RFID technology for the development and competitiveness of an SME in the Croatian metalworking industry

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Abstract: *Today, it is imperative that small and medium enterprises (SMEs), which are the backbone of any economy, make the transition to the Industry 4.0 paradigm and adopt new technologies to improve business and become competitive in the marketplace. Some SMEs in the metalworking industry in Croatia face the challenges of achieving and maintaining a competitive position in the market within the Industry 4.0 paradigm. Due to problems with inadequate enterprise information systems, without the application of innovative technologies, due to obsolete machinery and equipment in production, enterprises cannot compete in a globalized market. Enterprises need to respond quickly to customized and individualized customer requirements and need to be flexible for producing numerous versions of products in small batches. To achieve this, enterprises need to introduce new innovative technologies of Industry 4.0, such as Big Data, Internet of Things, Artificial Intelligence, RFID technology, ...*

The objective of this paper is to review RFID technology and propose a conceptual model for the application of RFID technology in a metalworking enterprise in Croatia. That enterprise belongs to the category of SMEs that represent the basis of the economy of each country. The paper describes the problems faced by the company in production monitoring and gives a proposal for the application of RFID technology to monitor the production and to facilitate production management using an ERP system.

Keywords*:* RFID TECHNOLOGY, SME, ERP SYSTEM, INDUSTRY 4.0, METALWORKING INDUSTRY

1. Introduction

The manufacturing industry is currently in the phase of transformation and change of production paradigm towards Industry 4.0. The dimensions of Industry 4.0 are horizontal integration, vertical integration, end-to-end integration, acceleration of manufacturing, digitalization of products and services, new business models, and customer involvement [1]. Industry 4.0 is based on innovative advanced manufacturing technologies and information and communication technologies. These are Big Data, Artificial Intelligence, Simulations, 3D Printing, Nanotechnology, Advanced Materials, Augmented / Virtual Reality, Robotics, Cyber-physical production systems, enterprise wearables, autonomous systems, Cloud Computing, Internet of Things (IoT), etc. The implementation of Industry 4.0 requires a digital infrastructure and the implementation of innovative technologies. The most important for achieving integration is the Internet of Things, and one of the technologies on which IoT is based - Radiofrequency Identification technology (RFID).

To strengthen competitiveness in the context of globalization and Industry 4.0, enterprises need to implement new technologies to meet Industry 4.0 requirements.

2. Research background

According to CEPOR - SMEs and Entrepreneurship Policy Centre, the share of medium and small enterprises in the Croatian economy is 99.7%. Almost three quarters (72.2%) of all employees in business entities in Croatia in 2018 are employees in micro, small and medium enterprises. Croatia ranks 63rd out of a total of 141 countries in terms of competitiveness, according to The Global Competitiveness Report 2019 (World Economic Forum) for 2020. That indicates the importance of SMEs and the need to strengthen their competitiveness.

The results of the research [2] show that Croatian manufacturing practices, technologies, and organizational models are obsolete, and the level of industrial maturity is low. Traditional industrial sectors and a low share of high value added activities, low levels of innovation, insufficient investments in scientific research and development and innovative activities. Namely, traditional industrial sectors and a low share of high value added activities, low levels of innovation, insufficient investments in scientific research and development [3, 4].

In EU countries, Finland, Denmark, and Sweden have a high level of digital infrastructure, while the Netherlands, Germany, Croatia, Luxembourg, and Spain have relatively high levels [5]. That does not necessarily mean that there is a high level of Industry 4.0 implementation, but that these countries have good potential in terms of Industry 4.0 infrastructure. Familiarity with some elements of Industry 4.0 in Croatian metal machining companies is not at a satisfactory level [6]. Despite some progress in the Croatian economy, Croatian industry lags behind the EU and readiness for implementation of Industry 4.0 is low. Additionally, compared to large enterprises, SMEs generally have less financial and human resources available to implement Industry 4.0 [7].

There are different models for determining readiness for Industry 4.0 [8]. According to the Ronald Berger Industry 4.0 Readiness Index[1], Croatia belongs to the group of hesitants, i.e. it does not have a reliable industrial base, like other countries from that group Southern and Eastern European countries.

Today, an increasing number of organizations are planning to introduce RFID systems into their business in order to increase competitiveness [9]. The application of RFID technology ensures the increased competitiveness of enterprises [10]. In Croatia in 2018, 4.5% of companies used RFID technology, which is more than the EU average of 4.2% in 2018, according DESI Report 2018[2].

Therefore, the paper proposes the introduction of RFID technology in the selected SME for production monitoring, tracking and tracing products and all resources through the production process, and for collecting and transmitting data to the ERP system in real time. Enterprises need to have an enterprise information system (e.g. Enterprise Resource Planning system) that will facilitate the management of business processes and resources based on data gathered in the production system in real time.

The research methodology included a review of relevant scientific literature and interviews method for collecting data in the selected real-world enterprise (in the category of metalworking small and medium enterprises). The aim is to propose a model of business process improvement in the target real-world enterprise with implementation of RFID technology in production monitoring.

3. Literature Review

The digital transformation of enterprises requires considerable investments, changes in business processes, new knowledge and skills [11]. By analyzing the factors of readiness of small and medium enterprises for Industry 4.0, the authors of the paper [12]

[1] Report, Ronald Berger GmbH: Industry 4.0 – The new industrial revolution. How Europe will succeed. Munich: Roland Berger Strategy Consultants GmbH. (2014).

[2] Report by country: Croatia: The Digital Economy and Society Index - DESI 2018, https://ec.europa.eu/digital-single-market/en/scoreboard/croatia

conclude that the SMEs will strengthen competitiveness by the implementation of Industry 4.0 and will gain many opportunities for cooperation and connectivity.

RFID technology is widely used in various fields as well as in manufacturing processes [13, 14]. Some of the reasons why SMEs decide to implement RFID systems are business improvement, increased competitiveness, improve product tracking efficiency [15]. The results of the research [16] indicate a positive effect of RFID technology on increasing the competitiveness of supply chains. The research [17] highlighted the importance of RFID technology for competitiveness due to data real-time production monitoring. The paper [18] highlighted significant savings achieved by reducing inventory, reducing the need for manual monitoring of production, and manual data entry during the process thanks to usage of RFID technology. Also, automatic data collection increases the efficiency of the ERP system.

There are many papers on RFID technology in citation databases. Figure 1 shows number of publications by publication year for search queries "RFID AND manufacturing" and "RFID AND competitiveness" within Web of Science Core Collection (WoSCC) databases (timespan: 1955 - 2019). The first article containing the keywords "RFID" and "manufacturing" in WoSCC databases was published in 1999 when the Internet of Things, which is based on RFID technology, emerged.

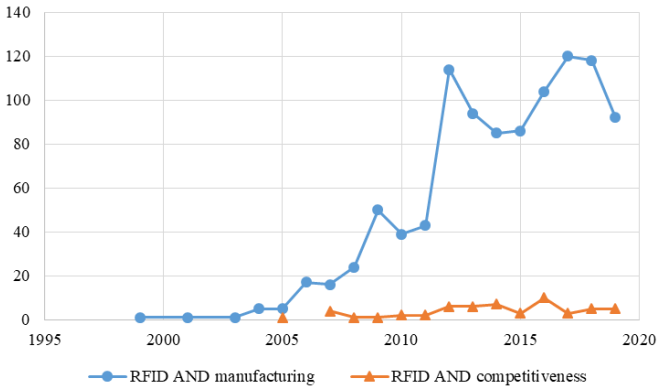

Fig. 1 *Number of publications per year (WoSCC)*

4. Situation in the real-world SME

Target real-world Croatian SME, which is located in the region of Eastern Slavonia, is specialized in the manufacturing of flue pipe elements and stoves. The share of production of flue pipe elements is 55%, and the share of stoves production is 45%. The products are placed on the market of the European Union, mostly in Germany, France, Scandinavia, Austria and Italy, but also outside the EU, in South Korea, Israel and others. The enterprise makes great efforts and invests financial resources in the introduction of modern information technologies, to modernize the entire production, increase flexibility and quality, and reduce the time required for the preparation of production, and thus costs.

The enterprise uses a locally installed SAP ERP 6.0 system, intended for small and medium enterprises, about six years. Also, uses automatic identification technologies in its business: bar-code and RFID technology. The enterprise uses bar-code technology in an automated rack warehouse for the storage of finished products. Once the production process is complete, the finished products have been packing into boxes, which are stacked on pallets and labeled with bar-code. By reading bar-codes with a handheld scanner, data is transferring to the SAP ERP 6.0 system. After that, it is necessary to once again scan for an automated rack warehouse. The pallet with the finished products has been placed in an automated rack warehouse to a predefined location.

An RFID system is used to record the presence of workers, and for the operation of the company's canteen. Every employee has an RFID ID card to automatically check-in and check-out at the entrance and exit of the enterprise. The RFID reader has been connected to a door that opens automatically after reading of RFID card and allows the employee to enter or leave the enterprise. Also, the enterprise uses RFID technology in the canteen to plan meals and to record employees, using an RFID ID Card. In the canteen, there is a computer with the canteen management system application with which workers enter the dishes they want to consume. In this way, it is possible to plan the amount of food that will be needed to prepare the meal a week in advance.

Unfortunately, there is no application of automatic identification methods in production, nor the possibility of monitoring production in real-time. The enterprise mostly uses the traditional manual production monitoring system. There is no system for automatic data collection and monitoring of production, nor a system for automated tracking and tracing parts and products in real time.

A major issue in the enterprise is monitoring production and monitoring the performance of workers. There is currently no monitoring through the production flow in real time. The enterprise produces a very large number of different products, which is why it is very challenging to establish effective monitoring of production.

The performance of operators in production is currently monitored by data such as the date, operations performed, time spent on these operations, the number of pieces processed by the operation, product type, and work order according to which operations are performed, which are employees enter manually to the paper worksheets. This type of entry is time consuming. An entry error can easily occur, which is why it is necessary to control the entered data. Once the data has been entered and verified, it still needs to be transferred to the ERP system by keyboard. The whole process is relatively slow and its automation would achieve certain savings in time, and therefore in costs. The entered data is checked by the engineers and the data is transferred to the ERP system. This data is displayed on computers located in production using an application developed by the company's IT experts. Figure 2 shows an example of a software screen for monitoring the performance of operators.

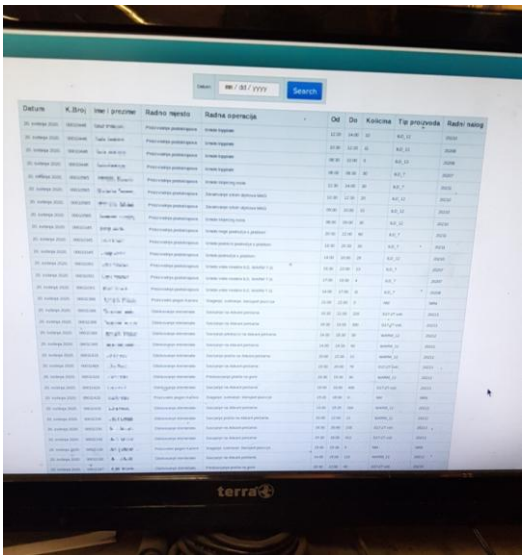

Fig. 2 *Monitoring the performance of operators*

5. Proposed model for production monitoring with RFID technology

The proposal of the information flow framework through the enterprise (vertical integration) and through entire supply chain (horizontal integration), with RFID technology, is shown in Figure 3 [19].

Horizontal integration implies that the RFID is already integrated into the enterprise (vertical integration), as well as at

suppliers and customers. Prerequisite is that all of them have linked ERP systems and other enterprises applications and share information. The first step to achieve the full form of integration is the integration of the operational level (using RFID technology, and wireless sensor networks) with the ERP system in the enterprise (vertical integration).

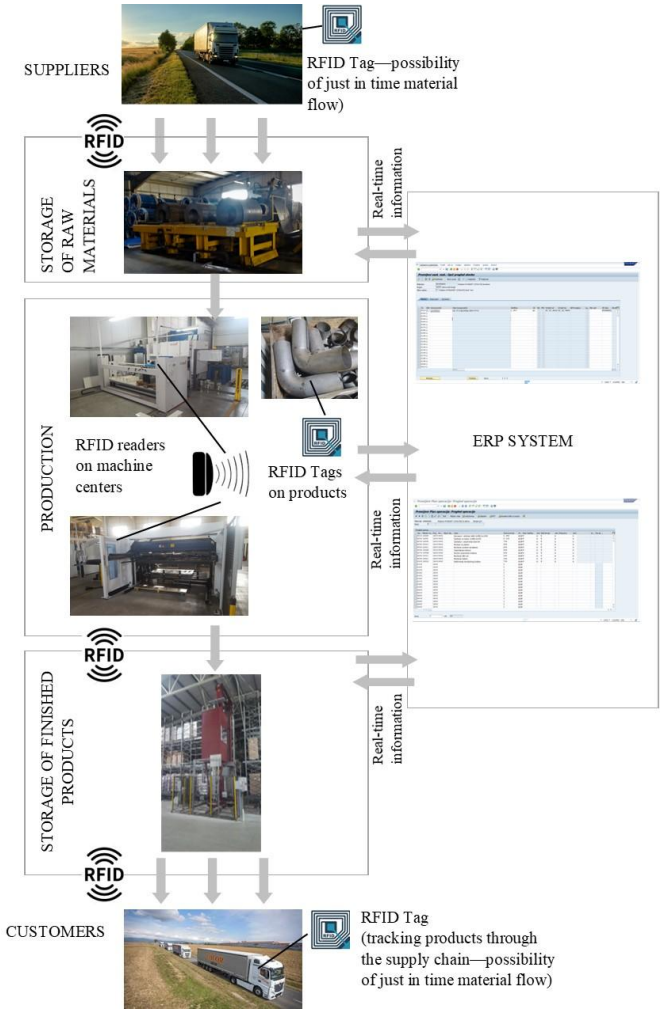

Fig. 3 *Proposed information flow framework for vertical and horizontal integration*

Previously, it is necessary to attach RFID transponders to all resources in the enterprise and to install RFID readers that collect data in the production plant. Production resources with attached RFID transponders (tags) become "smart" objects as they carry information about themselves and independently communicate with the environment. RFID readers transfer real-time data such as material consumption, duration of operations, quantity, product location, tools to the ERP system. RFID technology significantly improves production monitoring and management processes and facilitates enterprise integration.

The Figure 4 shows a proposal for installation of RFID readers in a part of the production plant. This analysis discusses only the production process of flue pipes. Ultra-high frequency (UHF) passive transponders were chosen because passive ones are cheaper and UHFs have the ability to read up to 6 meters. They should have multiple programming capabilities because the enterprise produces a lot of different products and there are often changes in the products according to customer and market requirements, and data should be written to them constantly. The physical shape of the transponder should be such that it can withstand high temperature conditions during welding and enameling processes. It all affects the price of such a system.

In the proposed conceptual model, fixed RFID readers are located at the entrance to the material storage, at the exit from the finished goods storage, and at the machines in the production plant. The RFID reader at the material storage inbound automatically identifies the material with the RFID transponder and transmits the data to the ERP system. The RFID reader automatically collects data on the material code, name, quantity, material specifications, a time when the material arrived.

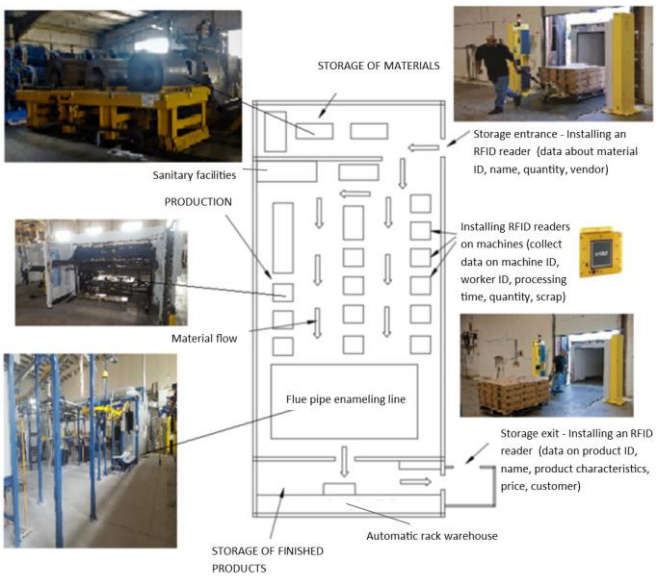

Fig. 4 *Proposal to install RFID readers in a production facility*

Identification and monitoring of finished products during storage operations is done in the same way. Also, when the finished products are released for delivery to customers, the installed fixed RFID reader reads the RFID transponders, and the reduced quantity of products is automatically recorded in the company's SAP ERP 6.0 system. RFID readers collect data on product code, name, quantity, product specifications, and price. By using RFID technology instead of manually scanning bar-codes from finished products, data will be automatically collected faster and more accurately, no line of sight is required as is the case with bar-code technology. RFID technology in addition to identification enables tracking and tracing of resources and products. To integrate RFID technology into the production process, it is necessary to install RFID transponders on all parts, and RFID readers on all machines. That way, tracking resources and products will be easier and more accurate. RFID readers in production (on machines) collect data on product code, product name, technological operations performed and their associated codes, processing time, operator code, code and name of the machine on which the technological operation is performed, number of processed pieces, amount of scrap, certain notes required for the following technological operations.

Table 1 shows approximate cost estimate only for basic RFID components for selected real-world enterprise with regard to the daily quantity of products, the total number of machines, and the number of warehouses [19].

Table 1: *Approximate cost estimate only for basic RFID components for selected enterprise*

RFID system components	Costs (EUR)
RFID transponder (UHF passive) for products/day (multiple use)	2.050,00
RFID reader (mobile), for machines	233.333,33
RFID readers fixed, for warehouse door	16.000,00
Total	251.383,33

6. Discussion

The major issues in the enterprise, production monitoring and monitoring the performance of workers, can be solved by introducing RFID technology. The RFID system enables real-time data acquisition, which is crucial for efficient production monitoring. In this way, it is possible to know exactly where a

particular product is located in the production facilities at a given time and information on the state of production is available at any time, and from any location. In this way, production is more flexible and management can react much faster to changing and unforeseen situations in production. In addition, processing on machines will enter data on technological data, processing times and operators on the RFID transponder. If certain defects in the product are noticed in production, it is possible to find out where the error occurred in a very short time, and to take quick action. It is important to solve certain shortcomings in production as soon as possible, which is why the real-time data obtained by RFID technology brings great savings in time and costs.

With the help of the collected data, it is possible to monitor the performance of workers. Operators will not spend time filling out worksheets on processing times and quantities. The automatically collected data is transferred to the ERP system. These data are more accurate, are obtained much faster and facilitate timely decisions to be made.

RFID technology will successfully replace the bar-code technology currently used in the automated rack warehouse for finished products. It will no longer be necessary to manually scan the bar-codes on the product boxes. The fixed RFID reader at the warehouse door will automatically read all the products on the pallet and transfer the data into the ERP system. This will reduce the amount of human labour, the possibility of error and storage inbound / outbound time. Also with bar-code technology, each product have to be scanned individually and the product must be in close proximity for the reading to be successful. No additional data can be entered within bar-code technology. RFID technology, compared to bar code technology, which allows only automatic identification, also facilitates tracking and tracing of parts, products and other resources. RFID technology would enhance the storage processes currently performed using bar code technology.

By integrating RFID technology together with supplier and customer information systems, it is possible to track the product throughout the entire supply chain. In this way, preconditions for just-in-time production could be realized. That would reduce the need for storage. By installing an RFID reader at the entrance to the raw material storage, reader will be automatically transfer the data about material into the ERP system, where the amount of material with that code will then increase. It will no longer be necessary to manually check the amount of material and enter it into the system. With the implementation of RFID technology, the possibility of errors would be significantly reduced.

The implementation of such technology is complex, requires large investments, and numerous adjustments that need to be made for the application of RFID technology to be successful.

7. Conclusion

The Fourth Industrial Revolution and globalization have had a major impact on the economy and society as a whole. The Croatian economy lags behind the economies of Central and Eastern European countries. Therefore, it is important to develop and modernize the manufacturing industry, in order to make Croatia more competitive in the European and global markets.

On the example of a real-world small and medium enterprise, the paper presents a way to increase competitiveness by implementing Industry 4.0 technologies. Implementation of RFID technology and integration with the information system would facilitate monitoring of all resources and tracking of products, which can significantly increase efficiency, visibility, traceability, accelerate the flow of materials through the company, and reduce costs.

RFID technology certainly brings many benefits, but also requires some time to implement and a significant investments. Therefore, it is necessary to conduct a cost-benefit analysis.

However, regardless of the high cost of implementing RFID technology as well as other innovative technologies, enterprises that fail to implement digital transformation will not be able to keep up with the competition on the market.

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