equipment make it profitable and convenient for transportation. Robotic equipment can be operated by one qualified operator. Therefore, this technology is appropriate in situations that are potentially hazardous to the health of workers. Analyzing construction manipulators and robots on the market can be divided into several groups.

The first group consists of manipulators, robots for performing assembly work. Robotics of the first group are characterized by a wide range of carrying capacity, mobility, and increased positioning accuracy. This group includes manipulators and robots for assembling building elements, partitions, assembling equipment and scaffolding.

The second group consists of construction manipulators and robots for concrete work. This group is subdivided into three subgroups: manipulators and robots for placing and compacting concrete mixture, means of robotics for reinforcement work at the facility, handling equipment for erection and dismantling of construction formwork.

The third group of construction manipulators and robots is made up of robots for finishing works. This group includes manipulators and robots for painting, plastering, facing works, applying insulating mastics to roofs, as well as for installing monolithic floors. This group is distinguished by a low carrying capacity of mechanisms, mobility of structures, the use of program control and the need for sensor devices.

The fourth group consists of manipulators and robots for excavation work. This group includes multifunctional handling equipment designed for the construction of excavations, backfilling and compaction of soil, laying communications. Equipment in this group is supplied with remote, software or combined control.

The fifth group includes manipulators and robots for loading and unloading operations. This group includes manipulators and robots of various carrying capacities for loading and unloading building structures and elements, containers and packages, as well as small-piece cargo. Such manipulators can be installed on vehicles and self-propelled chassis.

There are a sufficient number of models on the market of robots that perform many operations in the construction, reconstruction of buildings and structures. Industrial and construction robots are characterized by active and purposeful interaction with the external environment. This is achieved due to the structural organization of the robot, which is determined by the purpose, the nature of technological operations, the type of movements in the working area, the requirements for carrying capacity and positioning accuracy.

5. Injury rate as one of the main aspects of the use of robotics

Construction according to working conditions is a potentially hazardous industry. The temporary nature of workplaces, the need to perform significant amounts of work at height and in difficult climatic conditions lead to the emergence of hazardous and harmful factors that pose a potential threat to the life and health of workers and others, which necessitates increased attention to labor protection issues.

During the construction of buildings and structures, being on the construction site itself, workers are faced with dangerous factors: the presence of moving mechanisms and machines, an increased noise level, an increased vibration level, the possibility of getting burned when working with hot mastics or a blowtorch, the danger of electric shock, physical overload, presence of gas-hazardous and flammable substances, unstable stacks of stored products, high or low air temperature of the working area depending on the season, risk of falling on slippery floors, moving parts of production equipment, location of the workplace at a considerable height relative to the floor surface.

Let us highlight the main causes of industrial injuries during construction: a) lack of supervision over the correct and safe conduct of work; b) operation of faulty equipment; c) gross violation of safety
requirements; d) violation of technological regulations, lack of construction organization projects, work production projects and other documentation or their poor quality development; e) work in difficult climatic conditions; f) violation of hygienic standards (increased content of harmful substances in the air of working areas; g) insufficient or irrational lighting, increased noise levels, vibration, unfavorable meteorological conditions, the presence of various radiation above permissible values); h) psychophysiological factor (physical and neuropsychic overload of the worker).

The reason for the terrible trend of injuries lies, first of all, in non-compliance with labor safety requirements in the construction industry. Neglect of norms is a subjective reason, depending on many factors: the physical and moral state of the employee, his responsibility, discipline, attentiveness. One of the factors to reduce subjectivity can be the introduction of robots and manipulators into the technology and organization of construction production.

6. Conclusion

The unique combination of compactness and power of robots finds its application in the most difficult conditions and inaccessible places on the construction site, while robotization provides a significant reduction in construction time. The emergence of robotic technology is associated with the desire of builders to shorten work times and increase profits.

The conducted research allows us to formulate the following conclusions: a) digital technologies allow the construction industry to function effectively and efficiently; b) robotization allows one to drastically reduce the construction time of the facility; c) automation and robotization makes it possible to build various unique structures at construction sites; d) the introduction of robotic technology will make it possible to build houses of non-standard shape with complex facades, arches and unusual curved interiors; e) the main positive factors of automation and robotization during construction are increased productivity, the ability to work in hard-to-reach and dangerous places for finding a person; f) robots save a lot of building materials.

As a result of the research carried out, the scientific problem of analysis and synthesis of specialized robots for the construction of unique buildings and structures has been considered. The solution to this problem is important, since it contributes to the development of highly effective means of complex mechanization and automation of construction processes that increase the productivity and quality of installation, finishing and plastering works, reduce their labor intensity, free people from harmful and dangerous working conditions.

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