Production Quality Control Using the Industry 4.0 Concept

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Abstract. Industry 4.0 is an application of the network concept of digital objects interconnection and the collection, exchange, analysis and distribution of data among them in industrial enterprises. For this purpose, other technologies belonging to the Industry 4.0 concept are also used. By appropriate application of these technologies, companies can obtain relevant information about the ongoing level of quality of the production process. Improving quality will significantly increase the profitability of the product and will act as a key strategic factor in the market. Many manufacturing companies use traditional manual techniques to assess product quality control. They take a sample from one batch at random and check the quality of the product at different points on the line. However, such an approach has its limitations and does not allow active intervention in the production process. A possible solution is to use the Internet of Things approach, which allows manufacturers to analyse product data that is generated from devices and thus they are informed about the quality of the production process in real time. Product data can be further used to remotely diagnose of the product and reduce the time it takes to process customer service requests.

It this paper will be described some technologies, which can help to achieve these aims and there will be also designed a possible information flow to get appropriate data.

Keywords: Information flow · Industry 4.0 · Data

1 Introduction

Achieving the required quality of production in the long run is currently one of the most important factors for the customer in deciding on the choice of supplier organization. Costumer selects companies which are able to declare the quality of production based on their long-term activities through historical and current data. In this context, data is becoming an important factor for companies of their position in the market. One of the prerequisites is the implementation of technologies and methods of the Industry 4.0 concept, which can significantly help companies succeed in the market. The most important in this context is the collection and subsequent analysis of data, where means and tools belonging to the category of Internet of Things (IoT) can be used. The basis is the interconnection of large number of heterogeneous terminals and the provision of

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acquired data for all kinds of different digital services. The role of IoT is to connect to the Internet, provide computing power, and enable the ability to scan, count, communicate, and control the environment. These capabilities are applied in many applications due to their potential impact. IoT offers a new perspective on what kind of data should be collected and how often and from where it should be collected in order to make available information that was not previously available [1].

The presented paper will analyse the proposed information flow in obtaining the necessary information about the quality achieved. Several technologies and procedures will be used in order to obtain as much relevant data as possible that can be further processed. The proposed information flow should also ensure the control of the operation activities to eliminate the possibility of poor quality production.

2 Tools and Methods

In the proposed information flow, we assume the use of several technologies and methods. According that, there will be introduce their brief description in the following subchapters.

2.1 IoT

Industry is increasingly focused on using resources more efficiently, increasing labour productivity, reducing operating costs, ensuring worker safety, and all this, it is brought about by the revolutionary Internet of Things (IoT). According to one of many definitions, it is a network of interconnected objects that are uniquely addressable, the network being based on standardized communication protocols for exchanging or sharing data and information in order to achieve higher added value. IoT is thus a concept for physical and virtual objects (things) that can share data through the Internet [2]. It is already possible to see that the Internet of Things is one of the main sources of big data [3]. The application of this technology to production creates a new concept - the Industrial Internet of Things (IIoT) (Fig. 1).

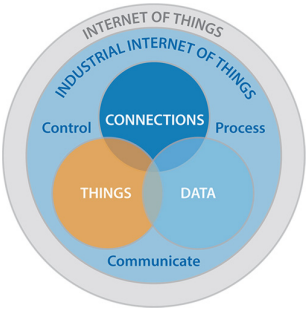

Fig. 1. Internet of things in manufacturing [4].

2.2 Vision System

These systems are used in all industry areas and are an essential part of achieving efficiency and high quality standards. They have also found application in the field of product quality control. Industrial machine vision systems are typically implemented in automated lines with manipulators or industrial robots to inspect, identify, diagnose, measure, count and track products. In most cases, industrial automation systems are designed to inspect known objects in fixed positions, characterize faults on items, and take steps to report and correct these faults and replace or remove faulty parts from the production line [5]. One such system is industrial vision systems, which are described as computer systems where the software performs tasks for acquiring, processing, analysing and understanding digital images. They are usually focused on industrial quality assurance, defect detection, part recognition, etc. [6]. They form "eyes" that capture the process and recover the analysed digital image using image special processing software (Fig. 2).

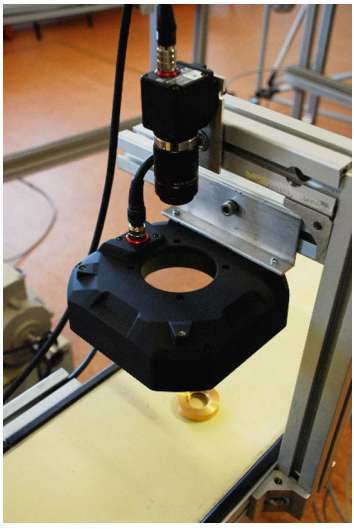

Fig. 2. A view of camera vision.

The basic principle of the machine vision system is that the camera captures images that are sent to the computer via one type of the serial communication protocol standard. Obtained images are subsequently evaluated in computer according set of rules. For assumed system it is the very important part because of its ability to detect wrong parts of objects. This aim can be fulfil using various methods. Nowadays there are used various methods of artificial intelligence to recognize the object [7, 8].

This system has advantages over other techniques in that the integration of a vision-based inspection system reduces production time, increases the efficiency and quality of inspection activity by eliminating human interaction in the inspection process [9].

2.3 Radio Frequency Identification

Radio Frequency Identification (RFID) is a technology that has gained popularity in many business sectors thanks to the relatively wide area of its applications [10] in many industries. RFID is a technology used to identify objects and transmit information from a distance via radio waves. Different types of RFID tags are used for different applications [11]. The advantage of RFID systems is that many objects can be detected automatically and almost simultaneously without visual contact [12]. Some of the reported benefits of RFID applications include flawless machining, reduced cycle times leading to shorter lead times, smaller inventory reductions, and more accurate inventory (lower inventory and out-of-warehouse opportunities). RFID systems consisting of one or more readers and several tags also play a key role in the IoT attitude. These technologies help automatically identify everything to which they are connected and allow objects to assign unique digital identities, integrate them into a network, and associate them with digital information and services (Fig. 3).

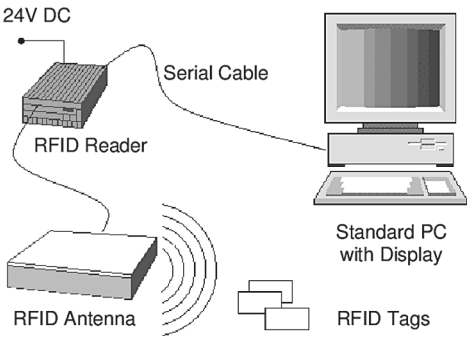

Fig. 3. Principle of RFID technology [13].

RFID technology, as the core of IoT, acts as a link between process flow data and physical asset data. All physical asset data can be assigned to process nodes based on RFID [14].

In the prosed information flow, we assume using the programmable logic controllers (PLC). They are described as reliable control system that can continuously monitor the status of devices connected to the inputs. A PLC is a controller with functions for performing timing, counting, arithmetic manipulations, control logic, and sequencing. PLCs are basically very similar to an industrial computer, which has a built-in memory, I/O interface, central processing unit (CPU) and programming device. 3 The central processing unit (CPU) of a PLC consists of a microprocessor, memory chips and control logic circuits for communication and monitoring. The CPU can be operated in programming mode to download logic from the device and in operating mode to execute the program and start the process [15] (Fig. 4).

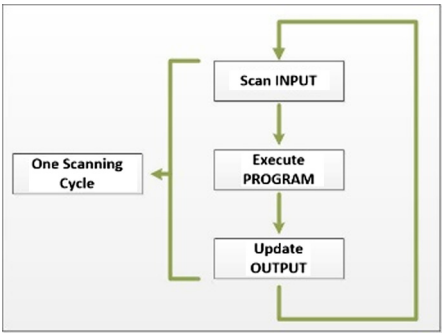

Fig. 4. Principle of PLC [16].

2.4 Software Tools

When a company obtains data from a number of sensors, each of these sensors is loaded with a large amount of computing power. In this case, it is more advantageous if the data is transferred to the cloud and processed there. Cloud computing capabilities are used to manage and store such data. By storing data in the cloud, companies can access large amounts of data. Cloud computing and IoT work to increase the efficiency of everyday tasks, and the two complement each other. IoT generates a lot of data, while cloud computing provides a way to process that data. It can be said that the cloud is the "brain" for most IoTs, because most of the collected data is finally processed and analysed in the cloud [17].

2.4.1 Cloud Technology

Cloud computing has changed the way technologies can be accessed, managed and delivered [17]. Cloud storage is a computer data storage model in which digital data is stored in logical files that are said to be located in a "cloud." Physical storage is spread across multiple servers (sometimes multiple locations), and the physical environment is usually owned and managed by the host company. These cloud storage providers are responsible for maintaining the availability and accessibility of data and the protection and operation of the physical environment. People and organizations purchase or rent storage capacity from providers to store data about users, organizations, or applications.

Cloud and IoT is a platform that enables intelligent use of applications, information and infrastructure in a cost-effective way. Although IoT and cloud computing are different, their properties are almost complementary [3].

2.4.2 Cloud Database Possibilities

In the presented proposal of information flow, we assume the storage of obtained data in a database, which should serve as a tool for various outputs based on individual queries, as well as a source of basic information about the product.

There are currently many different cloud database service providers that provide database as a service, DBaaS such as Amazon RDS, Microsoft SQL Azure, Google

AppEngine Datastore and Amazon SimpleDB and more. Each service provider differs from the other depending on the quality and type of provided services.

When implementing a cloud database, it is necessary to consider some of its disadvantages:

- Companies must pay for the use of a cloud database every time data is transferred from the database. If the company's traffic to transfer data to the database is high, then the company may pay more than expected.
- Security issues - we do not have full control over the server where our database is stored. We have no control over the software installed on these computers. To increase the security of the cloud database, the client must rely only on the provider.
- Internet speed. Because a large amount of data is stored in a cloud database, it is very difficult to transfer this data to a personal computer. For this reason, the speed of the Internet must be high.
- Change of provider. If a client wants to change the database from one service provider to a new one, they may encounter problems. This is because each service provides its own methods and techniques for storing data.
- Data from the database is retrieved over the Internet, so if the server is down, it may make it impossible to access the data from the server. This causes huge losses when information is not available when needed.

The advantage, however, is that the cloud database is a very powerful technology and companies prefer it because they can get information from anywhere and at any time.

3 Design of Information Flow

For the proposed information flow, we assume the storage of individual parameters, using database software. An already created database schema with clear items is assumed, into which information will be written through individual supporting technologies.

The following scheme shows the expected information flow of the workplace (Fig. 5).

3.1 Description of the Assumed Events

In position "1", the initial product information (eg information from the drawing documentation, ID numbers, etc.) is read using RFID technology and sent to the PLC.

RFID tags can be attached to the pallet and RFID readers and antennas are placed at fixed workstations to monitor the entry or exit of these pallets. Through wireless identification, these tags can communicate with RFID readers to obtain real-time data and possibly decide on further material flow.

The information continues through the server to the database on the cloud storage. The product continues with further production operations and in a certain state of development it is necessary to check the current quality "2" (e.g. to assess the key dimension of the product, whether it meets the requirements, or to find out the correct location during assembly, etc.) (Fig. 6).

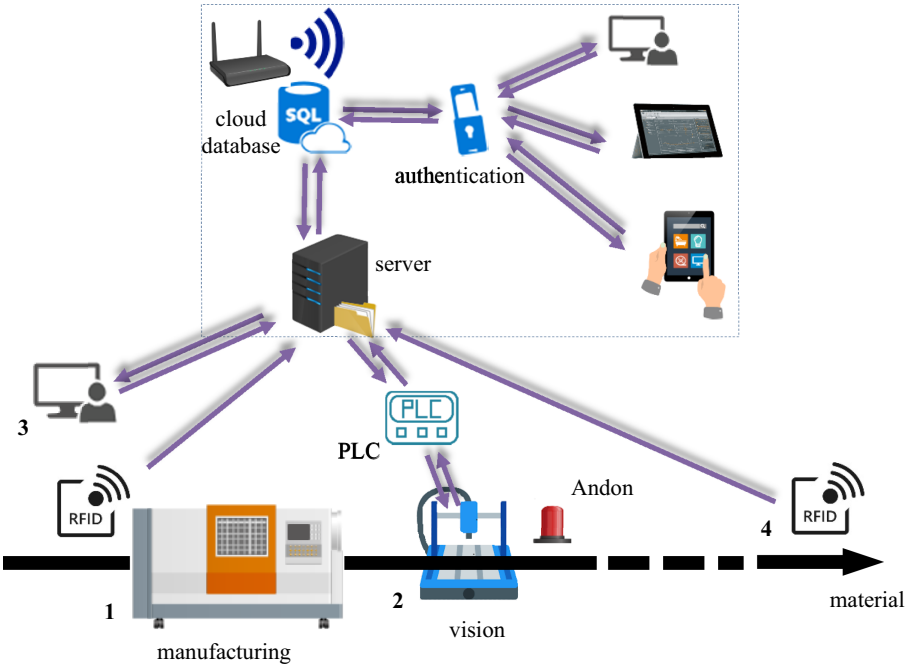

Fig. 5. Assumed information flow

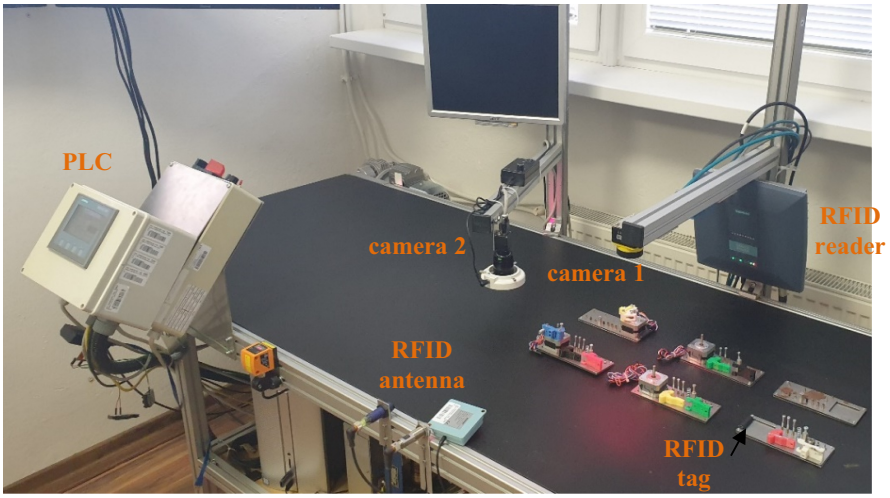

Fig. 6. View of the experimental workplace.

At this point, a camera system can be used, which evaluates the set parameters and sends the information via PLC again to the database, where the added information will be paired based on the agreed rules.

The course of individual products is displayed at the control station “3”. The following figure represents a desktop showing a possible software environment (Fig. 7).

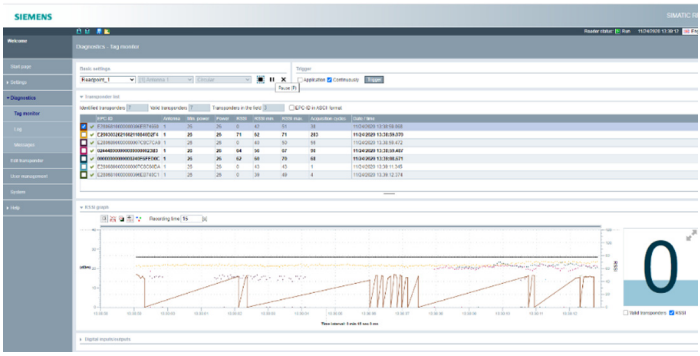

Fig. 7. Settings SIMATIC web controler.

As part of the quality assessment at this point, LEAN tools and methods can be used, where a warning system (e.g. andon) can be applied, which in case of non-compliance will signal an error. In this case, different approaches can be used to solve the problem:

– stop of operation and determination of the causes of non-compliance with the set parameters
– automated disposal of an individual product and its subsequent manual inspection. In this case, it is then possible to add the required information to the database off-line.

If the required parameters are met, the product proceeds with further operations until it reaches the last required item “4”. Data is reloaded to the database from this item via RFID.

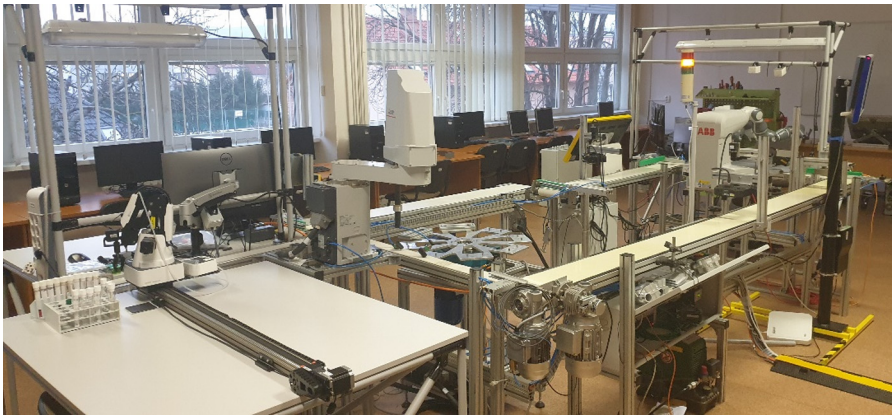

Fig. 8. Experimental workplace.

In the near future, the goal is to expand the experimental workplace with other objects (e.g. robots) and create an experimental automated line where the possible use and interconnection of the described technologies and tools would be tested. The next figure shows experimental workplace (Fig. 8).

The area of research will be mainly the area of production quality control, data collection and its analysis to ensure the automatize quality control and to create relevant database, which can serve as a possible tool for customers decision..

Conclusion

Today, data is one of the most important areas of interest in any business. By using the latest trends and technologies, companies try to obtain and analyse as many relevant data as possible, which would allow them to assert themselves, respectively. Remaining in the market. In the present paper, the anticipated information flow is proposed, with the application of various current high-performance technologies and tools. All the described technologies have great potential to bring the required data in shape with the right configuration, regardless of place and time. Companies thus gain important information for their presentation to potential new customers and can strengthen their position with existing customers.

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