RESEARCH PAPERS
FACULTY OF MATERIALS SCIENCE AND TECHNOLOGY IN TRNAVA
SLOVAK UNIVERSITY OF TECHNOLOGY IN BRATISLAVA

2018 Volume 26, Number 42

RACIONALIZATION OF ROBOTIC WORKSTATION IN WELDING INDUSTRY

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Received: 31.05.2018, Accepted: 26.06.2018, Published: 19.09.2018

Abstract

The growing pressure to increase productivity and production quality is one of the reasons for the growing interest in using automated production facilities, such as robots. In many enterprises, automated lines are introduced that partially or completely replace the human factor. The automotive industry was one of the first to start using automated robots and still is the one of the largest users of these devices. Flexibility and affordability enabled robots to become part of the industry's automation strategy. In order to achieve the desired goals, it is necessary to modernize and automate workplaces or to create completely new concepts of grouping of machines and industrial robots. An increasing trend in the use of robotic technology has caused several factors that have changed significantly in the recent years in favor of automated workplaces. The main changes made by industrial robots to the fore are improving their technical parameters, high reliability, affordability, reduced operating and maintenance costs.

Key words

Industrial robot, welding robot, layout

INTRODUCTION

The automotive industry was one of the first to start using automated robots and still is the one of the largest users of these devices. Flexibility and affordability enabled robots to become part of the industry's automation strategy. The automotive industry has different spans of machining and assembly processes. Some means of assembly operations have a high degree of automation, such as a car body or a paint shop. Bodybuilding and assembly factories are the largest users of robots in a car company. These factories are typical recipients of molded parts and have hundreds of welding robots that perform finishing welding operations. The construction is further sprayed on an automated line that uses automated spray heads and long-range robot arms. Varnishing operations are highly automated because of the malicious environment in which operations are performed. The production process is usually highly automated with robots that are used to raise or seize parts between workplaces or to transport between them. Reliability and easy programmability of the current industrial robots make them ideal for this type of operation as commonly designed single-purpose parts of hard automation (1).

Industrial robot and manipulator

Industrial robots and manipulators are mechanisms for transferring motions and forces, transforming one kind of mechanical force into another or conducting an object along a given path. Industrial robots protect workers from repeated, banal and dangerous tasks. They are highly flexible devices and can adapt to complex functions. They are still being used to a greater extent and can run 24 hours 7 days a week. They also reduce waste and produce high-quality products with the required precision. They consist of several mutually interconnected members, one of which does not move, but forms a frame. The individual movable members are called kinematic couples. More connected members form a kinematic chain (2).

The sort and alignment of the kinematic pair in the chain determines the kinematic structure and their movement capabilities. Under the kinematic structure, we understand the structure of movement capabilities of individual units and the whole of the robot and manipulator. The basic part of a kinematic pair is the same number of independent shifts and rotation that they can perform relative to each other. The binding dependence, indicating the number of degrees of freedom of the spatial mechanism is given by the relation (3):

$$i = 6(n-1) - \sum_{j=1}^{5} \mathrm{j} * \mathrm{dj}, \qquad [1]$$

where:
i - number of degrees of freedom,
n - number of members in the industrial robot and manipulator mechanism with the frame,
j - pair class designation,
dj - number of pairs of the appropriate class.

Any kinematic chains can be assembled by individual members, reciprocally coupled by sliding or rotating kinematic pairs. The number of kinematic pairs used and their mutual configuration will be directly proportional to the manipulability of these kinematic chains. The kinematic chain may contain different combinations of kinematic pairs, where the arrangement of these pairs results from the conditions imposed on the functional and design of industrial robots and manipulators (3).

Basic features of industrial robots that differ from other machines (3):

1. Target orientation - the task assigned is divided into partial sequence targets. The robot then begins to plan the necessary activities and performs them so that the partial targets are synchronized.
2. Flexibility - The ability of a robot to adapt to its surroundings can be achieved by automatically exchanging individual mechanical components - end effectors and/or selecting control algorithms.

3. Programmability - This robot becomes a universally usable machine.
4. Auto Action - The robot can work without constant and immediate human support, so according to a particular program it can perform a complex sequence of tasks.
5. Exchange of information with the environment - based on the exchange of information with the surroundings, the robot recognizes the environment in which the environment is located and influences the environment in order to reach predetermined goals. This interaction is carried out by various sensors and is essential for the proper operation of the industrial robot. The intensity of the interaction increases with the increasing complexity of the task and the degree of dynamic changes in the environment.
6. Mechanical action on the environment - the industrial robot has manipulation elements that can mechanically act on the environment.

The most important conditions for industrial robots and manipulators include, for example, the center of gravity of the manipulated object, the accuracy of the positioning when manipulating the center of gravity of the object, the design of the industrial robot and the manipulator, etc. (3). The ability to use the full 6-axis industrial robot provides almost unlimited application capabilities. Industrial robots and manipulators interfere with almost all human activities. These are, above all, activities that are repeated monotonously, activities that are physically or healthy unsuitable for humans, and so on.

Welding

Welding is the most economical way of permanently bonding metals and alloys, making it the most widespread way of joining two or more components into an unmatchable unit (4). In today's car body parts production, the most extensive resistance spot welding is present, with about 90% of all welding joints. It is used because of high labor productivity and robotic capabilities. Due to the high input costs, robotic resistance welding is mainly applied in large-scale production (5).

Robotic welding

Robotic welding is a combination of welding, robotics, sensor technology, control systems and artificial intelligence. The sensors are used to monitor and measure the process parameters that are sent to the control system. By analyzing this information, the control system adapts the welding process. Various types of sensors are available. Depending on their function, the sensors are divided into process and geometric. Processes measure the parameters of the welding process el. current, voltage, wire feeding speed. Geometric analyze the geometry of the joint, e.g. gap dimensions, deviation from the nominal track, and orientation changes. Weld localization and adaptive welding are used in real time (6).

DOI 10.2478/rput-2018-0019

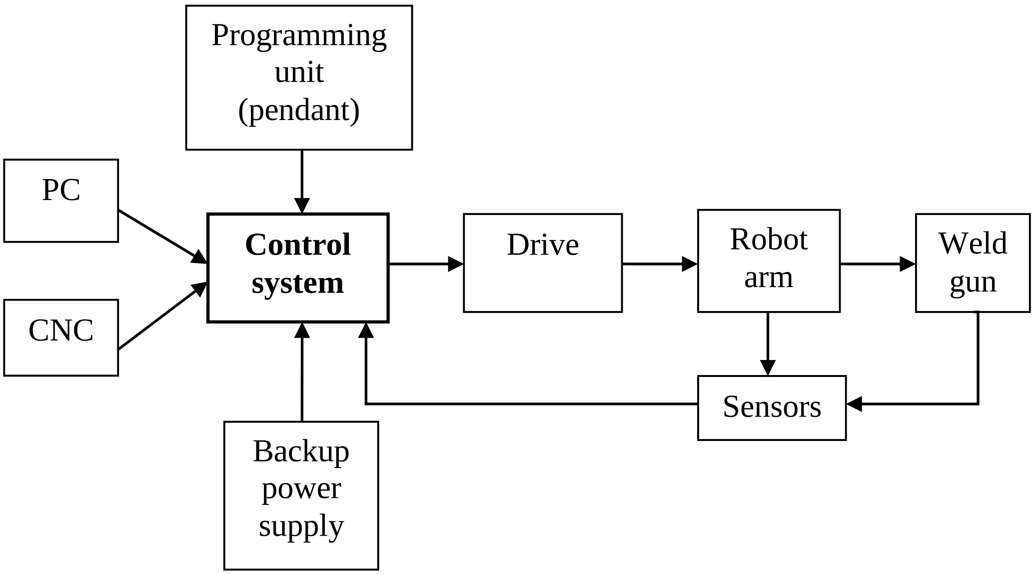

Fig. 1 *Block diagram of industrial robot control* (7)

Solution 1

The basic element of Design 1 is an industrial robot. In this case, two welding devices of the same construction were used (FIG. 2). The robot point welding pliers were used as a technological head. The worker's safety against the robot is ensured by sensors around the device. If a worker enters the preparation area while the robot is working, the process automatically stops. In this proposal, the welding process is exclusively a robot. Man in this case only serves for loading and unloading to ensure a higher quality of welding and increased production.

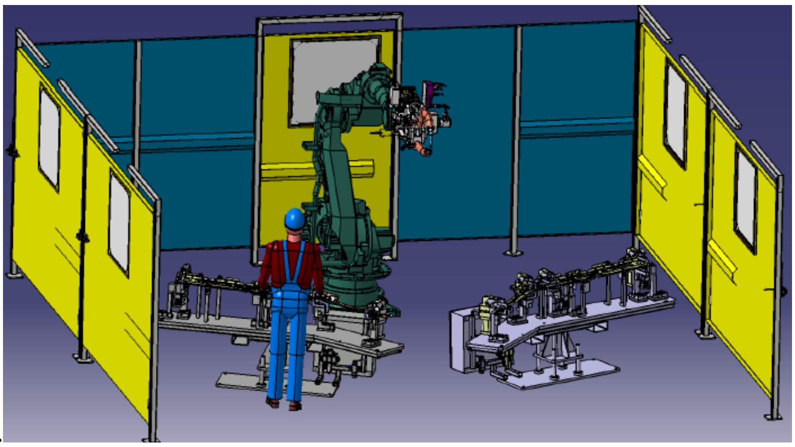

Fig. 2 *Variant 1*

Solution 2

The second proposal contains more components and is therefore financially the most demanding for input investment. This variant was designed with two formulations (FIG. 3) and four preparations (FIG. 4). In the proposal with four preparations, two serving for the cutting of parts and the other two for their unloading. On an industrial robot, a manipulator, which has been specially designed for the shape of the parts, is optionally installed in this case. The manipulator grabs the two parts, transfers them under a stationary point welding machine where the welding process takes place, and then the component travels to the unloading device. In order to exploit the full potential of the robot's speed, this workplace was adapted from two workers. The worker's safety against the robot is ensured by sensors around the device. If a worker enters the preparation area while the robot is working, the process automatically stops.

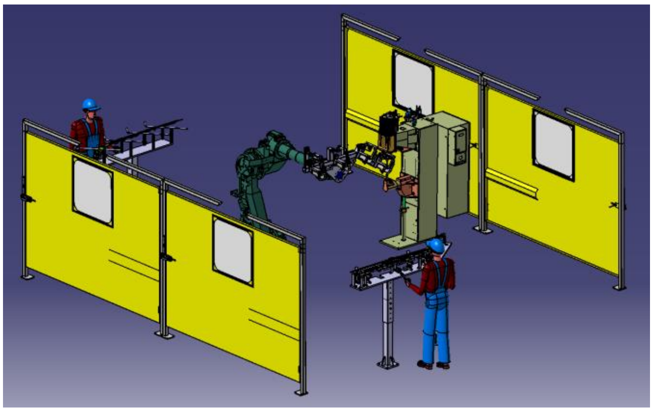

Fig. 3 *Variant 2 with fixtures*

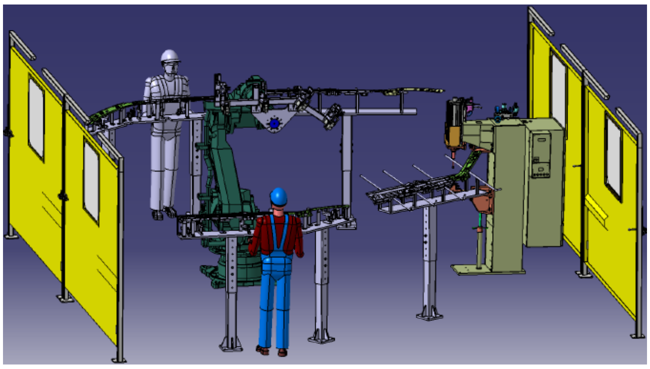

Fig. 4 *Variant 3 with four fixtures*

By combining single-purpose machines and industrial robots, it is possible to ensure a seamless production process without delays. The system is somewhat reconfigurable, allowing better use of the initial investment due to the change in the assortment or production program.

CONCLUSION

When designing a workplace, it is important to correctly select the functional units that will be used in the workplace. In this case, it is an industrial robot and a suitably chosen technological head and manipulator.

The development of industrial robots is predominantly focused on the formation of robotic groups, a "Family", which ensures a high degree of automation of the production process. Additionally, development aims to reflect high demands on functionality, performance and operating parameters, minimizing dimensional portions and operational reliability.

In the field of mechanics, kinematic structures with self-reconfigurability features are sought. Try to design a technical sensor system based on the principles of physical phenomena of living and non-living nature according to the required level of intelligence and to propose application on a smaller but sufficient number of technical sensors as well as the number of collectors. In the field of management, the use of the robust control method (feedback control, model of the closed control system). Using adaptive control methods with the link to the intelligent components of the robot mechanism, respectively.

Utilization of properties and possibilities of new materials (composite materials, materials with hybrid structure ...) in the design of mechanical parts of robots. In the area of operation, the implementation of methods and means of modeling and simulation in the management and operation of robotic systems, as well as the development of models for the diagnosis of the technical condition based on robot equipment for forecasting and control of further operation.

Acknowledgement

The article was written as part of the Young Researcher project 1333 "Research the possibilities of increasing the efficiency of the production system in the industrial production" supported by the scientific program - Motivation and support in quality and effectivity elevation of young researchers and scientists.

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