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THE MANUFACTURE OF ROCKWELL HARDNESS STANDARD BLOCKS IN BRAZIL

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Abstract: In the present work, the heat treatments used during production of national Rockwell hardness standard blocks, in the ranges of 60-80 HRB, 85-100 HRB, 20-30 HRC, 35-55 HRC and 60-70 HRC as well as their resulting microstructures are presented. Two kinds of steels with different contents of carbon and a very low level of impurities were used in the manufacturing process of the blocks. The microstructural changes were studied by means of optical microscopy analyses. The hardness measurements were carried out in hardness tester machines belonging to the Brazilians institutions involved in the present study. Preliminary results suggest that the heat treatment parameters influence directly on the microstructural homogeneity and stability and consequently on the uniformity of hardness values.
Keywords: Rockwell Hardness, Standard Blocks, Uniformity

1 INTRODUCTION

The present work is part of a larger project which is being developed in partnership between INMETRO, ITUC/PUC-Rio and INT since 1995. Its main purpose is the establishment of a national metrological system with hardness scales, whose procedures and standards must have traceability to metrological institutes recognized worldwide [1-3]. The current stage of the project involves the development and certification of Rockwell hardness standard blocks, for the scales B and C.

The reasons for the manufacture of national standard blocks are the increase in demand by research institutes and national industries, at the moment estimated in 20,000 blocks/year, and the lack of production of hardness standard blocks in Brazil. The brazilian market uses imported blocks, whose prices for the national consumer are very high, as well as the time for delivery, which decreases the time of its use because of the expiration of the validity date on the calibration certificate.

Some of the heat treatments used during production of national Rockwell hardness standard blocks, in the scales B and C, are presented. For the scale B, standard blocks in the ranges of 60-80 HRB and 85-100 HRB have been developed, while for the scale C the ranges of hardness are 20-30 HRC, 35-55 HRC and 60-70 HRC. Two kinds of steels, supplied by a national enterprise with different contents of carbon and very low level of impurities, were used in the manufacturing process of the blocks [4].

The purpose of this work is to discuss the influence of different microstructures in the non-uniformity of hardness values for each condition studied, once this parameter is one of the most important for the acceptance of hardness standard blocks. To achieve the desired hardness ranges and also the uniformity of hardness values, different heat treatments were performed, changing some parameters like austenitization temperatures, cooling rates and tempering times and temperatures.

2 EXPERIMENTAL

In order to obtain five different hardness ranges (60-80 HRB, 85-100 HRB, 20-30 HRC, 35-55 HRC and 60-70 HRC), two different kinds of steels were used (low carbon and high carbon), both with very low content of sulphur and phosphorus [4]. For the manufacture of hardness standard blocks in the range of 60-80 HRB, a low carbon steel was used, while for the other ranges the raw material was a high carbon steel.

The steels were supplied in the form of 650 mm cylindrical bars. The bars were cut and machined to the final dimensions of the standard blocks: 550 mm in diameter and 10 mm in thickness.

To achieve the desired hardness ranges and also the uniformity of the measurements, different heat treatments were performed in a furnace under argon atmosphere, adopting various austenitizing and tempering temperatures, cooling rates and tempering times. All the specimens were austenitized for half an hour. For each condition of heat treatment, three specimens were studied in order to evaluate the reproducebility of the process.

After the heat treatments, Rockwell hardness measurements were carried out on the entire surface of the blocks. The non-uniformity of hardness was calculated according to EN 10109-3 standard [5,6].

In order to correlate the hardness results to the microstructure of the heat treated materials employed to manufacture the blocks, microstructural analyses were carried out on representative specimens of each heat treatment.

3 RESULTS AND DISCUSSIONS

The hardness values of the blocks and the indentation depths, obtained for the different heat treatments, are presented in Table 1. The encountered non-uniformity values as well as the maximum non-uniformity are also presented in the same Table [5].

Table 1. Hardness and heat treatment parameters used to manufacture the blocks.

Hardness Range	Heat Treatment Parameters	Hardness Value	Depth (mm)	Maximum Permissible Non-Uniformity (mm)	Non-Uniformity (mm)
60-80 HRB	Oil quenched	55 HRB	0,15	0,0045	0,0038
85-100 HRB	Normalized	91,5 HRB	0,077	0,0023	0,0036
20-30 HRC	Oil quenched and tempered	29,3 HRC	0,14	0,0021	0,0014
35-55 HRC	Oil quenched and tempered	41,8 HRC	0,12	0,0018	0,0010
60-70 HRC	Oil quenched	62,9 HRC	0,074	0,0011	0,0006

Concerning the non-uniformity values for the specimens studied, the results are considered to be acceptable except for the 85-100 HRB range. This behaviour can be related to the high microstructural heterogeneity observed in the block after applying the normalizing heat treatment. Figures 1 and 2 show the microstructural characteristics of the 85-100 HRB block, where one can notice the presence of a very coarse pearlite.

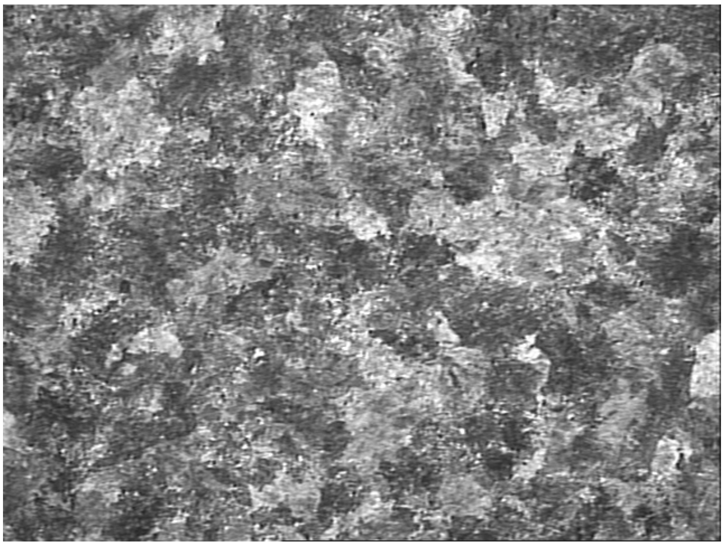

Figure 1. Microstructural characteristics of the 85-100 HRB range, showing a high degree of heterogeneity. 300X.

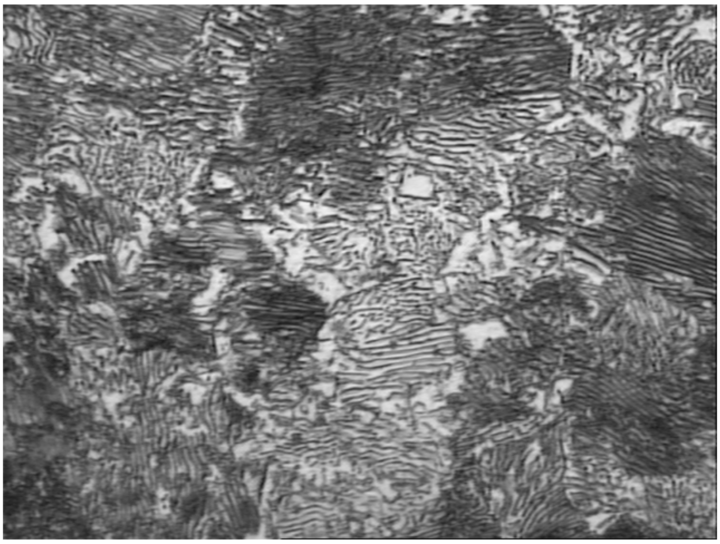

Figure 2. Micrography showing a detailed area of Figure 1. Coarse lamellar pearlite colonies. 600X.

Figure 3 shows the microstructure, which characterizes the heat treatment effects on the material used for the 60-70 HRC range. The oil quenching heat treatment produced a fine martensitic structure, responsible for the very low non-uniformity values obtained for that range.

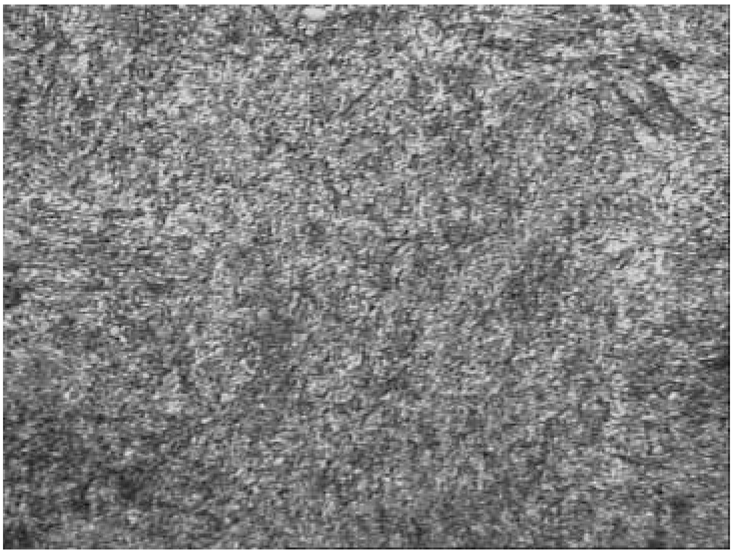

Figure 3. Microstructural characteristics of the 60-70 HRC range, showing a very fine martensite, resulting from the oil quenching heat treatment applied to the material. 300X.

The heat treatment applied to the specimens in the 60-80 HRB has produced a microstructure consisting of ferrite, pearlite and probably bainite (Figure 4). Despite the microstructural heterogeneity observed, the fine microstructural character of the material allowed uniform hardness results.

The microstructure related to the blocks in the 20-30 HRC range is illustrated in Figure 5, which shows a microstructure consisting of fine grained tempered martensite. Tempered martensite usually presents a higher microstructural uniformity and consequently better uniformity results than the pearlitic phase, since the ferrite nucleation and growth from the austenite occur at a high temperature range, leading to finer interlamellar spacings.

The specimens in 35-55 HRC range presented a tempered martensitic microstructure as can be seen in Figure 6. The hardness values (Table 1) indicate that, concerning the hardness uniformity, the heat treatment parameters were adequate, signifying optimized tempering time and temperature.

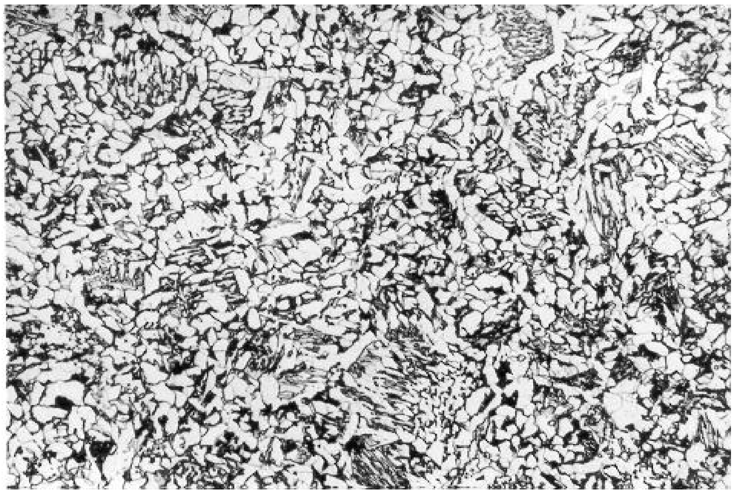

Figure 4. Microstructural characteristics of the 60-80 HRB range. Ferrite, pearlite and bainite. 300X.

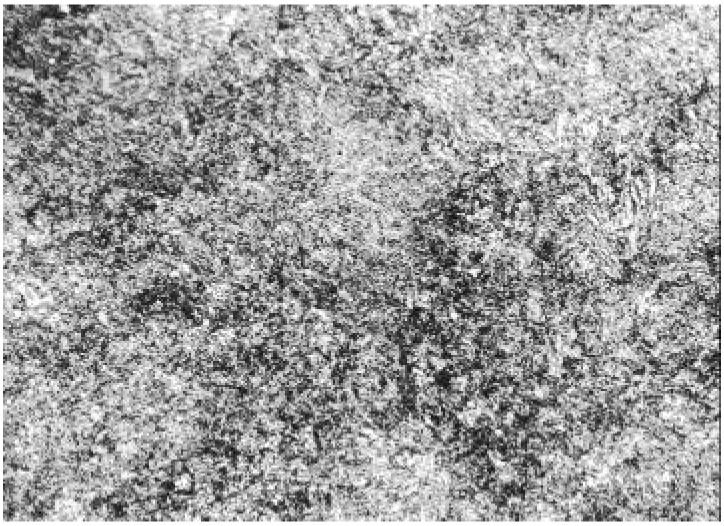

Figure 5. Microstructural characteristics of the 20-30 HRC range. Microstructure consisting of fine grained tempered martensite. 300X.

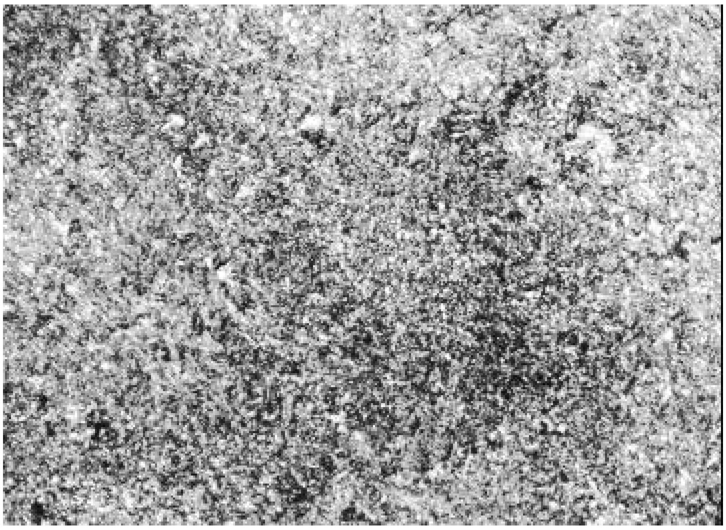

Figure 6. Microstructural characteristics of the 35-55 HRC range, showing a tempered martensitic microstructure. 300X.

4 CONCLUSIONS

Oil quenching is considered to be the most adequate way to achieve a better homogeneity as well as microstructural stability, indicating the important role played by the cooling rate on the uniformity of the hardness values obtained from measurements on the standard blocks.

The results presented in this work show that the uniformity of the Rockwell B and C hardness values is directly related to the microstructural aspects of the blocks.

In the present stage of development of standard blocks, dimensional parameters, like parallelism, flatness and roughness, were not analyzed. The relationship between these parameters and the microstructural aspects and therefore hardness uniformity is the subject of a future study.

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