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THE USE OF QUALITY MANAGEMENT TECHNIQUES TO IDENTIFY SOURCES OF INCOMPATIBILITIES IN SEALANTS

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Purpose: The effectiveness of the NDT tests is to identify the incompatibility of the products without their destruction, but NDT tests do not point out the root of incompatibility. The aim of the study was to identify the incompatibility in the product (the mechanical sealer) using the fluorescent method (FPI) and to identify the root of this incompatibility using quality management techniques (5W2H method, Ishikawa diagram, 5Why method).
Design/methodology/approach: To identify the root of incompatibility in the product the quality management techniques were used, i. e. 5W2H method, Ishikawa diagram and 5Why method. The subject (the mechanical sealer) on which being incompatibility (porosity cluster) was identified, was made from 410 steel. The problem in which the porosity cluster was identified after the fluorescent method (FPI).
Findings: It has been shown that integrating NDT with the selected quality management techniques is an effective way to identify the problem and the root of its creation.
Practical implications: This approach can be used in enterprises to analyze different types of products and incompatibilities.
Originality/value: It was proposed to integrate the NDT tests with the selected quality management techniques. This integration allows identify the root of the problem and achieving the needed quality of the product.

Keywords: quality, mechanical engineering, non-destructive test, quality management, incompatibility.

1. Introduction

Assessment of the process of creating product quality is a necessary action within enterprises that strive for continuous improvement (Siwiec et al., 2019; Pacana et al., 2019a). This causes the need to practice complex qualitative analyzes that allow not only to detect incompatibility, but also to discover the reasons for its occurrence (Pacana et al., 2019b).

Quality analysis carried out in a skillful way allows showing the root of incompatibility. In turn, correctly identifying the root of incompatibility allows making adequate improvement actions by which is possible to minimize or eliminate the incompatibility (Pacana et al., 2015, 2019a, 2019b). In the case of the industry sector, and especially aviation, quality analysis of the product is the key to creating the needed quality of the product. The approach used is non-destructive testing (NDT) (Son, and Kim, 2019; Doaei, and Tavallali, 2018), and mainly the fluorescent method (FPI) (Brasche et al., 2006). This type of testing allows effective analysis of product surfaces without their destruction (Fischer et al., 2002; Shipway et al., 2019) and has, over the years, met with improvement (Daneshvar, and Dogan, 2010; Guo, and Ruhhge, 2009) and the results from the FPI analysis are now considered basic to that of other methods (Zheng et al., 2015). A review of selected items of the literature indicates that non-destructive testing (NDT) has been applied to identify and classify incompatibility (Joshaghani, 2019; Sangoju et al., 2019; Barluenga et al., 2018; Chauveau, 2018), and NDT is an officially approved approach for quality assessment (Guo, 2019; Anouncia, 2018; Bernieri et al., 2018; Rentala et al., 2018; Gurieva et al., 2018).

From literature review, we concluded that it is important to show the effectiveness of integrating NDT with quality management techniques to identify incompatibilities and the root of their occurrence. Enacting NDT alone cannot allow the root of incompatibilities to be discerned. This can only come about by applying selected quality management techniques. Therefore, it was concluded that non-destructive testing integrated with quality management techniques is an effective way to achieve the necessary quality of the product.

2. The study and place of research

The enterprise, in which the analyze was made, was a production and service manufactory located in Podkarpacie (in south-eastern Poland). In the enterprise, quality analyses of the product using non-destructive testing (the fluorescent method) were performed. This enterprise carried out unit control on various types of products, but the number of type of products on which there was incompatibility was not analyzed. Also, the number of types in-compatibility was not assessed. Despite the unit control, the individual types of non-compliance identified were often repeated. Herein, one of the types of incompatibility that was often identified on various types of products were porosity clusters. Because of the desire to develop as an enterprise and to capture more market, and because a large number of similar types of incompatibilities were continuously encountered, the enterprise wanted to improve the non-destructive testing process.

In the enterprise, it was important to identify incompatibilities (using the NDT) and also to show the root of these incompatibilities. In this aim, it was proposed to follow-up NDT with a sequence of selected quality management techniques. These techniques were the 5W2H method, the Ishikawa diagram and the 5Why method. These techniques were selected because when they are used in a sequential way, this procedure allow analyzing and defining a problem (in this case, incompatibility). Accordingly, the 5W2H method can be employed to identify the potential and main causes by means of Ishikawa diagramming, and, next, to identify the root of incompatibility through applying 5Why methodology. The choice of these techniques is an expert choice, and in other cases, it can be duplicated or the composition and order of the techniques used can be modified depending on the nature of the problem.

The aim of the study was to identify the incompatibility in the product (the mechanical sealer) using the fluorescent method (FPI) and to identify the root of this incompatibility by applying the quality management technique sequence (5W2H method, Ishikawa diagram, 5Why method). The choice of the FPI method was conditioned by the individual preference of the enterprise. The product, a mechanical sealer using in aircraft engines, was analyzed because of the incompatibilities that were found to often recur during qualitative analyzes via NDT (porosity cluster).

3. Material

A mechanical sealer (flange air sealer) made from ferritic steel 410 (ASIS 410) was analyzed. This steel is used in an environment free of contact with water. The flange sealant is one of the latest generation of mechanical sealing techniques. It can be incorporated in devices with a rotary shaft in which it is impossible to use traditional mechanical contact sealants, and is used in the aviation industry as an air seal. The choice of this product for analysis was determined by the type of incompatibility identified (porosity cluster).

4. Method

The methods employed to identify and characterize the incompatibility were FPI and quality management techniques, i.e., the 5W2H method, the Ishikawa diagram and 5Why method. As integrated, the selected methods and the sequence of their use is shown in Figure 1.

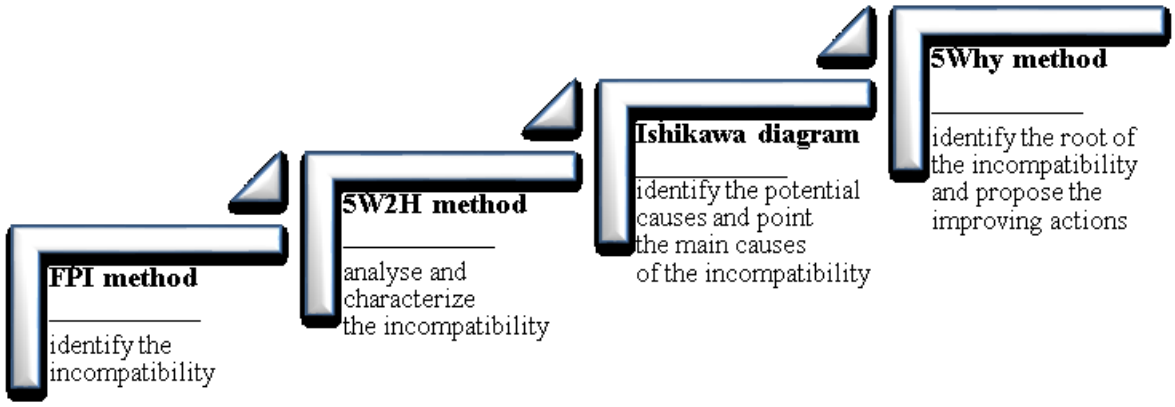

Figure 1. The sequence of selected methods used to analyze the incompatibilities and to identify the root of their occurrence.

The fluorescent method (FPI) is a penetration method that has been applied to identify surface discontinuities (PN-EN ISO 3452-1:2013-08). In this method, the penetrant is a dye, the presence of which can be identified during UV, so it is necessary to darken the test stand (PN-EN ISO 12706:2010). The FPI method is one of the more often practice methods for quality analysis of products from the aviation and automotive industry (Brasche et al., 2006). The application procedure of the FPI method can be found in literature specific to the technique (for example, Pacana et al., 2019a). The incompatibility (porosity cluster) was analyzed and characterized using the 5W2H method. The 5W2H method has been employed to analyze and characterize in a short and readable way (often in the table form) the most important information about a problem (in this case, the porosity cluster). The 5W2H method consists of a set of general criteria questions, i.e.:

Who? Who has detected the problem?
What? What is the problem?
Why? Why is this problem occurring?
Where? Where was the problem detected?
When? When was the problem detected?
How? How was the problem detected?
How much? How big is the problem?

Through the posed questions, it is possible to standardize and document the most important information about the problem (Pacana et al., 2018). After characterizing the problem (a porosity cluster on the mechanical sealer), an Ishikawa diagram was prepared.

The Ishikawa diagram (the fishbone diagram or cause and effect diagram), allows showing the potential causes of the problem (Ulewicz, 2003). To analyze the problem (i.e. porosity cluster on the mechanical sealer), the basic six Ishikawa categories were used (5M+E), i.e.: man, machine, method, material, management and environment, as these were adequate to this problem (Pacana et al., 2019a, 2019b; Wolniak, 2017). To the categories, the potential

causes were assigned, from which two main causes were selected. To show the root of the problem (porosity cluster on the mechanical seal), the 5 Why method was then employed.

The 5Why method is allows for the identification of the root of the problem. During the analysis, the main causes were made recognizable by utilizing the Ishikawa diagram. Next, the '5Why?' questions were asked with regard to each of the indirect cause seen via the Ishikawa diagram until the root cause was indicated. After identifying the root cause, improving actions were proposed, after which it was possible to eliminate or reduce the root of occurrence (the porosity cluster) (Pacana et al., 2018, 2019a).

5. Results

After analyzing the mechanical sealer by applying the FPI method, the incompatibility was identified, which was a porosity cluster (Figure 2). This problem was assessed and characterized using the 5W2H method (Table 1). In order to identify the root cause of the porosity cluster, the problem was made apparent in a sequential way by utilizing quality management techniques.

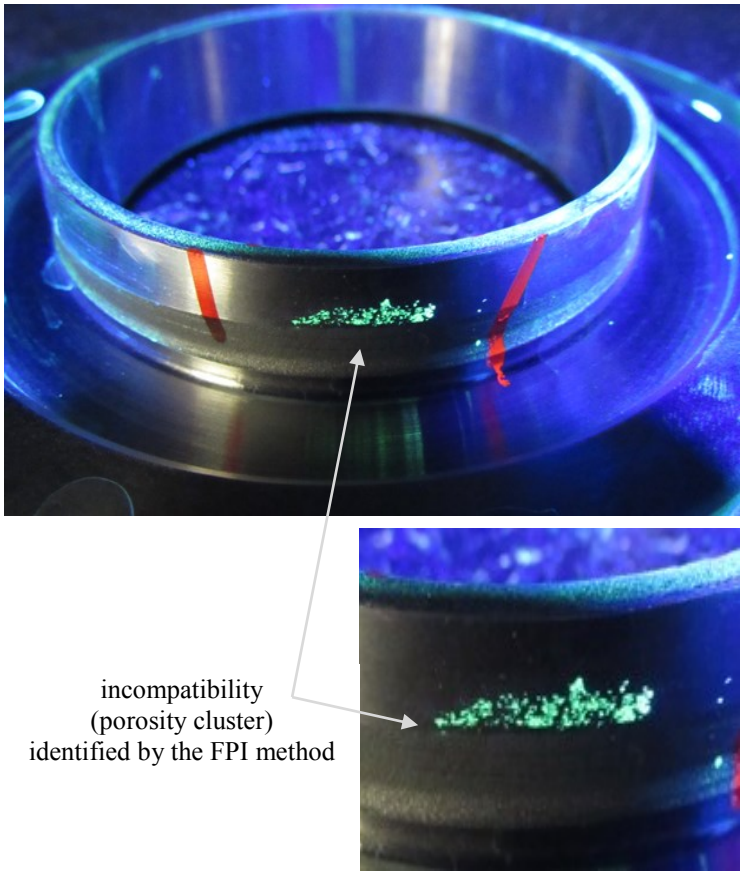

Figure 2. The porosity cluster on the mechanical sealer.

Table 1.
The 5W2H method as applied to the problem of porosity clusters on the mechanical sealer

The 5W2H method		
Question		**Answer**
Who?	Who has detected the problem?	the employee who applied the FPI method
What?	What is the problem?	porosity cluster
Why?	Why is this a problem?	product disqualification
Where?	Where was the problem detected?	on the product surface
When?	When was the problem detected?	during FPI control
How?	How was the problem detected?	FPI method
How much?	How big is the problem?	1 piece of the product

By utilizing the Ishikawa diagram, the potential causes of the incompatibility were identified. From the potential generators of the incompatibility, two main sources were selected, i.e.: material supplier, production errors and bad molding sand (Figure 3). In order to show the root of the problem, the 5WHy quality management technique was applied.

By way of 5Why methodology, the root of the porosity cluster on the mechanical sealer was made apparent - faulty material from the supplier (Figure 4). The action made after identifying the root of the incompatibility was to inform the supplier to institute better quality control.

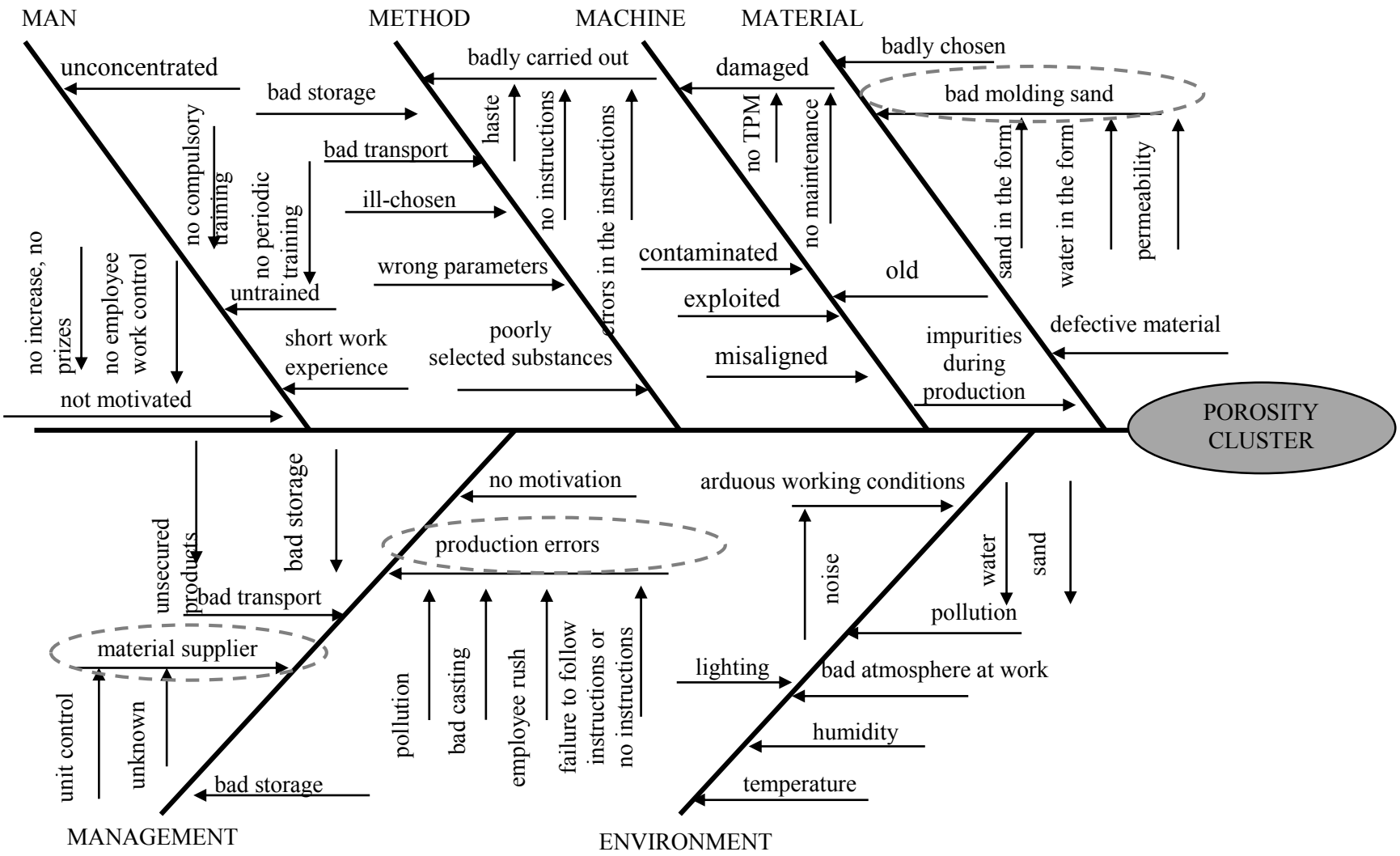

Figure 3. The Ishikawa diagram for the problem of porosity clusters on the mechanical sealer.

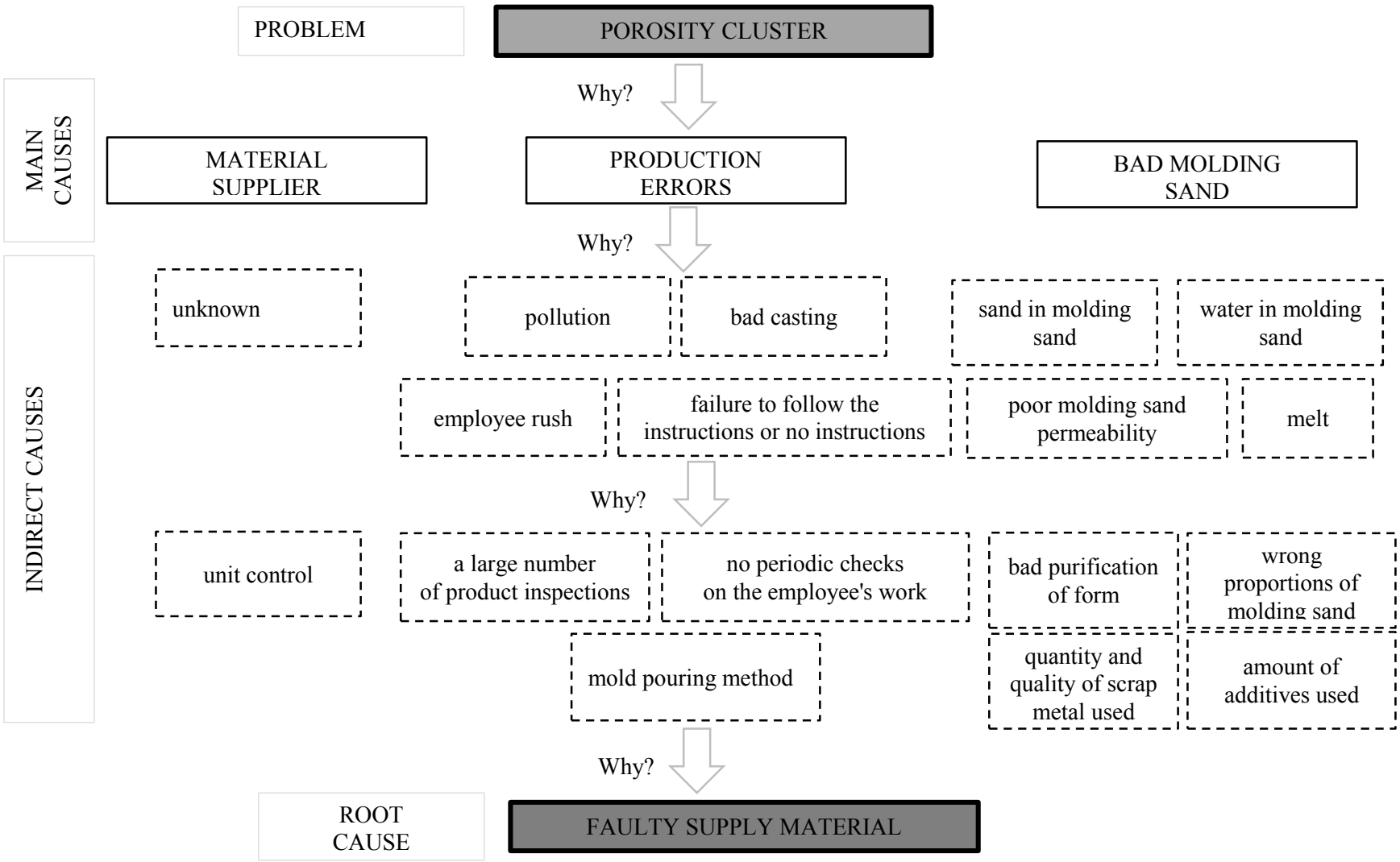

Figure 4. The 5Why method for the problem of porosity clusters on the mechanical sealer.

6. Conclusions

Effective improvement of the quality of products comes about through identification of a problem (incompatibility) and then tracing the source (the root) of this. Detection of incompatibility alone for developing enterprises is insufficient. It is necessary to identify the root of the incompatibility, which allows the application of procedures to eliminate or reduce the occurrence of this incompatibility. To identify the incompatibility, NDT methods are used, as these are an effective way to assess the quality of various types of products, without destroying them. In the case of products from the aviation or automotive industry, the fluorescent dye method (FPI) is often used. Despite the efficiency of this research in identifying the incompatibility, it is important to identify the root of their occurrence, so other techniques must be harnessed to do so. These techniques are the 5W2H method, Ishikawa diagramming and the 5Why method. These practices used in a sequential way allow analyzing and defining the incompatibility (5W2H method), be way of recognizing the potential and main causes of the problem (Ishikawa diagram) and seeing the root of their occurrence (5Why method). Thus, non-destructive testing, integrated with selected quality management techniques, is an effective way to achieve product quality.

In the case study, the sequence of the selected quality techniques was applied in an enterprise located in Podkarpacie. The aim of the study was to identify the incompatibility in the product (the mechanical sealer) using the fluorescent method (FPI) and to recognize the root of this incompatibility by means of applying the quality management technique sequences of 5W2H method, Ishikawa diagram and 5Why method.

In the case study, the enterprise's practiced fluorescent method was chosen for product analysis. Using this method, the incompatibility that was the porosity cluster was identified. Next, the problem was analyzed and defined by utilizing the 5W2H method. Subsequently, Ishikawa diagramming was undertaken, and by means of the basic Ishikawa categories (5M+E), the potential causes of porosity cluster were identified. From these, the main causes were made evident. These main causes were: material supplier, production errors, poor molding sand. After analyzing the problem via the 5Why method, the true root of the porosity cluster was identified (faulty material from the supplier). Thus, by means of this case study, it has been shown that non-destructive testing integrated with selected quality management techniques is an effective way to achieve desired product quality. Moreover, this approach can be practiced in any enterprise so as to analyze various types of products and find non-conformity.

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