

QUALITY ANALYSIS OF THE MECHANICAL LEVER AND IMPROVEMENT OF NON-DESTRUCTIVE TESTING PROCESS

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Abstract: The analysis of product quality is an indispensable action in developing enterprises. In case of mechanical products, the non-destructive tests (NDT) are effective way to make control. Non-destructive tests allow making assessing product quality without destroying it. Due to the dynamically growing requirements of customers and necessary, the improvement actions for demanding organizations important is to make a complex analysis of quality products. Such an action was proposed to a production and service company located in Podkarpacie region of Poland. The aim was to analyze the quality of the mechanical lever and improvement the process of non-destructive tests, in order to identify the source of nonconformity with using quality management techniques. These activities were to demonstrate that the sequence (NDT and selected quality management techniques) would allow the detection of unconformities on the product surface and also identify the source of this unconformity. In the enterprise, the quality research of the product using fluorescent and magnetic-powder methods was made. After identified the unconformity on the product the additional actions which could point the source of unconformity were not practicing. The proposition of improvement in the NTD was use appropriately selected quality management techniques (Ishikawa diagram and 5Why method) after identified the unconformity. The mechanical lever was tested, which its surface using the magnetic-powder method was analyzed. After identified unconformity (scratch) using the Ishikawa diagram, the potential causes were identified and four main causes were selected (i.e.: uncleaned pattern, impurities during production, poor molding mass, poorly carried out product production method). It has been shown that sequence of NDT, Ishikawa diagram and 5Why method allows to identify the unconformity on product surface and source its creation. This sequence could be practicing to analyze other product in production and services enterprises.

Keywords: mechanical engineering, mechanical product, quality, non-destructive test, magnetic-powder method

1. INTRODUCTION

Product quality analyzes carried out in manufacturing and service enterprises should be effective. Quality analyzes should be realizing in the right way, so as to achieve the desired results at relatively low costs (Pacana et al., 2019; Siwiec et al., 2019; Pacana et al. 2015). Non-destructive testing is considered such analysis because allows showing the unconformity of the product without their destructive. However, for developing enterprises, detection only of unconformity are detected may not be sufficient. Important is not only pointed the unconformity, but also identify in right way the source of unconformity. It is important in view of realizing improvement actions, make in order to eliminate or minimize the source of unconformity (Malindzak et al. 2017). Building the right relationship between the source of unconformity and improvement actions is an indispensable step in the process of eliminating the problem (Pacana et al. 2014). Therefore, pointed in the right way the source of unconformity allows to right pointed the improvement actions, and the same eliminate in whole the problem. So, it was aiming to integrate in sequential ways often used NDT methods with quality management techniques which are simple and also effective in identifying the source of unconformity.

A review of the literature on the subject indicates that non-destructive testing (NDT):

- were used, among others to identify or classify unconformity on products (Joshaghani, 2019; Sangoju et al., 2019; Barluenga et al., 2018; Chauveau, 2018),
- were analyzed and an assessment of their effectiveness was carried out (Guo, 2019; Anuncia, 2018; Bernieri et al., 2018; Rentala et al., 2018; Gurieva et al., 2018),
- have been improved or modified (Son and Kim, 2019; Doaei and Tavallali, 2018).

It was concluded, that the subject of implementing quality management techniques in the NDT process is not currently being analyzed. By what, it was purposeful to show, that the research sequence of NDT, Ishikawa diagram and 5Why method allows pointed the unconformities on the product surface and source their creation. These actions were proposed in the production and service enterprise localized in Podkarpacie region of Poland. The aim was to analyze the quality of the mechanical lever and improvement the process of non-destructive tests, in order to identify the source of nonconformity with using quality management techniques. These activities were to demonstrate that the sequence (NDT and selected quality management techniques) would allow the detection of unconformities on the product surface and also identify the source of this unconformity. In the enterprise, the NDT methods were used to quality analysis of the product, but after identified the unconformity on the product additional actions that may indicate the source of unconformity were not practicing. In order to improve the NDT process, the quality management technique was used, i.e.: Ishikawa diagram and 5Why method. Subject of the study was mechanical lever made from CPW-S 5613 steel (steel 410). NDT method, which was used to analyze the product was the magnetic-powder method. By used this method the unconformity on the mechanical lever was identified – scratch. By using the Ishikawa diagram, the potential causes were identified and four main causes were selected (i.e.: uncleaned pattern, impurities during production, poor molding mass, poorly carried out product production method). Source of unconformity (i.e. incompatible material from the supplier) was identified by the 5Why method. It has been shown that sequence of NDT, Ishikawa diagram and 5Why method allows to identify the unconformity on product surface and source its creation.

The mentioned approaches may be also useful in other industry branches requiring high quality of semi-products and final products e.g. fuel cells (Włodarczyk et al., 2011), surgical implants (Pawłowska et al., 2017) or biotechnology (Skrzypczak-Pietraszek, 2016; Skrzypczak-Pietraszek et al., 2017; Skrzypczak-Pietraszek et al., 2018). Other large-scale industries also may be interested in such approach to the quality issue e.g. steelworks (Ulewicz et al. 2013; Ulewicz et al. 2014) or heavy-duty machines actuators (Domagała, 2013; Domagała and Momeni, 2017) and valves (Domagała et al., 2018a; Domagała et al., 2018b), control (Filo, 2013; Filo, 2015) and maintenance (Fabis-Domagała, 2013; Fabis-Domagała and Domagała, 2017). It also should be taken into consideration in industrial databases (Gawlik et al., 2015; Karpisz and Kiebus, 2018).

2. METHOD

Magnetic-powder method (MT) allows detection of surface and subsurface discontinuities in ferromagnetic materials. It involves the use of ferromagnetic powder on discontinuities by scattering the magnetic field (Sozański, 2012; Son and Kim, 2019). General provisions for magnetic particle testing are contained in the ISO 9934-1 standard (PN-EN ISO 9934-1:2017-02). The magnetic-powder method is considered the most sensitive, reliable and efficient NDT method. This method is not suitable for detecting defects deep below the surface. The method applies, among others in the aviation, automotive and foundry industries (Zientek, 2016; Krysztofik and Manaj, 2011).

In selected industry, the management had in mind the fact that for the complex quality analysis, it is necessary after identified the unconformity using the NDT method, also identify the source of unconformity. That's why, the use of quality management techniques (Ishikawa diagram and 5Why method) was proposed because are effective, simple and not expensive way to identify the source of unconformity (Skotnicka-Zasadzień B., et al. 2017). It is important to use them in sequential way, which was characterized in the next part of the method.

Ishikawa diagram called causes and effects diagram or fishbone diagram allows identifying the potential causes of problem. A good practice is to use them with a brainstorm because it allows to effective analysis of the problem. In the main part of the diagram, the problem was recorded, which was defined by the MT method (scratch). Next, it was considered that to analyze the problem it may be possible to use six, basic Ishikawa categories (5M+E), i.e. man, method, material, management, environment, machine (used to product production) (Wolniak, 2017; Ulewicz, 2003; Skotnicka-Zasadzień et al. 2017). To each of the categories after brainstorm (composed of president, quality control manager and employees who made non-destructive test) the potential causes were pointed. From the potential causes of the problem, four main causes were selected. In order to identify the source of the problem, it was necessary to make next analysis with used the 5Why method.

The 5Why method called Why-Why method applies to identify the source of the problem. In this method, after precise the problem (scratch on the product surface), the „Why?” question was asked. The first answers were the four main causes that were pointed out by the Ishikawa diagram (Pacana et al. 2019; Ulewicz, 2018). Next, to each of the main causes, the „Why?” question was asked, after that the indirect causes were pointed. The “Why?” question was asked until to identify the source of the problem, after which it was possible to indicate improvement actions.

3. MATERIAL

The subject of the study was mechanical lever made from CPW-S 5613 steel (410 steel), which is stainless, hardened, martensitic steel. This steel has good mechanical and corrosion properties. It has high wear-resistant alloys (Hejripour and Aidun, 2017). It applies, among others for products subjected to heavy loads (Stone et al., 2018). The choice of the subject of research was conditioned by the widespread use of the analyzed product (mechanical lever), among others in machines. It was not possible to make a decision on the basis of the number of identified unconformities on the product types due to the enterprise's unit checks. So, the choice of the subject of research was conditioned by the ascending number of unconformities type (scratch), which identified during the last magnetic-powder test on the mechanical lever.

4. RESULTS

The quality control of the surface of the mechanical lever was made using the magnetic-powder method, after which the unconformity was detected. The scratch on the product surface was this unconformity, which is shown in Fig. 1.



Fig. 1. Scratch on the mechanical lever

Next, the non-destructive testing process was expanded to include the sequence of the quality management techniques. In the first steps, the analysis of unconformity (scratch) on the mechanical lever was made using the Ishikawa diagram, which is shown in Figure 2. Of the potential causes identified, four main causes were selected, i.e.: uncleaned pattern, impurities during production, poor molding mass, poorly carried out product production method. In the next steps, the analysis of the problem of scratch on the mechanical lever was made using 5Why method, which is shown in Figure 3. It was concluded that source of problem was incompatible material from the supplier. Improvement activities aimed at eliminating or minimizing the problem was to inform the client ordering the product quality analysis about the source cause.

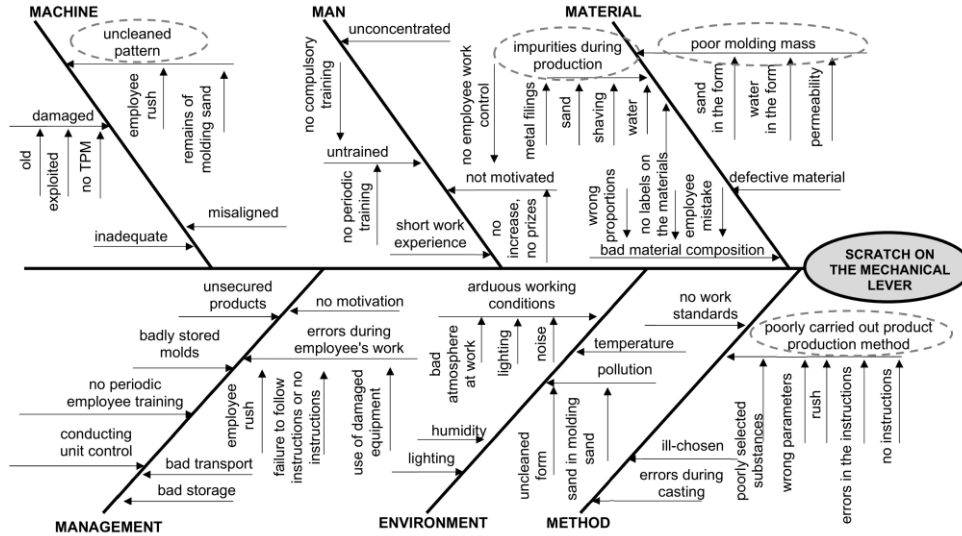


Fig. 2. The Ishikawa diagram for unconformity (scratch) on the mechanical lever

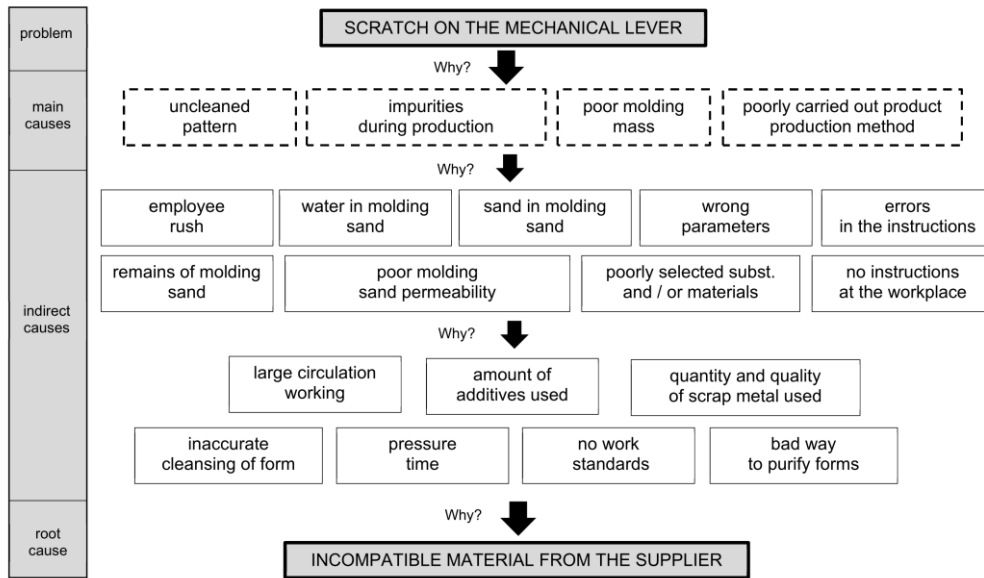


Fig. 3. The 5Why method for unconformity (scratch) on the mechanical lever

5. DISCUSSION AND CONCLUSION

The development of manufacturing and service enterprises is related to improvement actions taken. One of these actions is to make a quality complex analysis of the product. Non-destructive testing (NDT) is the most practiced test for assessing the surface quality of a product. This research was practicing in the production-service enterprise located in Podkarpace region of Poland, which was selected for analysis. Although NDT methods showed unconformities, they did not indicate the source of their occurrence. Therefore, it was purposeful to propose a comprehensive analysis that would allow this. The aim was to analyze the quality of the mechanical lever and improvement the process of non-destructive tests, in order to identify the source of nonconformity with using quality management techniques. These techniques were the Ishikawa diagram and the 5Why method. The subject of the study was the mechanical lever made from CPW-S 5613 steel (410 steel). The surface of the product was researched using the magnetic-

powder method, after which the unconformity (scratch) was identified. In a sequential way, the Ishikawa diagram and 5Why method (during brainstorm) were made. Four main causes were selected from potential causes, i.e. uncleaned pattern, impurities during production, poor molding mass, poorly carried out product production method. To identify the source of unconformity (scratch) on the mechanical lever the analysis using the 5Why method was made. It was concluded that source of problem was incompatible material from the supplier. Improvement activities aimed at eliminating or minimizing the problem was to inform the client ordering the product quality analysis about the source cause. It has been shown that sequence of NDT, Ishikawa diagram and 5Why method allows to identify the unconformity on product Surface and source its creation. This sequence could be practicing to analyze other product in production and services enterprises.

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