QUALITY ANALYSIS OF THE STEEL BARS IN CHOSEN METALLURGICAL ENTERPRISE

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Abstract

Quality management tools are instruments that enable collecting and processing data on events and processes taking place in the organization, related to various aspects of quality management. The most important group of tools is called Seven Basic Tools of Quality, Magnificent Seven or 7 QC Tools. They are called basic because they are suitable for people with little formal training in statistics and they can be used to solve the vast majority of quality-related issues. They allow to easily analyze the quality of chosen products. They also allow for data visualization, monitoring and diagnosis of processes. Thanks to them, an enterprise can check the effectiveness of the actions taken and decisions made. In the paper the quality analysis of the steel bars was presented. The data comes from the steelwork in Poland (its rolling mill). Pareto chart and Ishikawa diagram were chosen for this analysis. The Ishikawa diagram allowed to group the causes of nonconformities of the steel bars, while the Pareto chart allowed to indicate which of these causes contribute to the formation of the largest number of nonconformities. The main result will be the indication of the most frequent causes of nonconformities of the steel bars and their analysis, which should reduce the amount of nonconforming products produced in the research object. The results can be used both by the research rolling mill and other rolling mills producing similar products. However, the research methodology can be an indication for other companies how to analyze the causes of nonconformities.

Keywords: Quality, Pareto chart, Ishikawa diagram, steel bars

1. INTRODUCTION

Steel round bars have been used for construction of various structures. It is important that the requirements imposed on the bars should be met since their quality will affect the quality and strength of final steel structures. Therefore, it is important to conduct analyses which may help improve the quality of the bars [1].

Quality management tools are the instruments which allow for collecting and processing the data about events and processes that occur in the organization and its environment, connected with various aspects of quality management. The most important group of tools is Seven Basic Tools of Quality, known as Magnificent Seven or 7 QC Tools. They are called basic because they are suitable for people with little formal training in statistics and because they can be used to solve the vast majority of quality-related issues. They allow for a simple analysis of the quality of selected products. They also allow for visualization of data, and monitoring and diagnosis of processes. They can allow for evaluation of the effectiveness of the actions [2].

The aim of the paper was to analyze the quality of steel bars produced by one of the steelworks in Poland. The analysis concerned the defects documented in the period from September to December 2017. The analysis used selected Pareto charts and Ishikawa diagrams. The Ishikawa diagram will help indicate what are the causes of defects in bars using the 5M principles. Furthermore, the Pareto chart should help indicate the causes of the highest number of defective products. These are the defects that should be eliminated in order to substantially reduce the amount of inconsistent products.

2. METHODOLOGY

The Pareto chart is a tool used for hierarchization of the factors which have an effect on a specific phenomenon. It helps obtain a graphical representation of the relative and absolute distribution of problems (defects) in the process and their causes. The main goal of the diagram is to identify the disturbances with the most significant effect on the analyzed problem, defined according to the 20/80 principle. The principle concerns the tendencies of events occurring in such areas as nature, technology, science or human activity. According to the principle, 20 to 30 % of causes of a specific phenomenon lead to 70 to 80 % of effects. Therefore, it is worth focusing attention and activities concerning facilitations and improvement on the most important part of the analysis of the causes of the problem in order to achieve greater effects at lower workload. The diagram allows for identification of the activities that are aimed at improvement in the level of processes and quality characteristics of physical products and services. The Pareto chart belongs to techniques which lead to identification of the most important characteristics (events, causes) with the most important effect on quality and, consequently, helping define the activities aimed at improving the level of process quality or certain quality characteristics of physical products and services [3-4].

In order to create the chart, it is necessary to start from the list of the causes of the problem. Next, for specific causes, the data for the specific time period are collected. The listed causes are arranged in the decreasing order and then moved on the chart in the form of a histogram. The bars which were formed are connected at the top with the linear chart which presents cumulative values for consecutive problems/causes [5].

As many Japanese researchers, Kaoru Ishikawa familiarized with American methods to control quality and started to improve them. The Ishikawa diagram helps arrange the causes of defects and interrelations of the causes using the most basic graphical form i.e. chart. Ishikawa diagrams are also called cause-and-effect diagrams or fishbone diagrams since their shape is similar to that of a fishbone. The diagrams can be used to examine problems with different cross-sections and different level of detail. They have been used to solve quality problems where chain of causation occurs. The problems analyzed in this method should be discussed in a bigger group of people who are familiar with the specific problem. These charts will be more valuable if more knowledge and experience of other people are collected (production workers, control and quality units, with particular focus on quality control offices, designers, technologists, organizers, sales department employees and even users). These people should be willing to be involved in the inquisitive discussion without hiding the root problems [3,6].

The cause-and-effect diagram, called fishbone diagram, allows for classification of defects and relationships between each other in the organization. A specific problem is presented graphically and analyzed. The tool is especially useful for teamwork as a supplementation ad visualization of the ideas generated during brainstorming. The main task and objective of using this tool of improvement of quality in the organization is to help identify the cause of the problem [5, 7].

The characteristic features of the Ishikawa diagram include:

- Easy visualization and description.
- Opportunity to segregate in terms of the importance of causes.
- Transparent transfer of information.
- Opportunity to demonstrate the relationships between the problem and the phenomenon.
- Oriented at solving the problem.

It is important that the diagram prepared for the specific defect is periodically supplemented or changed in order to maintain its topicality and transparency. It should be remembered that if solved, the problem or defect should be crossed out from the diagram in order to emphasized that it has been removed. The method is used in several modifications which depend on the skills and experience of the task team. The cause-and-effect diagram can be presented with the following modifications [8]:

- 5M (Man, Material, Machine, Method, Management).
- 5M + 1E (+ Envionment = Mother nature).
- 7M (+ Measurement).
- 8M (+ Money).

Firstly, the quality analysis was performed for steel round bars by means of the Ishikawa diagram. The diagram also allowed for indication of individual defects in the bars and grouping them according to the 5M principle.

Next, the analysis of frequency of the defects used the Pareto-Lorentz diagram. The examinations were performed in the period from September to December 2017. The analysis indicated the defects which were the most frequent in the period studied.

The steelworks X is one of the biggest suppliers and steel importers in the European market, active in each link of the steel supply chain. The enterprise has the plants which process scrap metals, steelworks, production plants and warehouses all over the world. The Bar Rolling Plant, opened in September 1999 by an Italian company, is the most modern production plant of this kind in the Central Europe. The investment allowed for offering high-quality products that correspond to European standards.

From steel, commercial activity, financing trade, distribution through to warehousing, the steelworks processes over million tons of steel products a year. With branches in 12 countries and additionally partnership commercial offices all over the world, the company has long-term commercial contacts with world producers, professional knowledge and resources that allow for supplies of any types of steel products in order to meet customers' needs in all places of the world.

3. RESULTS

Figure 1 presents the Ishikawa diagram which captures the potential defects of steel round bars produced in the enterprise studied.

In the case of material, the major problems include: the lack of control of material control, improperly chosen chemical composition of the material and poor quality of materials, which caused coarse-grained steel, non-metallic inclusions, microshrinkage and internal cracks

In the case of methods, the following problems were identified: improperly adjusted furnace parameters; improperly set machine operating parameters during rolling; improperly adjusted calibration system; poor transport; improper proportions of components; improper storage and, consequently excessive thickness of decarburized layer, oval and non-homogeneous structure over the cross-section.

In the case of men, the major causes are: non-observance of the workstation manuals: no awareness; hurry and low level of motivation. For two first causes, root-causes were also documented.

Analysis of **Figure 1** reveals that the most steel defects of steel round bars were caused by material, methods and human mistakes.

Next, the analysis of the defects was performed using the Pareto-Lorenz diagram. The examination was performed for the period from September to December 2017. The examinations identified only these defects which were recorded in a specific period. Comparison of the defects, frequency of their occurrence (in percentages) and helpful computations were presented in **Table 1**, whereas the results of the analysis were presented in **Figure 2**.

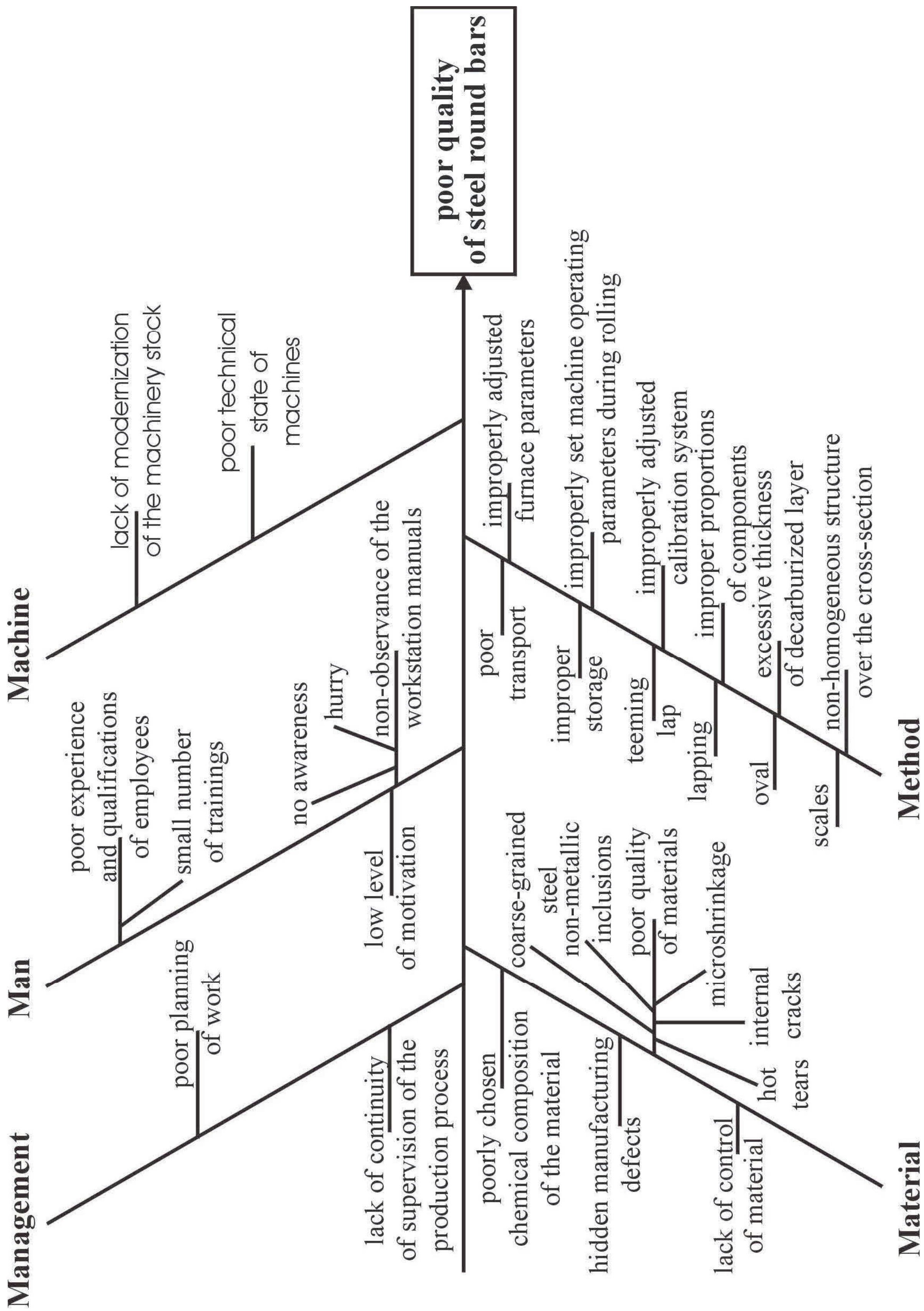

Figure 1 Ishikawa diagram for steel round bars [own study]

Table 1 Causes of defects in steel round bars [own study]

Symbol	Causes of defects	Percentage	Cumulative percentage
N1	Hot tears	31.65	31.65
N2	Teeming lap	12.95	44.60
N3	Coarse-grained steel	10.07	54.68
N4	Non-metallic inclusions	10.07	64.75
N5	Microshrinkage	8.63	73.38
N6	Lapping	5.76	79.14
N7	Internal cracking	5.04	84.17
N8	Excessive thickness of decarburized layer	5.04	89.21
N9	Scales	4.32	93.53
N10	Oval	3.60	97.12
N11	Non-homogeneous structure over the entire cross-section	2.88	100.00

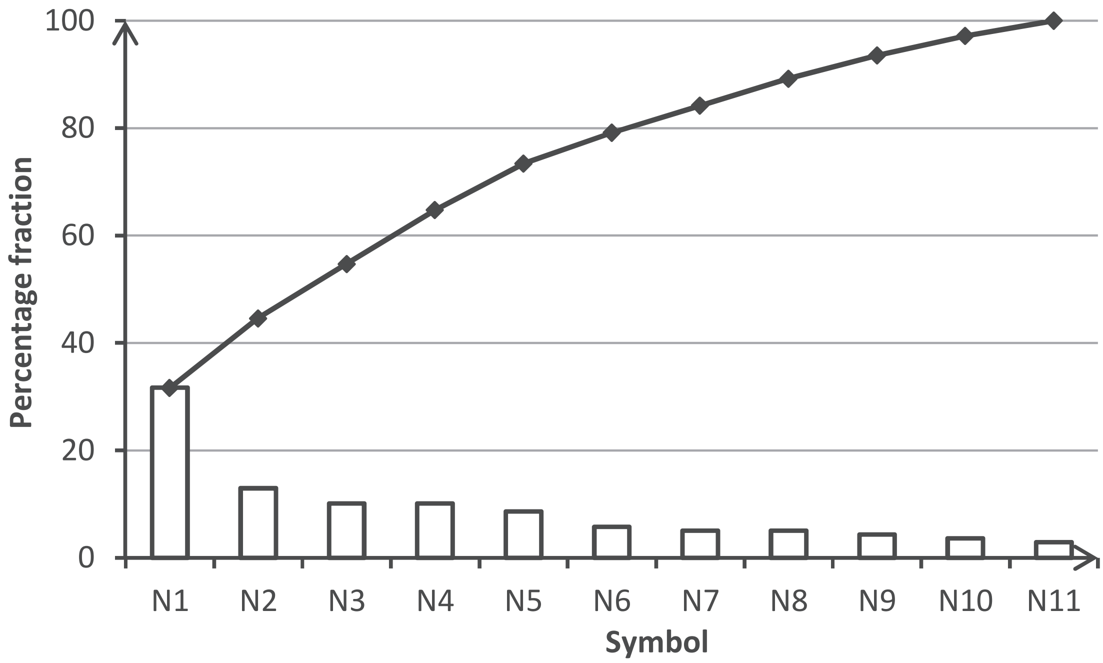

Figure 2 Pareto chart for steel round bars [own study]

Analysis of the **Figure 2** reveals that in the case of the quality of the rods examined, the principle 20/80 was not maintained. It was documented that over 35 % of causes is responsible for nearly 65 % defective products.

The most frequent cause was hot tears (N1) They were responsible for nearly 32 % of defective products. Other causes which had an effect on the results included teeming lap (N2), coarse-grained steel (N3) and non-metallic inclusions (N4).

Hot tears and teeming lap are mechanical damages. Teeming lap occur mainly due to problems with the rolling method, mainly by furnace parameters. In the case of hot tears, these are material defects. However, in both cases, analysis of the rolling process and analysis of composition of the materials used for production of the steel bars are necessary to reduce the effect of the causes.

Coarse-grained steel and non-metallic inclusions are defects related to the material used for rolling i.e. improper composition of the alloy. In order to reduce the number of defective products in this group, it is necessary to the analysis of proportion and amount of alloy components.

4. CONCLUSION

This paper presents the quality analysis of steel round bars produced by one of the steelworks in Poland. The examinations were conducted in the period from September to December 2017. The analysis used two popular tools of quality management i.e. Ishikawa diagram and Pareto chart.

The Ishikawa diagram indicated the most of the defects in the bars, grouped according to the 5M principles. The most of the defects were found for the group of material, method and man.

The Pareto chart showed that the most frequent defects were hot tears, teeming lap, coarse-grained steel and non-metallic inclusions. Analysis of the rolling process (teeming lap) and a more accurate analysis of the alloys used for production of the bars studied was proposed in order to improve quality of the rods and, consequently, limit the effect of the indicated defects.

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