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THE ANALYSIS AND CONTROL OF THE NON-CONFORMANCES OF PRODUCTS MANUFACTURED IN A PLATE ROLLING MILL IN THE ASPECT OF QUALITY MANAGEMENT

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Nowadays, when the most important condition for the survival and development of a company is to satisfy the varying expectations of customers, quality starts to be an important element of the strategy of each firm, which wants to achieve the success. Presently, the Polish steel industry is on the stage of stagnation, so the improvement of the quality management system in the activity of metallurgical companies can be an important factor for making this situation better. However, it must be remembered that the elimination of non-conformances and their sources as early as in the manufacturing process is a very important step to obtaining „high" quality products. Within the study described in this article, an analysis of the non-conformances of products manufactured in the Plate Rolling Mill of one of the largest steelworks in Poland was carried out for the period from January, 1999 until March 2000.

Key words: *quality, quality management, non - conformances, plates, rolling*

Analiza i kontrola neujednačenosti proizvoda valjaonice debelog lima s aspekta reguliranja kvalitete. Danas, kad je za preživljavanje tvrtki najvažnije da zadovolje promjenljiva očekivanja kupaca, kakvoća postaje važan strateški element svake tvrtke koja želi biti uspješna. Trenutno Poljska industrija čelika stagnira. Stoga za promjenu takve situacije važnu ulogu može odigrati unapređivanje sustava regulacije kakvoće. Međutim, ne smije se zaboraviti da je uklanjanje neujednačenosti proizvoda još u tijeku proizvodnje vrlo važan korak prema postizanju "visoke" kakvoće proizvoda. U okviru studije opisane u ovom članku provedena je analiza neujednačenosti proizvoda u valjaonici debelog lima u jednoj od najvećih čeličana u Poljskoj i to za period od siječnja 1999. do ožujka 2000.

Ključne riječi: *kvaliteta, upravljanje kvalitetom, neujednačenost, limovi, valjanje*

INTRODUCTION

Changes in the Polish economy that took place after 1989 have enabled the development of new economic ideas. The old way of thinking, which had resulted in Poland's backwardness in relation to highly developed countries were rejected.

Striving for cooperation with European Union countries begun. These changes have compelled Polish enterprises to improve the quality of their products.

An important factor of activity in those enterprises has been a Quality Control System. Very important elements of a Quality Control System in an enterprise are inspection and testing [1]. These enable product non-conformances to be disclosed in all production phases, starting from incoming raw materials through to final inspections and tests prior to the delivery to the finished-product storage. The disclosure of non-conformances in an enterprise during the production process rather than by the customer permits a reduction of additional costs associated with product complaints [2].

The article discusses the results of the analysis of non-conformances occurring in the production process of plates manufactured in the Plate Rolling Mill of one of the steelworks of southern Poland. Investigations were carried out since January 1999 until the end of March, 2000. An appropriate classification of non-conformances enabled a more complete analysis of the acquired results to be performed [3].

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CLASSIFICATION OF OCCURRING NON-CONFORMANCES

According to the standard, a non-conformance is a failure to satisfy specific requirements [4]. In the case of the products under study, a non-conformance means a failure to meet requirements for the physico-chemical, mechanical and dimensional characteristics of the product.

The analysis of non-conformances was performed by using data derived from the production of plates. The general classification of non-conformances is based on the location, where they have been found [5]. Non-conformances disclosed during the production process and their classification are shown in Figure 1.

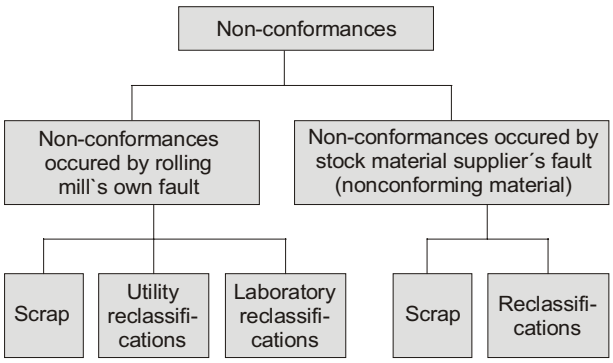

Figure 1. **Classification of non-conformances occurring in the products of the Plate Rolling Mill**
Slika 1. **Klasifikacija pojava neujednačenosti proizvoda valjaonice debelog lima**

At the same time, percentage shares of particular non-conformance types have been calculated, in relation to the amount of the raw material supplied. Items 1 - 3 apply to non-conformances detected in the finished product, whereas items 4 and 5 refer to non-conformances disclosed in the raw material delivered to the Rolling Mill. The results are summarized in Table 1.

Table 1. **Shares of particular types of non-conformances found during the period studied, in relation to the amount of the raw material delivered**
Tablica 1. **Udio posebnih neujednačenosti ustanovljenih tijekom perioda proučavanja u odnosu na količinu isporučene sirovine**

L. p.	Non - conformance type	Share of non-conformance [%]
1	Utility reclassifications in the Rolling Mill	1.20
2	Laboratory reclassifications in the Rolling Mill	0.37
3	Scrapping in the Rolling Mill	0.11
4	Raw-material reclassification	1.18
5	Raw-material scrapping	1.29
	Total	4.15

It has been found from the performed analysis of particular types of non-conformances that the greatest number of non-conformances occurs in the raw material supplied for production (Items 4 and 5). The share of these non-conformances is 2.47 %, while as much as 1.29 % of the raw material delivered to the Rolling Mill is sent for scrapping.

NON-CONFORMANCES OCCURRED BY STOCK MATERIAL SUPPLIERS' FAULT

Non-conformances occurred by fault of stock material suppliers concern the material supplied for the rolling process. Due to its degree of non-conformance to the specified quality requirements, this material is sent, either to [6-9]:
- reclassification,
- scrapping.

The material used for the production of plates comes from three different sources:
1. external raw material supplied from another steelworks,
2. raw material coming from the steelworks' own electric furnace, and
3. raw material coming from the steelworks' own open-hearth furnace.

Table 2. **Amounts of material delivered from particular suppliers and the share of non-conformances in the total volume of delivery**
Tablica 2. **Količina materijala zaprimljena od posebnih dobavljača, udio neujednačenosti u ukopnom vremenu isporuke**

Supplier	Amount of delivery [t]	Amount of non-conformances to be reclassified [t]	Percentage share	Amount of non-conformances to be scrapped [t]	Percentage share	Total amount of non-conformances [t]	Percentage share
1	8785.2	20.26	0.23	54.1	0.61	74.36	0.84
2	519316.6	7063.1	1.36	8789.8	1.69	15852.9	3.05
3	249947.3	2032.7	0.81	1181.9	0.47	3214.6	1.28

Table 2. shows the amounts of raw material delivered by particular suppliers and the shares of non-conformances found in this material. The percentage share of non-conform-mances is related also to the quantity of material delivered by a supplier. Figure 2. illustrates percentage magnitudes of non-conformances, including a division into non-conformances intended to be reclassified and scrapped, respectively.

The most part of material nonconforming to the requirements came from the electric furnace which is situated in the enterprise studied. The least share of non-conformances was observed in material coming from the outside of the enterprise. Among the materials reclassified and sent to be scrapped, the following was recognized as the most frequent causes of their of their incorrectness:

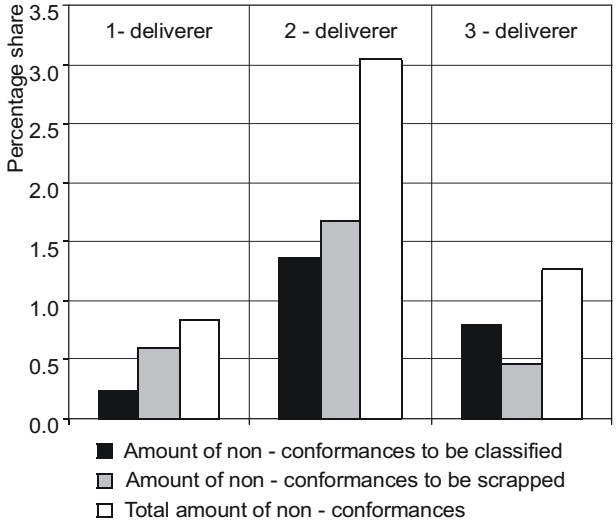

Figure 2. **Share of non-conformances occurred by stock material supplier's fault in relation to the amount of material delivered**
Slika 2. **Udio neujednačenosti zbog pogrešnog skladištenja materijala greškom dobavljača u odnosu na isporučenu količinu**

- scales of the surface - irregular metal surface layers, not bonded, or only partially bonded with the bulk of metal,
- surface cracks - material discontinuities with sharp edges, extending from the surface deep into the material,
- too short or narrow plates after a defect was cut out,
- material discontinuities disclosed during ultrasonic examination (internal material defects).

NON-CONFORMANCES OCCURRED BY THE ROLLING MILL'S OWN FAULT

Non-conformances occurred by the Rolling Mill's own fault are those occurred during the rolling process. These are detected as a result of inspection and set aside for, either:

- utility reclassifications - plates for reworking or to other orders,
- laboratory reclassifications - reclassifying plate into a different grade to be sent to a different customer or a different order;
- scrapping - plates are burnt and sent to remelting.

Table 3. **Classification and shares of non-conformances in respective quarters of the period under study**
Tablica 3. **Klasifikacija i udio odstupanja u odgovarajućim kvartalima proučavanog perioda**

Type of nonconforming product handling	utility reclassification	laboratory reclassification	scrapping
Quarter I 1999	1.20	0.32	0.12
Quarter II 1999	1.18	0.40	0.12
Quarter III 1999	2.21	0.08	0.09
Quarter IV 1999	1.23	0.30	0.09
Quarter I 2000	0.43	0.10	0.12
TOTAL	1.20	0.36	0.11

Table 3. summarizes the shares of particular groups of non-conformances, as divided into respective quarters of the period studied.

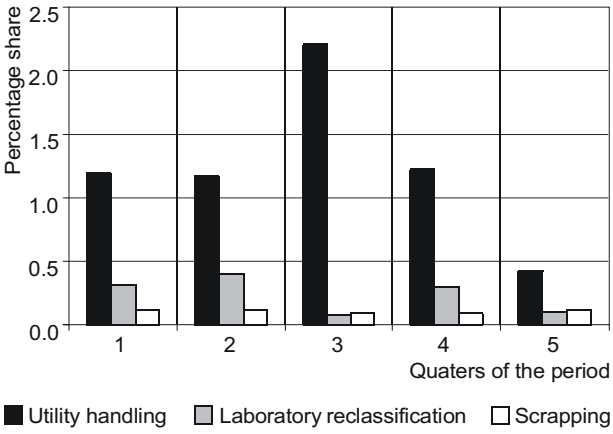

Figure 3. **Non-conformances occurred in the Plate Rolling Mill - Percentage shares**
Slika 3. **Neujednačenosti nastale u valjaonici debelog lima - udio izražen postotkom**

It was found from the analysis (Table 3., Figure 3.) that non-conformances designed for utility reclassifications constituted the greatest share. Within the entire period considered, this share was 1.2%. Most non-conformances occurred in Quarter III, 1999. The cause of the most part of non-conformances could be a personnel shortage due to the vacation period.

Non-conformances found in products that were designed for utility reclassifications include:

1. mechanical damage,
2. both-side wavy and not straight plates,
3. one-side wavy and falcate plates,
4. either too narrow or too wide plates - incorrect dimension: width,
5. either too short of too long plates - incorrect dimension: length,
6. incorrect thickness,
7. pits + dents + scratches,
8. cuts,
9. jagged edges,
10. others.

The results of the analysis of this group of non-conformances are shown in Figure 4.

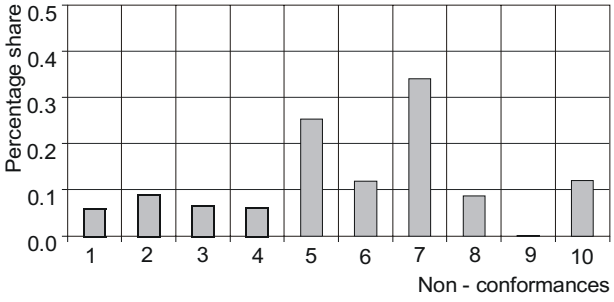

Figure 4. **Amounts of particular types of non-conformances designed for utility reclassifications during the period under study**
Slika 4. **Količina posebnih neujednačenosti planiranih za reklasifikaciju korisnosti tijekom perioda proučavanja**

The most frequently occurred defects of plates examined included pits, dents and scratches (defect no. 7). Dents occurred in the form of either depressions or bosses on the plate surface. Most frequently, they were mappings of the roll surfaces, or imbedded foreign materials or indentations left by them. Scratches are surface defects occurred as a result of plate contacting with rolling and conveying equipment.

The second most frequent defect of plates examined was their incorrect length - either too long or too short plates (defect no. 5). Incorrect length means exceeding the permissible difference between the plate length measured in any location on the plate width and the nominal length.

Jointly, both types of non-conformances accounted for almost 50 % all non-conformances in the examined group of utility reclassifications.

The laboratory reclassification group encompassed plates with incorrect mechanical properties. These non-conformances include:

1. non-conformances to the internal specifications,
2. other causes.

The results of the analysis of laboratory reclassifications are shown in Figure 5.

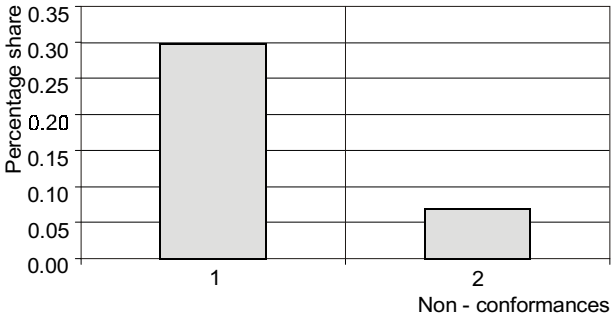

Figure 5. **Amounts of particular types of non-conformances designed for laboratory reclassifications in the period under study**
Slika 5. **Količina posebnih neujednačenosti planiranih za laboratorijsku preklasifikaciju tijekom perioda proučavanja**

Due to non-conformances occurring in this group being treated too generally, only non-conformances related to internal specifications could be subjected to analysis. These concerned material strength not conforming to the values of strength indices provided in specifications.

For scrapping, those plates were designed, which were unsuitable for use because of their high defectiveness. The following were distinguished in this group:

1. incompletely rolled plated,
2. indents,
3. folded plates,
4. others.

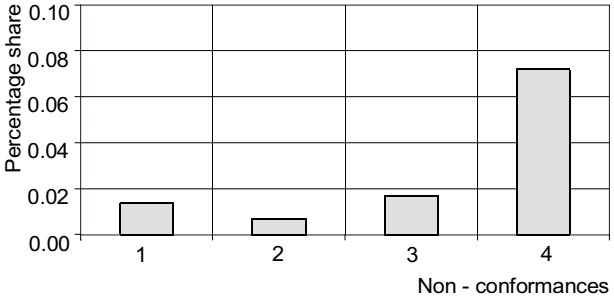

Figure 6. **Amounts of particular types of non-conformances designed for scrapping in the period under study**
Slika 6. **Količina posebnih neujednačenosti određenih za otpad tijekom proučavanja**

Figure 6. shows the shares of particular types of non-conformances designed to be scrapped.

Plates designed to be crapped are irreparable plates, the defectiveness of which makes their reworking either technically not feasible or economically unjustifiable. They are directed to the steelmaking plant as a charge material.

Table 4. and Figure 7. show the overall share of all non-conformances in respective quarters of the period under study and, for comparison, the average share of non-conformances in this period.

The figure shown above indicates that much more non-conformances occurred in Quarter III of the year 1999. However, this situation considerably improved - a substantial decrease in the share of non-conformances was observed in Quarter I of 2000. Supposedly, such a large amount of non-conformances was caused by a vacation period in Poland.

Table 4. **Overall share of non-conformances in respective quarters of the period under study**
Tablica 4. **Ukupni udio neujednačenosti u odgovarajućim kvartalima tijekom studija**

Period	Overall amount of nonconformances
Quarter I 1999	4.98
Quarter II 1999	4.68
Quarter III 1999	6.29
Quarter IV 1999	4.13
Quarter I 2000	1.41
Average share	4.15

The present situation of the enterprise should motivate it for a further, continuous improvement of quality in the Plate Department. This will help the enterprise to create its proper mark and acquire new customers to increase the profit.

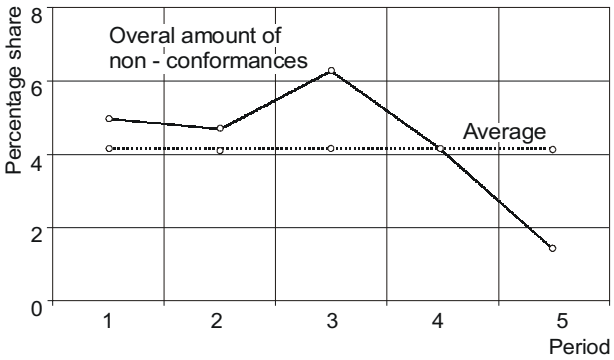

Figure 7. **Overall amount of non-conformances in particular periods examined, compared to the average amount of non-conformances in the whole period under study**

Slika 7. **Ukupna količina neujednačenosti ispitana u posebnim vremenskim periodima i uspoređena s prosječnom količinom neujednačenosti tijekom cijelog vremena proučavanja**

SUMMARY AND CONCLUSIONS

A quantitative analysis of non-conformances disclosed in the production process during the period from January 1st, 1999 to March 31st, 2000 was carried out within the study described in this article. It can be concluded from this analysis that:

- the largest share of non-conformances found in the Steelmaking Plant falls to non-conformances in the raw material supplied to production,

- most of nonconforming material originated from the electric furnace existing in the enterprise studied. The least share of non-conformances was noted for material derived from the outside of the enterprise,

- the largest share of non-conformances occurred by the Steelmaking Plant's own fault was constituted by non-conformances designed for utility reclassifications,

- in total, non-conformances in the form of pits, dents, scratches and incorrect length accounted for nearly 50% of all non-conformances in the group of utility reclassifications,

- the main reason for laboratory reclassifications were non-conformances to the internal specifications, related to strength indices.

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