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The Possibilities of Safe Application of Modern Robots in the Production Process

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Abstract

The modernization of production processes in any industry involves the use and rapid development of industrial robots together with further improvements related to technical solutions in the field of automation of technological processes. These machines are faster, more powerful and more accurate than people, and, therefore, they significantly improve the volume and quality of production. Workers are excluded from difficult and monotonous work activities in hostile and hazardous environments. To have a robot system functioning properly, it is necessary to pay special attention to the safety of workplaces where robots operate so that any malfunction that may lead to injuring workers could be prevented. When using the robots, it is important to emphasize operational safety, software-defined boundaries of robotic movement and risk assessment.

Keywords: modern technologies, application of robots, robots, safety.

Introduction

Industrial robots are mainly used in the activities requiring the manipulation of materials and servicing of machines, in process operations (such as welding, painting, cutting, grinding, polishing, etc.), in assembling and the production control. Industrial robotics deals with the design, management and application of robots in industry.

A robot is a mechatronic system that is a combination of accurate mechanics, electronics, software and other state-of-the-art technologies including the sensor systems technology and the artificial intelligence technology as well.

In food processing industry, packing of food and beverages requires delicate and safe manipulation of goods, and, therefore, the robots that are capable of performing fast, accurate and precise operations are used in this field.

In the automotive industry, the robots are used for assembling, welding and painting activities in a fast, reliable and flexible manner, and thus they enable higher productivity and reduction of costs.

In electronic industry, to provide for mass production of computers, mobile devices and cell phones, fast assembling of semi-conducting elements requires the use of robots whose work enables fast and reliable performance with invariable quality. If this were done manually, it would require the engagement of a greater number of educated and skilled workers and a higher degree of quality control to achieve the same quality of performance, which would consequently increase the cost of work. (Strategic Research Agenda for Robotics in Europe, 2014), (World Robotics, 2015), (Holland, 2004)

In the pharmaceutical industry, the speed, precision, and accuracy of robots provide for the high quality of products.

The use of modern technologies results in achieving a higher degree of occupational safety and health. (Stojanović & Cvetković, 2013)

Working conditions are changing towards the reduction of physical labor, and hence technology has to be reliable providing safe work in case of any incidents. Safety is more and more often becoming an integral part of any process. Workers' exposure to hazards or any possible injuries caused by mechanical sources is reduced to the minimum or is entirely avoided. (Stojanović, 2012)

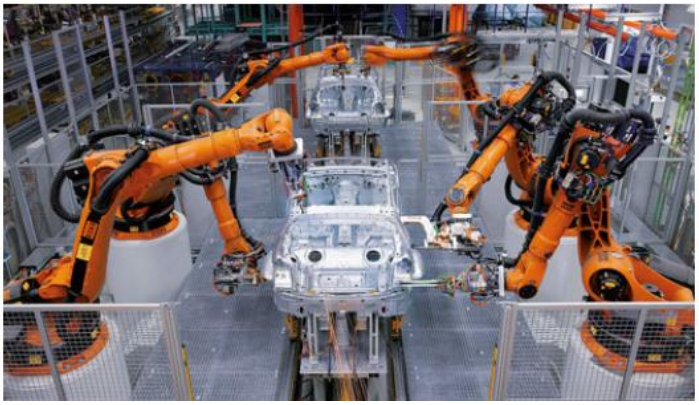
The application of modern robots regarding their accuracy, strength and durability, may easily lead to making human personnel redundant.

It is necessary to consider thoroughly and establish standards for the specific issues of occupational safety and health in accordance with the changes brought about by the implementation of modern technologies and their impact on the physical and mental health of people. (Stojanović, 2014)

Furthermore, the paper presents how a safe application of robots is achieved using the integration and use of the state-of-the-art devices of the modern technologies to provide for the functional safety, software-defined safety boundaries, and obligatory risk assessment.

Contemporary Robots in Production Processes

The automation and modernization of a production process in any industrial branch cannot be imagined without utilization of robots. Industrial robots are designed to work long hours in challenging production conditions in the industrial environment, for example, the welding of a car body, picture 1. .[Robots-pictures, 2015][Svet kompjutera, 2015][Robot montaža i rukovanje materijalima]



Picture 1. Robotic spot welding used for forming the car chassis, an example of a robot used by the German producers KUKA

The performance of spray painting activities is also done by robots. The reason for using robots in the activities of surface protection lies in the fact that these are very filthy activities, the air in painting units is full of evaporations, which are usually highly poisonous and carcinogenic substances. Since these substances are regularly inflammable, the danger of fire also poses a risk. For all these reasons, painting activities are considered to be a category of activities from which workers should be excluded.

In addition to this humanization of work, robots create other benefits in painting activities: better quality, material savings, energy savings, and there is also a rise in productivity brought about by reduction of human work.

Due to these advantages, nowadays all classic car producers of high-class automobiles utilize robots for spray painting.

Spray painting robots are mostly used in the mass production for painting car chassis and engine parts, motorbikes, bicycles, household appliances, dishes, etc. (Stojanović, 2014)

In electronic industry, it is necessary to have fast assembling of semiconducting elements in the mass production of computers, mobile devices and cell phones, which is achieved by the use of robots that provide fast, reliable performance and invariable quality.

Picture 2. Robotic assembling - a robot at the cell phones assembly line

If done manually, in order to achieve the same level of quality, it would require the engagement of a number of educated and trained workers and much higher level of quality control, which would incur immensely higher costs compared to the solution based on the use of robots.

In food-processing industry, packing of food and beverages requires delicate and safe manipulation of goods and, therefore, the robots that are capable of providing fast, precise and accurate performance are used for these tasks.

Picture 3. Robots performing the activities of packing and manipulation

Means of modern technologies achieve a higher level of occupational safety and health. Working conditions are being changed in terms of having physical efforts decreased, and thus technology has to be reliable and include a safe working mode in case of any incidents. Safety is ever more frequently an integral part of any process. Consequently, workers' exposure to hazards or any possible injuries caused by mechanical sources is reduced to the minimum or is entirely avoided.

During the work of industrial robots, it is necessary to take care of safety and protection of the workers who operate the robots or are in the vicinity of the robots' working environment. Various systems are applied to cater for the workers' safety and health, whereas the choice of these systems is related to the frequency of access to the robotic systems. The choice of safety and protection systems to be applied is subject to the manner and speed of accessing a robotic system. What are the possibilities of safe application of contemporary robots?

The Possibilities of Safe Application of Contemporary Robots

A robot is a man's helper. Robots cannot work without a man. A man is always in a direct or indirect interaction with a robot that performs a man's commands.

Typical situations of direct interaction between a man and a robot:

- a robot works independently without a man's direct involvement, e.g. automatic robotic line or a robotic technological cell,
- a robot works along with a man without sharing a workplace or a working task, e.g. hybrid production lines, semiautomatic lines,
- a robot and a man work as a team, sharing a workplace and a working task. (Automatika, 2015)

The example for the last situation can be found in the production plants of the Audi Company. In the production process with a higher diversity of model versions, a robot provides precious help to workers. It chooses an appropriate component and makes it ready to be taken over. This means that workers no more have to go to the distant places or bend down several times to pick up the components. A robot becomes an assistant that works as fast as the workers at the assembling. Owing to a soft protection covering with integration safety sensors, there is no risk for workers (a specialized KUKA robot), picture 4 (World Robotics Survey, 2015).

Picture 4. The man-robot cooperation in the production plants of the Audi Company

Functional safety – the aim of applying functional safety is to define, and at the same time, to assess engineering solutions, safety measures, technology, and procedures, which have to be applied to achieve an acceptable level of safety risk in accordance with the safety standard.

The applied components and their integration into the safety control system have to meet the requirements set regarding safety performance, defined exploitation time and life span, which are necessary to fulfill all the safety requirements.

Functional safety provides for the reduction of risk.

Software-defined safety boundaries– historically, robot safety and self-protection have always been based on boundaries controlled by hardware in the combination with the restrictions of the access to the area of movement. These boundaries are in the form of physical stops on the robotic joints, structural walls, boundary switches on the robot and contactless sources.

Safety zones used to be larger than it was necessary for the functioning of a robotic cell.

Software-defined safety boundaries are the defined boundaries of the robots' motion. The limitation of space is used to define any geometrical form that can be internal or external working zone, or it can be used to limit the robot's movement within a designed robot's space or to prevent the robot's access to the defined space.

Robotic installations must be designed and integrated in such a way to reduce potential exposure to human mistakes in order to reduce safety space. The maximum space must be limited to internal or external systems that limit the movement of a robotic system, i.e. they limit the axes and motion.

The development of the safety boundaries is the main innovation in the production of robots. Those are the boundaries that can be programmed and defined by software to determine the robot's movement within the robotic operating system. Using such boundaries, the robot space can be reduced to fit the shape and form of the required working zone, thus taking up less space on the floor. (Robotic Automation Seminar 2014), (The European Strategic Research Agenda for Robotics, 2014)

Risk assessment is the third important change, and it has been incorporated into the standard.

RIA R15:06-2012=ISO 10218-1+ISO 10218-2+R15.06 (according to Robotic Automation Seminar 2014) should take into account all the changes made to the application and usage set in the previous risk management.

Risk assessment should be conducted by the distributor and the end-user. All risks should be at an acceptable level of risk (Robotic Automation Seminar 2014), (SPARC, 2015)

Contemporary safety systems can be organized as:

- the sensor systems that enable safe work for robots and people at a close distance without barriers using the software for supervision of robotic movement.
- a complete management system with integrated safety, which is controlled by a PLC controller.
- the systems using laser-based safety scanning to detect intrusion into the working space, etc. (Thomas R. Kure, 2005), (SPARC, 2015)

Programming based on the users' software of a higher level is used by every producer of contemporary robots. The simulation of robots and their environment provides a realistic overview of the working process, and this can be upgraded by the introduction of CAD models in various formats. In this way, a programmer can generate a precise plan of movement at short notice. Such a plan is necessary for checking the possibilities of the realization of the planned task and the optimization of its implementation.

Conclusion

Given the requirements set for the industrial robots, regarding higher capacity and faster performance, the robots can be of large dimensions and the final device can move at a very high speed. Therefore, dangerous situations might occur if a man is found within the robot's working environment during the automatic operation mode that could lead to severe and fatal injuries.

To prevent and avoid such situations, it is necessary to meet the standards relating to construction, usage of robots and safety of robotized workplaces.

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Biography

Nada Stojanovic works as a teacher at the College of Applied Technical Sciences in Nis. She is a mechanical engineer by profession, Master of Science. She has published several papers, participated in the international conferences and participated in the TEMPUS project.

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