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ANALYSIS OF THE CAUSES OF POROSITY IDENTIFIED BY NON-DESTRUCTIVE TESTING

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Abstract

Product quality management refers to a set of activities, which allow checking the product quality and eliminating any inconsistencies. In eliminating incompatibilities its necessary to identify their root causes. It is possible by using the selected quality management techniques. As it was shown, it is very useful after analyses the incompatibilities identified by popular non-destructive tests (NDT), which are used to check an incompatible product. It was concluded that practice quality management techniques after NDT are necessary because NDTs are effective in finding incompatibilities in the product (without its destruction) but not identifying their causes. The aim of the study was the analysis of using the selected quality management techniques (Ishikawa diagram and 5Why method) to identify the source of the porosity which was detected by the fluorescent method. The problem was identified in an enterprise localized in the Podkarpacie region. But after identifying the incompatibility in the product, no further analyses to find the root cause of the problem occurrence were made. After the NDT (fluorescent inspection method) on the product (made from 410 steel) used in the aviation industry, the porosity was identified. Because the root cause of porosity was not known, the sequence of the Ishikawa diagram and 5Why method was used. These methods were used in an adequate way (first the Ishikawa diagram and second the 5Why method) because only in this way it is possible to find the root cause of the problem. By the Ishikawa diagram, the potential causes and two main causes (i.e. inadequate preparation, water in molding sand) were identified. The source of the porosity (contaminated material) was found through the 5Why method. It was concluded that the selected quality management techniques (Ishikawa diagram and 5Why method) were useful in finding the root cause of the porosity of the product. Additionally, the paper proposed the use of the Ishikawa diagram and 5Why method after the NDT test, and this sequence was effective in finding the root causes identified by NDT tests, so it can also be used to solve other problems with incompatibilities.

Keywords

Quality management, mechanical engineering, non-destructive test, Ishikawa diagram, 5Why method.

1. Introduction

The companies should strive for continuous improvement through constant checking of the processes and relationships connecting them, as well as making the right decisions in the area of improvement [7, 11]. All organizations want to ensure the high quality of their products as well as the fulfillment of the customer's requests. Therefore, the aim of companies is not only to satisfy customers' needs but also to produce products that will bring profit [11, 15]. So, it is important to make comprehensive analyses which allow it. One of the methods is quality management techniques. The selected quality techniques, like for example Ishikawa diagram and 5Why method, used in a sequential way allow finding the source of the problem [4, 14, 15]. Therefore, the sequence of these methods was used to solve the problem with the imperfection identified by the non-destructive test.

The problem with the incompatibility of the product was identified in the production-service enterprise localized in the Podkarpacie region. In the enterprise, the individual sample NDT test (fluorescence and magnetic-powder control) for the external customers was carried out. In the study one of the types of incompatibilities was analyzed, which was identified in the product from the customer. After the NDT test (fluorescent method) on the product the porosity was identified, but the root cause of the problem was not known. So, it was necessary to use additional methods to find the source of this problem. The aim of the study was to use the selected quality management techniques (Ishikawa diagram and 5Why method) to identify the source of the porosity, which was detected by the fluorescent method.

2. The subject and methods of the study

The subject of the study was the product used in the aviation industry. The product was made from 410 stainless steel (AMS 5613). The 410 stainless steel is a general purpose martensitic steel coming in both the annealed and hardened states [13]. On the product,

the incompatibility was detected (porosity), by using the fluorescent method. The NDT control was commissioned by the external customer, so in the enterprise where the NDT test was made, the volume of the production of this product and its purpose was not known. Additionally, in the enterprise the NDT testing of different types of products was based on individual sampling. So, the number of types of products with incompatibility was not noted. However, the types of incompatibilities which were identified in different products were repeated frequently. One of the types of incompatibilities was the porosity. For this reason, it was useful to analyze this type of incompatibility (porosity) in order to identify the root cause of its occurrence. Additionally, if the source of the porosity is identified in an adequate way, it will allow to perform improvement actions that reduce or eliminate the occurrence of this problem in the future.

The fluorescent method (FPI) is one of the non-destructive tests which allows finding the incompatibilities in the product without destructing it [10]. In this method, it is necessary to use a fluorescent penetrant, and the test has to be done in a dark place [6]. The main steps of the method of FPI are the pre-cleaning and drying and next the penetrant application, intermediate cleaning, developer application, inspection and in the end the final cleaning [6, 16]. On analyzing the product in the selected enterprise using the FPI, the incompatibility (porosity) was identified. To find the source of the problem with porosity on the product, the adequate methods were used sequentially. These methods are the most popular methods used to identify the potential causes (Ishikawa diagram) and the root cause of the problem (5Why method). The Ishikawa diagram, called the fishbone diagram or the cause-and-effect diagram of defects, is applied to find the potential causes of the problem [1, 5, 9]. Next, from the potential causes, the main causes of the problem can be selected. The Ishikawa diagram is created in a graphical way. The visualization of the problem allows to analyze the causes of the problem in a simple and practical way. Its creation begins by drawing the so-called fish bones [3, 6]. In the main part of the diagram, the problem should be recorded. Then, the categories, adequate to the problem, should be selected. The traditional rule is to use the six basic Ishikawa categories (5M+E, i.e. man, method, management, measure, machine and environment), but the categories can be different [4, 8]. The next step is to associate the potential causes with each of the categories. The potential causes of the problem should be identified by brainstorming because it allows finding more examples of the potential causes and effectively analyzing the problem [7, 14]. Then, from the potential causes, the main causes should be selected and analyzed by the next method (5Why method), by which it is possible to find the root cause of the problem.

The 5Why method is a quality technique which is useful in analyzing the problem in order to find its origin. In this method, the "why" question is asked in a sequential way [2, 12]. After finding the root cause of the problem it is necessary to make adequate corrective actions in order to eliminate or reduce the problem.

To solve the problem with the unidentified source of the porosity the Ishikawa diagram was created as the first step. In the center part of the diagram the problem was pointed out (porosity). The traditional rule of the Ishikawa diagram (5M+E) was used because it was adequate for this problem [6]. From the potential causes brainstorming allowed finding the two main causes, which were considered as the most possible causes of the problem. These two main causes were analyzed by another method, which was the 5Why method [7]. By using the 5Why method, the source of the porosity on the product, was identified. In the last stage, an improving action was proposed.

3. Results

After analyzing the selected product, by fluorescent inspection method, the incompatibility in the form of porosity was identified, whose example is shown in Fig. 1.

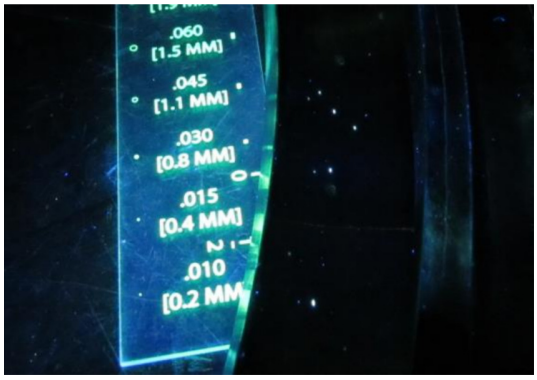

Fig. 1. Incompatibility (porosity) on the product.

In order to identify the potential causes and subsequently the main causes of the problem, the Ishikawa diagram was created (Fig. 2). From the potential causes of the problem, during the brainstorm, the two main causes were selected, i.e.: inadequate preparation and water in molding sand. Then, in order to identify the root cause of the porosity on the product the 5Why method was used (Fig. 3). It was concluded that the source cause of the problem was contaminated material.

As part of the improvement activities, which were undertaken, the supplier was informed about the root cause of the porosity on the product.

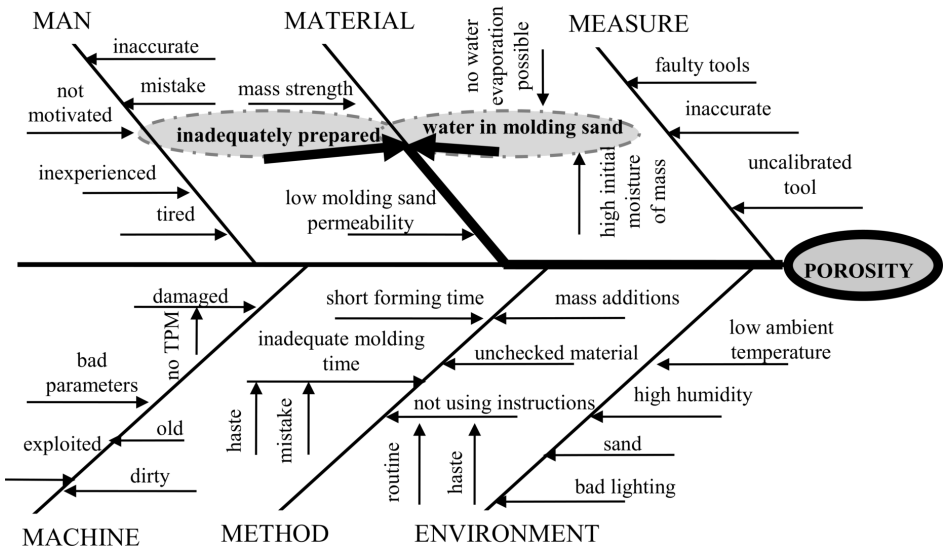

Fig. 2. The Ishikawa diagram of the problem with the porosity on the product.

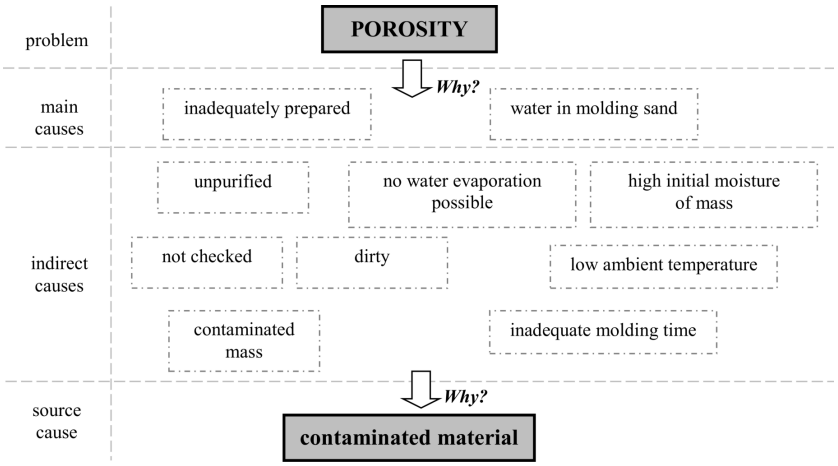

Fig. 3. The 5Why method of the problem with the porosity on the product.

4. Conclusions

Detecting the incompatibilities in the product is one of the most important actions to improve the product quality. It is possible by using the non-destructive tests which are effective in identifying incompatibilities in the product. Also, the NDT allows the identification of the incompatibility in the product without its destruction, so the costs of the test are lower. But only detecting the incompatibilities is not enough to ensure a high level of product quality. It is necessary to take adequate measures, by which it is possible to reduce or eliminate the problem. It is possible by using quality management techniques which allow finding the potential causes of the problem and also the root cause of the problem. But identify the root cause of the problem by these methods is possible when they are well selected and used in a sequential way. The quality techniques used in a sequential way that allow identifying the root cause of the problem are the Ishikawa diagram and the 5Why method. Therefore, these techniques were used to solve the problem with the porosity on the product identified by the fluorescent method, whose source was unknown.

The aim of the study was using the selected quality management techniques (Ishikawa diagram and 5Why method) to identify the source of the porosity which was detected by the fluorescent method. Ishikawa diagram allowed finding the potential causes of the problem, from which two main causes were selected. These two main causes were selected by brainstorming and were considered as the most possible causes of the problem. The main causes were inadequate preparation and water in molding sand. In order to find the source cause of porosity on the product the 5Why method was used. It was concluded that the source cause of the problem was contaminated material. As part of the improvement activities which were undertaken, the supplier was informed about the root cause of the porosity on the product. To eliminate the problem, the production enterprise has to take further improvement measures, for example, conduct periodic employee training.

It was concluded that the selected quality management techniques (Ishikawa diagram and 5Why method) were useful to find the source cause of the porosity on the product. Additionally, the paper proposed to use of the Ishikawa diagram and 5Why method after the NDT was performed. As it is shown this sequence is effective in finding the root causes of imperfections identified by NDT and can be used to solve other problems with incompatibilities.

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