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Analysis of the implementation of the identification system for directly marked parts - DataMatrix code

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Abstract

A photocode in Polish is a common name for a two-dimensional code, which is characterized by higher information capacity than a traditional barcode. The paper analyses the use of the two-dimensional coding system - DataMatrix to identify and classify the material stream in the production process. The analysis showed the effectiveness of the implementation of the coding system in the context of increased availability, machine use and increased product quality. The improvement in the production process is confirmed by an increase in the OEE index. As part of further improvement measures, the coding system should be implemented throughout the enterprise, its compatibility with existing systems should be ensured and applied to all products.

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1. Introduction

The use of computer techniques for business management entails the need to collect, process and transmit large amounts of data. Various methods have been developed to improve such processes. One such method is Automatic Data Caprure (ADC) using barcodes (Kost et al., 2010). One-dimensional barcodes are generally used for marking goods, as they contain relatively small volume of information in the code. Marking the goods with a one-dimensional barcode comes down to assigning a unique code number. Such codes do not even take into account the essential description that would characterise a particular good. This impracticality can be eliminated by using two-dimensional DataMatrix barcodes. Unlike one-dimensional barcodes, the DataMatrix symbol has a greater information capacity of up to 3116 digits or 2335 alphanumeric characters. For this reason, DataMatrix offers the possibility of encoding more messages about a specific product, such as: name, serial number, date of production, expiry date, manufacturer's data, precise dimensions, instructions for use, as well as the inclusion of a short description of product processing, product history and its processing (Jerczyńska at al., 2000; Langman et al., 2007; Janicki, 2014).

2. Two-dimensional code (2D) - DataMatrix

In a system of two-dimensional codes, the so-called 2D codes, the carriers of information are black and white squares, which consist of two-dimensional images, most often with dimensions of about 15 × 15 mm. Unlike barcodes, these codes have a larger coded data size due to the location of the code characters on two axes. A single two-dimensional code can contain information from several barcodes. For this reason, they are used wherever multifaceted information needs to be placed on a small area. Two-dimensional codes can be damaged by physical factors (e. g. abrasion, interruption, moisture), but even damaged codes can be read using error correction techniques (Fish-er at al., 1995; Knels, et al., 2010; Liu et al., 2012).

In Poland, matrix codes are called photocodes. According to different classifications, there are several dozen different varieties of photocultures, however, the most commonly used ones include: QR code, Data Matrix, EZcode, Microsoft Tag (Tag) and SnapTag (Leg, 2013; Leg, 2017; Sosnowski, 2000).

The DataMatrix code always takes a rectangular shape, and in many cases even a square shape. Its left and bottom lines are the thickness of one module, which means that they have the thickness of the smallest component of the code, and at the same time they have a black color. They are used to locate the position of the code, while the right and top lines are dashed and allow you to determine the size of a single module (Langman et al., 2007; Huang et al., 2012; Tang, 2005). Figure 1 shows the DataMatrix codes with information of different lengths.

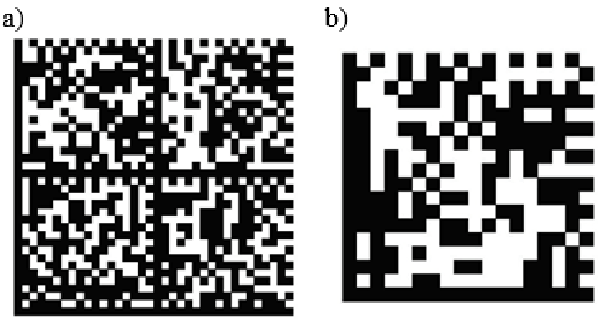

Fig. 1. a) DataMatrix symbol encoding the following text: a) "This is a very long text encoded in DataMatrix. In order to ensure easier decoding, the symbol has been divided into sections"; b) A DataMatrix symbol encoding a short text (Langman et al., 2007).

The DataMatrix code is a two-dimensional code that allows for encoding many production information on a small area of the product. However, this symbol is not intended for use in retail outlets. The DataMatrix symbols are read by the appropriate 2D image scanners or video systems. The DataMatrix code itself can be placed directly on the product, components or individual parts. In this case, the code can be engraved with a laser, directly on the surface of the product or chemically etched or knocked out. Subsequent code characters are placed in the form of overlapping square blocks arranged diagonally. As a result, the code is irremovable, even under particularly difficult conditions, and the product marked with it can be processed or used e. g. in industry, in the presence of chemical substances or lubricants. DataMatrix codes can be perfectly used in so called difficult conditions, which do not allow for marking products with a traditional barcode (Frąckowiak, 2015). For this reason, one of the applications of DataMatrix in production is the identification of manufactured products in the entire manufacturing process, obtaining current information on the course of the production process, control of products in production, operations performed, positions and employees, preparation of process statistics (Pacana et al., 2014; Pacana et al., 2015)(determining the number of deficiencies, measuring working time, productivity, labour intensity and workload).

DataMatrix codes are used in many ISO standards and the code itself is described in ISO 16022 (Karbowniczek, 2016).

3. Purpose of the article

The aim of the article is to analyze the effectiveness of the implementation of the system of identification of aluminium castings marked with the DataMatrix code in a direct way and to determine the impact of the system on the quality of products.

4. Research subject

In order to assess the possibility of using the identification system for aluminium castings marked with the DataMatrix code, experimental tests were carried out directly. The subject of the study was a batch of car connector products weighing 3. 24 kg cast from AlSi7Mg0. 3 alloy (Figure 2).

Fig. 2. Research subject - car connector model

Products manufactured in one of the plants in the south of Poland.

5. Selection of DataMatrix code application technology in the manufacturing company

In the production company, barcodes were used to mark and monitor castings during the production process. Due to the lack of permanence of securing the codes, there were situations in which, during transport between operations, stickers with the code were lost, which made it impossible to determine the serial number and melting number of the workpiece, and at the same time made it difficult and delayed the implementation of subsequent operations of the production process.

As part of the solution to the problem and streamline of the production process in the company, marking of products with DataMatrix code was introduced.

In addition to choosing the formatting of the code and its content, it was important to choose the optimal method of marking the code on the castings. In the automotive industry and aluminium products, the most commonly used methods are: dot peening, laisser marking, continuous inkjet printing, and electrochemical etching. Comparison of DataMatrix code application methods is presented in Table 1.

The dot peening technology was selected as the optimal solution in the company. In which the code is applied to the product using a needle making an incision for each point in the DataMatrix code

Table 1. Comparison of the most commonly used marking technologies

	Laser printing	Dot peening	Continuous inkjet	Electro-chemical etching
Labelable materials	Big	Big	Average	Small
Flexibility (distance between part and marking device)	Average	Big	Average	Small
Investment	Average	Big	Small	Small
Easy integration (with PLC in the production cell)	Big	Big	Average	Small
Type of marking method	Non- contact	Non-contact	Contact	Contact a
Resistance of the code to wiping off	Small	Big	Big	Small
Mobility	Big	Small	Big	Big
Frictional or chemical stresses	No	Yes	No	No

Source: own elaboration based on: www.videojet.com of the day: 10.03.2019

Figure 3 shows an example of the applied DataMatrix code on an aluminium casting.

Fig. 3. Example code of DataMatrix on aluminium casting

6. Research methods

In the company, a laser filaire Lec-teur, designed specifically for fast production environments, is used to read the source code from marked products. The digital scanner uses digital imaging technology to accurately read a wide range of one-dimensional (1D), two-dimensional (2D) as well as direct part marking (DPM) codes, while showing high performance. In addition to reading high-density matrix codes, the scanner captures and transmits images.

The company's scanners are equipped with image sensors with a directly connected charging device (CCD) for more accurate code capture and processing. In addition, they are equipped with omnidirectional scanner functions that allow operators to capture DataMatrix codes at any angle, eliminating the need to set codes on laser lines.

In addition to the performance features necessary to maintain the continuity of the production process, scanners provide investment protection. Thanks to the built-in support for the interface, the standard scanner function allows the device to be used in many different corporate systems. This facilitates integration and enables efficient data migration to new systems that can be introduced in the future in the company.

The effectiveness of the introduced system of identification of marked parts was directly monitored and measured by means of the OEE (Overall Equipment Effec-tiveness) indicator. The OEE efficiency model expresses the overall operating efficiency using three main factors (table 2).

Table 2. Performance indicators for OEE

Accessibility	Effectiveness of activities	Quality
$D = \frac{t_d - t_p}{t_d}$ (1) t_d – Available time t_p – Standstill	$E = \frac{t_c \cdot n}{t_o}$ (2) t_c – theoretical cycle time n – the quantity processed t_o – operational time of operation	$J = \frac{n-d}{n}$ (3) n – the quantity processed d – number of defects
$OEE = D \cdot E \cdot J$ (4)		

Source: own elaboration on the basis of: Nakajima S. (1988)

7. Results and discussion

On the basis of the data collected after the implementation of the identification system for aluminium castings marked with the DataMatrix code, the availability, usage and quality index comprising the value of the OEE index was calculated.

Figure 4 shows the results of the availability index for the 4 weeks before and 4 weeks after the introduction of the system on an experimental batch of car connectors.

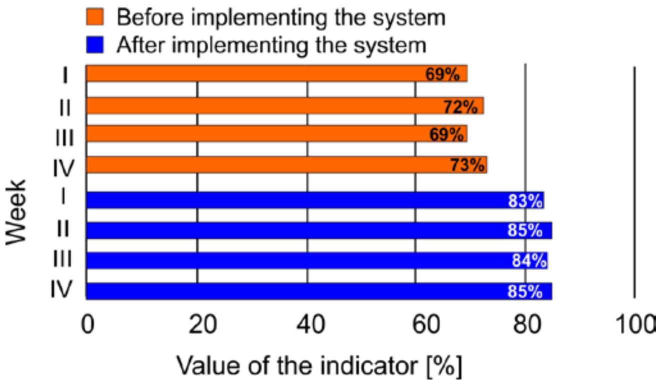

Fig. 4. Value of the rate of the availability before and after implementing the labelling scheme of products with DataMatrix code.

Too long time spent on finding cards with product codes, and thus information about the parameters of the next operation of the production process contributed to the extension of the waiting time for the machine changeover. Lost or mistaken of code of the product results in making unnecessary rearming the machine or performing this activity several times. Due to this state of affairs, the value of the indicator before the implementation of the system did not exceed 75%.

The loss of the product code also has an impact on the next indicator - the use of machines. Inactivity of the equipment and minor downtime caused by the loss of product flow delay the implementation of the production process. Value of the indicator of using machines from the period of 4 weeks before and 4 weeks after the introduction of the product marking system is shown in Figure 5.

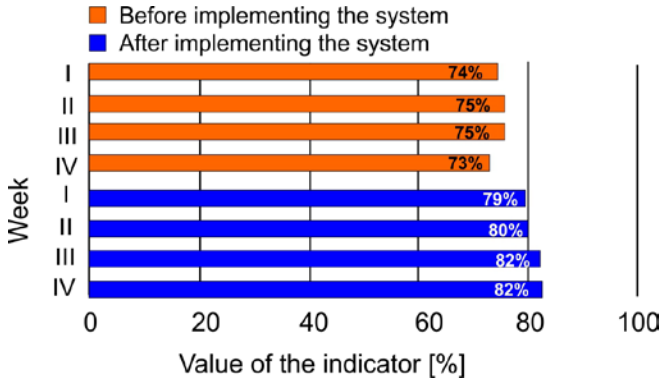

Fig. 5. Value of the indicator of using machines before and after implementing the labelling scheme of products with DataMatrix code

Before the implementation of the product marking system within 4 weeks, the value of the machine utilization rate was in the range of 73-75%, and after the implementation of the system this value increased and oscillates between 79-82%.

The impact of the implementation of the DataMatrix code marking system on the quality of products is presented in Figure 6.

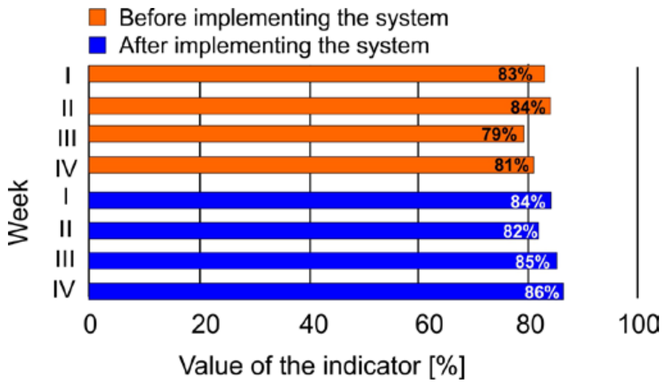

Fig. 6. Value of the quality indicator before and after the implementation of the product marking system with the DataMatrix code

After the implementation of the system of marking products with the use of DataMatrix code, the level of product quality has significantly increased. This was due to the elimination of operational errors related to the lack of product marking and its intuitive processing.

The OEE index, consisting of the availability, machine usage and quality index from 41-45% before the implementation of the photocode system, rose to 55-60% (Figure 7).

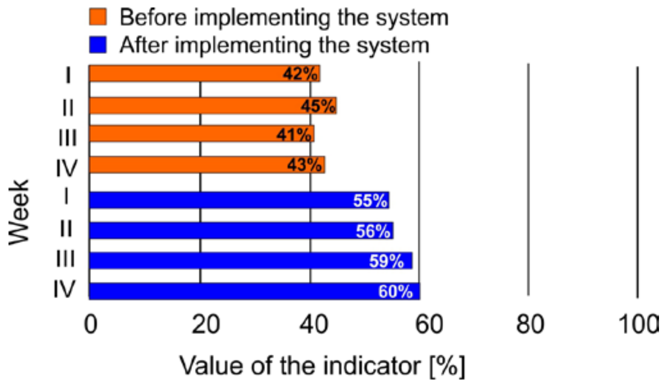

Fig. 6. Value of the OEE indicator before and after the implementation of the product marking system with the DataMatrix code

8. Summary and conclusion

Direct marking of products is essential for full verifiability in the production process. Two-dimensional DataMatrix codes can be applied to a variety of products where traditional code marking is not suitable due to insufficient information capacity and difficulties in attaching the code to the surface of the product. Placing a code on the products will help to identify them more quickly at each stage of the production process.

As part of further research, a coding system should be implemented throughout the company and all products should be coded after the casting process.

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直接标记零件识别系统的实现分析 – 数据矩阵码

關鍵詞
一维码
二维码
DataMatrix代码
生产工程

摘要
波兰语中的光电码是二维码的通用名称，其特征在于比传统条形码更高的信息容量。 本文分析了使用二维编码系统--DataMatrix来识别和分类生产过程中的材料流。 分析表明，在提高可用性，机器使用和提高产品质量的背景下，实施编码系统的有效性。 OEE指数的增加证实了生产过程的改善。 作为进一步改进措施的一部分，编码系统应在整个企业中实施，应确保其与现有系统的兼容性并应用于所有产品。