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QUALITY CONTROL SYSTEM IN PRODUCTION OF THE CASTINGS FROM SPHEROID CAST IRON

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In work opinions of form incompatibility were executed during process of production of casting articles from spheroidal cast iron. Using the quality tools such as the Ishikawa diagram and the Pareto-Lorenz analyses one identified often-appeared defects and, were identified and qualified. Identification of critical points of productive system was executed and the range of correcting workings was qualified. On basis of data from analysis of causes of occurrence of incompatibilities and appointed critical points system of control of quality was worked out for serial and isolated production. Use of statistical method of casts in connection with active control of quality and selection of productive stages for serial production of casts from spheroid cast iron caused lower level of defects, and in economic aspect contributed to the reduction of costs of connected production with low level of quality.

Key words: *cast iron, founding, control, quality control*

Sustav kontrole kvalitete u proizvodnji ljeva od sferoidnog lijevanog željeza. U pogonu su ispitivane varijante kompatibilnosti oblika tijekom procesa proizvodnje lijevanih predmeta iz sferoidnog lijevanog željeza. Uporabom kvalitetnih metoda kao što su Ishikawin dijagram i Pierto-Lorenzova analiza utvrđene su i opisane najčešće greške. Na osnovu podataka dobivenih analizom izvršena je identifikacija kritičnih točaka u proizvodnom sistemu i određene radnje za ispravljanje grešaka. Temeljem podataka dobivenih analizom uzroka pojava inkompatibilnosti i istaknutih točaka razrađen je sustav kontrole za serijsku i pojedinačnu proizvodnju. Uporaba statističke metode praćenja talina, zajedno s aktivnom kontrolom kvalitete i odabirom proizvodnih faza za serijsku i pojedinačnu proizvodnju talina iz lijevanog željeza, smanjuje broj grešaka te s ekonomskog aspekta doprinosi nižim troškovima.

Ključne riječi: *lijevano željezo, taljenje, kontrola, kontrola kvalitete*

INTRODUCTION

Steelworks rolls belong to the elements working in very heavy-duty conditions. Additionally, a strong competition upon the market results in the fact that the quality is the main advantage in winning new sales markets. Any negligence at the successive stages of production affects the quality of the final product.

Therefore, a strong emphasis should be put on the control of the whole process, beginning with the control of the input of raw materials, through the control of the material melting, up to the control of the finishing processing of rolls. Attention should be paid to the fact that the production of steelworks rolls is, principally, of a unit nature, especially in the case of rolls weighing several tons. It is difficult to control the stability of the process. What counts the most is above all the experience and high involvement of workers at each working stand.

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THE PARETO-LORENZO ANALYSIS

The Pareto-Lorenzo analysis [1] is perfectly apt to systemize the data coming from all the stages of roll production. Thanks to the identification of threats corrective actions can be taken aimed at counter-acting negative most often occurring phenomena and the phenomena that increase production costs [2].

The analysis covered the data coming from the production cycle of two types of rolls, from two successive years:
- the first group: ferric spheroidal cast iron alloy rolls weighing up to 1 000 kg,
- the second group: spheroid alloy ferric rolls weighing up to 8 000 kg.

The analysis of these data indicated that the most often occurring product defect in both of these groups of rolls are bubbles at the barrel surface. This problem constitutes about 75.4 % of all defects found out. The other source of defects was an inadequate hardness at the barrel surface, which was 13.2 %. Exemplary values and percentage distributions of defects are illustrated at Table 1. Based on the diagram (Figure 1.), it could be stated that for over 88 % of all detected defects are responsible only 33 % types of defects. 88 % of defects are connected with only two problems: bubbles and inadequate hardness at the barrel surface, whereas the remaining types of defects are merely 12 % in total of all defect.

Table 1. **Reasons and numbers of defect for cast iron rolls up to 1000 kg**
Tablica 1. **Uzroci nastanka grešaka i njihov broj - za valjke od lijevanog željeza mase do 1000 kg**

No.	Defect	Number Defect	%	Cumulated Number Defect	Cumulated %
1	Bubbles at the barrel surface	126	75.4	126	75.4
2	Inadequate hardness at the barrel surface	22	13.2	148	88.6
3	Breaks at the barrel surface	10	6.0	158	94.6
4	Bubbles at the upper pin	4	2.4	162	97.0
5	Corosion at pins	3	1.8	165	98.8
6	Breach of overall dimensions	2	1.2	167	100.0

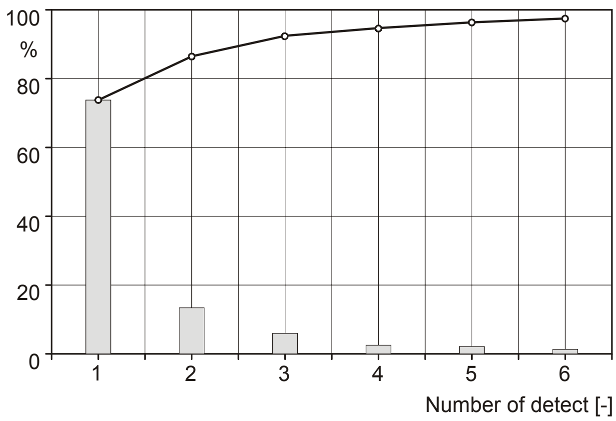

Figure 1. **The Pareto-Lorenzo Diagram for cast irin rolls up to 1000 kg**
Slika 1. **Pareto-Lorencov dijagram za valjke od lijevanog željeza mase do 1000 kg**

ISHIKAWA DIAGRAM

Having conducted the Pareto-Lorenzo analysis for the two types of rolls: the big ones weighing 1 000 kg and the small ones weighing 8 000 kg, the problem was identified, breaks and holes on the barrel. In constructing the Ishikawa Diagram the modified 5M principle [3] was used, the organization-management structure was not taken into account, and the group "Man" was divided into two sub-groups: "Man-User" and "Man-Producer". The results of the analysis of the occurrences of breaks and holes is presented at Figure 2. While analyzing the pieces of information gathered upon the basis of the Ishikawa diagram the sources of defect were asserted. Also, the frequencies of occurrences of all defects were defined, and places where they occurred were identified. Special attention was paid to the contents of oxides within the material used in the production cycle, delivered by suppliers. Based on the information communicated by direct production workers and technical inspection employees, the sources of occurrences of non-conformances at the stages of production and usage of the finished product were identified. Analyzing the reasons of the occurrences of defects at the foundry, it was found out which ones occurred most frequently, and the main sources of defects were identified at the electric furnace molding unit. After the analysis, immediate corrective actions were taken, i. e. a new operational chart for the molding unit was prepared, which was instructed to be implemented within a month. The diagram drawn up was distributed among all the cells responsible for quality in the roll casting process.

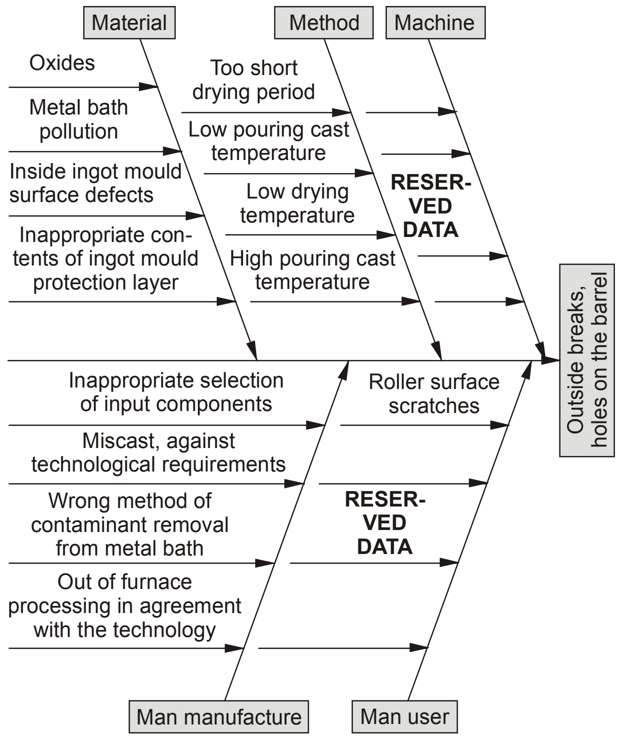

Figure 2. **Ishikaw´s alloy spheroid roller breaks and holes diagram on the barrel**
Slika 2. **Ishikawin dijagram lomova za legirane sferoidne valjke**

MACHINE TOOL QUALITY PERFORMANCE FACTOR DEFINITION

Also, the universal machine tool quality capacity index was calculated, using the data for 710 mm and ∅ 325 mm rolls measured in the quality management department

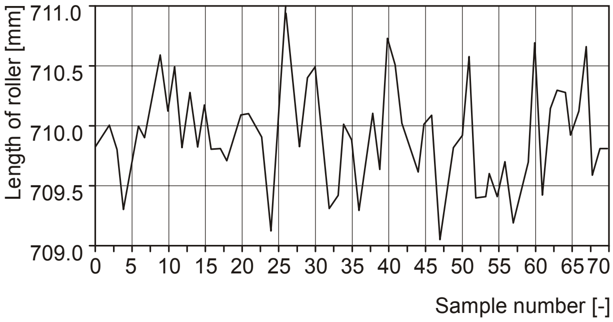

Figure 3. **Measurement data for a roller of nominal length of 710 mm**
Slika 3. **Mjerni podaci za valjak nominalne dužine od 710 mm**

after turning at a universal turning lathe. Rolls size data are visualized in Figure 3., whereas the probability of the occurrence of a particular size are presented in Figure 4. Based on the data, C_{m_1} (for dimension 710 mm), and C_{m_2}

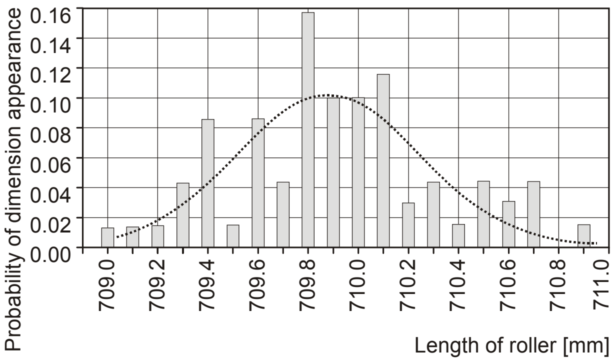

Figure 4. **Measurement distribution probability for a roller of nominal length of 710 mm**
Slika 4. **Mjerenje vjerojatnosti raspoređivanja na valjku nominalne dužine 710 mm**

(for ∅ 350 mm) the quality performance factors for a multipurpose machine tool were defined, according to the following formula:

$$C_m = \frac{B - A}{6\sigma} \geq 1.33 \qquad (1)$$

where

A - lower limit,
B - upper limit,
σ - standard deviation,
B - A = 2, for the measurement of 710 mm,
B - A = 3, for ∅ 325 mm.

Thus, quality performance factor for C_m for the measurement 710 mm is C_{m_1} = 0.802, for the ∅ 325 C_{m_2} = 0.846.

CONCLUSION

Analyses of quality capacity of the universal machine tools indicated that they were quality capable. Conditionally, the coefficient C_m = 1.00 may be accepted, while in our work it did not exceed the value of 0.9. Calculation data were collected for the period of two years. Thanks to the application of the Pareto-Lorenzo Analysis, the most significant sources of defects were identified [5]. For 1 000 kg cast iron rolls it was established that important non-conformances were bubbles and inadequate hardness at the barrel surface, whereas for 8 000 kg rolls breaks and inadequate hardness at the barrel surface. Eliminating the sources which were identified and systemized into source groups using the Ishikawa diagram 80 % reduction in the occurrence of non-conformances was achieved in the technological process of the production of rolls. An active quality management was introduced as well as more stringent statistical control of the product acceptance between the particular technological operations. This resulted in an implementation of a process attitude in the production management. Comparative analysis for the last quarter of the years 2000 and 2001 indicated a 74 % reduction in defect products (outside breaks, holes on the barrel).

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