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Determining the source of errors in a LEAN cell using RFID technology

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Abstract

According to the LEAN philosophy, one of seven major losses incurred in the production process are errors in the quality. Any error in the products quality as a consequence has losses in the entire production process. Quick detection of the source of errors and causes of their occurrence are of vital importance for the management of production processes. With this aim, the paper proposes the use of RFID technologies to improve the monitoring of workers within the work cell. Under the proposed model, all activities of workers are collected and recorded independently or with very little involvement of workers. By analyzing the data collected, in addition to monitoring the activities of workers in terms of product quality, often other losses can also be identified according to the LEAN philosophy, such as over processing or waiting time, and thus affect their reduction or elimination from the production process. The results of applying RFID technology according to the above model are improved work processes in terms of efficiency and quality of working environment.

Key words: *assembling process, quality, RFID technology, tracing*

1. INTRODUCTION

In the roots of LEAN philosophy, from the first moments of its development, is a principle according to which it is not acceptable that the product leaves the production with error [1]. Widely accepted term "zero defects" has developed since that time. Also, as a basis for the implementation of LEAN philosophy, there are working cells which can have different numbers of workers. Work cells are formed so that one complete part of the production process is covered by. Current trends in designing the work cells indicate the need for training workers to perform multiple tasks within the work cell. Regarding the amount of different jobs a worker needs to know, as an insight, there is a Cross Training Matrix [2]. Starting from the principle of "zero error", the designing of the work cell and training multi skilled workers (Cross Training Matrix), the issue of the means of monitoring the quality of products and workers in certain work cells has been raised.

Maintaining product quality at a high level is an always present problem. There are many reasons that can lead to deficiencies in the quality of products and they are often unpredictable. In addition, in the processes that are dynamic and require the involvement of a large number of workers in the process, for example the process of manual assembling, the problem is even more complex. In such circumstances, errors often arise there where it is difficult to identify who made them. All this leads to the stress of workers while performing tasks, and on the other hand, also to the stress of managers who manage the processes.

This is the most common reason for conflicts between managers and process workers in some parts of the manufacturing process in work cells. Latent conflict often becomes direct, resulting in reducing efficiency and effectiveness of the process as a whole.

To enable unambiguous identification of places and times of occurrence of the specific errors or activities (like e.g. process control), in this paper a model will be

proposed for monitoring workers activities in the manufacturing process, with the use of RFID technology (Radio Frequency IDentification) [3]. Data collected with the use of RFID technology can be used not only to identify the errors, but also for a comprehensive analysis of the production process in an effort to integrate LEAN principles and a system of continuous improvement (KAIZEN) into the system [4-5]. Usage of RFID technology is an attempt to attain complete traceability of the production process activities.

2. PAST PRACTICE

The problem for which this paper proposes a solution relates to the manufacturing process of assembling cables for cars. The production process takes place in a number of working cells, where in some of them there is up to forty people involved. Principle of "zero error" is applied in each of the cells, as well as in the whole manufacturing. In addition, the process is very intensive and requires conducting operations of assembling according to tact time of production, to which everyone has to adhere. It is not allowed to delay the execution of certain tasks. In order to run the production according to takt time, there are workers who are trained to perform different tasks in a number of various operations of assembling. The more the worker is familiar with work at several workstations, the more flexible he is as an employee. Company policies should become the increase of salary or other incentives to workers who are proficient to work at more workstations [2].

During the performance of assembling operations it is often a problem for individual operations to achieve their planned objectives. As a result, there are deviations from the planned tact time of production, which results with deviation from the planned volume of production and losses. To avoid this scenario, in the points where the tact time is different than the planned tact time (at the position of performing certain assembling tasks), workers trained for performing tasks on more workstations assist workers which are slow in performing their tasks. This is eliminating bottlenecks from process of assembling. In this situation, problems arise because workers often deny claims of supervisors and managers that they are responsible for errors made during assembling, and ascribe them to workers who help them in some point of performing their task.

In case of errors it is often a disagreement which worker has made the mistake. For each worker only a smaller number of errors is tolerated. After detecting them, for operations on which the errors are noticed, it is necessary to conduct brief training for performing operations. If the employee continues with mistakes after the repeated training, the next step is to transfer the worker to another working position, or even his dismissal. Finally, often as a consequence of this, epilogue which follows is the court.

Monitoring the quality of the work process at this point is mainly based on standard or traditional approaches. The employee receives working assignments in certain tasks of assembling and all errors related to the task for which he is responsible are attributed to him.

Traceability of products and completion of certain phases of assembling is very well conducted. It is exactly known when the product moves from one operation to another. There is software - technical solution which is developed for this purpose. However, the problem arises in monitoring the activities of workers in the process of assembling. The reason for this is because there are no mechanisms for monitoring the activities of workers during the shift, and there is no solution for monitoring the performance of activities at certain operations (Figure 1). For quality control there are also workers that control processes.

Figure 1. An example of workers activities during the shift

Figure 1 shows the workstation for assembling of cables. The employee gets the work area on the panel for assembling, and a set of tasks which should be performed. This means that every worker gets its share for the assembling on the panel in the work cell and a set of tasks that should be performed in this area (for which the worker bears all responsibility). The problem arises when the performance of certain activities in the process of assembling at each work location should be precisely defined, but there is no mechanism that disables transferring of responsibility between the worker responsible for a particular position and the one who is responsible to assist in removing the bottleneck. In such a situation, considering the existing system, it is impossible to definitely say, whether the worker or the multi skilled worker is responsible for the task in which the error has occurred. Both could have made the mistake, because there is no firm evidence.

How in such circumstances to ensure traceability of work activities of individual operations? To overcome this situation, one of the solutions could be the application of RFID technology. Implementation of this technology is simple and most importantly, does not require too much investment.

3. IMPLEMENTATION OF RFID TECHNOLOGY

Assembling of cables for cars is carried out on large panels (Figure 1). The entire panel is divided in areas for different tasks for assembling cables. For each of these areas there is a group of assigned tasks (Figure

2). This means that each worker knows its position in the group during the work shift. For assembling operations, which should be performed within the specific area on the panel, there is an appropriate technological procedure for workers which have passed training. Number of areas can vary, depending on the type of cable which shall be assembled. Process of assembling is divided in the working cells, and some of the cells have up to 40 people.

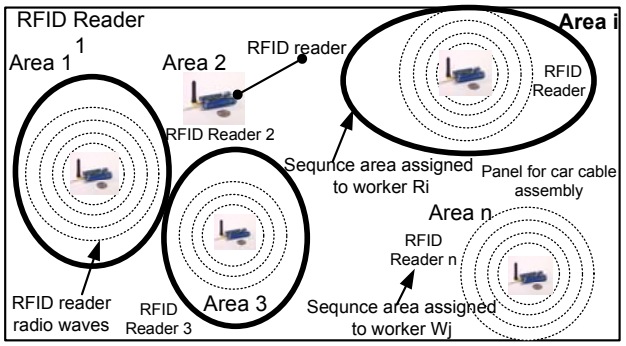

Figure 2. Panel for car cable assembly with specified working area

The sequential motion in the production consists of the individual operations of assembling. The sequential movement of cable through process of assembling, with the adequate operations on the panel, leads to (Area 1, ... , Area N - Figure 2) finished tasks according to the technological procedures.

3.1 Basics of RFID technology

RFID represents a system for Automated Data Collection (ADC) which allows business processes to wirelessly receive and transmit data using radio waves [6-8]. RFID technology allows companies to assign unique identification to individual products or resources. By means of radio waves, data are received and transferred in a wireless mode to any business activity in real time. Basic components of any RFID system are: tag – data carrier, reader, antenna, controller, (mandatory components), and sensor, indicator, and actuator (optional components) which are required for external input/output, computer and software system – theoretically, RFID system can function without these components, but is practically useless, communication infrastructure – which is mandatory and consists of both types of networks (cable and wireless), and the infrastructure required for communication between the previously listed components.

3.2 Method of application of RFID technology

The idea of applying RFID technology means that on some parts of the panels, in areas that are assigned to each employee and which are defined with a technological procedure, the appropriate RFID readers are placed (Figure 2). RFID readers (Figure 2, Figure 3-position 1) register the activity of performing certain operations from the start to the completion of the operation performed by employees, in each work area of panels for assembling. The chosen RFID reader is a short range reader (Figure 2 and Figure 3-pos. 1).

Reading activities of workers are carried out with RFID readers. RFID reader registers presence of each RFID tag which is in range (Figure 3). In the reader area (Figure 3 position 4) the RFID tags dedicated to workers that needed to perform the operation task can be found. Also, in the same area, RFID tags dedicated to inspectors and managers responsible for inspecting and monitoring the assembly process can be found.

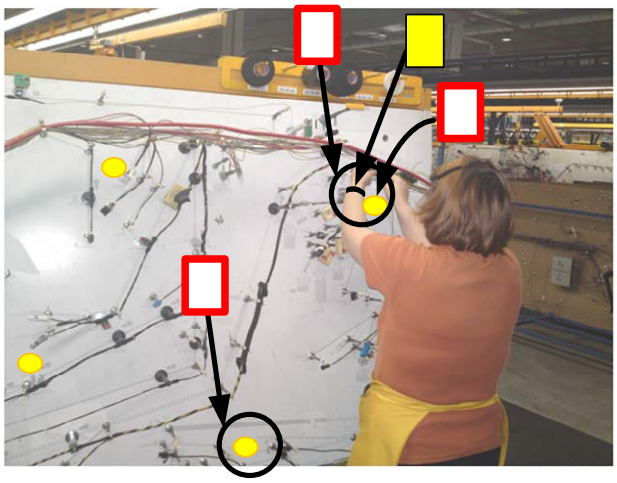

Figure 3. RFID tag and reader positioning on panel

Each worker gets an RFID tag which he must carry constantly. In accordance to the concept, there are two types of RFID tags that can be used.
One type involves tags that are placed on the workers wrist as a clock (Figure 3 position 3). The second type includes a tag in the form of cards (Figure 3 Position 2). One of the solutions is with the RFID tags that are in the form of watch (Figure 3 position 3), which is advantageous because the worker does not have to think about the reading of RFID tag. While carrying out activities in the assigned area, the reading of RFID tags is fully autonomous (Figure 3 position 3).
On the other hand, tags in the form of cards can be used (Figure 3 Position 2). In that case, worker must put the RFID card on the RFID reader, in order to perform registration of workers in the operations execution. Figure 4 presents the types of RFID tags that can be used.
The use of RFID tags in a form of watch is more convenient. In this way the worker is not burdened in any way with additional activities in the work. Any additional activity, such as reading of RFID card increases the possibility of making mistakes or failure in reading the cards.

Figure 4. Wide range of RFID tags [9]

3.3 Data Collection

Area of assembling, as shown in the figures (Figure 1 and Figure 2), is located on the appropriate panel. According to technological procedure for assembling, each worker carries out its operations at the appropriate part of the panel for assembling (Figure 2, Area 1, ..., Area n). Thus, each worker belongs to the specific area of panel, and there the employee performs related technological procedures for assembling (Figure 2).

During the execution of assembly operations, the employee must at some point put his hand close to the RFID reader in the particular zone of the panel. Each zone that is assigned to a certain worker has a corresponding RFID reader (Figure 2). Each RFID reader has an appropriate broadcasting area (Figure 2, Reader 1, ... , Reader n). By putting the hand in the working area while performing the tasks of assembling, the worker allows the RFID reader to register the activity in the broadcasting area (Figure 3). RFID reader registers the presence of workers in the area and a computer program takes over the required information. When another worker assists in carrying out assembling operations in a certain area, the RFID reader gets information from this worker from his RFID tag.

When an error has been noticed, the detecting of its root cause is significantly easier, since for all operations of assembling the detailed data are collected. Identification of the person responsible for the error is easy, and therefore it is easier to define measures for eliminating the causes of its occurrence.

The information obtained by reading the RFID tag is connected with the reading date and time in each area. The frequency of tag readings can be changed by the manager. The required frequency of reading by the RFID reader mainly depends on the production rhythm and the speed of assembling operations execution. Since there are time records of entry and exit of cable in each phase of the process assembling, it is not difficult to connect this information with the information obtained from the RFID reader.

4. DISCUSSION

Although RFID technology in the proposed solution can provide only one information about the employees conducting the assembling operations on the panel, there is a great number of results with positive responses. Analyzing the losses in the system starting from 7 basic wastes according to the LEAN philosophy [2], the time which is registered at different areas on the panel for assembling shows a lot in the analysis of wastes: wait time, overprocessing, motion, defects / rejects. Long period of inactivity, i.e. long time without readings of the activities of employees on the working positions from the RFID reader, indicate the need to analyze the reasons for it. On the other hand, long readings of conducting certain operations, indicate that it is necessary to speed up the process of assembling at certain points.

The precise information of the employee that makes losses (defects/rejects), could help to remove the losses in the process of assembling. Reading of tags in the workplace gives an accurate answer to that question. The information which worker should be directed to training and which is the bottleneck in the technological chain is also very useful.

It is also important to emphasize that the inspector or manager confirms the time of certain activities in the process with his RFID tag. The moment of possible observed errors on the product is confirmed by reading the RFID tag of the inspector at the appropriate position of error on the cable.

Analysis of the times of RFID information for each worker can provide information about how the process of assembling is designed. Imbalance in terms of time indicates the possible need for redesign of the process in some parts. A special importance is the application of RFID technology in the application of theory of constraints in the system analysis and value-added product in the system for installation of products [4].

5. CONCLUSION

The application of RFID technology significantly improves traceability and analysis of product quality in the process of assembling. Information on the presence of a worker on a panel for assembling makes room for review of certain phases of the process. Gathering information flows spontaneously, without pressure. Presence / absence of workers and the time they spend at a certain operation are much more significant. Those who analyze this information are responsible to use it in a qualitative way. Developing the software solutions that automatically monitor and analyze the data collected by RFID technology is the next the step in its implementation.

The possibility that the information system can extract the exact moment of workers and supervisors presence

at the specific operation and record the moment of discovering errors is one of the initiators of the idea of applying RFID technology. Traceability of the process assembling, which is achieved by using RFID technology concept that is presented, is not absolute and there are a number of issues to be resolved. Although the traceability and product quality are in the focus of the presented concept, the results obtained show several aspects of its applicability. Some aspects of the analysis indicate the level of employee satisfaction in the workplace.

LEAN philosophy speaks of the need for permanent changes toward the better in the system. The information collected by the RFID reader, although very simple, can be the basis for initiating this sort of change in the system - by small steps to big change.

6. REFERENCES

[1] Womack J. P. and Jones D. T. (1996), *Lean thinking*, Simon&Schuster

[2] Ortiz, C. A. (2006), *Kaizen Assembly Designing,Constructing, and Managing a Lean Assembly Line*, Taylor and Francis Group, LLC, CRC Press is an imprint of Taylor & Francis Group, an Informa business, ISBN 0-8493-7187-2

[3] Lahiri, S. (2007), *RFID Sourcebook,* IBM Press Pearson, New York, NY,USA.

[4] Bell, S.(2006) *Lean Enterprise Systems Using IT for Continuous Improvement*, Published by John Wiley & Sons, Inc., Hoboken, New Jersey, ISBN: 978-0-471-67784-0

[5] Web site: Lean Study: MRO and Indirect Material Cost Reduction, RFID enables holistic PLM Enabling Integrated Information Management, with RFID, Indirect Material Management and Cost Reduction Enterprise, Available from: www.cribmaster.com, August 2006., Accesseed: 22.11.2013.

[6] Kelepouris, T., Bloch Da Silva, S., McFarlane, D. (2007): *"Automatic ID Systems: Enablers for Track and Trace Performance"*, Auto-ID Labs White Paper WPBIZAPP- 037, Auto-ID Lab, University of Cambridge, UK, May 2.

[7] Ostojić G., Lazarević M., Stankovski S., Ćosić I.(2008): *RFID Technology Application in Disassembly Systems* , Strojniski vestnik = Journal of Mechanical Engineering, Vol. 54, No 11, pp. 759-767

[8] Stankovski S., Lazarević M., Ostojić G., Ćosić I., Purić R. (2009): *RFID Technology in Product/Part Tracking During the Whole Life Cycle* , Assembly Automation, Vol. 29, No 4, pp. 364-370

[9] Web site: http://www.cetwinservice.com/products/rfid-tags.aspx Accesseed: 22.11.2013

Određivanje izvora grešaka u Lean ćeliji koristeći RFID tehnologije

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Rezime

Prema LEAN filozofiji, jedan od sedam velikih gubitaka u procesu proizvodnje su greške u kvalitetu. Svaka greška u kvalitetu proizvoda, za posledicu ima gubitke u celom procesu proizvodnje. Brza detekcija izvora grešaka i uzroka njihovog nastanka, od vitalnog su značaja za upravljanje proizvodnim procesima. U tom cilju, autori predlažu upotrebu RFID tehnologije za poboljšanje praćenja radnika u okviru radne ćelije. Prema predloženom modelu, sve aktivnosti radnika se prikupljaju i evidentiraju samostalno ili uz vrlo malo angažovanje radnika. Analizom prikupljenih podataka, pored praćenja aktivnosti radnika u pogledu kvaliteta proizvoda, često mogu biti identifikovani i drugi gubici prema LEAN filozofiji, kao što je npr. vreme čekanja tokom obrade čime se utiče na njihovo smanjenje ili eliminaciju iz proizvodnog procesa. Rezultati primene RFID tehnologije prema navedenom modelu su poboljšani procesi rada u pogledu efikasnosti i kvaliteta radnog okruženja.

Ključne reči: *proces montaže, kvalitet, RFID tehnologija, sledljivost*