THE ANALYSIS OF NON-CONFORMANCES OF PRODUCTS IN PLATE MILL USING SELECTED QUALITY TOOLS

KARDAS Edyta

Czestochowa University of Technology, Czestochowa, Faculty of Production Engineering and Materials Technology, Poland, EU,
ekonstan@wip.pcz.pl

Abstract

The paper presents the analysis of non-conformances of metal plates produced in one of Polish steelworks. Selected quality tools were used in the analysis. In the first part of the paper quantitative analysis of total and non-conforming production, taking into account the ways of procedure with non-conforming products, was made. In the second part of the paper the analysis of different types of non-conformances was done. Selected quality tools were used: Pareto's chart, cause and effects analysis and FMEA method. The analysis covers the period of 1 calendar year.

Keywords: Non-conformance, quality analysis, Plate Mill, quality tools

1. INTRODUCTION

Quality of products is one of the factors determining customer satisfaction and profits for the company. Companies that generally have to multiply profits, must ensure that the quality of products they offer is as high as possible. They realize that in order to be competitive on the market they must take care of their customers by meeting their requirements and expectations. Quality is created at each stage of production process: from the designing phase, though the manufacturing to deliver products to the customers. Proper operation of manufacturing process which the quality parameters of products are optimal and within the standards and customer requirements is very important element of quality management. Continuous monitoring and analysis of quantitative parameters of products is intended to keep them at the optimal level and rapid response to any of their changes [1, 2].

Continuous analysis of products at each stage of the production process, from assessment of quality of materials, through the various stages of manufacturing, to the control of products in stock, is one on the most important factors relevant to the quality of finished products. Many authors show that various quality tools can be used successfully to evaluate the quality of different products. There is no one universal set of tools that can be used for this purpose. The selection of appropriate set of tools depends on many factors, e.g.: production industry, the type of product, volume of production, the type of results to be analyzed [3, 4, 5].

The evaluation of quality of products using selected quality instruments was the main purpose of this paper. The analysis of non-conformances of metal plates is presented. Quantitative analysis of production and non-conformances, Pareto chart, the analysis of causes of non-conformances and FMEA method used in this paper. Major non-conformances occurring in products were identified, quantitative analysis of non-conformances was made and reasons of occurrence were determined. The analysis was based on results from the company working in steel industry. This analysis includes industrial results of quality parameters under study. The analyzed period of time covers one calendar year.

2. CHARACTERISTICS OF DATA

The analysis was based on results from the company working in steel industry. Plates produced in one of Polish steel mills were tested object. In this company 80 potential non-conformances of plates were identified.

In analyzed the period of time only few of them were detected. The following numbers of non-conformances occurring during the analyzed period were used for the analysis [6, 7]: 1 - hulls from the bottom, 2 - hulls from the top, 3 - cracks from the bottom, 4 - cracks from the top, 5 - discontinuity of material after machine testing, 6 - discontinuity of material after manual testing, 7 - short after cutting defects of material, 8 - Cracks at the edge, 9 - narrow after cutting defects of material, 10 - cracked edge - to cut, 11 - transverse cracks - from the top, 12 - cross-section cracks - acceptable tolerance of thickness, 13 - other non-conformances (after ultrasound examination - snowflakes, axial cracks - from the top, axial cracks - from the bottom, transverse cracks - from the bottom, bad after griding of non-conformances of steel, other defects caused by charge deliverer).

3. ANALYSIS OF RESULTS

The quality analysis of plates was made. The following quality instruments were used to assess the quality of product: quantitative analysis of production and non-conformances, Pareto chart, causes analysis and FMEA method. The research covers the period of 1 calendar year.

3.1. Quantitative analysis of production and non-conformances of plates

Quantitative analysis of production of plates was made. **Figure 1** shows volume of total production plates in particular months of investigated year. **Figure 2** shows structure of production of plates according to their thickness.

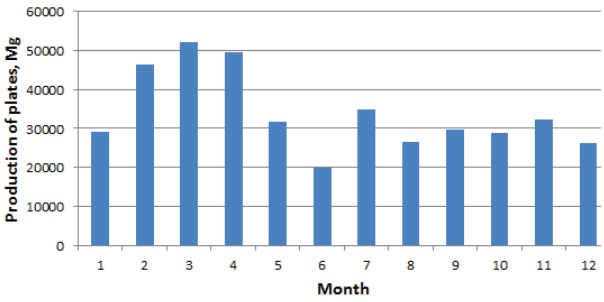

Figure 1 Volume of production of plates
[Own study based on: 6, 7]

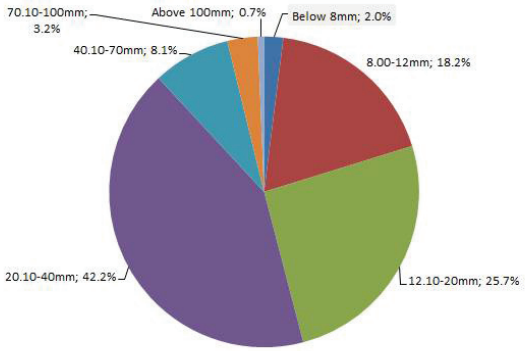

Figure 2 Structure of production of plates
[Own study based on: 6, 7]

Based on the information presented in **Figure 1** it can be said that the largest volume of production of plates was recorded in the first half of the year, mainly in March, April and February (about 50 000 Mg), while in the second part of the year was significantly lower (about 30 000 Mg). The structure of production (**Figure 2**) shows 42% of total production was that plates with thickness 20-40 mm, 25% of total production - plates with thickness 12-20mm and 18% - 8-12 mm were produced most frequently.

Percentage of non-compliant production of plates in total production in particular months of investigated year was calculated (**Figure 3**). Structure of non-complaint production of plates according to method of dealing with non-compliant production of plates was analyzed (**Figure 4**).

Average percentage of non-compliant production of total production during investigated year was at the level of 1.4%. The highest percentage (**Figure 3**) was noticed in December (2.5), January (2%) and May (1.9%), while the lowest in April (0.5%), April (0.8%) and September (0.8%). About 42% of non-compliant production was regraded, 29% - repaired. Only 4.5% was scrapped.

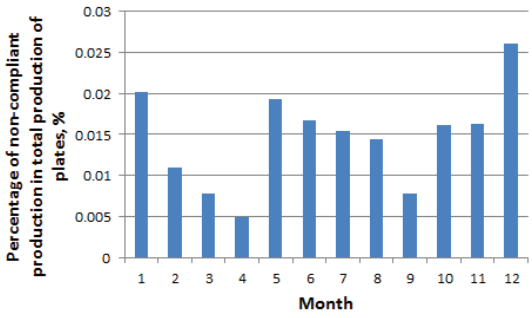

Figure 3 Percentage of non-compliant production in total production of plates,
[Own study based on: 6, 7]

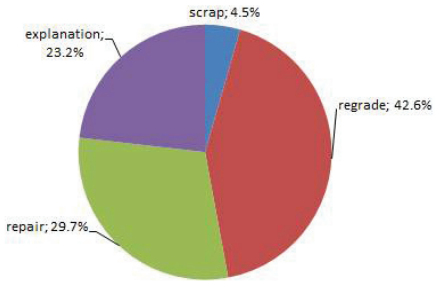

Figure 4 Structure of non-complaint production of plates according to method of dealing with of plates
[Own study based on: 6, 7]

3.2. Pareto chart of non-conformances of plates

Pareto chart s of non-conformances of plates was created. **Figure 5** shows Pareto chart of total non-conforming production of plates, while **Figures 6 - 9** show Pareto charts of non-conforming production depending on the method of treatment the products.

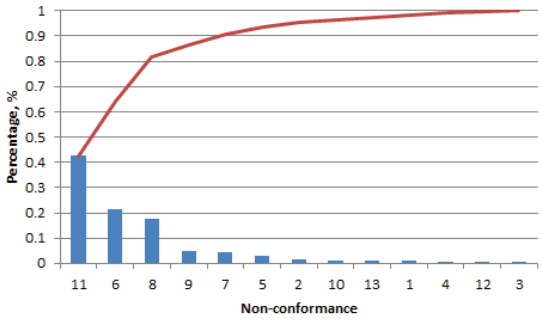

Figure 5 Pareto chart of total non-conforming production [Own study based on: 6, 7]

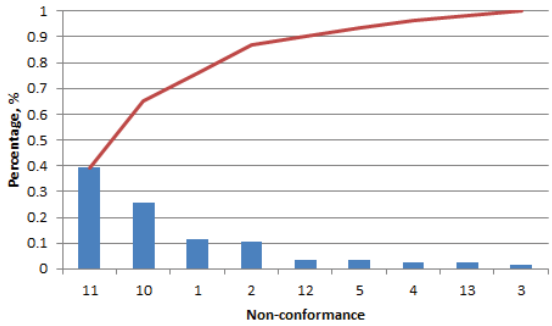

Figure 6 Pareto chart of non-conforming production directed to scrapping [Own study based on: 6, 7]

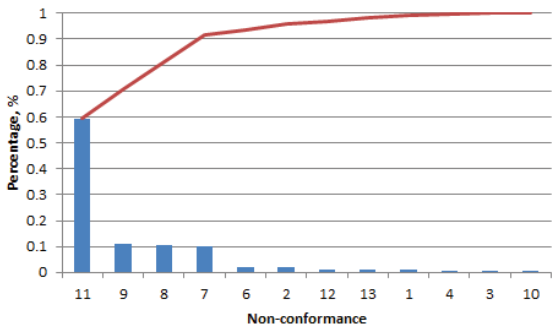

Figure 7 Pareto chart of non-conforming production directed to regrading [Own study based on: 6, 7]

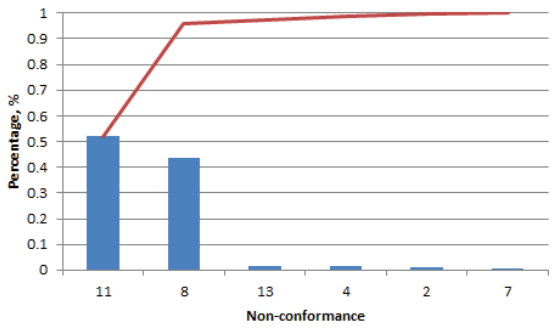

Figure 8 Pareto chart of non-conforming production directed to repairing [Own study based on: 6, 7]

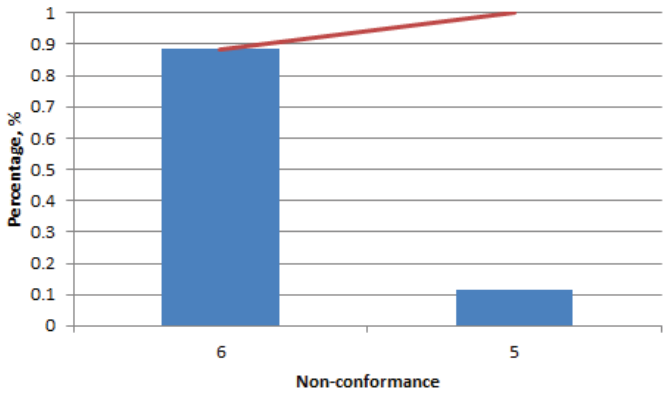

Figure 9 Pareto chart of non-conforming production directed to explanation [Own study based on: 6, 7]

The Pareto charts presented in **Figures 5 - 9** shows that:

- In total non-conforming production 3 non-conformances have significant importance: 11 (transverse cracks - from the top) - occurred in 42% of non-conforming products, 6 (discontinuity of material after manual testing) - 21% and 8 (cracks at the edge) - 17%. The rest 10 non-conformances occurred only in nearly 20% of non-conforming products.
- In non-conforming production directed to scrapping 2 non-conformances occurred most often: 11 - in 39% and 6 - in 25% of non-conforming production directed to scrapping.
- In non-conforming production directed to reparing 1 non-conformance occurred in nearly 60% of such production - 11.
- In non-conforming production directed to repairing 2 non-conformances were discovered in over 95% of such products: 11 - in 52% and 8 - in 43%.
- Non-conforming production directed to explanation was connected with only two non-conformances, in most of non-conforming products defect 6 (in 88%) was discovered.

3.3. The analysis of causes of non-conformances

The analysis of causes of non-conformances was made. This analysis was based on the rules of Ishikawa diagram. All causes were divided into 5 groups connected with classic division of causes of Ishikawa analysis: M1 - machine, M2 - material, M3 - man, M4 - management, M5 - method. The results of the analysis were presented in **Figure 10**. Based on the results of the analysis it can be concluded that main reasons of occurrence of most crucial non-conformances are mainly: material (28%) and machine (27.5%).

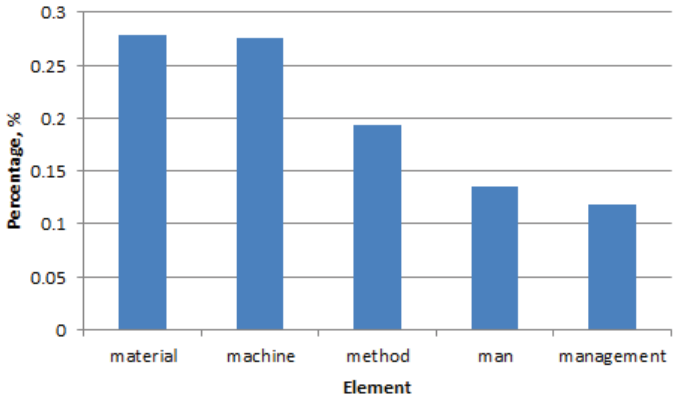

Figure 10 Percentage of non-compliant production of plates according to causes of their appearance [Own study based on: 6, 7]

3.4. The analysis of the causes and effects of non-conformances using FMEA

The analysis of the causes and effects of nonconformance using FMEA was done. For all non-conformances effects, causes, applied control methods and recommended corrective measures were defined. Also analysis indicators were calculated: Z - importance for customers, R - probability of occurrence, W - detectability. All indicators take values from the range 1-10. Also risk priority number (WPR) was calculated as product of indicators: Z, R and W. Results of the analysis are presented in **Table 1**.

Table 1 FMEA analysis of non-complaint production of plates [Own study based on: 6, 7]

No	Effects, defects, limitations	Causes	Applied control methods	Z	W	R	WPR	Recommended corrective measures
1	Improperly selected material, outdated mechanism	M1, M2	Visual control of surface, process parameters measurement	3	6	3	54	Additional control, new work station for one activity and related, additional employee training
2	Improperly selected material, outdated mechanism	M1, M2	Band measurement, process parameters measurement	3	5	2	30	Additional control, new work station for one activity and related
3	Outdated mechanism	M1, M2, M5	Visual control of surface, measurement of plate dimensions	3	9	2	54	Additional control, additional employee training
4	Outdated mechanism	M1, M2, M5	Visual cotrol of surface, measurement of plate dimensions	3	7	2	42	Additional control of machinery and equipment work
5	Unfulfilled parameters	M1, M2	Control of test results, manual testing of plate surface - examination of external quality of plates	5	6	2	60	Additional control, new work station for one activity and related
6	Improperly selected material	M1, M2, M3, M5	Manual testing of plate surface - examination of external quality of plates	3	3	7	63	Additional control of machinery and equipment work
7	Improperly selected material	M1, M2, M3, M5	Visual control of surface - surface condition, accuracy, marking	6	5	5	**150**	Additional control, additional control of machinery and equipment work
8	Improperly selected material	M1, M2, M3	Process parameters measurement, visual control of surface - surface condition	4	4	6	**96**	Additional control, additional control of machinery and equipment work
9	Mechanical damage	M1, M2, M3, M4, M5	Process parameters measurement, visual control of surface - surface condition	4	4	6	**96**	Additional control, additional control of machinery and equipment work
10	Mechanical damage	M1, M2, M5	Process parameters measurement, visual control of surface - surface condition	2	5	4	40	Additional employee training
11	Unfulfilled minimum requirement of product	M1, M2, M4, M5	Manual testing of plate surface	9	2	9	**162**	Additional employee training
12	Unfulfilled minimum requirement of product	M2, M5	Measuring of dimensions of plates, control of test results	2	8	2	32	Additional control, additional control of machinery and equipment work
13	Unfulfilled minimum requirement of product	M1, M2, M3, M4, M5	Manual testing of plate surface, automatic testing of surface and edge of plates - examination of external quality of plates	3	5	3	45	Additional control, additional employee training, additional control of machinery and equipment work

Based on results of the FMEA analysis (**Table 1**) it can be said that two non-conformances should be regarded as critical, because their WPR is higher than 100: 11 (transverse cracks - from the top) and 7 (short after cutting defects of material). Vales of two other non-conformances are also alarming: 8 (cracks at the edge) and 9 (narrow after cutting defects of material). Causes of these four non-conformances should be eliminated first.

4. CONCLUSION

The evaluation of quality of products using selected quality instruments was the main purpose of this paper. The analysis of non-conformances of metal plates is presented. Based on the results shown in the paper it can be concluded that production of plates depends on the level of orders from customers and 42% of production were plates with thickness of 12-20 mm. Average percentage of non-conforming production during investigated year was at the level of 1.4% of total production. Only in 2 months level of 2% of non-conforming production was exceeded. 42% of non-conforming production was regraded and 29% - repaired.

Pareto chart shows that 3 non-conformances occurred the most frequently: traverse cracks from the top, discontinuity of material after manual testing and cracks at the edge. Furthermore, products with traverse cracks from the top were scrapped, regraded or repaired, while products with discontinuity of material after manual testing were directed to explanation.

Main reasons of occurrence of non-conforming products were material and machines. They caused occurring about 50% of total non-conforming production.

FMEA analysis confirmed that the most critical non-conformance was transverse cracks - from the top.

Based on this results it can be said that in order to improve the quality of finished products, the following actions should be introduced:

- first, actions connected with changes of supplied material
- take the attempt to modernize machinery and equipment.

REFERENCES

[1] HAMROL A., MANTURA W. Quality analysis. Theory and practice. PWN, Warsaw 2009.

[2] SALACINSKI T. SPC - statistical process control of production. Publishing House of Warsaw University of Technology, Warszawa 2009.

[3] KADŁUBEK M., INGALDI M., Evaluation of the Strategic Position of the Company of the Metallurgical Industry by SWOT Analysis, In Metal 2016, 25th Anniversary International Conference on Metallurgy and Materials, Ostrava: TANGER, 2016, pp. 1844-1850

[4] INGALDI, M.; DZIUBA, S.T. ; KADLUBEK, M., Integrated management systems as an element of globalization in production management, 16th International Scientific Conference on Globalization and its Socio-Economic Consequences, Rajecke Teplice, SLOVAKIA 2016, Globalization And Its Socio-Economic Consequences, 16th International Scientific Conference Proceedings, PTS I-V, pp. 750-758

[5] CZAJKOWSKA A., Identification and analysis of non-conformities in production of construction materials with the example of hot-rolled sheet metal, , In Metal 2015, 24th International Conference on Metallurgy and Materials, Ostrava: TANGER, 2015, pp. 1878-1833

[6] Information materials from Company X.

[7] POSYLEK N. Evaluation of functioning of quality management system in selected research object, Master work under the direction of Edyta Kardas, Czestochowa University of Technology, Czestochowa 2016.