ANALYSIS OF PROBLEMS WITH MAINTAINING THE DESIRED QUALITY OF GAS SEALANT

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Abstract

The successful management of product incompatibility remains a challenge. Therefore, the study aims to analyze the possibilities of effective management through qualitative analyses. The sequence of two quality management techniques added to the fluorescent method was proposed. These techniques were the Ishikawa diagram and the 5Why method. For a specific incompatibility example identified by using the penetration tests (the fluorescent method), the causes of these incompatibilities were searched using the Ishikawa diagram and the 5Why method. An analysis example was the linear indication problem on the product surface, the gasodynamic sealer. By supplementing the penetration method, the proposed sequence of selected quality management techniques has shown that it is possible to detect incompatibilities and identify the source cause, also. In turn, finding the source cause can allow proposing the improvement actions. The proposed solution can also be used in other quality problems and other enterprises to improve the production processes.

Keywords: Mechanical engineering, quality, quality management tools, production engineering, improving quality of products

1. INTRODUCTION

The non-destructive tests are considered a quick and straightforward way to identify the potential incompatibility products. Still, although they allow identifying incompatibilities, they do not identify the reasons for their occurrence. It is concluded that the important, from the point of quality analysis, is to propose the way thanks which will be possible to make complex analyses of the product, thanks which the incompatibilities and their causes for their creation will be identified. Implementing the quality management technique to improve the gasodynamic sealer was proposed. The analysis of implementing the sequence of quality management techniques in improving the gasodynamic sealer by using the non-destructive tests and, more precisely, the penetration test was made. Therefore, it was justified to review the latest literature on the subject (from 2015 to March 2019). The technique to identify faults in the unsupervised learning process, which helps identify faults on the product subsurface of the product, was proposed [1]. To test the material, the research of the ultrasonic tools using the non-destructive tests was carried out [2]. It was checked that it is possible to use the non-destructive tests by using innovative gel electrolytes by using the mobile cells [3]. The ultrasonic scan was used to check whether there is temperature dependence in the ultrasonic speeds in steel 1018 [4], the measurement problem of steel constructions with the non-destructive method (the penetration of the impact cone). Also was done, among others: measuring the microstructure and the speed of eutectic penetration on irradiated metallic fuel [5], the analysis of the plastic with the penetration test, in which the metallic penetrant was used to identify the crack on the pipe's surface was made, the study of the ceramic properties and depth parameters of the penetrant on the ceramic product was made [6]. The research was carried out on the resistance to penetration of hybrid ceramic-metal structures [7]. Subsequent items of the literature related to, among others: using the NDT method to measure the concrete cover and to locate the subsurface object and defects, non-destructive tests on the concrete material [8, 9]. Other applications of non-destructive testing and a literature review of the subject are discussed in the paper by Hristoforou [10]. After the literature review, it was concluded that the different analyses using the non-destructive tests were made, but the implementation of the sequence of the techniques (the Ishikawa diagram and the 5Why method) after the non-destructive tests during which the identified incompatibilities were not analyzed. Thanks to this, it was purposeful to the proposed implementation sequence of the quality management techniques (the Ishikawa diagram and the 5Why method) in the improvement process of the selected product (gasodynamic sealer). It was considered that this sequence is an option for effective quality management in the quality analysis and allows one to make complex quality control of the product by using non-destructive tests. The proposed solution can also be used in other quality problems (e.g. failures in ESD coatings [11], their corrosion resistance [12] and their laser machining [13]) and other enterprises (e.g. desalination [14], castings [15] or military production [16]) to improve the production processes.

2. METHOD

The non-destructive tests are counted, among others: visual tests, ultrasonic tests, radiographic tests, and penetration tests. Visual tests are carried out to identify the surface and passage irregularities. They rely on the with of the surface by the unarmed eye observation using optical tools and devices for remote observation. Visual tests can be applied to all materials, although these tests are mainly designed for cracks, pitting, and corrosion in the case of welded joints [10,17]. The ultrasonic tests (UT) introduce the ultrasonic waves, which are reflected by material discontinuities, and then diffracted and diffused on their edges. Theirs apply mainly to research products from ferrite and austenitic steel, made of aluminum, copper and its alloys, magnesium, and others. This method aims to examine parts of machines or welded joints and castings [2]. Radiographic tests, like ultrasonic tests, are counted as volumetric research. In these tests, the X-rays are generated, thanks to which the test result is prepared in the form of a radiogram. This test allows one to locate the defect and its size. The radiographic test identifies the internal, surface, and subsurface discontinuities in metal and alloy products and nonmetals [17]. The penetration tests allow the penetration of liquids to the material discontinuities. The purpose of these tests is to identify the discontinuities or cracks made during the production and exploitation. In the penetration test, depending on the used liquid (penetrant), methods like fluorescent, color, and color-fluorescent are distinguished. In the case of the fluorescent method, the penetrant is used, due to which the fluorescence phenomenon is achieved. The fluorescence is possible to identify the incompatibilities in the surface on analyzing products. To make the fluorescence method the right way, it is necessary to use UV lamps and conduct the research in a darkened room. The advantages of the penetration tests are, among others: to study different types of materials and products in any form size, quickly and simply identify the incompatibilities and low cost, realize these tests and high efficiency. The disadvantages include detecting only open defects or aging of the preparations used [17].

Each of these tests is used to identify the incompatibilities. Still, the use of a specific method for non-destructive tests depends on, among others: type and condition, material, the shape of the product, accessibility of the studied area and the type and condition of the surface, methods of making welds, type of welded joint and its size, expected types of incompatibilities, and their location. To analyze the gasodynamic sealer, penetration tests (the fluorescent method) were used. Because the surface analysis of only one piece of gasodynamic sealer was made and because the test aimed to identify only discontinuities on the surface. It was, therefore, reasonable to choose the penetration method, which allows identifying all discontinuities on the surface of a product in one research, does not require high qualifications of the person performing the research, and is a cheap method.

3. RESULTS

The analysis with the fluorescent method, the Ishikawa diagram, and the 5Why method were subjected to the gasodynamic sealer applied in the aircraft turbine. The gasodynamic sealer is a type of mechanical sealer (frontal), where a gas film is used to seal the rotating shaft, which is formed between the slip rings of the sealer. The gasodynamic sealer is used in devices with a rotating shaft in which it is impossible to use a traditional mechanical contact sealer [18]. The choice for gasodynamic sealer analysis was because this product is classified as the latest generation of mechanical seals and used in the aerospace industry. The gasodynamic sealant impacts the safety and efficiency of the work processes. Gasodynamic sealant has an impact on workplace safety and the efficiency of processes. Implementing the quality management technique sequence in the gasodynamic sealer improvement process seemed to be current and useful for the enterprise's industry, particularly the aerospace industry. The fluorescent method's penetration tests were made on the nickel alloy AMS5383. This alloy is characterized by heat resistance and corrosion resistance. It consists of: 52.5Ni - 19Cr – 3.0Mo – 5.1Cb (Nb) – 0.90Ti - 0,60Al - 18Fe, melt homogenization and heat treatment process [19,20]. The aim has tested the possibility of reaching the source cause of incompatibilities detected by the fluorescent method in the gasodynamic sealers used in aircraft turbines. Given this aim, it was decided to supplement a penetrant method with the sequence of quality management techniques, i.e., the Ishikawa diagram and 5Why method. Effective sources of non-conformity were expected to reach the root cause, which could result in rational corrective actions. The gasodynamic sealer was cooled down (maximum temperature 40°C) and degreased by immersion in the penetrant MH-406 for 30 minutes. Subsequently, it was immersed in the prerinse bath for 10 seconds before the final cleaning process. The fluorescent control of the gasodynamic sealer with penetrant HM-406 was made according to the internal instructions. The penetrant sensitivity was checked with the TAM 14604 master plate. The product was cleaned under the UV lamp with the water spray at a maximum temperature of 10-38 °C with a pressure of 0.275 MPa. Direct spraying on the product was carried out at a minimum distance of 300 mm under lighting. The product was dried in a dryer chamber at a maximum temperature of 70 ° C. The dry developer ZP-4B was applied in the form of a powder mist at an air pressure of a maximum 0.172 MPa and a minimum development time of 10 minutes on the product's surface. After a minimum time of 10 minutes, the excess developer was removed using conjugated air with a maximum pressure of 0.034 MPa. The control was carried out in a control cabin under the UV lamp and a minimum radiation intensity of 1200 μW/cm2 on the surface and by the light intensity in the cabin that does not exceed 20 lux on the checking surface [21,22].

a)  b) 

Figure 1 Examples of linear indications on a gasodynamic seal

After the inspection was completed, the product was washed in an aqueous solution to remove the developer and residues of other materials used during the inspection. During the control with the fluorescent method, the incompatibilities were identified. To identify the cause of incompatibilities, the sequence of quality management instruments was used, i.e. the Ishikawa diagram and the 5Why method. The Ishikawa diagram, called the fishbone diagram, was prepared. From the basic categories, i.e., 5M + E, selected categories were chosen for the analysis, method, man, environment, management, and material, which were considered adequate for the analyzed problem. The Ishikawa diagram allowed us to identify the potential causes [23-25], choosing the main causes from among them. For the selected main causes, the analysis was performed with the 5Why method [26,27], which consisted of asking successive questions "why?". The 5Why method allowed identifying the source cause of the problem [28,29]. The analysis of the problem with the fluorescent method allowed us to find incompatibilities in the gasodynamic sealer, which is shown in **Figure 1**. The linear indications were recognized as non-acceptable because their length exceeded the acceptable value of the customer acceptance standards. These incompatibilities were further analyzed to find the source cause of the problem. The Ishikawa diagram was made to find the potential causes of the problem (**Figure 2**).

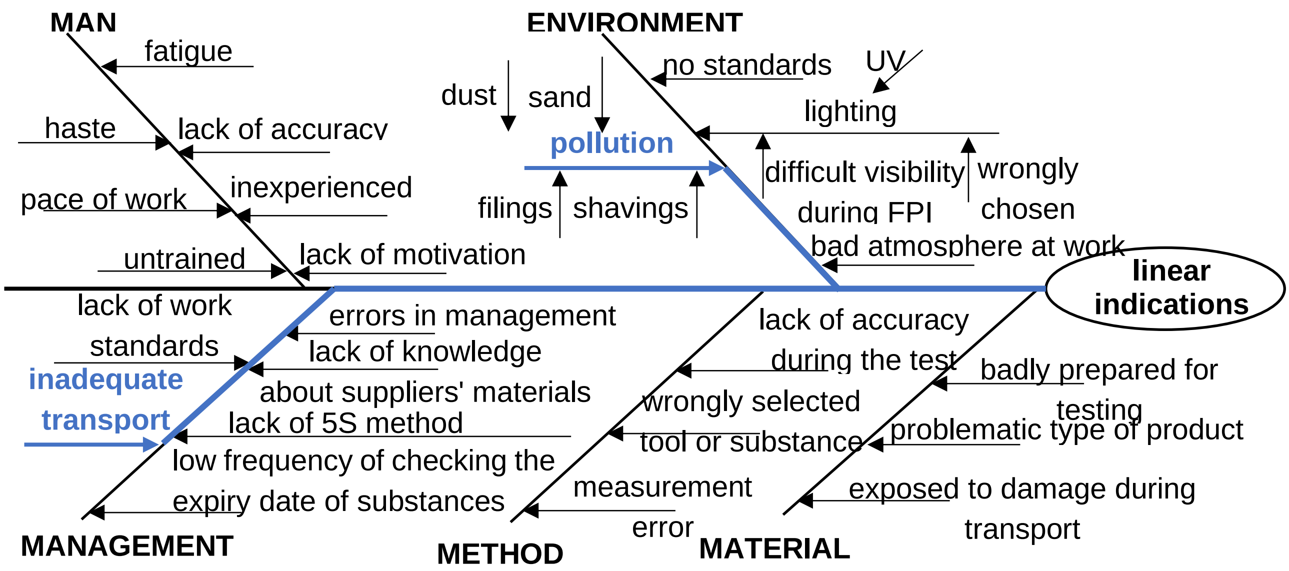

Figure 2 Ishikawa diagram for linear indications on gasodynamic seal

It was concluded that the main causes that were pointed on the Ishikawa diagram were material contamination and defective material. Then the 5Why method was made (**Figure 3**).

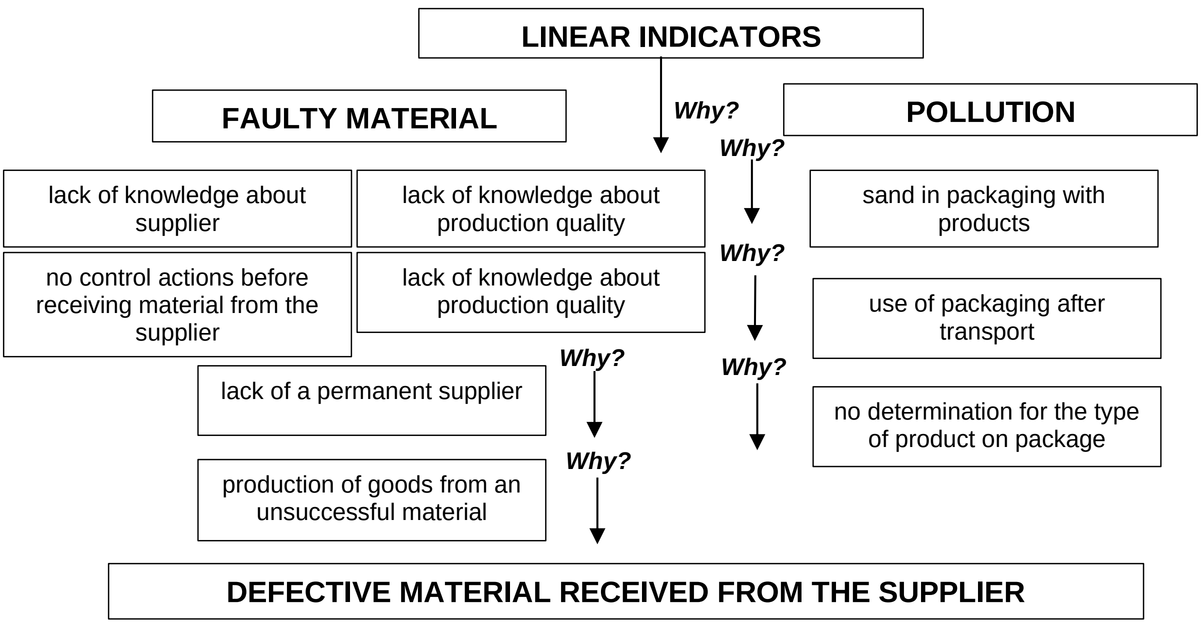

Figure 3 The analysis 5Why the problem with linear indications with gasodynamic sealer

It was concluded that the source cause of the linear indications on the gasodynamic sealer was the faulty material from the supplier. This was considered due to the lack of a permanent material supplier or poor packaging for transporting sand. It was concluded that the actions that will be possible to eliminate or minimize the linear indications are establishing favorable relationships with suppliers and using proven storage resources during the transport of products (including packaging).

4. CONCLUSIONS

The analysis of the product with the penetration test (fluorescent method) allowed us to identify the incompatibilities, which were linear indications on the gasodynamic sealer. The analysis of the Ishikawa diagram allowed us to find the potential causes and then the main causes of the problem, i.e., faulty material and contaminated box. The 5Why method allowed us to identify the source cause of the problem: the supplier's defective material. It was concluded that it was beneficial to implement the sequence of techniques, i.e. the Ishikawa diagram and the 5Why method, which turned out to be the possibility of effective quality management in the qualitative analysis of mechanical products. Applying this sequence of quality management techniques made it possible to identify incompatibilities and, in turn, their source cause. In the problem analyzed, this source cause was inconsistent material from the supplier. The proposed solution can also be used in other quality problems and other enterprises to improve the production processes. The workflow presented in this study can also inspire modification of methods for statistical developing nonparametric predictive models [30,31] that often take into consideration procedural scheme [32].

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