Quality analysis of plates for car industry

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Abstract. In 2013, global steel production reached a level of 1.548 million tons. This value indicates that, in the 21st century, steel is still one of the most popular construction materials. In Poland 8.2 million tons of steel was produced in 2013. A large share of steel is used for the production of hot-rolled plates for car bodies. Steel products made in high temperature processes are used in virtually all sectors of industries. The hot-rolled plates for car bodies should comply with the highest quality requirements. In this chapter the results of research from the 3-month follow-up are presented. To assess the level of non-conformity in hot-rolled plates the Pareto-Lorenz diagram was used. The results are the basis for the improvement of the production process of hot-rolled products.

Key words – hot-rolled products, Pareto-Lorenz diagram, steel company, TQM

1. Introduction

Quality is a concept with a philosophical grounding. Plato said: 'quality - (gr. poiotes, łac. qualitas) is a certain level of perfection'. According to the standard PN-EN ISO 2000:2006, quality is defined as: 'the degree to which a set of inherent characteristics fulfils requirements'. The quality level of hot-rolled products depends on: wrong thickness, mechanical damage, shell.

Polish Standard PN-EN ISO 9000:2006 defines nonconformities as non-fulfilment of a requirement (PN-EN ISO 9000:2006).

For car companies the quality of products is crucial because it is one of the main factors influencing the degree of customer satisfaction. To meet the expectations of customers car companies should look for new methods of improving quality. In order to apply appropriate improvement tools, it is necessary to identify non-conformities that affect the quality of the product.

2. Experiment

The assessment of the quality of the hot-rolled plates was carried out in a hot mill in Poland. The observation period was one calendar year. During the 3-month study period, data was collected on any emerging non-conformities and their quantitative presence. Research was carried out for one grade of steel. The steel used for production of the plates belongs to a group of structural steels for cold forming. The investigation was carried out on S260NC steel. Chemical composition of the steel investigated is given in Table 1 (PN-EN 10149-3:2000, DOBRZAŃSKI L. 2012).

Table 1. Chemical composition of steel S260NC [%]

STEEL GRADE	C	Mn	Si	P
S260NC	0.16	1.2	0.5	0.025
	S	Nb	V	Ti
	0.02	0.09	0.1	0.15

3. Analysis of non-conformities during the hot-rolled plates production process

For the assessment of non-conformities in hot-rolled plates the Pareto-Lorenz diagram was used.

Pareto-Lorenz diagram is one of the seven basic tools of quality management. It is based on an established empirical regularity that in nature, technology and human activity, usually 20÷30% of the causes decided by about 70÷80% impact (BORKOWSKI S. 2004). Pareto - Lorenz can be used to present all phenomena and relationships that can be presented numerically and make a percentage. It sets out to give validity to factors causing the problem (BORKOWSKI S. 2004, BORKOWSKI S., ULEWICZ R. 2003, ULEWICZ R. 2009).

The non-conformities discovered during the research are presented in the Table 2.

Table 2. Types of nonconformities detected during of the hot-rolled plates production process

Symbol of non-conformities	Names of nonconformities
N1	Interruption of metal
N2	Other
N3	Bad thickness
N4	Pinchers
N5	Honeycomb blowholes
N6	Irregular dimensions
N7	Mechanical damages
N8	Overlap
N9	Shells
N10	Cockles (two sides)
N11	Cockles (one sides)
N12	Alligatoring

Table 3 shows the percentage share of non-conformities occurring during hot-rolled plate production processes in the first quarter of the year.

The data presented in Table 3 contains information about mass non-conforming plates (Mg), and the percentages of each non-conforming plates.

Based on data from Table 3 the Pareto-Lorenz diagram was constructed (Fig. 1).

It was found that in the first quarter year 7794.07 Mg of nonconforming products were produced.

Table 3. Percentage share of non-conformities occurring during the production of hot-rolled plates in the first quarter of the year

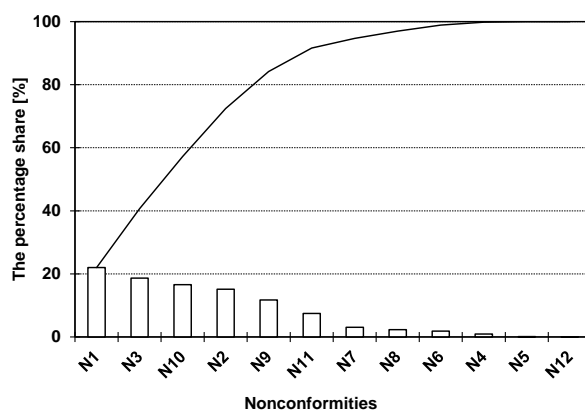| I QUARTER YEAR		
Symbol of non-conformities	Amount [Mg]	The percentage share [%]
N_1	1714.9	22.00
N_3	1456.7	18.69
N_{10}	1292.3	16.58
N_2	1181	15.15
N_9	914.7	11.74
N_{11}	579.9	7.44
N_7	240.7	3.09
N_8	180.7	2.32
N_6	146.7	1.88
N_4	73	0.94
N_5	11.1	0.14
N_{12}	2.36	0.03
Σ	7794.07	100

Fig. 1. The Pareto-Lorenz diagram for the nonconformities occurring during the production of hot-rolled plates 1ˢᵗ quarter of the year.

Source: own study

Based on the Table 3 and Figure 1, it could be stated that for over 57.27% of all detected non-conformities only 25% types of non-conformities were found.

57.27% of defects are connected with only three problems: interruption of metal, insufficient thickness and cockles (two sides) whereas the remaining types of defects are merely 42.73% in total of all defects.

Based on the test of results obtained, it was found that the most common causes that affect the nonconforming products are:

‒ Cockles (two sides) - srelated to a non-uniform deformation of the metal along the width during rolling. Local deformation causes a local elongation of the sheet. Wave is caused by excessive deflection rollers or badly matched by rolling method.

‒ Interruption of metal is due to poorly prepared ingot causing decrease in strength of sheet and its mechanical properties.

‒ Insufficient thickness is associated with bad calibration rollers.

4. Summary

This chapter presents the results of research carried out in the mill plates. The aim of the study was to determine the level of quality of hot-rolled plates for car bodies.

The global market requires manufacturers to deliver the highest quality products. Quality is a determinant of customer satisfaction. Steelworks in Poland produce about 8 million tons of steel per year of which 90% is used for the production of hot-rolled products.

The results obtained illustrate the main causes of non-conforming products. The rolling mill has significant problems with the quality of the product. The total mass of non-conforming products amounted to 7794 tons. The analysis of 10 studies detected nonconformities. The greatest losses generate three problems: Interruption of metal, cockles (two sides) and bad thickness.

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