Metrologia
Fortaleza - CE 2017

Monitoramento da qualidade do ensaio de dureza Rockwell C através de cartas de controle

Monitoring the quality of the Rockwell C hardness test through control charts

Lisiane Trevisan[1], Daniel Antonio Kapper Fabricio[2], Afonso Reguly[3]

[1] Instituto Federal do Rio Grande do Sul – Campus Farroupilha; [2] Instituto Federal de Santa Catarina – Campus Chapecó; [3] Universidade Federal do Rio Grande do Sul

E-mail: lisiane.trevisan@farroupilha.ifrs.edu.br

Resumo: O ensaio de dureza Rockwell C é um ensaio mecânico amplamente utilizado na indústria. Recomenda-se que o equipamento utilizado no ensaio de dureza seja verificado anteriormente a cada ensaio. Este trabalho tem como objetivo demonstrar o uso de cartas de controle em medições de dureza realizadas com um padrão de verificação com 65 HRC ao longo dos anos de 2011 a 2016. Os resultados evidenciaram a importância do uso de cartas de controle no monitoramento da qualidade de ensaios, mostrando a existência de alguns pontos fora dos limites de controle, o que exigem ações por parte do sistema de qualidade.

Palavras-chave: Ensaio de dureza, Rockwell C, Cartas de controle, Garantia da qualidade.

Abstract: The Rockwell hardness test is a mechanical test widely used in industry, and the verification of test equipment prior to each hardness test is recommended. This study aims to demonstrate the use of control charts in hardness measurements performed with a 65 HRC standard between the years 2011 and 2016. The results have demonstrated the importance of the use of control charts in the quality assurance of hardness testing. Some observations in the control charts were outside the control limits, which requires actions in order to improve the quality management system.

Keywords: Hardness test, Rockwell C, Control charts, Quality assurance.

1. INTRODUCTION

Rockwell hardness is one of the hardness scales most widely spread, due to its facility of implementation. The Rockwell hardness test begins in the selection of an indenter, depending on the scale used, and the load to be applied to the specimen surface. The read value depends on the depth of the indentation performed by the indenter [1].

The combination of different loads and penetrators allows the coverage of a wide range of hardness values, including the metallic materials mostly used in industry [2].

ISO/IEC 17025 standard stablishes the general requirements for technical competence in testing and calibration laboratories. One of the requirements is the quality assurance of results based on pre-stablished acceptance criteria [3-4].

Statistical process control (SPC) is a statistical technique applied to production that allows the systematic reduction of variability in the characteristics of the quality of interest, contributing to the improvement of the intrinsic quality, productivity, reliability and cost of whatever is being produced. SPC allows the monitoring of the characteristics of interest, ensuring that they will remain within pre-established limits and indicating when to take corrective and improvement actions [5].

Statistical control of variables is performed by monitoring two control charts simultaneously, considering that any special cause (an atypical event) may act by altering the central tendency or variability of the process. Thus, the X-bar chart is usually monitored to detect when the central tendency of the process changes, and the range chart is used to detect changes in process variability. The X-bar chart monitors the variability between the samples averages over time and the range chart monitors the variability within the samples, i.e., the variability over a given time period [5].

Each point outside the control limits should generate an analysis of the operational conditions in order to seek the respective cause. From the statistical results an analysis should be performed, considering the process itself and the people involved [5].

In some situations, it is necessary to control the process using individual values rather than averages of the measurement quantities. In such cases, a moving range (calculated as a difference between each pair of successive values) is used. Thus, the sample size is considered, in such cases, as n = 2 [5].

Therefore, this work aims to present the application of control charts for individual values and for moving range in the Rockwell C hardness test, in order to monitor the quality of this mechanical test.

2. METHODS

This work was based on data obtained from the periodic measurement of Rockwell C hardness standards in a mechanical testing laboratory accredited according to ISO/IEC 17025:2005 requirements.

The verification standard used in this work has a specified value of 65 HRC, which was verified in a durometer periodically between the years 2011 and 2016. A total of 59 measurements was performed. The analyzed equipment has a capacity of 100 HRC / 150 kg and a resolution of 0.2 mm, and it is calibrated annually according to ISO 6508-2 [6].

The control limits for the individual values chart were calculated according to Table 1.

Table 1. Control limits in individuals charts [5].

Control chart	Control limit
Moving range	$UCL = D_4$
	$LCL = D_3R$
Individual values	$UCL = X + E_2R$
	$LCL = X - E_2R$

Were D_4, D_3 e E_2 are tabulated constants that depend on the sample size (in the case of individual charts, n = 2), X represents the average of the individual values and R the average moving range. UCL and LCL represent upper and lower control limits, respectively.

3. RESULTS AND DISCUSSION

Table 2 shows the parameters of the range and individual values control charts.

Table 2. Control charts parameters.

Parameter	Value	Unit
Sample size	2	-
Average (X)	65.31	HRC
Average moving range (R)	1.02	HRC
D_4 (n=2)	3.27	-
D_3 (n=2)	0.00	-
E_2 (n=2)	2.66	-
Range UCL	3.32	HRC
Range LCL	0.00	HRC
Individual UCL	68.01	HRC
Individual LCL	62.60	HRC

From the parameters on Table 2 and from the hardness values obtained over time, the control charts were plotted. Figure 1 shows the control chart for individual values, and Figure 2 presents the control chart for moving range, along with their respective control limits. The points outside the control limits are highlighted.

In Figures 1 and 2, the measured values (observations) are presented along the horizontal axis. The solid green lines represent the upper and lower control limits (UCL and LCL). Three measured values (observations) were outside the control limits, evidencing the occurrence of special causes. The measured values outside the specification were, respectively, 61.90 HRC, 60.00 HRC and 68.00 HRC.

Figure 1. Control chart for individual values.

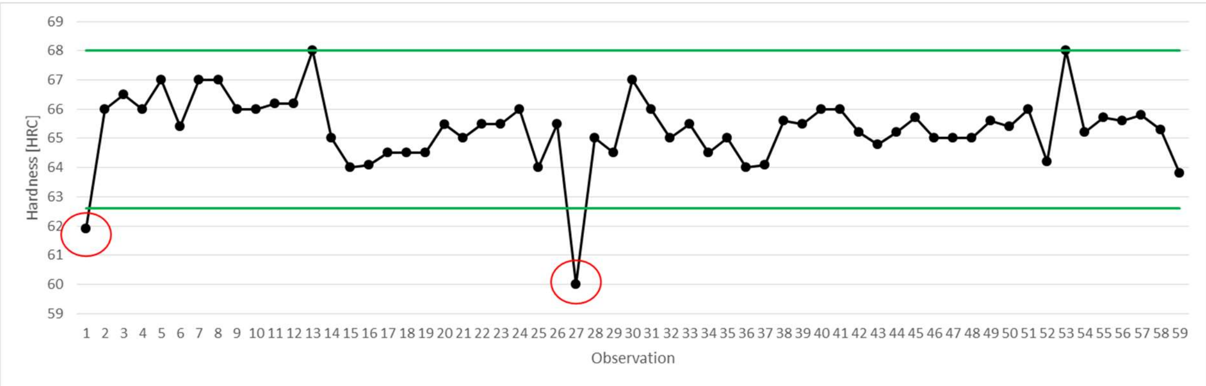
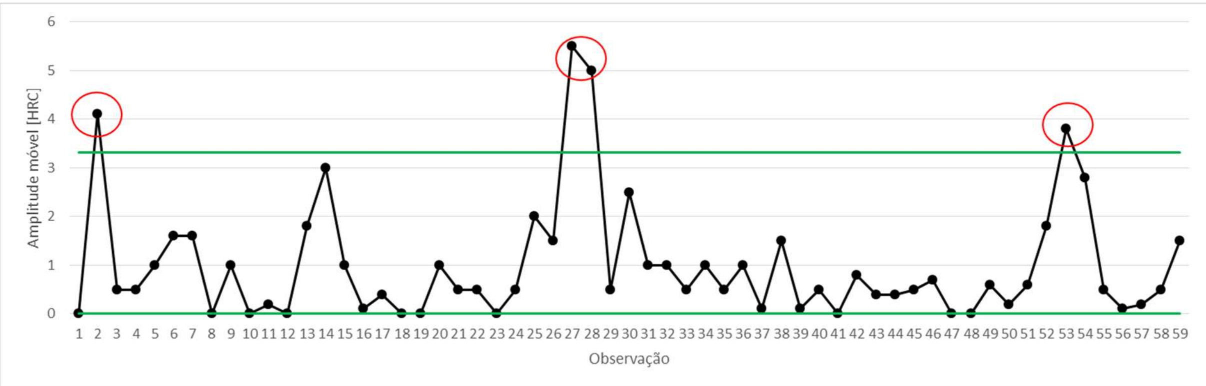


Figure 2. Control chart for moving range.



The occurrence of deviations from control limits may have been due to special causes. This reinforces the importance of monitoring the quality of testing and the elaboration of control charts, in order to identify deviations of the measured values.

ISO/IEC 17025 standard does not prescriptively indicate the actions that should be taken when problems of this order occur. The quality management system (QMS), however, must provide that problems or errors during measurement are registered and actions are taken to solve them and avoid incorrect measurements to be misused [3].

For the analyzed laboratory, the internal QMS requires that, when deviations from control limits occur, the quality manager is notified and the equipment is identified as “out of use” and disabled until a corrective action is taken.

Considering that the measured values presented in Figure 1 were obtained from the verification standards used, three observations were outside the control limits previously determined. As the durometer is calibrated and the verification standards were subjected to previous measurements, there may have been problems related to the lack of training by the operators who performed the measurements. All the technicians who work with the equipment are trained, as recommended by ISO / IEC 17025. However, when measurements performed with the HRC scale have a pre-load to be applied, and when the measurement is performed in regions where there is no support of this preload, expressive measurement errors usually occur. Thus, these measures are likely to result in values outside the stipulated control limits. The actions taken to solve this issue were the training of the operators and the indication in a visible place of the need to control the surface region that will be measured.

4. CONCLUSIONS

The use of control charts in mechanical testing is important to meet the quality assurance requirement of ISO/IEC 17025 standard. Furthermore, control charts allow the identification of deviations and the occurrence of special causes over time.

In this study, individual values and range control charts were applied for Rockwell C hardness test and some observations outside the control limits were identified. In this situation, the equipment was disabled and the quality manager was notified.

This type of analysis may be used in several quantitative tests, and not only in Rockwell hardness, for example, it could be applied to other hardness scales (Brinell and/or Vickers).

REFERENCES

[1] Callister W, Rethwisch D (2007) “Materials science and engineering: An introduction” 7ª ed., John Wiley & Sons

[2] ASTM E18-16 (2016) “Standard test methods for Rockwell hardness of metallic materials” West Conshohocken

[3] ISO/IEC 17025 (2005) “General requirements for the competence of testing and calibration laboratories” Geneva: ISO

[4] Fanezi CLF, Fabricio DAK, Costa VM, Reguly A (2015) “Quality assurance of absorbed energy in Charpy impact test” Bento Gonçalves: 8th Brazilian Congress on Metrology

[5] Ribeiro JLD, Caten CST (2012) “Série Monográfica Qualidade: Controle Estatístico do Processo” Porto Alegre: FEENG/UFRGS

[6] ISO 6508-2 (2015) “Metallic materials – Rockwell hardness test – Part 2: Verification and calibration of testing machines and indenters” ISO: 3rd Edition.