RESEARCH IN LOGISTICS & PRODUCTION

COMMUNICATION MODEL OF MEASURING POINTS USING A RFID GATE IN PRODUCTION LOGISTICS

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Abstract: An infrastructure of modern production systems is based on technologically advanced machines and devices. One of the important issues in this aspect is to ensure the smooth communication among elements of the industrial automation infrastructure to ensure the quality, stability and safety of a production system as well as the right identification of resources using in production processes. The article presents a model of communication between measuring points in a production system with the use of a selective RFID gate as a result of R&D project made by DataConsult Sp. o.o. The model can be scaled and applied in different manufacturing companies. It is based on the assumption of parallel and independent communication on a configuration of industrial automation components that enable to use advanced and safety solutions of data collection, processing and sharing.

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1. INTRODUCTION

An infrastructure of modern production systems consists of technologically advanced machines and devices that automate manufacturing and supportive processes. The reliability of communication among elements of the infrastructure functioning in a production sphere is one of the important problems to ensure quality, stability, security of production and the right identification of materials, goods and other resources used in the production processes. Nowadays, manufacturing enterprises expect such communication systems that provide fast and accurate data flow in real-time, are resistant to the interferences of machines and devices placed in the production area, and work with supportive systems, e.g. warehouse systems.

The above premises supported by an analysis of market trends and the implementation of warehouse logistics systems, which are the domain of DataConsult Sp. z o.o., ware a source of inspiration for a research conducted by the company in N=104 manufacturing companies.

The research results show that 53.3% of manufacturing enterprises use in their production halls machines and devices that disturbe the data transmission, 22.2% are not able to implement effectively information systems due to the high number of electromagnetic disturbances, 69% note that the use of other technologies than RFID to identify products or elements is often not possible in their production plants because of the difficult working conditions. The main obstacles are: a high degree of dust, the possibility of code contamination causing difficulties in an optical identification, a high temperature resulting the label's destruction and irregular or small shapes of parts that prevent an attachment of a bar code.

In addition, the research has shown that the creation of a comprehensive measuring points system using a selective RFID gate fits to identified problems of enterprises because it allows to modify and develop production lines with new industrial automation components without the need to stop production or shorten the time required to make necessary changes to a minimum.

The aim of this article is to present a communication model between measuring points with using a selective RFID gate in a production system that is scalable and can be used in a variety of industrial automation infrastructure solutions with an integration with warehouse management systems as well as with ERP systems. The model is based on the assumption of simultaneous independence of the communication from the configuration of industrial automation components, which allows providing a high level of security for data collection, processing and sharing. This model is the result of R&D project called "Resistant to electromagnetic disturbances prototype of measuring points system at the production cells based on a selective RFID gate technology".

The article consists of three parts. The first part is an introduction to the problem. The second part presents the prototype of a selective RFID gate and its meaning in the communication system between measuring points placed in the production sphere. The third part shows the communication model between two measuring points using a selective RFID gate and the elements relevant in terms of its scalability. The assumptions of this model are based on an analysis of currently available solutions for communication interfaces between measuring points in the production space. The last part contains a summary of issues presented in the article. In particular, the attention has been paid to the effects that an enterprise can achieve by using the presented communication model between measuring points in production logistics.

2. PROTOTYPE OF A SELLECTIVE RFID GATE

2.1. Results of research using EMC absorption materials to eliminate interference in radio communication systems

The state of the art (Elektronikab2b, 2015) shows that despite of its popularity RFID technology continues to grow and provides new opportunities for Automatic Data Capture (ADC) in various industries. However, the problem of using RFID gates in production management is discussed by few authors (Ahson & Ilyas, 2008; Angerer, Langwieser & Rupp, 2012, pp. 309–321; Akbari, Mirshah & Hashemipour, 2015, pp. 497–501; Grabia, Majewski, Sokołowski & Hołubowicz, 2011; Gaitan, Turcu & Goloca, 2008, pp. 1351–1356; Oflazgil, Hocken & Schenk, 2016, pp. 325–337; Pupunwiwat, Darcy & Stantic, 2011, pp. 827–834).

As the literature research note, the purpose of using RFID is to share data encoded in tags and reading them in time and place required by adopted solutions of the system. The typical RFID activity is based on a set of antennas connected to a controller and embedded on a company specific structure called the RFID gate. It turns out that currently most of the RFID gates operate in a non-selective way, that means that not only the tags that pass through the light of the gate, but also those next to, and even behind, can be read in the identification process. This gives an incorrect identification of objects (e.g. materials, work in progress, final products).

Therefore, at the stage of industrial research carried out by DataConsult Sp. z o.o. in cooperation with the Institute of Logistics and Warehousing in Poznan, solutions as in electromagnetic compatibility, radiofrequency ablation and eliminating unwanted phenomena such as collapse and reflection of waves were applied. It has been verified whether and when it is possible to shield undesired back-light RFID antennas using EMC absorbers, which is an important limitation for the correct objects' identification during the production processes. The research was made by measuring the intensity of electromagnetic field in the fixed area behind the gate. For this purpose, a grid of measuring points was used to form a square of 1.2 m at the height of the RFID antenna The results have shown that the use of tapered absorbers significantly reduces the field intensity generated by the antenna behind the RFID gate and thus eliminates unwanted tag readings (Maćkowiak, Sieczkarek & Łobaziewicz, 2014, pp. 4633–4639).

2.2. A selective RFID gate

The results of research discussed above became an input to the design of a selective RFID gate (Fig. 1), that is the pioneering use of this device in the manufacturing industry and the second in the world (Łobaziewicz, Maćkowiak & Sieczkarek, 2014, s. 39–42).

Fig. 1. Element of a gate with an RFID antenna

Most of RFID gates are based on metal structures that can interact with radio waves used in RFID systems as information carriers. As a result, the RFID gate is not selective, meaning that it can read data from tags placed not only in its "light" but also outside it. In addition, the typical RFID gates do not allow to create the area to be readable as a result of characteristics of the antennas used and often requires the specific organization of the gate environment so that there are no undesirable markers in the range of the readings. Fig. 2 presents the results of selective RFID gate activity.

The selective RFID gate reads information from tags passing only through the gate's light that creates a space inside the device. As a result, the RFID gate is highly resistant to electromagnetic interference, allowing for densification of measuring points in production without increasing the risk of reading redundant tags. In the next part of the article was presented its application in communication between measuring points located on the production line.

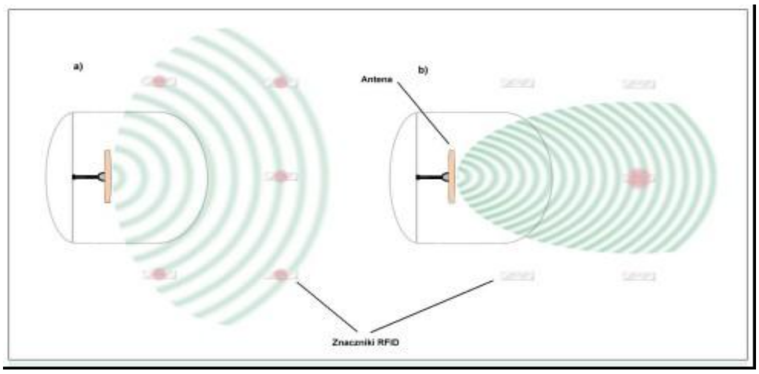

Fig. 2. Comparison of RFID gate reading area: standard (a), selective (b)

3. COMMUNICATION MODEL BETWEEN MEASURING POINTS WITH THE USE OF A SELECTIVE RFID GATE

3.1. Analysis of communication between measuring points in a production system

In practice, there are several variants of communication between measuring points in the production system. One of them is the direct communication that connects RFID tag readers to Ethernet using standard LAN and WLAN ports. In consequence, this allows to configure communication between measuring points based on the IEEE LAN / WLAN communication standard. Thus, this imposes a choice of communication interface based on TCP/ IP protocols. On the one hand, this solution makes it easy to implement it into the production system and, on the other hand, the data collection for reporting and control requires additional devices. Moreover, there is no certainty that the communication between the points is in the correct order according to the logic of manufacturing process.

The second approach is the communication of measuring points through a database. The Ethernet and built-in an internal data communication protocol with RFID tags allows the reader to connect to an external data server. In this approach, each RFID reader may have an assigned IP address during a system configuration. It is also necessary to define the appropriate order of asking the measuring points through database server services. Reading RFID tag with a unique TID / EPC code by a specific reader allows to place a resource at a specific location. Then, information about the registration of transition of the marked resource is transferred to the database, which can be saved for reporting purposes or for further processing. This solution provides easy scalability. Data collection by the database enables monitoring of all tagged assets, particularly "lost" and "abandoned", which can be identified by an operator having a portable RFID tag reader connected via a WLAN to the database. The acquisition of data beyond RFID readers enables to minimize the effects of a device or software failure and the related consequences, e.g. the lost of already accumulated data.

The third approach of communication between measuring points is the use of RFID tags when the communication is not possible via Ethernet. Current RFID readers are mostly under Windows CE and have flash memory. This allows to program a reader behaviour while reading RFID tags. Each measuring point equipped with the RFID reader independently reads the tag and directs it to the corresponding process on the base of information contained in its memory. On the one hand, this is a secure solution, but such system limits the ability to supervise measurement processes only to those measuring points that can be connected to the Ethernet or where surveillance procedures have been defined. Although it is possible to include additional sums recorded in tags that inform about the quantity or a number of objects passing through the measurement points, however, due to the limited capacity of tags' memory, with the turnover of large quantities of goods in production or in stock, it can turn out to be inadequate. Using this solution results that an each measuring point operates independently and requires the installation of up-to-date software that will work with other measurement points. This configuration requires manually software updating in the measuring points at the same time, which may increase system maintenance costs and require technical breaks.

Summing up, the analysis leads to the conclusion that the desired and optimal way of communication between the measuring points is to use the database. This approach gives better possibilities to develop the communication system with new functionalities and to connect additional measuring points. It allows to monitor continuously the flow of objects and to collect data. The communication with using database services enables to identify quickly the technical problems that can appear during the work with the measuring points.

3.2. The concept of communication model between two measuring points

The results of analysis of available communication approaches between measuring points have become the basis for creating the communication model between them through the SQL database server (Fig. 3).

The model's architecture (DataConsult, 2014, pp. 1-16) requires a software installation in the measuring points linked to the database server by the dedicated service. The measuring points log to the terminal server that provide information generated from tags to the database. In parallel, parameters such as the time of tagging and the gate's IP are stored in the database. At the same time, additional information about other characteristics of the objects passing through them, such as weight, size, etc., can be read with the information generating from the RFID tag in the measuring point.

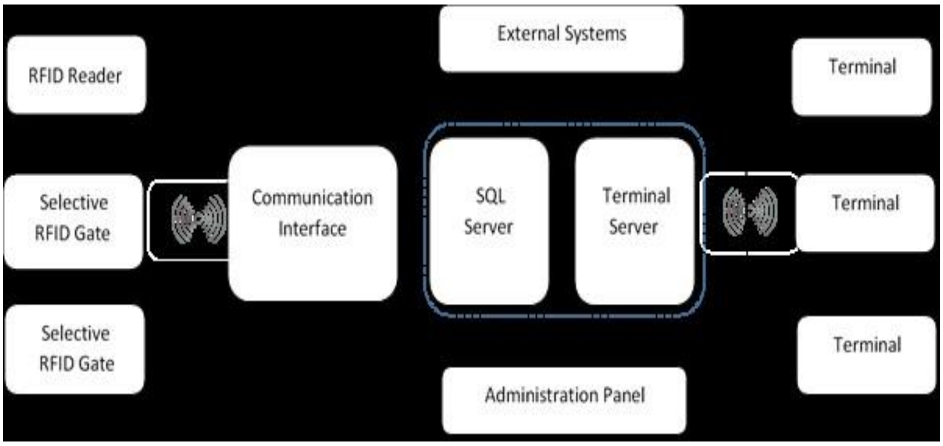

Fig. 3. The communication model between two measuring points of a selective RFID gate

During the analysis and implementation of production or warehouse systems it is important to define what sort of information flow between two measuring points. Setting up communication with using the system database enables to define a wide range of measuring points behaviours, depending only on the design of the measuring point automation.

In the communication model between two measuring points, many system components can be used, such as e.g.: (1) Processes – an object registration at the measuring point can be treat as an individual process that generates not only a warehouse document, but also successive commands and documents, the realization of which will be conducted on the flow of tagged object through the next measuring work centre; (2) Technology – it can be defined, for example, a production order in which the input measuring work centre records objects through RFID tags before they come to a production hall and the output measuring work centre automatically registers and controls the products coming from the production hall.

The Universal Data Exchange Interface (UDEI) is designed for the communication between measuring points which is responsible for exchanging information with any external system. When using dedicated transition tables, information is exchanged between the measuring points software and the system database tables. Data processing configurations are implemented in the database, enabling the implementation of pre-defined measuring data centers actions.

During the system implementation in an enterprise should be defined such elements of communication between measuring points as: Services, Cycle Tasks, Tasks, Templates, Document Types, Warehouses. The characteristics of configurations are available in ERP system. It has been assumed that the communication interface between two measuring points requires validation tests. The parameters of communication interface should be tested during the analysis and at the implementation stage. An important element required for the implementation of the communication interface is to provide an adequate way of information presentation aggregated from the measuring points. In conclusion, the use of the selective RFID gate in the communication system between measuring points allows for: increasing the reliability of unambiguous identification of goods passing through the gate light, which is a great advantage with respect to classic RFID gates, an increased system resistance to electromagnetic disturbances, the possibility of intensification of measuring points within the production line, the possibility of reducing the gap between production lines without a risk of reading the element from the next production line; automatic recording of information to RFID tags, integration with external IT systems and automation devices, flexible adaptation to existing solutions in the enterprise production system.

4. CONCLUSION

The article presents part of results of the research and development works carried out by DataConsult Sp. z o.o. within the framework of the project "Resistant to electromagnetic disturbances prototype of measuring points system at the production cells based on a selective RFID gate technology" that meets the requirements of manufacturing enterprises. The design of a selective RFID gate has the significant advantage of being able to read transponder correctly – the objects moved next to the gate are ignored so that only the appropriate objects moving on the production line are identified. The use of such approach in a communication system between measuring points, each equipped with a set of sensors and meters that register information about the identified components and has the functionality to programming RFID tags leaving the measuring point, enables advanced marking of products at the level of an only element. The article discusses the issue on the example of the communication system using two measuring points, which can be scalable that confirmed the development works carried out within the project.

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BIOGRAPHICAL NOTES

Monika Łobaziewicz is Adjunct at University of Tevhnology in Lublin. She has experience in academic teaching: new trends in enterprise management, quality management, logistics as well as the professional experience as the project manager in R&D projects realized in cooperation with companies as DataConsult sp. o.o.. ("Resistant to electromagnetic interference prototype of measuring points system in production cells based on selective gate of RFID technology", "ExpertAR-Augumented Reality in logistics and production"), OPTeam SA ("Prototype of innovative and advanced B2B OPTIbud system supporting the management of business processes in construction companies"). Her papers appear in numerous journals including indexed in Web of Science, or chapters in books edited by Springer, Elsevier, CRC Press. Since 2014 she has been the expert in peer review of innovative projects for National Center of R&D, Ministry of Development, Bank Gospodarstwa Krajowego. She is also the chair of working group of Smart National Specialisation 17. Automatization and robotics of technology processes, Expert of Polish Confederation of Private Employers LEWIATAN in Lublin Region.