Methods of RFID data processing in intelligent systems for the identification and movement control of industrial products

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Abstract. The article describes the development and research of methods of RFID data processing to build intelligent systems that provide timely and reliable automatic movement control and identification of industrial products. Conducted and presented an analytical review of Russian and foreign scientific-technical base for the development of methods and algorithms for movement control systems. The structure of the hardware-software complex of the system developed. The method of movement control products is presented. We presented experimental studies of the developed system and methods.

Keywords: RFID, movement control, identification.

1. Introduction

One of the most important elements of the quality management system of industrial production, which largely determines the efficiency of its functioning, is the mechanism of identification, which makes it possible to ensure traceability of products throughout the technological production cycle. Traceability in production helps to ensure compliance with government requirements and international quality standards, to perform a fast and targeted tracking of the entire technological cycle of manufacturing products, which, in turn, minimizes financial consequences. Especially relevant is the question of tracing products in the enterprise, if the production cycle consists of many stages, implemented in large production areas. The organization of the mechanism for tracing products is possible by automating the control of the movement of industrial products.

According to the GOST 18353-79 standard, there are 9 methods of non-destructive testing, of which 2 were widely used in the MCS: radio frequency identification and technical vision [1]. The use of technical vision approaches is complicated by the need for graphic marking of proper quality, which is difficult to realize in real production conditions and requires significant financial and human resources. The use of radio frequency identification is less demanding in the process of marking products. Traffic control, based on radio frequency identification methods, is an advanced information technology for the construction of warehouse accounting systems.

A large number of companies around the world are engaged in developing software and hardware for movement control systems (MCS), but the tasks of developing and implementing automated product tracking systems in production are still unresolved. At present, there are still a number of

problems in industrial enterprises, the solution of which is not realized by means of modern MCS. These include:

- not all radio frequency markings may be in the field of view of equipment;
- a number of existing MCS can not be used in view of safety restrictions;
- not all MCS can ensure continuous and correct operation in large industrial areas;
- a number of modern MCS can work only in the presence of positioning systems, which are equipped with transporting devices;
- the presence of interference and signals that make identification difficult.

The listed problems do not allow to organize automatic traffic control at all sections of the production process. To solve these problems, it is necessary to develop new methods that allow more efficient processing of RFID data.

Thus, the development of new methods for processing RFID data for the construction of automatic systems that provide an operative and reliable control over the movement of industrial products is topical.

The aim of the project is to develop and study methods for processing RFID data for the construction of intelligent systems that provide prompt and reliable automatic traffic control and identification of industrial products.

To achieve this goal, it is necessary to solve the following tasks:

1. Analytical review of the Russian and foreign scientific and technical base on development of methods and algorithms of MCS.

2. Development of the structure of the hardware-software complex MCS.

3. Development of an intelligent system and methods for controlling the movement of products.

4. Experimental research and modernization of the developed methods.

2. Analytical review of the Russian and foreign scientific and technical base on the development of methods and algorithms MCS

The PCS software is developed by: PCT-Invent (Russia, Sakt-Petersburg), AiTiProekt (Russia, Moscow), Impinj (USA, Seattle), Motorola (USA, Morrisville), Nordic ID (Finland, Salo), FEIG (Germany, Weilburg) and many others. However, the main activity of these companies is the development and production of the hardware part of radio frequency identification systems and the creation of specialized software for working with it. This implies that for the development of automatic identification systems based on the proposed software and hardware, it is necessary to collect a whole team of technical specialists to write the project "from scratch."

To quickly obtain real-time information on the location of the product and all its movements, systems based on the principles of radio frequency identification of product labels are used. The basis of the systems is the method of remote receipt of product data by transmitting a radio signal from the RFID tag located on its surface to the tags recognition devices (read) and then writing the information received to the database of computers forming the computer network. Such world-famous companies as Wal Mart, METRO Group, Gillette, Procter & Gamble, Tesco, Benetton and others demonstrate on their practical experience the benefits of using RFID technology in the organization of automated warehouse accounting and cargo control.

The automatic identification system (AIS) of objects of rolling stock of railway transport (locomotives, cars, and also large-capacity containers) "Palma" is known, including a corporate computer network, code onboard sensors and reading points equipped at reference points, (RFID tags) the information on the location of the monitored object is automatically removed.

The disadvantage of this AAL Palma is the limited functionality of the system, which consists in the fact that information from the RFID tag is read only when the object passes the specially equipped information reading point (reader). Further location of the facility, for example in the warehouse, is not automatically recorded, which reduces the reliability and efficiency of using AIS when solving the problem of cargo storage.

The closest approach to the proposed approach is the JPL RFID system for warehouse accounting of metal pipes, based on the marking with radio frequency labels of plugs installed at the ends of

pipes. This approach allows the inventory of stored products in an automated mode using hand-held portable readers.

The disadvantage of this AIS is that the movement of pipe products is produced by various means of minor mechanization in such a way that the marking installed on the product in most cases does not fall within the field of view of the reading sensors, which makes it impossible to track the products in automatic mode.

A common disadvantage for this kind of AIS is that for the organization of automatic traffic control, readers are installed permanently, and the movement of the tracked products occurs as it passes along this device. An obligatory requirement is that the marking is in line of sight for the reader, which is practically impossible with the use of such transport devices as bridge cranes, loaders, stackers and other means of minor mechanization. The movement of products for this type of transportation is of a stochastic nature, and the location of the cargo can close the direct visibility of the reader to the marking.

The scientific community is also working on the introduction of RFID technologies in various spheres of human activity. A great contribution to the development of radio frequency identification technology and SKD in various spheres of life was made by Bondarevsky AS, Zolotov RV, Do Zuy Nyat, Kamozin D.Yu., Manish B., Shahram M., Ke-Sheng Wang, Worapot Jakkhupan, Somjit Arch-int, Yuefeng Li, Mahir Oner, Alp Ustundag, Aysenur Budak and many others. The latest works in this area are [2-7].

The application of these knowledge-intensive technologies makes it possible to automate the processes of controlling the movement of industrial products at enterprises of various spheres of life and, ultimately, to improve the efficiency and reliability of the control of transportation and warehouse accounting of manufactured products.

However, they are not without flaws. The use of existing software and hardware solutions is more focused on the organization of automated warehouse accounting and is less suitable for automating traffic control. In confirmation of this at a number of industrial enterprises.

3. Development of the structure of the hardware and software complex MCS

The development of intellectual MCS is aimed at solving the task of organizing and providing control over the movement of products through the territory of industrial enterprises, handling and cargo transportation, including warehousing of goods equipped with multi-code marking. Information on the identification of products can be collected in the database of computers that are part of the computer network that encompasses the points of the cargo transportation route and stores data on the origin and destination of the products and on its location in warehouses.

The proposed MCS consists of 4 main modules: server, client, product marking and marking of the storage area.

Marking of storage areas is performed using Bluetooth-labels, and the current location of the small-scale mechanization means is determined using the IBeacon technology.

Labelling of products at the enterprise is done by attaching an RFID tag to them. In the event that the product contains components shielding the signal from the mark, the marking is applied to several sides of the product.

The client is a stand-alone device equipped with an RFID reader to collect data from RFID tags of products, a Bluetooth adapter for determining the current location, a microcomputer for collecting, processing and sending telegrams to the server and batteries to provide autonomous operation.

The server is a computing device that receives telegrams from client devices, compares the received data with information from the database and generates messages about movements transmitted to the server of the plant's process control system.

The structure of the hardware-software complex of the MCS being developed is shown in Figure 1.

The developed architecture is applicable to various means of minor mechanization. Figure 2 shows an example of placement on a bridge crane.
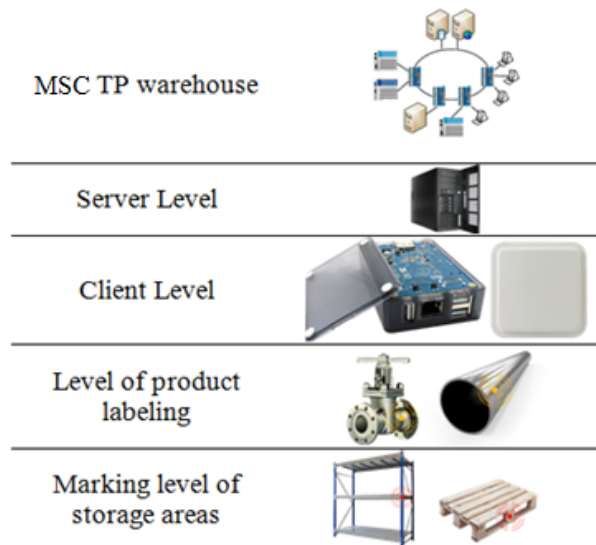
Figure 1. The structure of the hardware and software complex of the developed MCS.
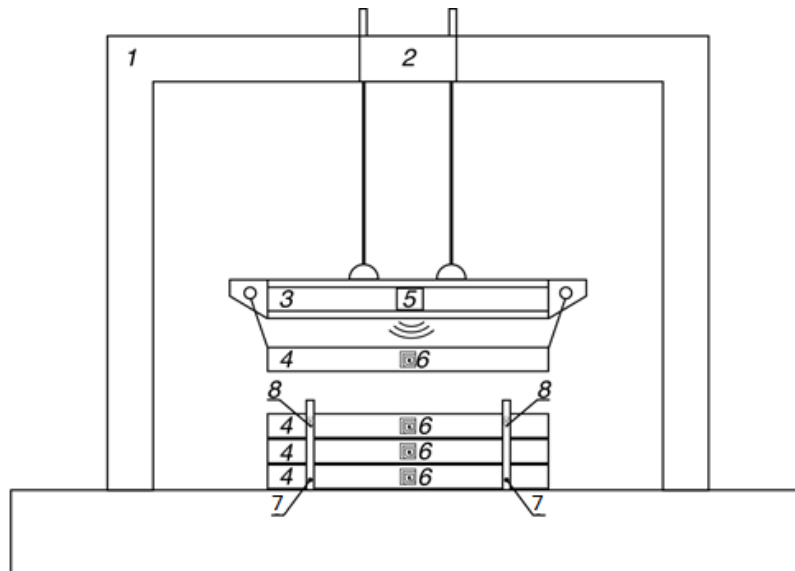

Figure 2. General scheme of means of moving pipes.

The proposed system is explained with the following drawing (figure 2), on which it is indicated:
1 - Bridge crane, for moving products;
2 - Bridge crane truck;
3 - Bridge crane beams;
4 - Movable cargo or article;
5 - Customer;
6 - Product identification;
7 - Warehouse area limiter;
8 - Marking of the storage area.

4. Experimental results
To test the evaluation of the reliability of the results obtained, an experimental study was carried out. The subject of the study is a system for automatic control over the movement of products. The object is a product, an enterprise or a warehouse.

Laboratory experience was conducted with a prototype system in conditions close to real production. To the moving cart was attached a model of the part of the beam, with the reading and

processing device mounted on the side. Under the traverse on the cart is mounted a pallet for products in the form of pipes. View of the laboratory setup is shown in figure 3.
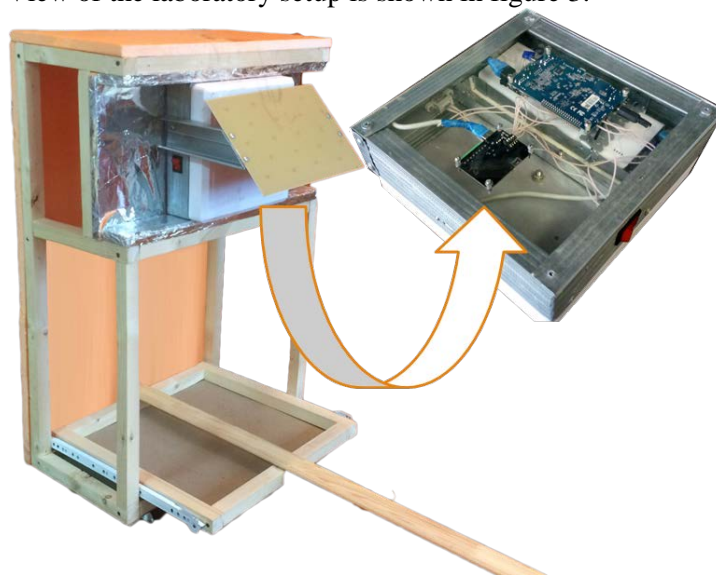

Figure 3. View of the laboratory setup.

For the experiment was created two racks (c1, c2), each of which is labelled iBeacon-tag. The movement of products made from rack 1 to rack 2. During the movement of production readings from their RFID-tags and iBeacon-tags of racks have been processed and are presented in tables (Table 1, 2).

Table 1. Readings from iBeacon-tags of racks.

Time	Rack 1	Rack 2
35:22:00	0	43
35:28:00	0	26
35:34:00	0	0
35:40:00	0	0
35:46:00	3	0
35:52:00	34	0
35:58:00	37	0
36:04:00	27	0
36:10:00	27	0
36:16:00	16	0

Table 2. Readings from RFID tags of products.

Time	Product 1	Product 2	Product 3	Product 4
35:22:00	65	16	91	89
35:28:00	61	5	101	101
35:34:00	75	20	105	105
35:40:00	81	11	108	107
35:46:00	73	9	110	109
35:52:00	57	21	98	95
35:58:00	38	7	103	110
36:04:00	38	21	99	110
36:10:00	61	2	107	110
36:16:00	35	3	78	80

The duration of the experiment was 1 minute. During the experiment with iBeacon-tags of rack has received 212 readings and from RFID tags of products - 2715. Graphic interpretation of the data presented in figures 4, 5.
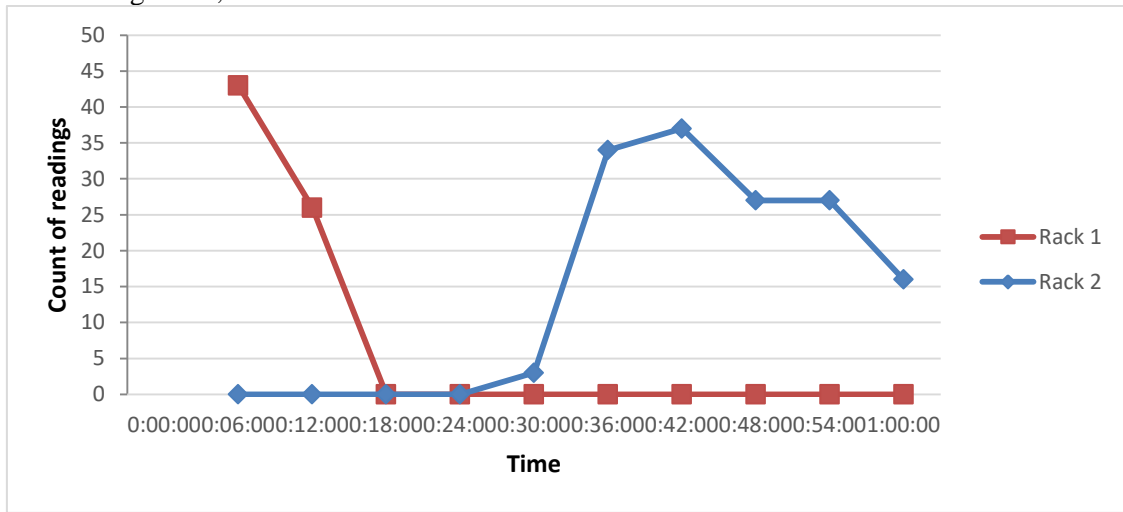

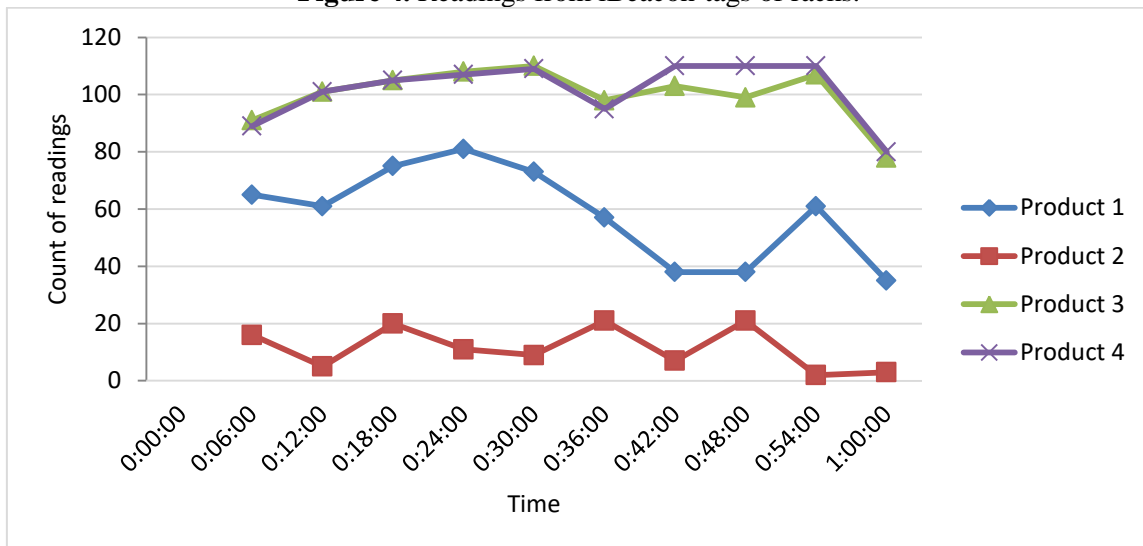**Figure 4.** Readings from iBeacon-tags of racks.

Figure 5. Readings from RFID tags of products.

From the graph in figure 4 shows that at time 00:18:00 readings from iBeacon-tag of the first rack were no longer received by the reader. At time 0:24:00 began to receive readings from iBeacon-tag of the rack number 2. This fact indicates that there was a movement of the transport device from the area of the rack 1 to the area of the rack 2.

Figure 5 shows the readings from the RFID-tags of products, time-spaced with an interval of 6 seconds. During the experiment, 4 items were moved. According to the graph it is clear that a stable signal came from all 4 product tags. This allows us to say that during the movement of the conveying device the products moved along with it.

In the course of the work, more than 150 experiments were conducted in the laboratory. Also, the installation was tested in an industrial plant. The results of the experiment showed the reliability of the movement identifications in the amount of 97.3%. As a result, information was also collected that allowed adjustments to the system to improve its efficiency.

5. Conclusion

A system and method for automatic control of the movement of products based on RFID-identification when moving hoisting-and-transport mechanisms is developed. Considered and analyzed the existing systems of automatic control of the movement of products based on radio frequency identification. The main advantages and disadvantages are revealed. The structure and levels of the hardware and software complex MCS are described, the methodology of its operation is described. Thanks to the presented system and methodology, the problems of moving several units of products simultaneously were solved, the accuracy of detail of the location information was high, the client-server approach and the movement history analysis algorithms were implemented, the problem of authenticity of identification and the tracking process outside the route was solved. Laboratory investigations were conducted, during which it was possible to obtain a high degree of reliability of the identification of displacements in 97.3%, proving the urgency of the developed system and methodology. These studies bear a high scientific value for providing control over the movement of products.

6. References

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