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STEEL MILL PRODUCTS ANALYSIS USING QUALITIES METHODS

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The article presents the subject matter of steel mill product analysis using quality tools. The subject of quality control were bolts and a ball bushing. The Pareto chart and fault mode and effect analysis (FMEA) were used to assess faultiness of the products. The faultiness analysis in case of the bolt enabled us to detect the following defects: failure to keep the dimensional tolerance, dents and imprints, improper roughness, lack of pre-machining, non-compatibility of the electroplating and faults on the surface. Analysis of the ball bushing has also revealed defects such as: failure to keep the dimensional tolerance, dents and imprints, improper surface roughness, lack of surface pre-machining as well as sharp edges and splitting of the material.

Key words: steel, mill products, faultiness, Pareto analysis, FMEA

INTRODUCTION

As the quality of steel products remained competitive differentiator in the market, quality management in metallurgical enterprises is carried out with the use of quality control tools. In the quality management systems of steel companies operate subsystems, which ensure the quality of products (Quality Control), which includes all activities leading to the improvement and quality improvement [1]. The aim of the Quality Control in steel companies is to obtain better steel products. In the companies operate strong quality departments that work in production departments. Avoiding defects of the products (programs “zero defects”) realized by overseeing processes, measurement products, receiving control techniques [2]. The aim of this publication is to present the application of quality control tools in ensuring the quality of steel products. For the case study were used the following steel products: bolts, ball bushing. The assessment methods were used: a Pareto-Lorentz, the FMEA. Pareto-Lorenz’s analysis helped to determine the defects that are most relevant in terms of the number of their occurrence. In contrast, the method of the FMEA made it possible to examine the impact of causes and effects of defects on the usefulness of steel products. For the products were determined risk factor for RLI (Risk Level Indicator). The use of qualitative methods in the steel industry is related to problems like: involvement (in terms of involvement of all employees) and quality tools domination over the production process. Techniques and tools of quality management are only a means to an end, not an end in itself. Otherwise, employees spend most of their time preparing and filling in questionnaires and charts, not recognizing the primary objective, which is the quality of the product [3-5]. In addition to the significant impact of technology on ensuring an adequate level of product quality it is important to the process the environment containing a number of other factors, such as: quality management, control of product development, control of purchases of raw materials, controls the development of the manufacturing process, information flow, research and development, supervising the equipment necessary for inspection and testing, people management, contacts with customers [6]. This approach has been included in the standard ISO 9001:2014 among the eight management principles, indicated, among others, the principle of procedural and systemic approach. An important element of proper understanding of the processes is the concept of the system. Just as processes can be of character: technical, organizational and social.

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ANALYSIS OF THE DEFECTIVENESS OF STEEL PRODUCTS

By using the method of Pareto-Lorenz shows the number of defects of steel products (bolts, ball bushing) in the scale of production for the full year 2015 were calculated the percentage of each of the defects and their cumulative participation. In the case of bolts annual production amounted to 2 000 pcs., In relation to the ball bushing annual production include 6 500 pcs.

ANALYSIS OF THE DEFECTIVENESS OF BOLTS

Table 1 shows the types and amount of defects occurring during the production of the bolt – Figure 1.

Based on these results were prepared Pareto-Lorenz diagram (Figure 2).

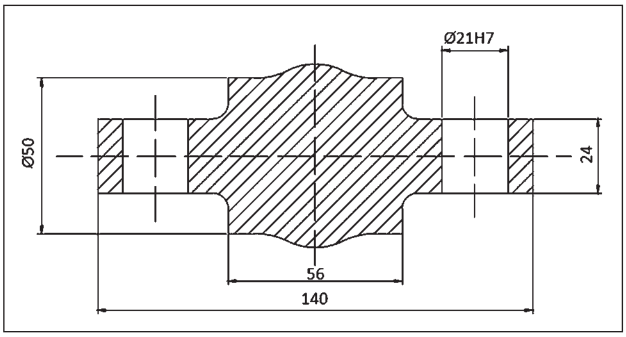

Figure 1 Bolt - pictorial drawing

Table 1 **Types and amount of defects occurring during the production of the bolt**

No	Defect	Quantity	Share /%	Cumulative share /%
1	Failure to maintain dimensional tolerances	32	34	34
2	Dents, imprints	26	28	62
3	Improper surface roughness	16	17	80
4	Lack of hard spots on surface	9	10	89
5	Incompatibility of galvanic coating	5	5	95
6	Jumps on the surface	5	5	100

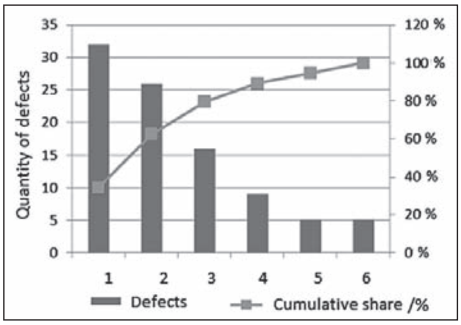

Figure 2 Pareto-Lorenz - the analysis of defectiveness of bolts

From the diagram shows that 80 % of all defects are the three of them. These are: Failure to maintain dimensional tolerances (34 %), dents and imprints on the surface (28 %) and improper surface roughness (17 %). These defects must be eliminated first from the manufacturing process.

ANALYSIS OF THE DEFECTIVENESS OF BALL BUSHING

Table 2 shows the type and number of defects occurring during the production of the ball bushings – Figure 3.

Analysis of Pareto-Lorenz (Figure 4) shows that the most common types of defects (key defects) is: failure to maintain dimensional tolerances (defect No. 1), lack of hard spots on surface (defect No. 2), improper surface roughness (defect 3) and dents and prints (defect 4). The next stage of the research was to determine the causes of key defects. And so, failure to maintain dimensional tolerances was due to: errors of machines: wrong set the machine geometry, as well as considerable wear and tear of tools and the wrong selection of parameters (employee error, lack of control of the process).

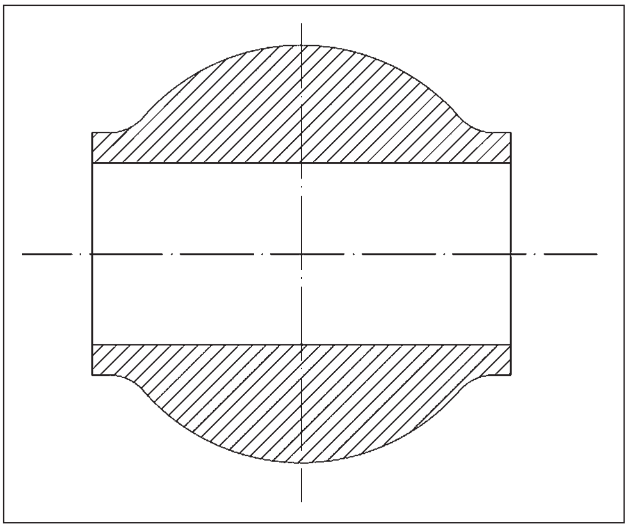

Figure 3 Longitudinal section (transverse) of the ball bushing

Table 2 **Type and number of defects occurring during the production of the ball bushings**

No	Defect	Quantity	Share /%	Cumulative share /%
1	Lack of hard spots on surface	58	39	39
2	Improper surface roughness	34	23	62
3	Failure to maintain dimensional tolerances	25	17	79
4	Dents, imprints	17	11	91
5	Sharp edges	12	8	99
6	Delamination of material	2	1	100

The result of defects was that element was not suitable for and required additional technology operations (corrections). Another disadvantage was lack of hard spots on surface caused by: material defects, errors during the initial machining operations - cutting and drilling or choice of material with too little overmeasure. Metallurgical product with this defect had reduced value in use, the item is not suitable for use due to premature corrosion. For the purposes of restoring its usefulness made an additional technological process which consists of covering the surface layer of corrosion protection. A third of the analyzed defect is improper surface roughness. Elements with this defect does not fit for use, and also made additional processes (grinding, polishing surface). The causes of this defect were badly chosen parameters, tool wear, wear of guides of the machine, dips in the mains voltage, badly chosen production technology. The last of the key disadvantages of

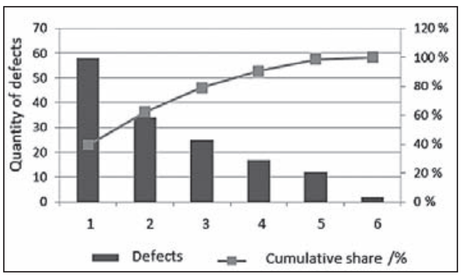

Figure 4 Pareto-Lorenz - Analysis of defectiveness of ball bushing

this are dents and imprints. Product had reduced value in use (the possibility of early corrosion). The reasons for this defect were: inattention of employees, improper transport of detail and improper storage of products.

FMEA ANALYSIS OF DEFECTIVENESS OF STEEL PRODUCTS

The next stage were Risk Priority Number – RPN (as the product of individual criteria) and the possibility of eliminating defects in order to provide better quality of manufactured steel products. At this stage in the analysis were used method FMEA. The first step was to determine the scope of the criteria: significance of defects, the probability of occurrence of the defect, detection of defects. In order to determine the value of the criterion significance of defects assumes point scale from 1 to 10, where: 1 - the importance of defects is very small, the defect has no influence on quality; 2 - the importance of defects is small , defect has a negligible impact on the quality of the product - its effects are tolerated or are easy for removal; 3 and 4 - average importance, defect has been noticeable effects on the quality of the product, its effects generate additional costs; from 5 to 7 - the importance of defect is high, the product does not meet the requirements, the costs of removing defects are high; from 8 to 10 - the importance of defects identified as critical, meaning that the product should not be permitted, because its use endangers the safety. The values of the criterion of the probability of occurrence of defects was determined on a scale from 1 to 9, where 1 means that the occurrence of defects is practically impossible; 2 - is a small probability of accepted for defects that occur infrequently; 3-4 likelihood average - the defect occurs periodically (at some time), the scale from 5 to 7 is a large probability that the defect recurs quite often; 8 and 9, while the probability for very large defects are difficult to avoid. Criterion for determining the value of detection of defects was adopted a scale from 1 to 10, where 1 means high detection of defects (virtually every defect in the product metallurgical is detected); 2 and 3 is the average detection, able to detect defects with the basic means of control is very high; from 4 to 6 is small detection of defects, they can be detected lower than the average, 7-8 the detection is very small - there is a high probability of that the defect is not detected; 9-10 are reserved for defects impossible to detect.

On the basis of the criteria set risk factor WPR (the next step of the analysis). The ratio of all the criteria began in Table 3.

Where:

- S − Severity (significance of defects)
- O – Occurrence (the probability of occurrence of the defect)
- D − Detection of defects

$$RPN = S \times O \times D \quad (1)$$

Table 3 **Analysis of the potential causes and effects of defects**

No.	Defect	D	S	O	RPN
1.	Failure to maintain dimensional tolerances	3	8	6	144
2.	Lack of hard spots on surface	1	5	6	30
3.	Improper surface roughness	2	6	7	84
4.	Dents, imprints	2	4	5	40

The next steps are actions taken to reduce the rate RPN. In the event of a defect No. 1 - failure to maintain dimensional tolerances - proposed the following preventive measures: additional checks during the process, check the status of cutting, the selection of parameters in accordance with the manufacturer's tools. In turn, in relation to the defect No. 2 (lack of hard spots on surface) will be corrected by controlling the material during delivery, a suitable material selection, process control, cutting and drilling. The defect No. 3, which is improper surface roughness, will be eliminated through: choice of parameters according to the manufacturer of tools, regular inspections of the technical status of machine tools, inference about increasing tensions in the network. The last of the key defect (defect No. 4) - dents and imprints - will be reduced through appropriate training of personnel. To prevent it an additional training (training bench) will be introduced. Furthermore sealed procedures for securing components during transport and storage. The value of the indicators of the RPN after the application of preventive measures was lower in relation to the initial situation (Table 4).

Table 4 **Analysis of the potential causes and effects of defects after the introduction of preventive measures**

No.	Defect	D	S	O	RPN
1	Failure to maintain dimensional tolerances	2	8	4	64
2	Lack of hard spots on surface	1	4	5	20
3	Improper surface roughness	2	6	5	60
4	Dents, imprints	2	4	3	24

Table 5 summarizes the ratios of the RPN before and after the implementation of corrective actions.

Table 5 **Summary of the RPN indicators before and after implementation of corrective actions**

No	Defect	RPN before	RPN after
1	Failure to maintain dimensional tolerances	140	64
2	Lack of hard spots on surface	30	20
3	Improper surface roughness	84	60
4	Dents, imprints	40	24

The final results are shown in Figure 5. Primary Conclusion: the most important is defect No. 1, that is failure to maintain dimensional tolerances, for which the RPN is 144. However, after applying the corrective action will be possible to reduce this value to 64. In the

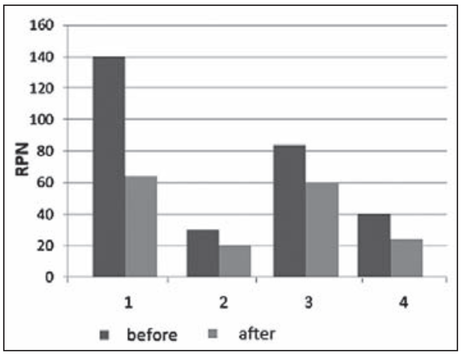

Figure 5 Diagram of the reduction of the RPN

case of other defects is also possible to reduce the ratio of the RPN (in the context of the proposed activities).

CONCLUSIONS

The presented analysis of defectiveness of steel products (bolts and a ball bushing) was made based on two methods: chart Prateo-Lorenz and FMEA. The analysis determine the key disadvantages of products and the reasons for their occurrence. Defects of products: failure to maintain dimensional tolerances, lack of hard spots on surface, roughness and surface dents and imprints were caused by factors: technical (eg. wear of work tools), human (wrong choice of material, improper setting parameters of equipment) and procedural (improper transport, storage). Taking into account all these factors and taking improvement action will improve the quality of steel products.

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Note: The responsible translator for English language is Ling House, Poland