Encapsulation and Functionality of Sensor Systems in the Welding Process

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Case study
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Abstract: This paper shows some aspects of interaction between human and robots and role of the sensors in welding process. Today, use of the robots is very important in modern industry. Sensors are very important in welding process and they increase the productivity and precision of the robot. It is very important to optimize use of the sensor, from choosing the right programming metod, creating good environment such as acceptable amounts of humidity in the air, temperature to educating the operators to be able to work with robot machine and understand and run pre-programmed codes. When all the mentioned steps are correctly defined, sensor will work perfectly and production can be as good as possible.

Keywords: robots, online programming, offline programming, welding process.

Introduction

Today, robots have taken a very important position in modern industry. Human-robot interaction plays a significant role in understanding, developing and evaluating the systems that humans control or collaborate with. Before starting to use robots, it is important to consider the basic principles and methods of robot operation, as well as the history of human interaction with robots. Also very important are the relationships between humans and robots when collaborating, and the challenges we face when interacting. In this paper, the use of robots and sensor systems in the welding process is processed and studied, with an emphasis on the use of iCSE sensor system and the functionality of offline robots. It is also very important to mention the importance of robotics, both in industry and welding technology, the basics of robot systems used in industry, welding robot programming, sensors to control the welding process, weld monitoring, robotic process control and the role of sensor integration monitoring the degree of adaptability on the example of an offline robotic welding system.

The practical part of the work, which was performed in the company ThermoFLUX with its headquarters in Jajce, in the department of the welding plant on the CLOOS robot, samples were made in the welding process.

Robots are machines that are capable of automatically performing a series of complex operations and actions. They do it very precisely, quickly and almost without error. Robots are programmed using computers and programming languages. Most often, robots are guided by an external control device, which is also called a joystick, but they can also be controlled by controls that are built into the robot. Robots can be constructed in a way that evokes human form, while most robots are machines designed to perform tasks, designed with an emphasis on functionality, not so much on aesthetics and imitation of human appearance. Robots can be:

- Autonomous
- Semi-autonomous
- Humanoids

Basics Of Industrial Robots

Industrial robots are a combination of a robotic system whose main role is to participate in the production process. Such robots are automated, programmed and capable of moving along several axes. Industrial robots have found the greatest application in the processes of welding, assembly, disassembly, varnishing, selection and installation of various parts, packaging and labeling of products and the like, all for the purpose of more durable, faster and more accurate manufacturing process. It is currently estimated that there are about 1.60 million industrial robots in the world in daily operation worldwide.

Welding Robot Programming

Online Programming Method

The online programming method is also called the network programming method and includes stopping the robot, putting it out of production and putting it into programming or learning mode. Programs are then created or modified using the joystick.

Joystick programming is the most common method for programming industrial robots. It is estimated that about 90% of industrial robots are programmed through the same. The joystick is also called the robot motion control control box. It's also called a "learning box". The robot is set up in a "learning" or "teaching" manner, and the pendant is used to control the robot step by step. The robots come with a compatible device that connects to the robot. Developers use the pendant interface to create and modify programs. Online robotic programming is a method in which a robotic arm is guided exactly through the waypoints of an application.

Offline Programming Method

Offline programming is computer-based programming that does not require robot movement, so it is convenient because the production process does not have to stop. The purpose of such programming is to create as many technological processes as possible on one robot and its workplace.

Offline programming includes the creation of programs via a computer using programming software and a simulation work environment. Unlike online programming methods, offline robotic programming does not require the presence of a robot, nor its exclusion from the production process if the robot is already set up in production. The robot can stay in operation while users create or modify applications using offline software. The simulation creates 3D replications of the robot's work environment so that thorough testing and debugging of the resulting programs can be performed. When the program is ready, it is downloaded to the robot and continues with production.

iCSE sensor system is a non-contact measuring system that works on the basis of laser triangulation. In this process, changes in the distance between the sensor and the reflecting surface are determined.

- Relative position measurements can be performed with the system.
- Furthermore, geometry readings from the sensor can be used as reference measurements.
- The laser beam of the system must not be aimed at people.

The following factors may affect proper operation:

- Placing untrained personnel on the sensor system. Failure to follow the instructions for use.
- Any other use not considered intended.
- Failure to follow work instructions on site.
- External factors
- Dirt on the lens
- Lens damage
- Oil film on the lens
- Irradiated with UV light
- Vapors from welding in the sensor beam path
- Direct sun
- Reflective surfaces on the measuring object
- Reflections from mechanically treated surfaces on the measuring object
- Dirty protective cap

Technical Properties of Icse Sensor System

According to the book: PA_iCSE_Rev. 3.1 :

Sensor is a device that measures certain parameters in the environment of the robot and allows the robot to adapt to the conditions in which it is at a certain moment. Accordingly, in robotic welding,

TECHNICAL PROPERTIES OF ICSE SENSOR SYSTEM									
Dimensions	**Housing**	**Weight**	**Operating temperature**	**Humidity**	**Nominal measuring distance**	**Measuring range**	**Vertical resolution**	**Horizontal resolution**	**Beam diameter**
H = 160 mm W = 85 mm D = 42 mm	Aluminum, anodised (black)	approx. 630 g	0 - 50 ° C	35 - 80%	100 mm	+/- 40 mm	16 µm	50 µm	0.1 mm

TECHNICAL PROPERTIES OF ICSE SENSOR SYSTEM									
Reaction time	**Power adjustment**	**Output signal**	**Tracking speed**	**Min. edge height**	**Min. spacing width**	**Search accuracy**	**Laser diode power**	**Laser diode wavelength**	**Laser protection class**
2.5 ms	a car	+/- 4V	approx. 300 cm / min	1 mm	1 mm	+/- 0.2 mm (depending on surface, speed, material, etc.)	max. 1 mW	650 nm, visible	2 according to DIN EN 60825-1”[1]

sensors are used to measure parameters in order to achieve a process that meets the required requirements in the best and most economical way.

Application of Sensors In Robotic Welding

A sensor is a device that measures certain parameters in the environment of the robot and allows the robot to adapt apropos to the conditions in which it is at a certain moment. Accordingly, in robotic welding, sensors are used to measure parameters in order to achieve a process that meets the required standards in the best and most economical way.

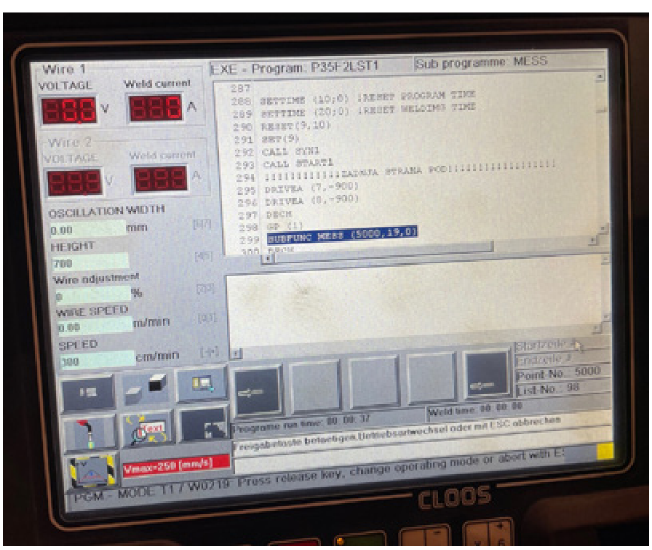

***Figure 1** Template 19*

Before robot starts the welding process and understanding the sensor function, we will explain the templates according to which the welding is performed. According to Template 19, which is used for welding the back or floor of the boiler. The program was entered into the robot by the offline method of programming and saved as Template 19. Speed of robot metric system in this template is 300 cm in 1 minute. After the welding process is over robot will take oscillations in width and height. At beginning of the process, oscillation in width and height is 0.00 mm, Wire adjustment is 0% and Wire speed is 0.00 mm.

Program:

!!!!!!!!!!!!!ZADNJA STRANA!!!!!!!!!!!!!

DRIVEA (7, -900)

DRIVEA (8, -900)

DECH

GP(1)

SUBFUNC MESS (500, 19, 0) - This part of the code in the program is in charge of calling Template 19 to be activated. After this part of the code, the robot starts the welding process according to the entered parameters by the template.

After the welding process with the existing Template 19, we transfered the robot to the measurement and later welding process. Figure 1 shows the path taken by the robot when making the weld. When programming the robot on template 19, the path taken by the robot is plotted.

[1] PA_iCSE_Rev. 3.1, Carl Cloos Schweisstechnik GmbH

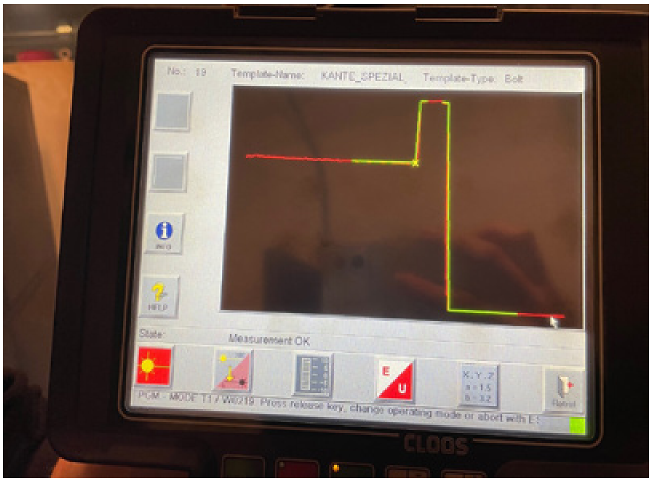

Figure 1 *Template 19 - new measurement*

The red line shows the plotted path while the green line shows the actual path that the robot went through while welding. We can notice that the difference in the path of the weld entered during programming and the actual, performed path is almost imperceptible, and we conclude that the sensor in this case correctly measured the path by the robot arm. The unit of deviation during the measurement was within the allowed limits, so the robot continued with the welding process. Given the large number of external factors that in this case could have caused damage during the operation of the sensor, which, among other things, partially affected the measurement of the sensor, it can be concluded that in this case the sensor performed the correct measurement. After comparing the programmed trajectory with the actual one and determining a small deviation within the limits, the robot starts its welding on the boiler.

Figure 2 *Deviations from the entered and measured path*

Figure 2 shows deviations from the entered and measured path. The template and its path are activated, the laser head has performed the path measurement process. The position according to the Y coordinate is 30.45 mm, according to the Z coordinate 82.40 mm.

Figure 3 shows the oscillations in the sensor measurement. According to figure 1 we can see the difference in the oscillation width and height, Wire adjustment and Wire speed. These are all values that the robot has recorded during the measurement and welding process. Oscillation in width is 1.58 mm, Wire adjustment is 2% and Wire speed is 13.50 m/min. The results are shown in the table 1:

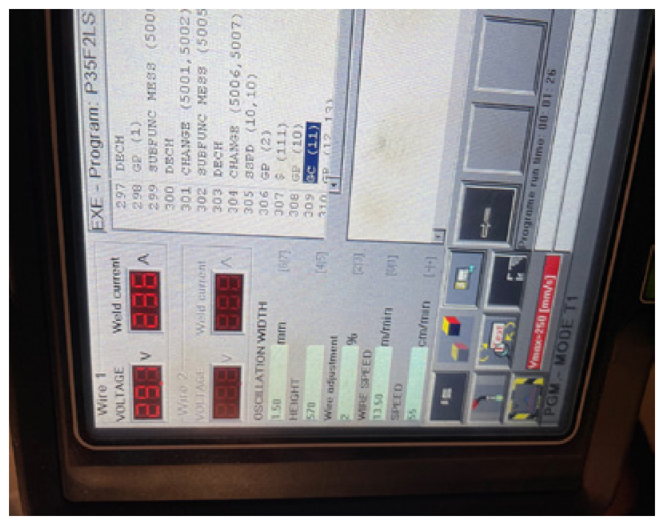

Figure 3 *Oscillations*

Conclusion

Encapsulation and functionality of sensor systems in the welding process is important class in the area of robot welding. Their essential function is to provide a safe space near the robot, and also to ensure fast, efficient and functional work. Before starting to use a robot, it is important to consider its principles and methods of work, as well as the way in which the robot interacts with the human environment. This paper investigates and presents how the sensor works, how it measures and determines the path by which it performs the welding process and what external harmful consequences can affect the quality of its work. From the research, we conclude that the robot made only small oscillations during welding according to the template entered

Table 1 *Oscillations at measured and default values*

	Position Y	Position Z	OSCILLATIONS (mm)	Wire adjustment (%)	Wire speed (m/min)	Speed (cm/min)	VOLTAGE
Default values	28,95	80,9	0	0	0	300	0
Measured dimensions	30,45	82,4	1,5	2	13,5	55	29,1

by the offline programming method, which did not significantly affect the welding process and its quality. The oscillations are within the allowable limits. It can be seen from the graph that the measured oscillation is 1.50 mm.

It is precisely these processes that require rapid change, which makes it very difficult to find literature that corresponds to this type of research. The information provided and explained in the paper are from the factory where heat boilers and pellet fireplaces are produced and is the result of practical work. It is precisely these processes that require rapid change, which makes it very difficult to find literature that corresponds to this type of research. The information provided and explained in the paper itself is from the factory where heat furnaces are produced and is the result of practical work.

References

[1] PA_iCSE_Rev. 3.1, Carl Cloos Schweisstechnik GmbH, 10/2017 Rev. 3.1

[2] PA_QIROX_V08.xx_Rev. 01/17_EN, Carl Cloos Schweisstechnik GmbH, 22.03.2017 Rev 01/17

[3] https://www.cloos.de/de-de/, 2022 Carl Cloos Schweisstechnik GmbH

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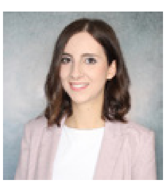

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