The influence of the cast iron structure upon the hardness of brake shoes meant for the rolling sock

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Abstract. An important characteristic with a high impact upon the exploitation durability of the brake shoes is hardness. The paper introduces the influence of the phosphorous cast iron structure upon the hardness of the brake shoes meant for the tractive and trailing rolling stock. The results presented show the variation of hardness on the surface and the cross section of the braking shoe

1. Introduction

The On manufacturing brake shoes meant for the rolling stock, phosphorous pig irons are largely used. They are pearlitic pig irons, with a high content of phosphor. A phosphorous ternary eutectic also appears in the structure, namely Steatite, which is made of pearlite, cementite and iron phosphide (Fe_3P). The microstructure of a phosphorous pig iron [1] is shown in Figure1.

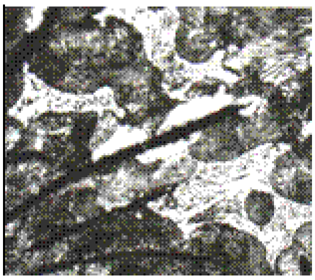


Figure 1. Microstructure of iron phosphorous, attack NITAL 2%, 400x [1].

The microstructure of the material used to cast brake shoes has to be homogenous, pearlitic with lamellar graphite and phosphorous eutectic, evenly distributed.

The phosphorous content of the cast iron used in manufacturing brake shoes is important, but the influence of other components upon the metallographic structure should not be ignored.

Also, an important role in the quality of the cast iron meant for brake shoes is played by the dimensions of the eutectic grains, by the distribution of the phosphide lattice within the structure, the shape, dimension and distribution of the graphitic lattice, as well as the quantity of graphite released during the graphitic crystallizing.

The P10 type brake shoes size S1, S2 and S3 are cast out of phosphorous cast iron and are used for the traction and trailing stock. Brake shoes are manufactured along a technological flux (Figure2) consisting in the elaboration aggregate – an induction electric furnace, an automated air-flow-pressure molding machine and a casting line.

Figure 2. Flow technology for producing brake blocks.

The iron casting process is carried out as required clogs provider must comply with the specifications nr.1/SFMR/SDT/2000 [2].

The body of the brake shoe for the traction and trailing stock is made of cast iron allied with P10 type phosphor, having the chemical structure according to the standards in force [2], [3], [4]:

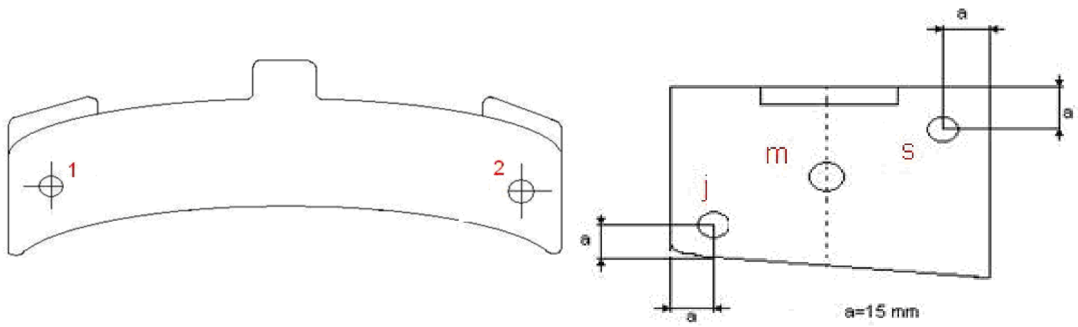
- The content of phosphor must range within 0,8% and 1,1%;
- The content of manganese must be calculated so as: 1,72%S + 0,30% < %Mn < 1%, (where S% represents the content of sulphur in the cast iron);
- The total content of carbon 2,90 % < % C_t < 3,30 %;
- The content of silicon 1,20 % < %Si < 2,00 %

The braking shoe backing for the traction and trailing stock is made of laminated steel [5-7]. The content of carbon, sulphur and phosphor of this steel must be: % C < 0,130 %; % S < 0,0062 %; % P < 0,0062 % [6], [9]. The braking shoe backing must have a cross section of at least 100 mm^2 and a length of at least 80 % of the shoe length.

2. Experimental regarding

An important characteristic with a significant influence upon the useful life of brake shoes if hardness. Hardness is tested according to SR EN ISO 6506-1:2006. Hardness is measured at the extreme points of the brake shoe (*1* and *2* – Figure 3.a), on its front and at three points located diagonally (*s*, *m* and *j* – Figure 3.b). The brake shoe must have on its lateral surface, as well as on the cross section, a Brinell hardness ranging within 197-225HB [2].

The industrial research has been done by analyzing 25 charges of phosphorous cast iron produced by a company specialized in brake shoe manufacturing [8]. The analyses focused on the content of the metallic charge, the chemical structure of the elaborated cast iron, the physical and chemical characteristics of the shoes, respectively the metallographic examination of the shoe cast iron, according to SR EN ISO 945-1:2009 and file UIC 832, with no chemical treatment and with a G magnifying of 100x.



a. shoe b. sample

Figure 3. Sampling areas hardness shoe [2].

The data pertaining to the standard chemical structure of the cast iron elaborated and the experimental data are shown in Table1. Table2 shows the data related to the brake shoe hardness variations, determined according to SR EN ISO 6506-1:2006, both on the surface of the shoe (HB_1, HB_2) and in its cross section (HB_s, HB_m, HB_j) at the points of hardness sampling (Figure 3). The mean values of the brake shoe hardness on the surface $(HB_1+HB_2)/2$ and in cross section $(HB_s+HB_m+HB_j)/3$ as well as their difference are given in Table3. The chemical structure of the charges under analysis is given in Figure 4.

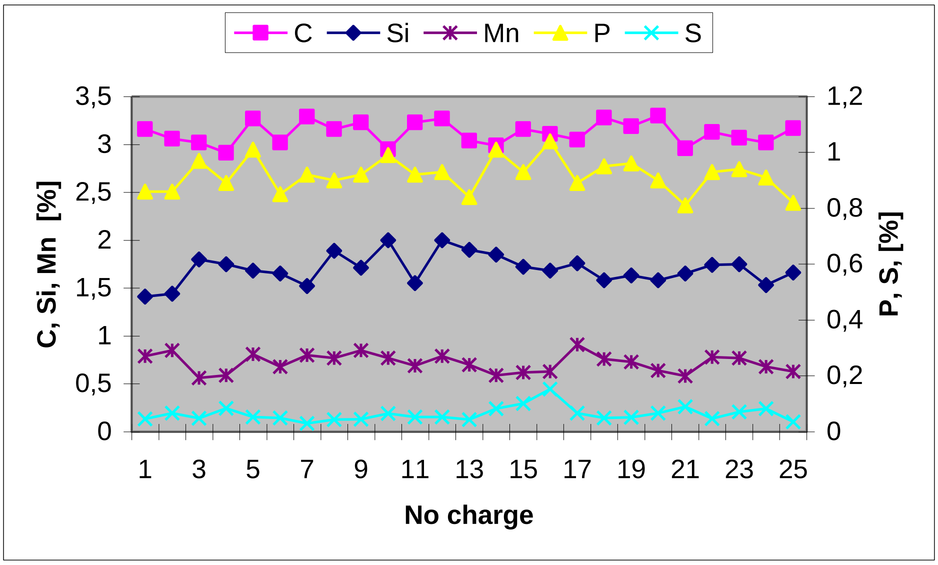


Figure 4. The chemical structure of the charges.

Table 1. Cast iron chemical composition

Terms	Values	Chemical composition, %					
		C	Si	Mn	P	S	Cr+Mo+Ti+Nb+V+W
	Maximum	3.30	2.00	1.00	1.10	0.155	-
Standard	Minimum	1.20	1.20	0.33	0.80	0.03	-
	Average	2.25	1.60	0.665	0.95	0.065	-
	Maximum	3.30	2.00	0.91	1.04	0.153	0.344
Exp.	Minimum	2.91	1.41	0.56	0.81	0.03	0.109
	Average	3.12	1.70	0.72	0.919	0.065	0.213

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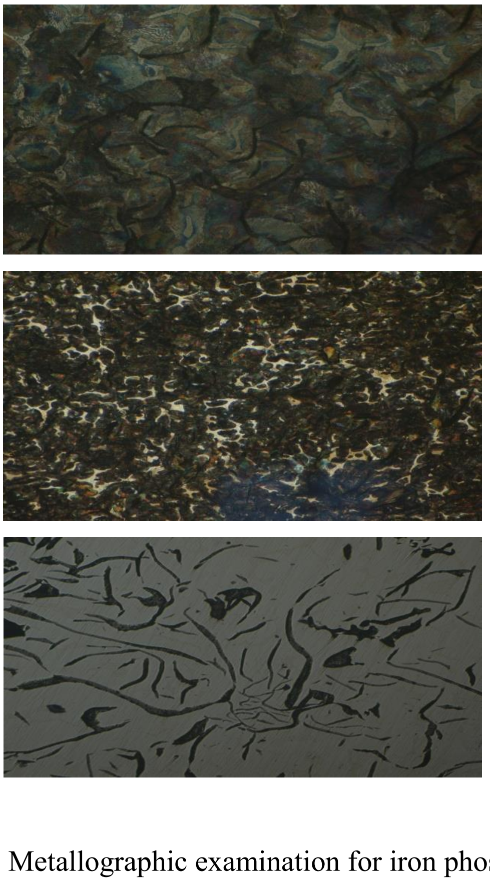
Table 2. Hardness tests

Values	According to standard	Hardness determined as shown in fig.3 [HB]				
	HB	HB_1	HB_2	HB_s	HB_m	HB_j
Maximum	255	249	246	245	232	241.66
Minimum	197	208	199	202	197	202.67
Average	226	222	220.62	220.44	208.60	217.02

Table 3. Average values of surface hardness and shoe section

Values	Hardness values and the average lateral cross-sectional area		The side surface hardness differences in cross-section	
	$(HB_1+Hb_2)/2$	$(HB_m+HB_m+HB_j)/3$	$\mid HB_1-HB_2\mid$	$\mid HB_s-HB_j\mid$
Maximum	247.5	241.66	9	11
Minimum	203.5	202.66	0	0
Average	221.61	217.03	3.77	4.07

Figure 5 presents metallographic examination for iron phosphorous developed. The analysis of the diagrams given in Figures 6 and 7 shows that there are slight variations of the hardness measured on the lateral surface and in the cross section of the brake shoe, respectively of their average. This is due to the narrow-limited variation of the shoe chemical structure. As to the difference between the hardness values measured on the lateral surface and in the cross section, whose graphic representation is given in Figures 8 – 13, the resulting values are relatively small, which points to a good chemical homogeneity of the brake shoes.



Pearlite

Phosphorous eutectic

Graphite

Figure 5. Metallographic examination for iron phosphorous.

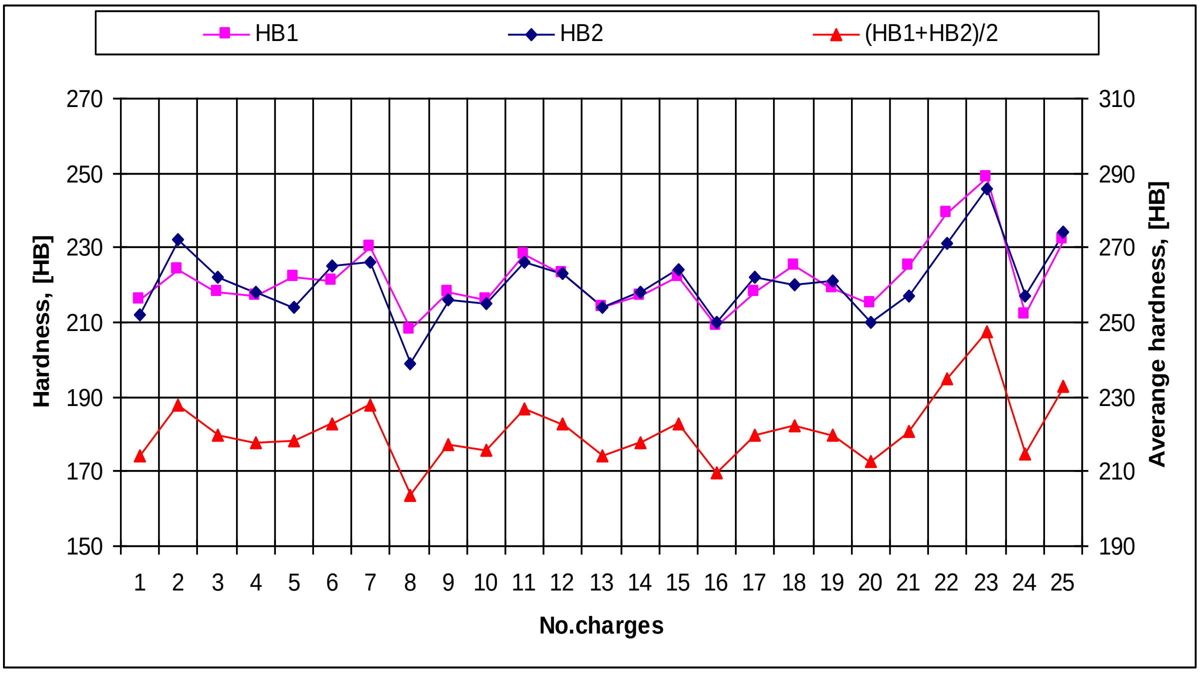


Figure 6. The variation of hardness and its average on the lateral surface of brake shoes.

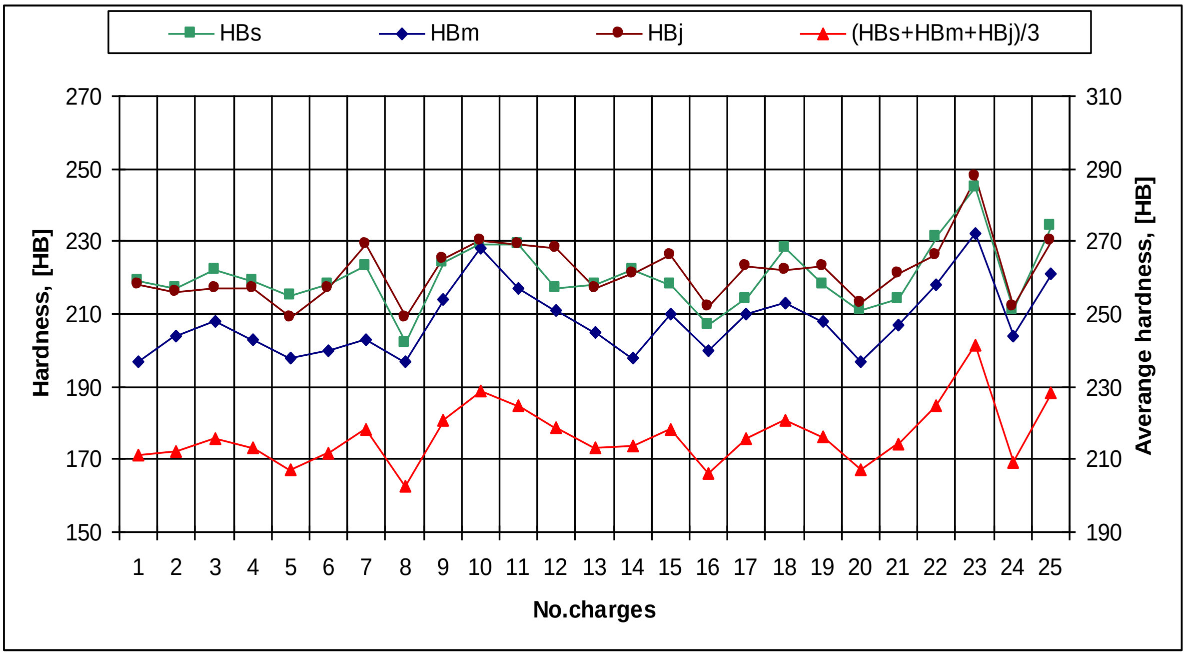


Figure 7. The variation of the hardness and its average on the cross-sectional surface of brake shoes.

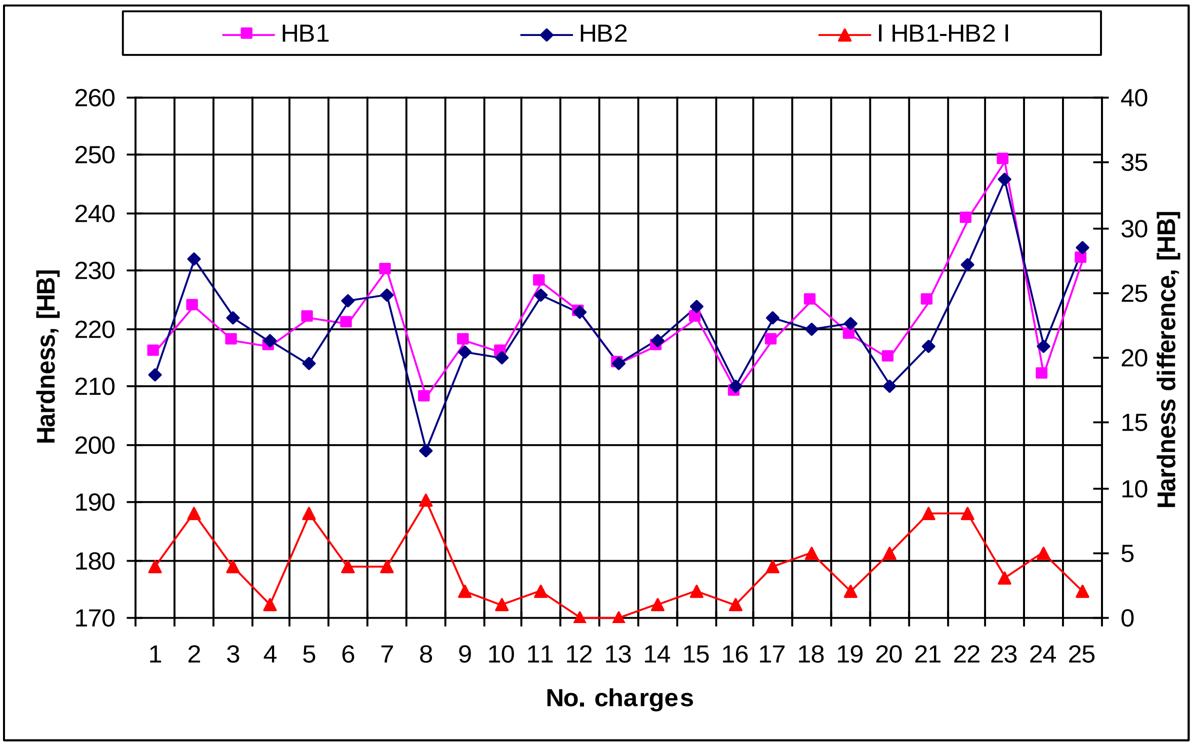


Figure 8. The variation of the hardness and hardness difference on the lateral surface of brake shoes.

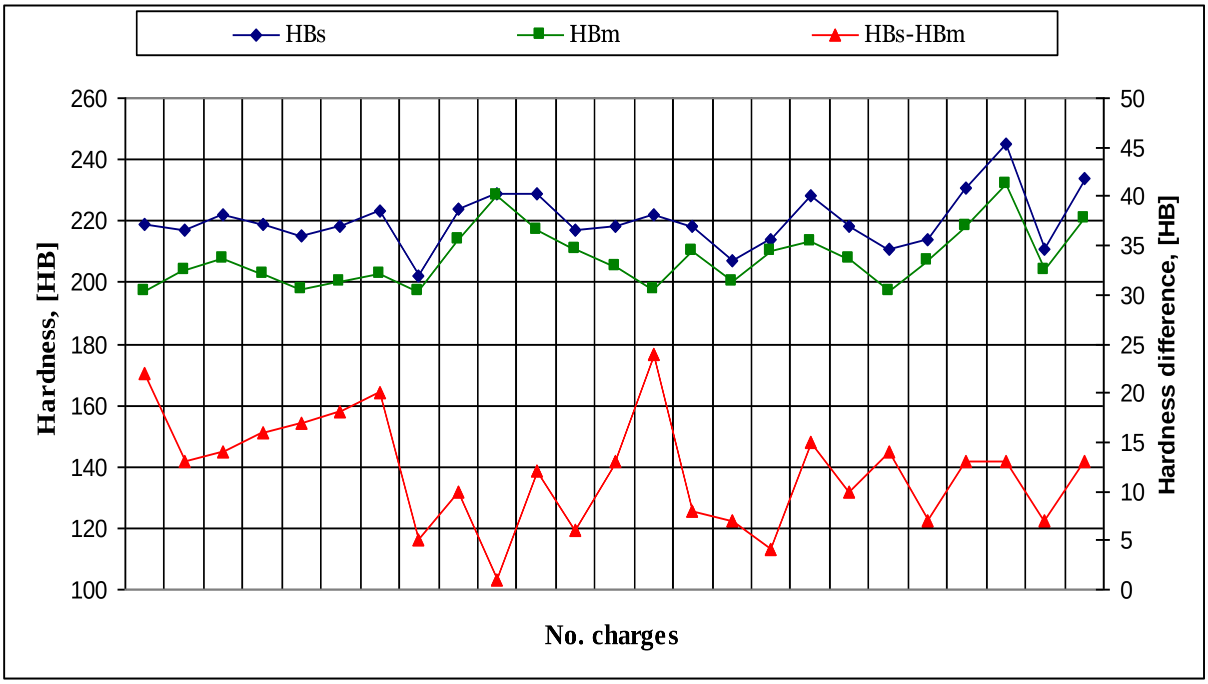


Figure 9. The variation of the hardness and hardness difference on the cross-sectional surface of brake shoes (the upper and central area).

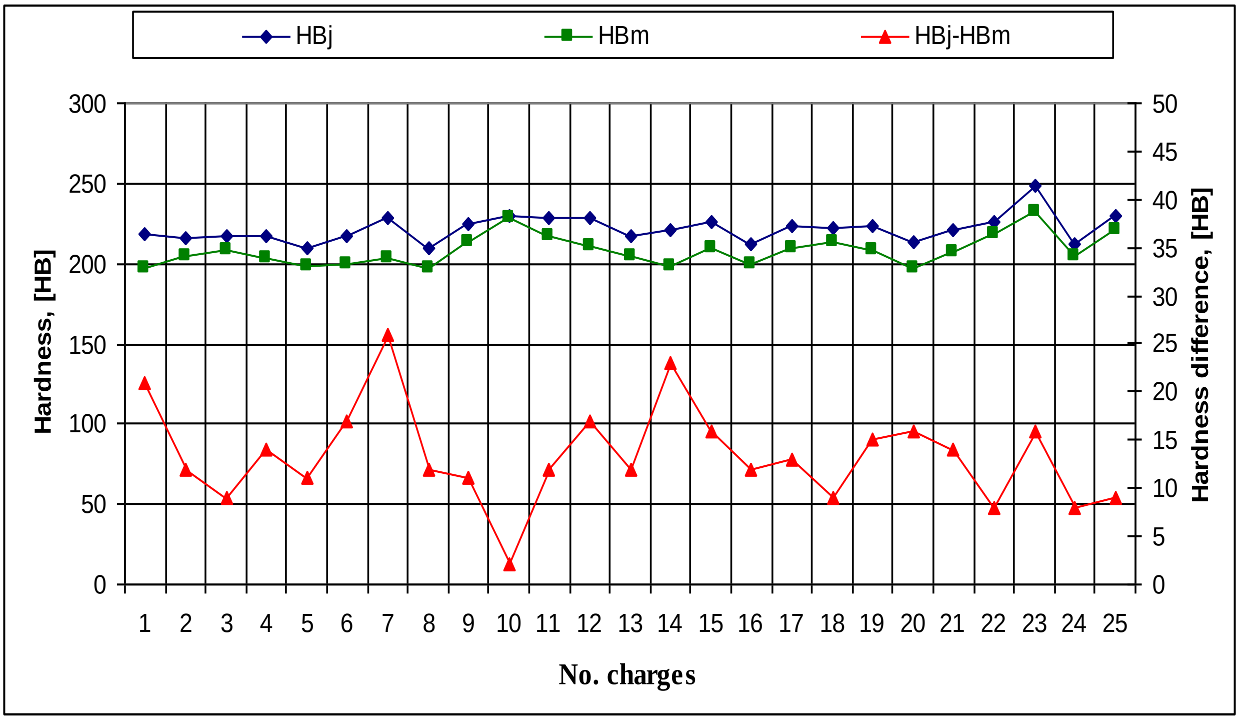


Figure 10. The variation of the hardness and hardness difference on the cross-sectional surface of brake shoes (the lower and central area).

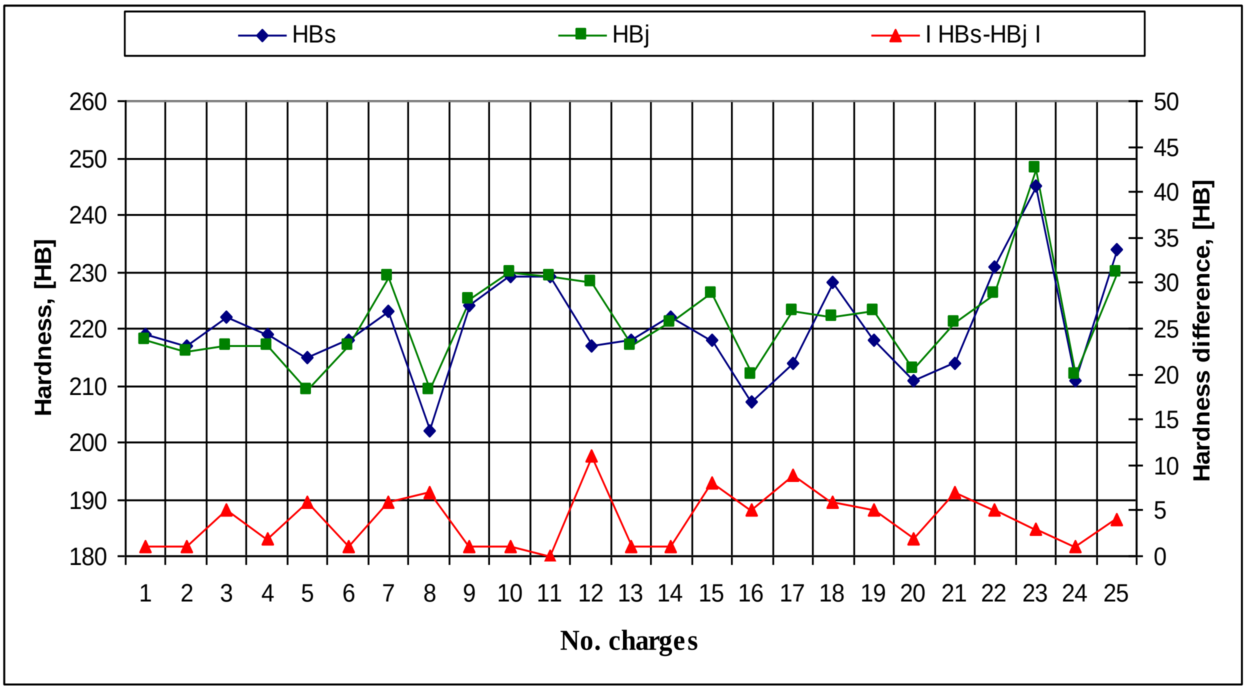


Figure 11. The variation of the hardness and hardness difference on the cross-sectional surface of brake shoes (the lower and upper area).

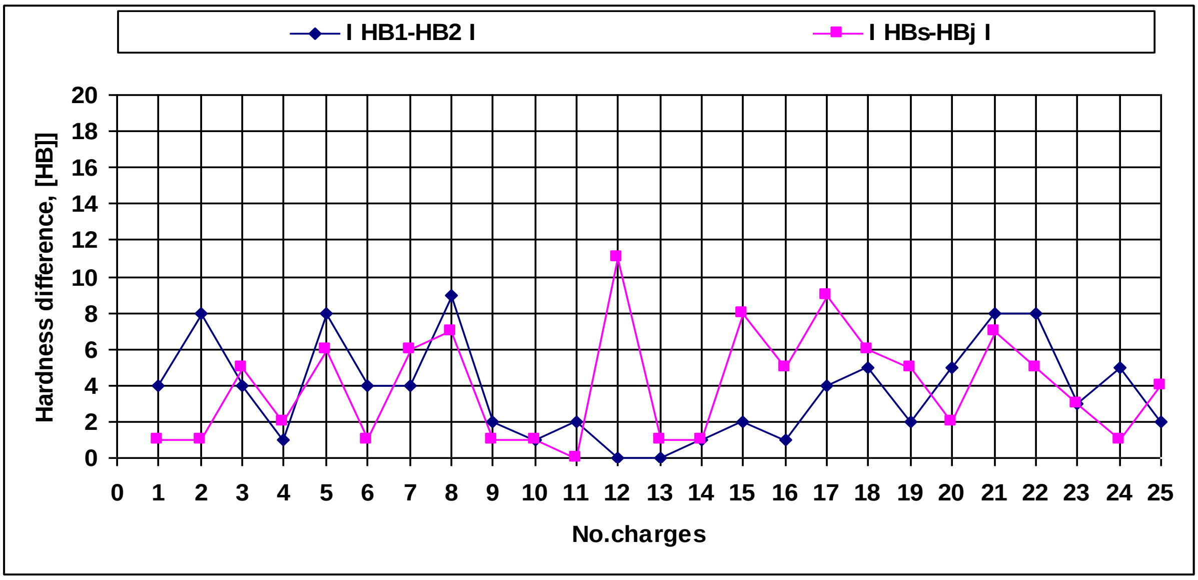


Figure 12. The variation of the hardness difference on the lateral surface and in the cross sectional area of the brake shoes.

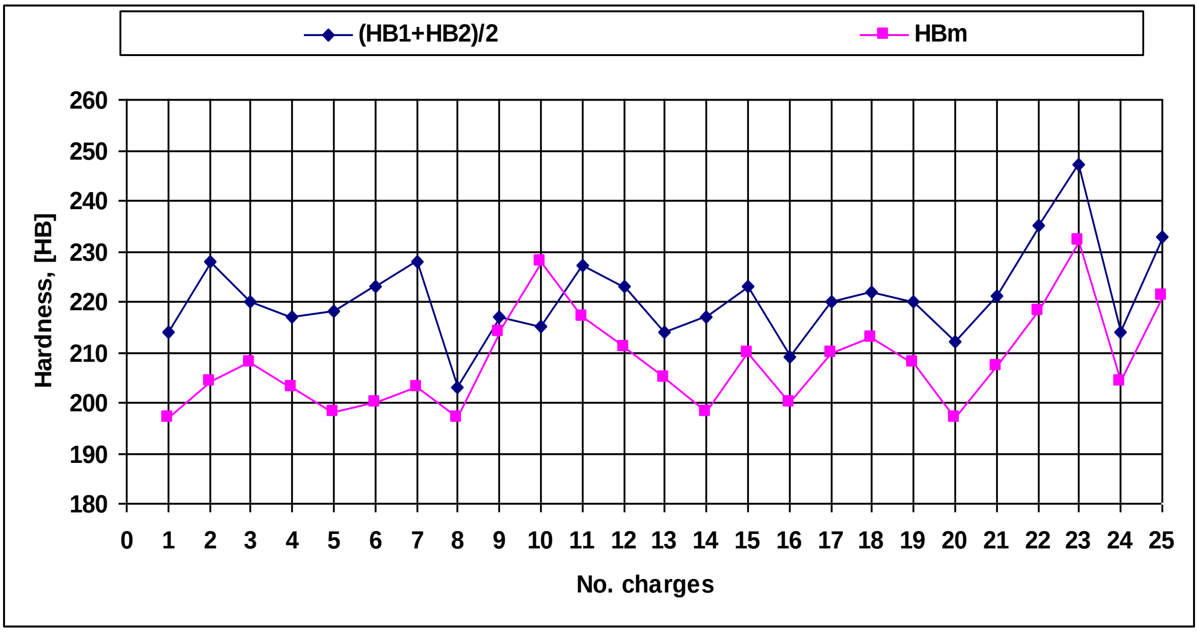


Figure 13. The variation of the average hardness on the lateral area and the hardness in the central area of the cross section of the brake shoes.

3. Conclusions

The values of hardness obtained during the industrial experiments range within the interval 197-240HB, which is in accordance with the international standards. The chemical and structural homogeneity of the shoe brakes leads to slight variations of the hardness values, both on the lateral surface and in the cross-sectional one, which will make for a good exploitation durability of the brake shoes.

Acknowledgments
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