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AN IMPROVEMENT OF QUALITY OF THE REAR COVER OF BEARING TURBINE WITH THE USE OF SELECTED METHODS

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Abstract: The analyses of the nonconformity of products are made in order to achieve the desired level of their quality. This is also the case in the analyzed enterprise located in south-eastern Poland. Due to production character in this enterprise to identify the incompatibilities of products the non-destructive tests are used. In the current approach to quality after identified the nonconformities the cause her arise were determined, it was noted in order to use by statistical analyzes. Unfortunately, no deeper qualitative analyzes were made which could specify the source of its creation. Therefore, it was considered that it is necessary to propose to use (near current actions according to non-destructive tests) the sequence of quality management instruments. In order to improve the quality control actions, the sequence of techniques which complement each other, i.e. non-destructive tests, Ishikawa diagram and 5Why method, was proposed. To demonstrate the effectiveness of the proposed sequence, the rear cover of the bearing turbine was selected as the subject of the analysis. The choice was conditioned by the unit character of production, which till now was discouraged a detailed analysis of sources of nonconformities. After analyzed the product with used the fluorescent method the nonconformities were identified on the rear cover of the bearing turbine, which was the porosity cluster. In order to identify the causes these nonconformities the Ishikawa diagram was drawn up. Next, the selected main causes (i.e. supplier of the product and nonconformities created during the production of the product) were analyzed the 5Why method in order to identify the source cause of the problem. In this case, it was the nonconformity material from the supplier. The proposed sequence, which uses the minimal resources let to show the wide range of information, which should be used to the improvement of quality. The presented the set of activities can be practised in each of the enterprises to analyze quality problems in order to identify the nonconformities and their causes.
Keywords: quality, improvement instruments, nonconformity, mechanical engineering

1. INTRODUCTION

The steel market makes up above 5% world PKB, and its percentage is getting bigger, in view of the progress in steel recycle technology (Hristoforou, 2018). The sectors of industry, for which are produced for example steel coils or rods, needs still quality control these materials. The control process has an aim to identify the nonconformities of the product, that is the way it is key to focus on practice actions in the area of quality analyze. The way of identifying the nonconformities on the product without violating its surface is to make the research with non-destructive tests, which except that allow to identify the nonconformities without violating the surface of the product, also they meet the need of the steel industry and they do not change the usable properties of the tested products. After the overview of the newest publications (from period of year 2019 - 2017) about the non-destructive tests, it was concluded that the non-destructive tests were made in order to analyze of products (Corbett and Tronca, 2017; Velay-Lizancos et al., 2018, Hong et al., 2018) in these the products from metal (Peterka et al., 2018; Markus et al., 2018; Monrrabal et al.,2018; Trung and Pham, 2017; Zhang et al., 2017) or composite products (Komarkova et al., 2018; Swiderski, 2019). It was researched the depending of parameters or measure the mechanical properties and theses influence on the quality of test or products (Trung and Pham, 2017; Beskopylny et al., 2017; Sorger et al., 2019; Aghadavoudi-Jolfaei et al., 2018). Also, it was made the research in order to improve the way of making the non-destructive tests (Hristoforou, 2018; Peterka et al., 2018; Ahmad, J. et al., 2019; Rosenkrantz et al. 2019). In analyzed literature items did not analyze the aspect concerning the possibility of practicing non-destructive testing in terms of extending them with additional qualitative analyzes in order to identify the causes of nonconformities detected by these methods. It was concluded that it should be considered as problematic for enterprises to achieve an effective way to identify product nonconformities and their causes, when the stage of non-destructive tests make by the human is end after identify the nonconformities without next steps (in order to identify the source cause of problem with use quality management instruments). And these were practiced in case the analyzed enterprise located in south-eastern Poland. After non-destructive tests and identified the nonconformities, any actions with use the quality management instruments were not practiced. In this enterprise the unit control of products was practiced, so the causes of nonconformities were not methodically analyzed, in view of time-consuming these actions. It was purposeful to proposed use the method sequence (non-destructive tests, Ishikawa diagram and 5Why method) as way to identify the nonconformities, and next the source cause of nonconformities, which allow to make the right actions. (Wolniak, Skotnicka-Zasadzień, 2011) By used the non-destructive tests (fluorescent method) the rear cover of bearing turbine made from alloy 718 (AMS 5383) was analyzed, after the test the nonconformities of the product were identified (porosity cluster). The choice was conditioned by the unit character of production, which till now was discouraged a detailed analysis of sources of nonconformities. The techniques which were used in the sequence were the complement each quality management instrument, which were selected in order to identify the source cause of the problem. In order to identify the potential causes of nonconformities, the Ishikawa diagram was prepared, and the main causes selected from potential causes were analyzed by 5Why method in order to identify the source of cause of the problem. The proposed sequence, which uses the minimal resources let to show the wide range of information, which should be used to the improvement of quality. The presented the set of activities can be practiced in each of enterprises to analyze quality problems in order to identify the nonconformities and their causes.

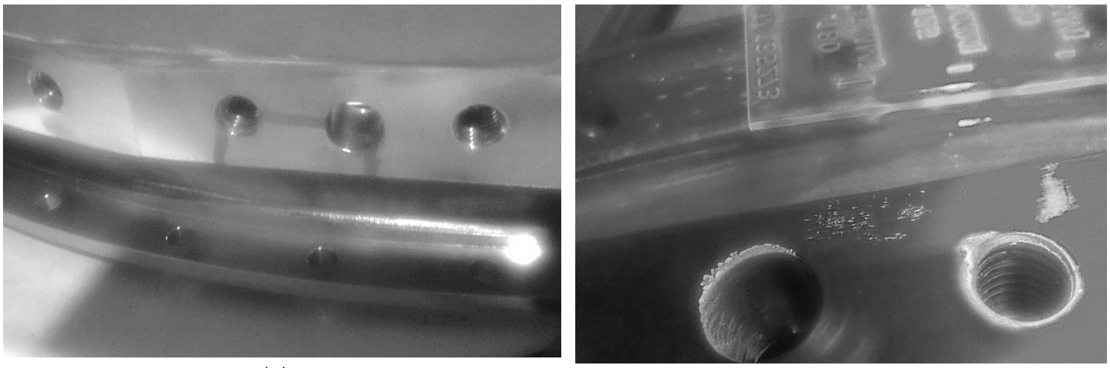
2. METHODOLOGY OF RESEARCH

The rear cover of bearing housing was analyzed, which has application in aircraft engines. The rear cover of bearing housing was made from alloy 718 (AMS 5383) which it is called Inconel 718 and it is counted among superalloys. This alloy is used in long-term work at temperature up to 650°C. Alloy 718 can be welded in annealed and dispersion-hardened. It is characterized by high mechanical strength, high temperatures, creep strength and resistance to oxidation (Kumar et al., 2019; Enrique et al., 2019; Zhong et al., 2019; Kong et al., 2019; Stone et al., 2018). The research of rear cover of bearing housing with use the fluorescent method was made in view of the condition of the surface of the product (PN-EN ISO 9934-1:2017-02; PN-EN 1369:2013-04) and requirement of the external customer, who ordered control of the product. The research was started from immersion in the MH-406 penetrant by 30 minutes cooled and defatted product into the maximum temperature 40°C. Then, the product was immersion by 10 seconds in the pre-rinse bath before the final cleaning process. The fluorescent control of the product with use the HM-406 penetrant was made according to internal instruction. The master plate TAM 146040 was used to check the sensitivity of penetrant. The product was cleaned under UV lamp with use the water spray (maximum temperature 10-38°C, maximum pressure 0,275 MPa) and the direct spraying on the product was made from a minimum distance of 300 mm at the lighting. The product was dried in a chamber dryer (maximum temperature 70°C). On the product surface the dry developer ZP-4B was put (maximum pressure 0,172 MPa, calling time 10 minutes). Next, the excess developer was removed with air pressure (maximum pressure 0,034 MPa). The control was made in control cabine uder the UV lamp and also by minimum radiation intensity 1200 μW/cm^2 on the surface, and by the radiation intensity in cabin which not exceed 20 lm/m^2 on the check surface. After the control in order to remove the developer and remains of others materials used in resarch, the product was washed in an aqueous solution.

After research with using the fluorescent method the nonconformities i,e. porosity cluster, on the rear cover of bearing housing, were identified. In order to identify the causes of porosity cluster the Ishikawa diagram and 5Why method were used. These methods are popular and are described in the literature of study (Bilsel and Lin, 2012; Chokkalingam et al., 2017; Pacana et al. 2014; 2015; 2019; Salvador and Goldfarb, 2004; Benjamin et al., 2015; Braglia et al. 2017; Malindzak et al., 2017). In the main part of the diagram the nonconformity was noted (porosity cluster) and the potential causes these problems were noted in the next element of the diagram. During made the Ishikawa diagram the category like “machine” was not selected because in this research (fluorescent method) any machines were not used. From potential causes of the problem (porosity cluster) the main causes of the problem were selected by the working team i.e. quality control manager, an employee performing fluorescent control, product supplier and two employees of the quality control department. These main causes of the problem were analyzed with the 5Why method in order to identify the source of the problem. During analyze, the “why” question was asked to each cause of the problem, until to answer based on which it was possible to make right improvement actions. After identified the source of cause the improvement actions were proposed in order to eliminate or reduce the occurrence of a given problem.

3. RESULTS

After analyze the rear cover of bearing housing with fluorescent method, the nonconformity was identified i.e. the porosity cluster (Fig. 1).



(a) (b)

Fig. 1. The porosity cluster on the rear cover of bearing turbine: (a) in white light (b) in UV.

After made the non-destructive test by fluorescent method on the rear cover of bearing housing, the source of cause these nonconformities was not identified, so it was necessary to make next quality analyzes. In this purpose, the actions according to the proposed sequence of the method were made. The main causes were selected from potential causes on the Ishikawa diagram (Fig. 2), which were the supplier of the product, who gave the product to the control and the nonconformities which was created during production. The source cause of the problem which was the nonconformity material from the supplier, which was identified by used the 5Why method (Fig. 3). Immediate actions that were taken after identifying the causes of nonconformities were the client's notification of material noncompliance on the supplier's side.

4. CONCLUSION

During non-destructive testing of products ordered by external customers, when a noncompliance was detected, there was the gap in the company regarding the non-trivialisation of methods for qualitative analyzes to identify the root cause of the noncompliance. As it turned out, this resulted in undertaking unreliable (unsatisfactory results from analyzes) decisions on further actions. After research on case of rear cover of bearing housing, it was concluded:

- the fluorescent method was effective and allow to identify the noncompliance which was the porosity cluster, so in order to identify the source of cause and take further appropriate actions (justified from results of analyses) the next analyses with use quality management instruments were made,
- the drawn Ishikawa diagram up for the problem of porosity cluster on rear cover of bearing housing allowed to identified the potencial causes of problem and selected the main causes which were the supplier of product and noncompliance,

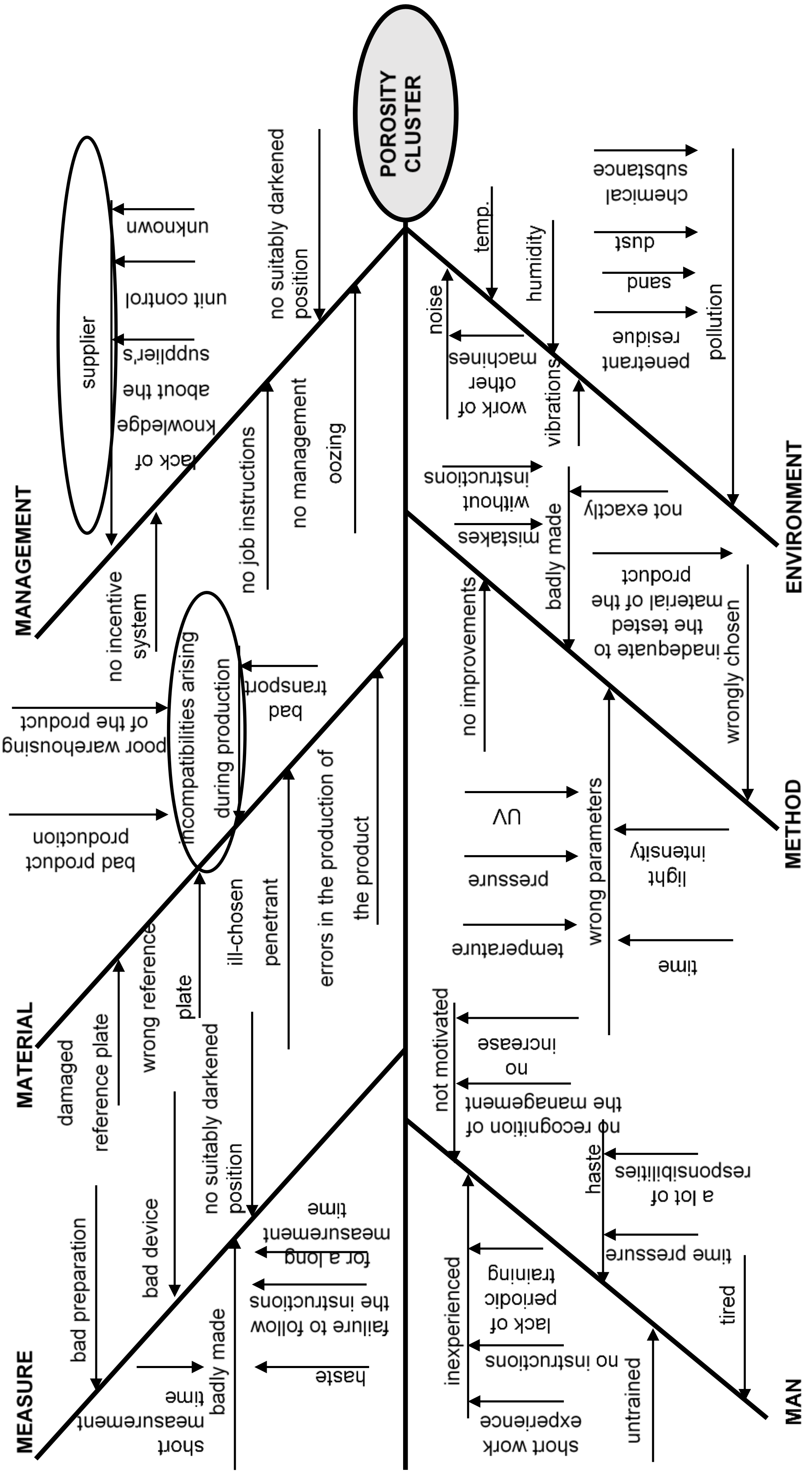


Fig. 2. The Ishikawa diagram for the problem of porosity cluster on the rear cover of bearing housing.

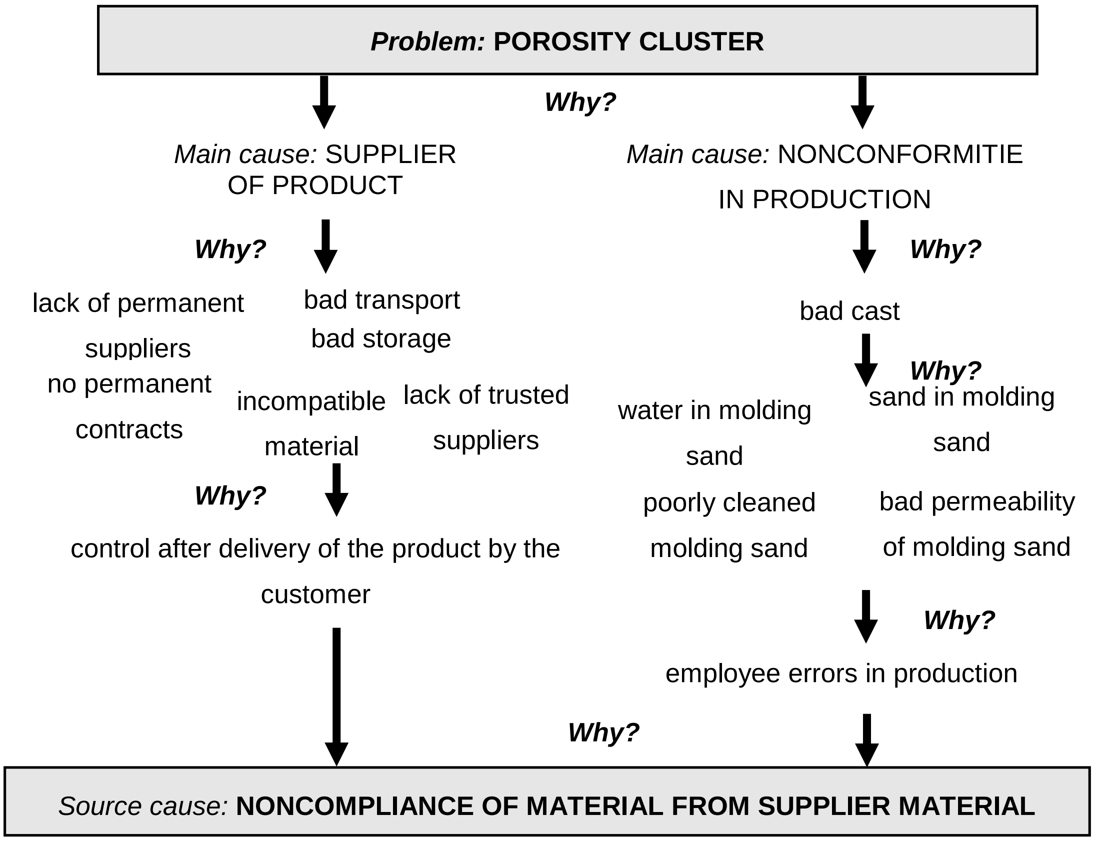


Fig. 3. The 5Why analyze for the problem of porosity cluster on the rear cover of bearing housing.

- the analyze with use the 5Why method for the porosity cluster on the rear cover of bearing housing allowed to identify the source of cause i.e. noncompliance of material from supplier, and then undertake the appropriate improvement actions;

The proposed sequence, which uses the minimal resources let to show the wide range of information, which should be used to the improvement of quality. The presented the set of activities can be practised in each of the enterprises to analyze quality problems in order to identify the nonconformities and their causes.

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