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DESIGNING THE SYSTEM OF RADIO-FREQUENCY IDENTIFICATION IN CONSTRUCTION AND ROAD MACHINES

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The task of designing the system of radio-frequency identification of construction and road machines (CRM) of various technological processes is being considered. The advantages of this type of identification have been substantiated. The mathematical models of designing the element base of the system of radio-frequency identification of objects have been developed.

Розглядається задача проектування системи радіочастотної ідентифікації будівельно-дорожніх машин (БДМ) різноманітних технологічних процесів. Обґрунтовано переваги даного типу ідентифікації. Розроблено математичні моделі проектування елементної бази системи радіочастотної ідентифікації об'єктів.

Рассматривается задача проектирования системы радиочастотной идентификации строительно-дорожных машин (СДМ) различных технологических процессов. Обоснованы преимущества данного типа идентификации. Разработаны математические модели проектирования элементной базы системы радиочастотной идентификации объектов.

Key words: *designing, identification, tag, reader, mathematical models, multicriterion optimization, structural model, element base.*

Introduction. Today a more complicated structure of the system of intellectualization of construction and road machines (CRM) is being developed. The main subsystems of this structure are: the subsystem of high-speed computer devices; the subsystem of information high-precision sensors; the subsystem of mathematical models of optimizing the parameters and working modes of machines. Each of these subsystems is characterized by a set of hardware and software with its requirements for operation and maintenance. Logistics processes of today require stringent conditions regarding accuracy, speed, control of moving objects that are essential in the functioning of technological process. The concentration of road construction work requires the use of high technology. Given the size requirements of these machines, extensive ways of their perfection only by increasing the drive power and design strength cay not provide a significant increase in performance. One of the effective ways to improve road-construction machines is implementing mechatronic design principles, which requires solution of an actual scientific task of creating the theory of road-construction machines workflows as intelligent mechatronic systems.

It is for this function that RFID (radio-frequency identification)-technology introduction can dramatically improve the speed of obtaining information, its probability and can reduce the number of errors in data input throughout technological process, avoiding the weaknesses of this technology.

Papers review. The development of CRM control systems is stimulated by the increasing number of sensors, modernization and complication of standard algorithms for managing complex work operations of construction and road machines [1]. There is an integration of algorithmic methods for managing complex objects and artificial intelligence methods for tasks with the uncertainty of the output information [2]. A distinctive feature of intelligent systems is the ability for planning, adapting and training [3]. The network-centric technologies are developed and implemented effectively accompanied by road-building equipment [4]. The advanced information technology, intelligent systems, sensors and identification systems are implemeted. An important role in this process is given to logistics [2], whose implementation depends on the level of any company development.

Increasing requirements of modern business organizations to enterprises within the overall objectives of maximum satisfaction of the end user puts the question of the need for their modernization and intellectualization [3]. Therefore, the choice of intellectual management system and, in the first place, the system of identification of objects has become topical for a wide range of companies [4].

The analysis showed that nowadays the problem of the choice of identification system using mathematical methods is paid very little attention [5,6].

Purpose and task setting. The aim is to improve the efficiency of technological operations by reducing the time for identification of machine, reducing the likelihood of errors during unloading, excluding the effect of human factors and increasing economic benefits from technological operation. This can be achieved by developing models of choosing the element base of the RFID intelligent system.

Based on the existing problems the main objectives of the study are the following - development of a mathematical model of choosing the element base and rational set of means of intelligent system of radio frequency identification. When designing the RFID intelligent system the multicriterion method of evaluation and optimization is a basic one.

Main stage of designing RFID system. Identification is the process of object recognition by its specific characteristics [8]. Identification can be divided by convenience into several types: visual ("paper" technology), bar coding and radio frequency (RFID). The latter two types are the examples of automatic identification.

However, for a number of applications the first two technologies are ineffective. Visual technology provides for low speed of information processing, increases the number of

errors caused by the human factor. A bar code technology can not provide control of moving objects in real time and work in rigid conditions of operation. Therefore, most companies have begun to shift to radio frequency technology of products identification during technological operations.

Radio Frequency Identification (RFID-technology) uses radio waves to automatically identify physical objects and enables non-contact input and reading data from tags at a distance and when they are out of the line of sight, using both fixed and mobile devices.

RFID-technology is a system that consists of a radio frequency tag or transponder, which contains the coded information about the product, a reader or reading device that reads information from tags and a software that performs operations of recording and reading the code.

RFID system reader serves as the interface for the application you want to read or transfer data to a mobile contactless transponder.

The main functions of the transponder is utilizing energy that the reader transmits by the radio, forming respective message to the reader in the form of code, writing data, transmitted from the reader, to the storage of the integrated circuit transponder.

Let us consider in details the example of tracking the objects in production using radio tags in terms of the ERP planning system:

- raw materials are delivered to the shop from the enterprise warehouses;
- power resources (steam, gas, water, electricity) are delivered to the shop and the orders for production are issued;
- raw materials are weighed and enter the shop;
- the technological processing takes place;
- the product arrives at the warehouse of finished products.

The technological processes of RFID-system are shown in Figure 1.

When raw materials are moved by car or electric loaders, it is reasonable to use transponders for identifying "large" containers and loaders and in the warehouses (including intermediates) and install the scanners of RFID-tags on the process equipment in order to reduce the time for accounting operations and the amount of false information on movement of goods.

As a result, the system users receive a number of benefits:

- the possibility of cross-cutting view of technological history;
- possibility of automatic making of a product batch passport ranging from raw materials and to the point of who at any time processed semi-finished goods at intermediate technological operations, the capacity of power consumed for the production of a given batch and a net working time;
- fixing, except nominal, the real weight of the batch. The use of transponders allows to know exactly the weight of each party (it is written in the tag) and their number, which is being read when the vehicle passes the reader antenna. As a result, the production planning system receives a nominal weight of the manufactured product;
- the possibility of building the transportation management system on the enterprise territory using active RFID-tags for marking loaders, machines and other equipment, their location will always be known to the system;

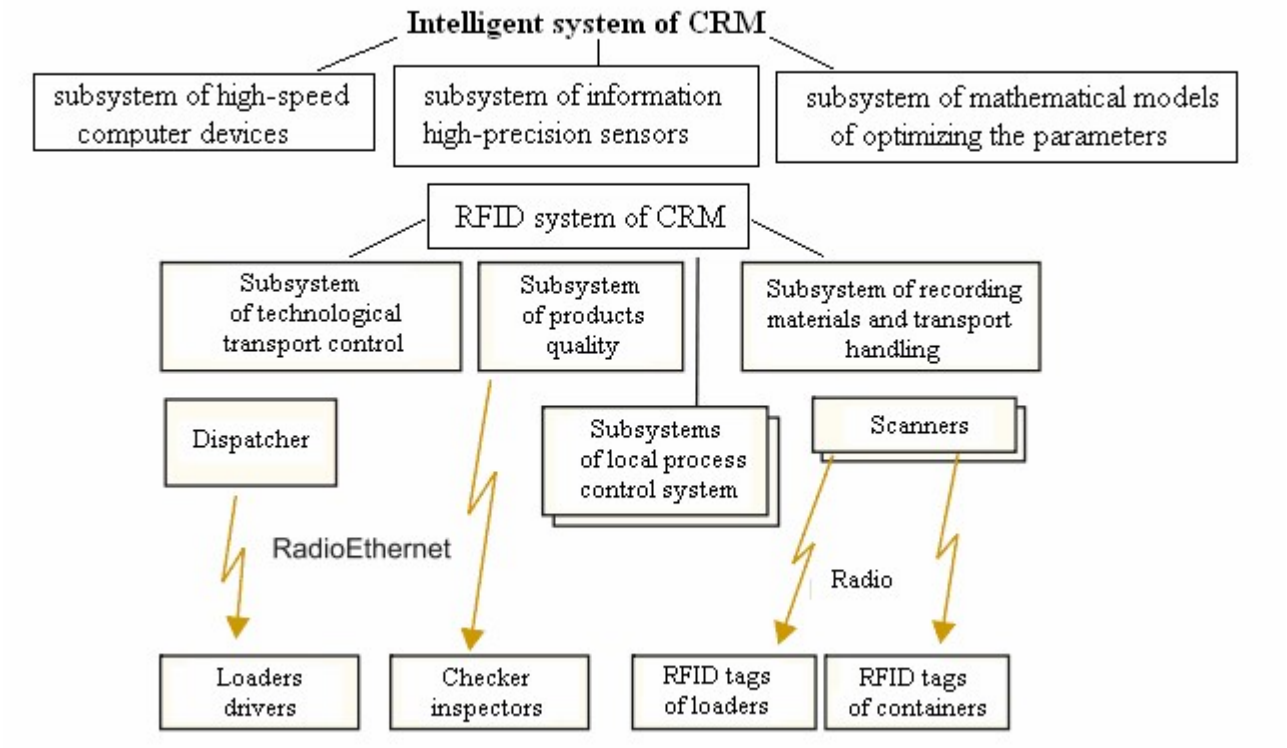

Fig.1. The structure of RFID system of CRM

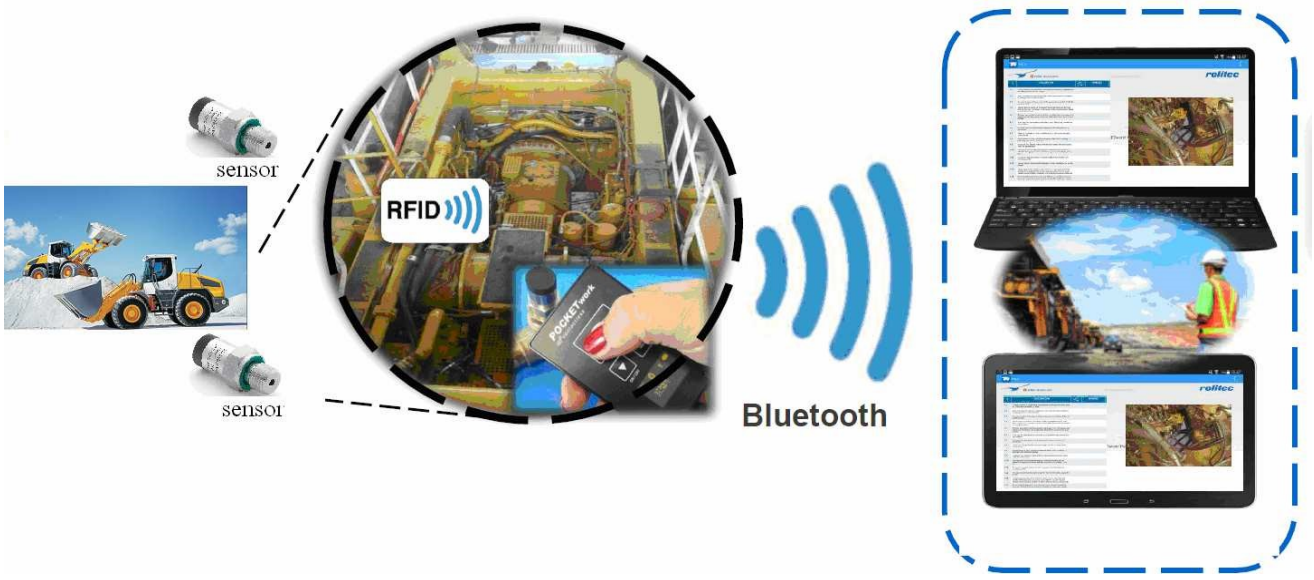

Fig.2. Intellectual work of CRM with RFID-system

- the review of the status of work in progress and a list of materials stored in the intermediate technological warehouses in almost the real time mode;

- intellectual work of the material movement accounting system that does not require operators and additional time for data input (Figure 2).

The main stage of designing RFID system is the choice of hardware and software. This problem can be solved by methods of multi-criterion optimization of this type of objects.

Setting objectives of the study involves the following. We know:

- the set of technical tools of elements base included in the RFID-systems;

- parameters and characteristics of the equipment;

- a set of software tools that are characterized by a set of software applications;

- parameters and characteristics of software applications that meet the requirements of the selected technical means.

It is necessary to choose the element base of the identification system, which will increase the efficiency and quality of all operations of objects movement.

The structure of the element base of RFID-system includes the reader and the radio frequency tag, so the choice of means is made by decomposition of the general task into partial problems. The choice of tags and the choice of the reader are made separately. The problem of tag choice is as follows.We know:

- multitude of tags types $D = \{D_i\}, \left(i = \overline{1, i'}\right)$, where i' - is a number of tags;

- parameters and characteristics of tags.

The choice of a tag is made by the following functional and cost-based indexes:

- the work frequency of the tag *WFT*;

- the radius of reading *RRT*;

- the storage capacity *SCT*;

- the realization of anticollision *RA*;

- the cost of the tag *CT*.

The partial criteria of optimization and the area of acceptable decisions of the tag choice are the following (Figure 3).

Setting the task of the reader choice includes the following. We know:

- multiple types of readers $N = \{N_j\}, \left(j = \overline{1, j'}\right)$, where j' - is a number of readers;

- the parameters and characteristics of the readers.

The choice of the readers is made by the folllowing functional and cost-based indexes:

- the work frequency of the reader;

- the radius of reading;

- the power supply;

- the mass;

- the cost of the reader.

The criteria of optimization of the readers look like this (fig.2) similarly.

The given mathematical model (fig.3) of selecting the equipment of radio freaquency identification applies to the class of the tasks of multicriterion optimization of discrete programming with Boolean variables.

Conclusions

The analysis has proven that the task of designing the system of radio frequency identification of CRM is generally complicated by multiple meaning and inconsistency of various parameters and characteristics of the system. In order to solve the problem of designing RFID systems the multicriterion optimization methods were used.

Characteristics	Partial criteria	Area of acceptable decisions
working frequiency of the tag	$WFT = \max \sum_{i=1}^{i'} WFT \cdot x_i;$	$\max \sum_{i=1}^{i'} WFT \cdot x_i \geq WFT_{sp};$
radius of reading	$RRT = \max \sum_{i=1}^{i'} RRT \cdot x_i;$	$\max \sum_{i=1}^{i'} RRT \cdot x_i \geq RRT_{sp};$
storage capacity	$SCT = \max \sum_{i=1}^{i'} SCT \cdot x_i;$	$\max \sum_{i=1}^{i'} SCT \cdot x_i \geq SCT_{sp};$
anticollision	$RA = \max \sum_{i=1}^{i'} RA \cdot x_i;$	$\max \sum_{i=1}^{i'} RA \cdot x_i \geq RA_{sp};$
cost of the tag	$CT = \min \sum_{i=1}^{i'} CT \cdot x_i.$	$\min \sum_{i=1}^{i'} CT \cdot x_i \leq CT_{sp}.$

Fig.3. The partial criteria of optimization and the area of acceptable decisions

The mathematical model of selecting the means of RFID-systems, which have been built, will, unlike the existing ones, select the best set of means of RFID systems by the specified criteria and restrictions that will significantly reduce the time for identifying moving objects and increase the efficiency of the enterprise performance.

The experience in development of theoretical foundations and practical implementation of CRM intelligent systems indicates their great promise for the use in roadwork.

The RFID systems can be the criteria that determine the need and possibility to use one of the structural, regulatory or diagnostic parameters in continuous monitoring of the technical state of the remote object:

- integrity of parameters (performance of the machine, engine power, fuel consumption) requires the following advanced troubleshooting, but can quickly respond to a possible change in performance efficiency of machines and reduce the amount of information transmitted;
- availability of the system of self-diagnosis of construction and road machines;
- the impact of controlled parameters on the intense wear of elements;
- the possibility to forecast on the base on the information obtained;
- the necessity to install additional sensors not native to a complete set;
- the cost of technical control of the selected parameters.

Designing intelligent RFID systems for CRM operator support is iterative in nature and is based on the design of individual modules, subsystems and their integration into a single unit based on artificial intelligence and the use of modern tools of creation of intelligent applications.

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