RFID TECHNOLOGY IN MANUFACTURING OF WELDED PRODUCTS

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Key words: RFID, Industry 4.0, manufacturing, welded products

Abstract:
The fourth industrial revolution, Industry 4.0, has a great impact on manufacturing today. Industry 4.0 is based on the new technologies related to information and communication technologies, the Internet of Things, Cloud Computing, Big Data Analysis, robotics, cyber-physical systems, artificial intelligence, etc. Among other technologies that enable Industry 4.0, this paper is focused on RFID technology, wireless identification, and tracking technology, which is an important part of the modern manufacturing industry. As welding has a significant role in the manufacturing industry, the purpose of this paper is to present the basic principle and application of RFID technology and RFID systems in the manufacturing of welded products within the Industry 4.0 framework.

1 INTRODUCTION

Each industrial revolution has led to radical changes in the production method, from machines powered by water and water steam in the first industrial revolution, through assembly lines and mass production in the second industrial revolution, automation and programmable controllers in the third industrial revolution, to the present fourth industrial revolution and Cyber-Physical Systems. The fourth industrial revolution, also called Industry 4.0, is changing the manufacturing paradigm globally. The main driver of Industry 4.0 is the development of new innovative technologies including advanced manufacturing technologies and information and communication technologies whose rapid development has given impetus to the digital transformation of the industry. New innovative technologies that enable such transformation include: Information and Communication Technologies (ICT), Cloud Computing, Big Data Analysis, Simulation, Augmented Reality, Artificial Intelligence, Cyber-Physical Systems (CPS), Cyber Security, Additive Manufacturing, Autonomous Robots, System Integration, Smart Factory, Internet of Services (IoS), and Internet of Things (IoT). One of the key technologies on which the Internet of Things is based is Radio Frequency Identification (RFID) systems (automated data acquisition systems) [1]. Interest in IoT and RFID is increasing [2], and there is a growing interest in their deployment in various industries [3].

Today, the global, turbulent and competitive market seeks for customized products with high quality and also price competitive. The manufacturing industry is facing high competitiveness from

competing companies and high demands from customers. Manufacturers need to be flexible and efficient and have to produce different variants of products (according to specific customer requirements) on the same product line so that components and products can be identified and tracked through the entire manufacturing process and also transmit the product information. Due to the increasing diversity of products on the same production line, it is necessary to apply an RFID system of identification of parts and products that makes production more flexible.

2 RFID TECHNOLOGY

The RFID technology is not new, it was first applied during World War II. The first article on the RFID topic that was indexed on the Web of Science platform was published in 1985. There are many published publications on the RFID technology as can be seen from the e.g. Web of Science platform [4]. The number of published scientific publications on the RFID topic has increased rapidly since the emergence of the Internet of Things in the early 2000s. New increased interest from researchers has followed the emergence of a new Industry 4.0 paradigm, after 2011.

RFID technology belongs to "automatic identification" technologies. It is a technology that wirelessly transfers a unique object code and enables communication between all resources of the production system and collecting real-time data about the status of production. RFID systems consist of three main components: a transponder consisting of a chip connected to the antenna, a reader that transmits radio signals and collects data from the transponders and server (to enterprise applications). There are three basic types of transponders: active (that have internal power supply - the battery, and a life span is limited by battery life), passive transponders which have no internal power supply, but must come within the range of electromagnetic field reader in order to reader aroused energy into them and establish interaction and data transmission.

Using RFID technology, objects (resources in production) are transformed into smart objects that carry information about themselves and that can independently interact with the environment and production system. Real-time data and accurate production data such as material consumption, worker data, machine status, order progress, planning data, product location, material tracking data, and tools are collected and connecting with different enterprise information systems (e.g. ERP, Supply Management System (SCM), etc.). It enables timely decision-making based on real-time production information.

RFID technology is widely used in the manufacturing industry [5]. RFID technology significantly facilitates horizontal, vertical and end-to-end integration, which is the core objective of Industry 4.0 and digital transformation.

3 RFID IN MANUFACTURING OF THE WELDED PRODUCTS

Welding is extremely significant in modern manufacturing, for many industrial sectors (for welded products like ships, constructions, vehicles, turbines, bridges, etc).

There are many relevant publications about welding in the relevant citation databases, which indicates the importance of this technology. The search of the Web of Science platform resulted in 83.969 publications between 1955 and 2018 (all types of publications where the "welding" keyword appeared is included). But in the context of Industry 4.0 and related technologies, fewer publications have been published which is understandable because Industry 4.0 is a new manufacturing paradigm over the last few years. There is ample room for research in this direction and the wider application of new technologies in practice. Figure 1 shows the number of publications by selected keywords: welding and RFID, welding and „Internet of Things“ and welding and „Industry 4.0“.

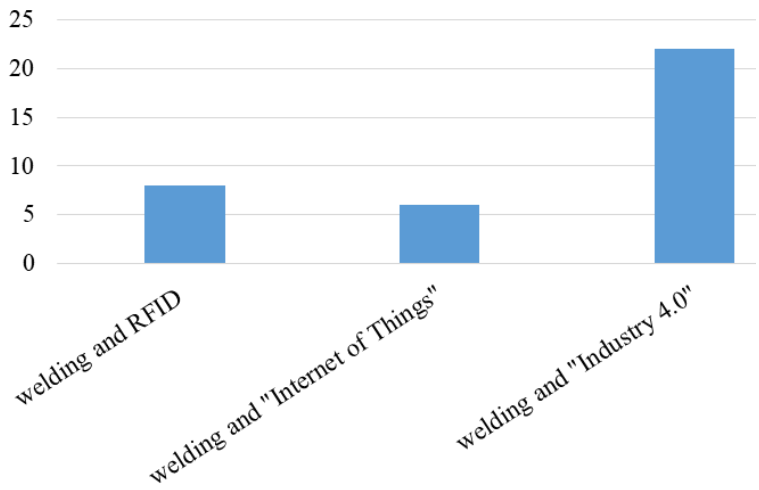

Figure 1. Number of publications within the Web of Science platform by keyword „welding“ in combination with selected keywords

In the article [6] authors provided an overview of RFID infrastructure for identifying arriving parts by which robots perform welding operations. They also highlighted the challenges of applying RFID technology in welding. The authors of the article [7] pointed to the disparity between research on existing manufacturing systems and Industry 4.0 requirements. The articles [8, 9] present researches on the application of RFID technology to identify the parts joined by welding. In the article [10] Liu, 2016 presents the pipe welding information management system based on RFID that has been implemented in some gas companies and results with benefits. Authors of the article [11] propose a solution with the Radio Frequency Identification (RFID) system for real-time data acquisition of welding, painting and assembly workshops in the automotive industry.

Type of transponders and readers used in industry depend on the type of industry and conditions in production, in adverse conditions (such as in the welding workshops) transponders must be

resistant to the conditions in the environment. During welding, adverse production conditions occur, sparks and weld splashes can cause damage to the sensors and cables. RFID systems are resistant to harsh environmental conditions such as high temperatures, dirt or humidity. The advantage of RFID technology is that data transmission occurs wirelessly through electromagnetic radio waves and is less sensitive to environmental influences.

The RFID system uses RFID transponders to collect information on various parameters in production that are important for material management, quality assurance, production scheduling, sales, etc. RFID transponders attached to objects contain the necessary object information on the chip.

Data collected from RFID transponders is transmitted to cloud analytics to facilitate real-time process adjustments and performance improvements. The RFID transponder moves along with the workpiece throughout the manufacturing process, including the welding workshop and welding processes.

Figure 2 presents a simplified schematic overview of the working principle of RFID systems.

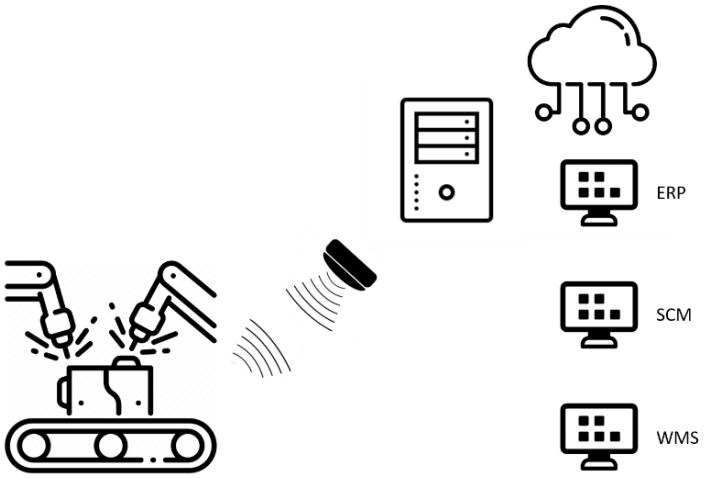

Figure 2. Simplified working principle of RFID system

Using RFID technology resources on the welding line can be adapted to the new circumstances in the case of changes in production. As the RFID transponder, as a data carrier about an object, moves with the object throughout the production process, production will be also optimized in the following processes.

Figure 3 shows the example of a passive UHF RFID transponder in the automotive industry which permanently remains on the car throughout the entire production process, from welding to final assembly and after. The RFID transponder records the object's data, including the routings, before processing. The RFID transponder instructs the workstation to perform correct operations.

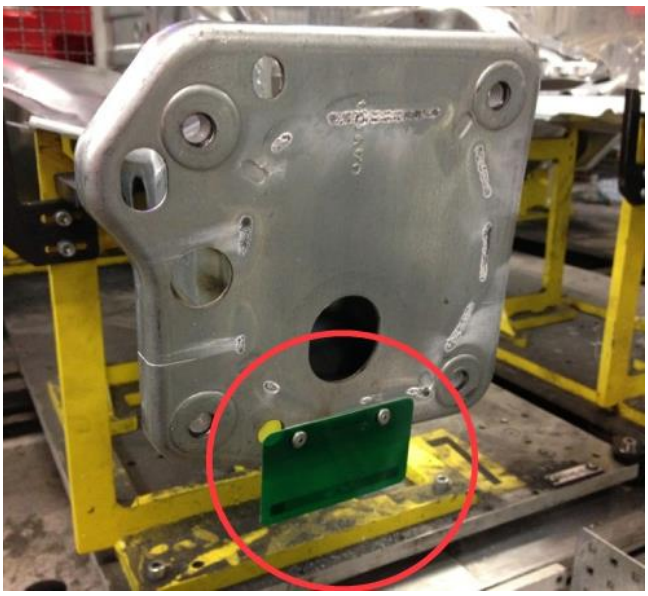

Figure 3. Example of RFID transponder attached on part of car body before welding[1]

Using RFID each workstation checks the assembly requirements and the actual condition of the workpiece to identify any errors, which greatly improves quality assurance. Welding quality information is entered on the RFID tags attached to the welding parts and the correct welded products go to the warehouse or the following processes and the faulty ones are separated for repair. The advantage of RFID systems is that they enable continuous identification and quality control throughout the production process.

Figure 4 shows an example of the interrogator/reader or RFID-read/wright head in the manufacturing of the car body.

Figure 4. RFID-read/write head for transmission of data from the RFID transponder on the car body[2]

[1] https://www.rfid-im-blick.de/en/201405091972/volvo-car-gent-takes-further-steps-towards-the-implementation-of-rfid-on-the-international-scale-in-china-and-sweden.html
[2] https://www.turck.us/en/rfid-in-the-body-shop-1069.php

Figure 5 shows the example of robots welding stations with RFID identification.

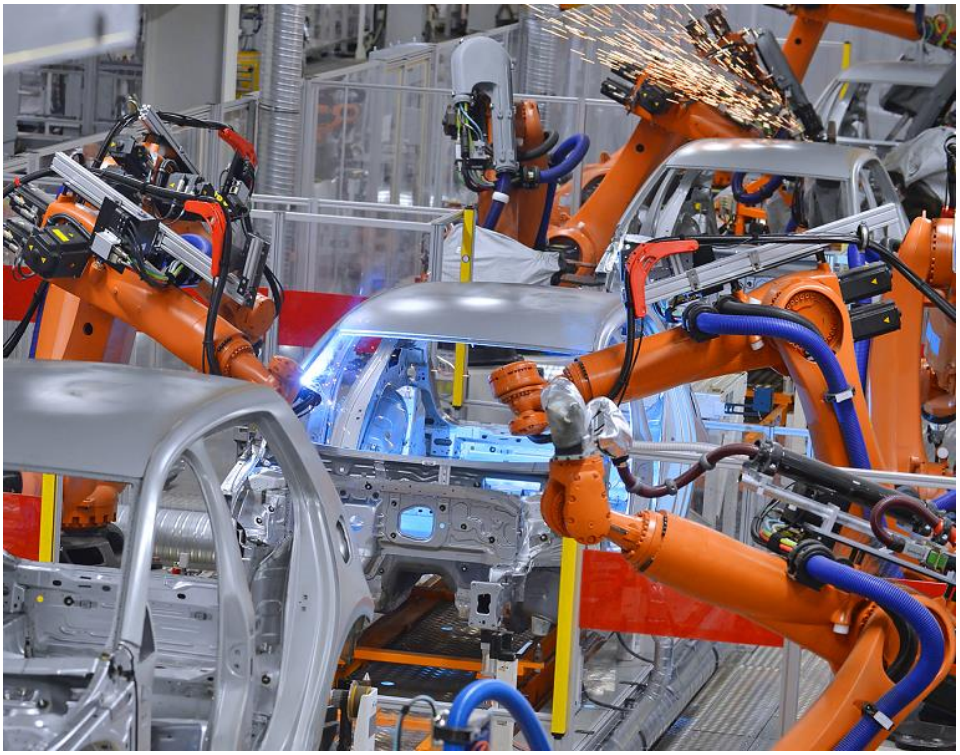

Figure 5. Robots welding station with RFID identification[3]

4 CONCLUSION

Radiofrequency identification is very important in the context of Industry 4.0 and the increasing automation and digital transformation in manufacturing, as it enables the automatic and non-contact identification and localization of all manufacturing resources and exchange information. RFID technology uses radio waves, data is transmitted wirelessly, and plays a significant role in the digital transformation of production and has a major impact on Industry 4.0.

The RFID technology and the Internet of Things could improve welding processes through real-time monitoring of the status of welding equipment and regulating the operation of the equipment, and also monitoring the quality of welding.

[3] https://willfront.com/opal_service/rfidbarcode-scanning-logistics-inventory-system/

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