Self-checking quality of welded structures

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Abstract. The problem of controlling the production processes is considered, the qualitative result of which cannot be confirmed by subsequent monitoring and measurements, and deviations from the established norm become apparent only after using the products. In this regard, there is a need to organize the product quality self-control by the performers of the technological process. The author's technique of self-controlling production quality of mechanical engineering is offered

1. Introduction

The basis of product competitiveness in the modern market is its quality, which is provided by many factors, both technological and marketing. Implementing the methodology of product quality improvement in the production process[6, 7, 13, 27], including methods of defect analysis [21, 31], methods of changing the quality of the technological environment [2, 5, 12, 26], means of increasing the level of interaction between the quality of technology and the quality of production relations [1, 4, 11] create the basis for further improving consumer evaluation of product quality[18, 22, 25, 30], which also includes informing the target audience of the product qualimetric characteristics [9, 10, 14, 19, 23].

In most enterprises, the quality control (from verifying the purchased product to product quality control) is handled by the specialized structural units, for example, the departments (authorities) of Quality Control (DQC). The main purpose of the quality control is to eliminate defects in the output products. However, this goal cannot be achieved in all technological processes.

At modern machine-building enterprises there are such special technological processes as welding, soldering, painting, crimping, gluing. A special technological process is a process, the result of which cannot be confirmed by subsequent monitoring and measurements, the deviation of which becomes apparent only after the beginning of using the products. The proper execution of such processes determines the quality of the final product. The workers of technical control are responsible for controlling the performance of technological operations, they can't provide it as they aren't experts in the field of the particular special process. Thus, the problem of organizing the product quality self-control by the performers of the technological process becomes vital. Currently, it is not sufficiently developed from a methodological point of view. Therefore, the author's team offers its methodological vision of providing quality self-control of special technological processes at the machine-building enterprise.

2. Discussion

At present, the technical control service is only able to separate low-quality products from high-quality ones, in other words – to reject, but it is not able to prevent the production of low-quality products, in this regard, the consumer's risk increases.

Improving the activity of technical control must provide carrying out works on introducing self-control of the main production workers (it also includes forming the list of the technological operations transferred to self-control, and providing the workplaces with necessary monitoring, measuring and test devices, tools, documentation and organizing the workers' special training).

The main task of self-quality control is implementing all the operations of quality control by the contractor directly in the workplace in full compliance with the technical documentation requirements. Thus, the bulk of control operations are transferred to the earliest stages of the product quality formation process, which naturally contributes to the timely detection and rapid correction or isolation of defects.

As an example, let's consider welding as one of the most intensively studied types of such processes [8, 15, 16]. This process is examined and improved both technologically [3, 17, 24, 28] and instrumentally [20, 29]. Since it is impossible to assess the quality after a special process, it is necessary to organize a system of self-quality control of the welding process. The challenge is to encourage the performer to ensure quality, and the performer's knowledge in this area may not be enough. The solution to this problem is to develop a system of welders' certification for self-control suitability. Training the performers of the special process should be focused on ensuring the quality of work performed by them.

Quality performance of welding operations in total is provided by [32]: the quality of welding equipment; the quality of welding materials; the quality of basic materials (products); the requirements for welders and welding operators' qualification; requirements for normative and technical documentation; requirements for labor protection and safety of welding works; production rooms and welders' workplaces needed to be appropriate for performing welding works.

The developed by the authors method of regulating the process of welding self-control is based on analyzing the experience of the product quality of machine-building enterprises (for example, Bryansk machine-building plant) [33]. This method can be presented in the form of the following block diagram (Fig. 1).

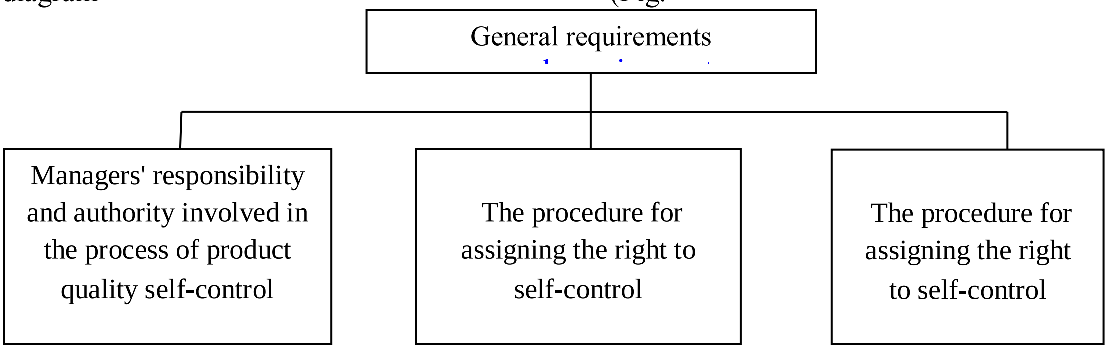

Figure 1. Structure of the welding processes self-control method.

As an "engineering" application to the self-control technique (Fig. 1) the authors propose a method of improving the reliability of the quality self-control process through PFMEA-analysis of a special process that requires "tightening" self-control. The algorithm for this analysis is shown in Fig.2 [33].

PFMEA of the technological process is an analysis of the originally developed and proposed technological process and (or) completion of this technological process in the course of the corresponding PFMEA-teamwork. It allows to prevent the introduction of insufficiently developed technological processes into production and to analyze all design features with respect to the planned technological process.

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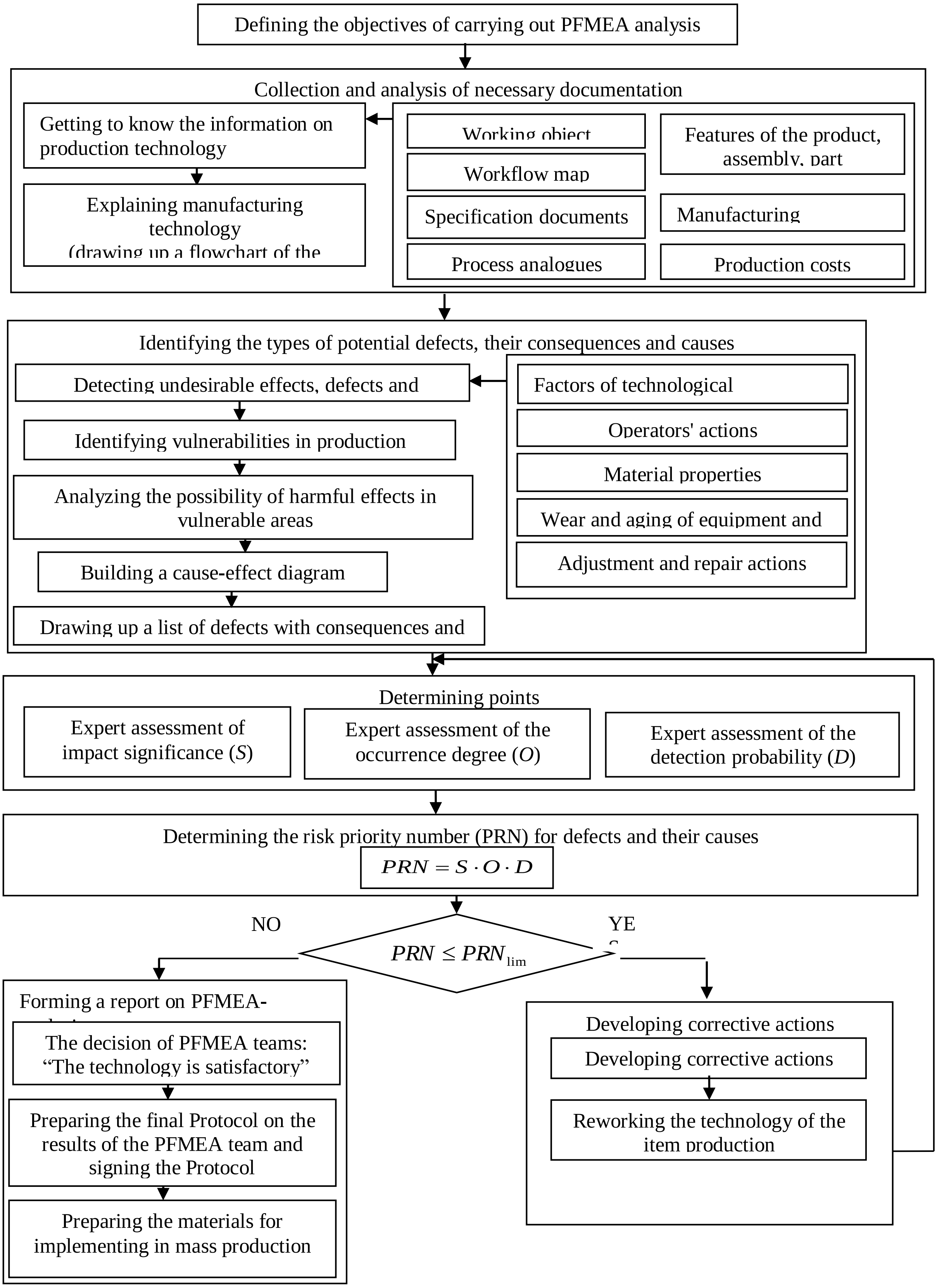

Figure 2. The algorithm of the FMEA team work.

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A key question in PFMEA process is: “How can failures in the technological process affect the product, process efficiency or safety?”

PFMEA is conducted by a specially selected FMEA team in the following sequence.

1. Determining the process analysis objectives. The aim of FMEA-analysis of the production process is to ensure the compliance with all requirements for the production processes quality, to insure the assembly by making changes to the process plan for technological actions with an increased risk, as well as by improving the quality of processes and product competitiveness.

2. Collecting and analyzing necessary information, including information on production technologies; on counterparts, technical documentation, etc. PFMEA team should not start the analysis until all the necessary information is collected. After getting to know the information on the production technology, an explanation of the manufacturing technology is carried out on the basis of drawing up a flowchart of the technological process.

3. Determining the types of potential defects, their consequences and causes. At this stage, adverse effects, the technological process mismatches are identified that may occur under the influence of various factors: various factors of technological environment; various properties of materials; operators' actions; wear and tear, aging of equipment, tools; steps for installation and repair.

4. Determining points. The consequences of potential failures are assessed by their significance (S). Significance is assessing the severity of a potential failure for the next component, subsystem, system, or consumer. The degree of occurrence possibility (O) of specific causes or mechanisms is described by a rank number from 1 to 10. The effectiveness of the envisaged control measures (D) is assessed by the ability of the proposed control actions to detect a potential cause (structural weakness) or to detect the next type of failure before the component, subsystem or system are put into production.

5. Determining the risk priority number (PRN). For each identified potential defect and each cause, the risk priority number is determined by the formula: $PRN = S \cdot O \cdot D$.

For risks having a calculated value of *PRN* larger than the predetermined threshold value $PRN_{\lim}$,special steps are taken allowing you to: eliminate the causes of risk; to prevent or reduce the probability of its occurrence; to reduce the impact of the risk; to facilitate and improve the probability of detection and identification.

6. PFMEA concludes with a report on the risk analysis in the form of a Protocol on the results of the PFMEA team.

Experimental verification of the proposed method of the welding process quality self-control is carried out on the example of welding the bottom of the container, AYDMK manufactured in Joint-stock company “Management Company “Bryansk machine-building plant”.

The PFMEA-analysis of the technological process of welding the container base, conducted by a multifunctional PFMEA-team reveals a potential defect that can lead to the failure of the structure that is failure of welded joints of the container base frame.

A potential cause of the defect is the welding technology imperfection, in particular, welding large thicknesses of welded parts (25 mm) in one pass, as well as welding joints in a vertical position, which leads to excessive complexity of the welding operation.

While discussing the type of the potential failure, the PFMEA team offered to weld the products by multi-pass welding with overlapping rollers in staggered order. With regard to implementing the weld in the vertical position, it was decided to develop and implement a horizontal marching rotator for the possibility of welding the container frame in the lower horizontal position.

In addition, the PFMEA team identified other potential defects in the process and eliminated their causes.

3. Conclusion

As the result of the carried-out PFMEA analysis, the risks identified in the technological process of welding the container base were reduced by technologists' performing corrective actions and, thus, the reliability of the self-control process of the welding work quality was increased.

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