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STUDY MECHANICAL BEHAVIOR OF HEAT RESISTANT STEELS IN THERMAL POWER LINES

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ABSTRACT
The paper presents the theoretical studies and experimental results obtained from the mechanical attempts of hardness at heat, made on a Brinell hardmeter, using original heating precincts of the test-bars. Thermal-resistant steel types had been used for testing, which practically are submitted at high functional temperatures. Therefore, the precincts and the annex elements as well as the obtained results are shown. They can be applied practically in order to determine the life length of component parts made of this steel.
Keywords: high temperature, thermal resistant steel, mechanical testing.

1. INTRODUCTIVE NOTIONS

Hardness is a conventional magnitude with a complex character, offering data obtained in a relatively short time with respect to the deformability of a material at the level of its superficial layers, under well-determined work conditions.
We have to point out that, until now, the hardness trials at high temperatures have not been standardized at national or European level. The few researches we met in the reference literature [1] aim at establishing correlations between the hardness characteristic at high temperatures and other mechanical material characteristics obtained at the same temperatures (for instance: the correlation between hardness and the traction resistance or the resilience at high temperatures).

2. THE PRECINCTS OF HEATING AT HARDNESS TESTING

In accordance with the specialized literature, [7], the main requirement with a view to the correct performing of hardness testing in the conditions of high temperature is **the equality between the temperature of the tested specimen and the temperature of the penetrator.**
The shape of the precincts which must be adjusted to the method through which the hardness testing is made, must provide the achievement of the test-bar and penetrator heating at a testing temperature. The precincts must be isolated from the device table that contains asbestos fittings or any other fitting that do not allow heat pass though.
In order to make the Brinell hardness testing possible, precincts of heating the test-bars had been done, which was adjusted to a **PH – C – 02/02** hardmeter. The scheme of the achieved precincts is shown in figure 1 [11].
The precincts temperature and implicitly the test-bars temperature is being adjusted by computer.
To provide the equality of the test-bar temperature and that of the penetrator (in this case – a steel ball) it has been resorted to the alternative of the rod penetrator’s prolongation as well as to the achievement of a thermal protection of this rod, through a jack suitable for the top of the Brinell hardmeter [10].

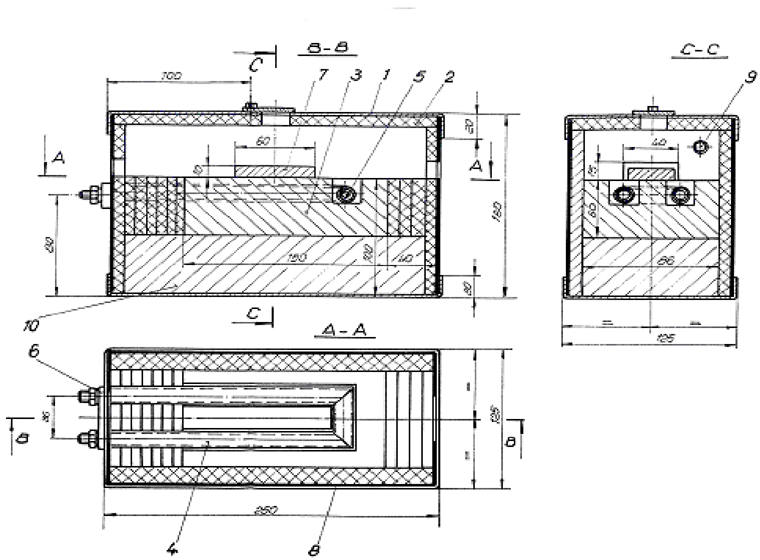
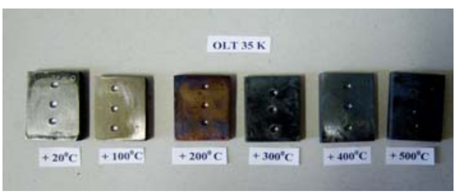


Figure 1. Precincts for hardness testing

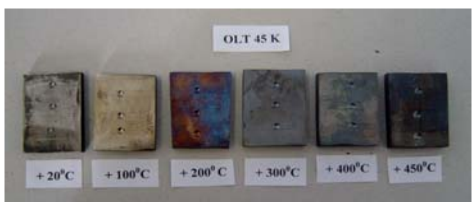
3. THE ACHIEVEMENT OF EXPERIMENTAL TESTING

The test-bar used is parallelipipedic-shaped and is sized in such a way so that three stamps can be made.

In order to make hardness testing at high temperature one must follow the following stages: the precincts of heating is set on the work-table of the Brinell hardmeter; the test-bard are being introduced in the precincts and the lateral orifices are being air-tightened; the penetrator of the apparatus, which is assembled at the end of the prolonging rod, is brought into contact with the surface of the test-bar; the lids of the precincts are placed around the jack, which provides thermal protection of the penetrator lengthener and the fixation of the test-bar for the testing; - computerized control for the testing temperature ; after obtaining the desired temperature in the test-bar, the hardness testing is done and it is being twice repeated without being necessary the drawing out of the test-bar from the precincts; at finishing the testing, the test-bar is drawn out of the precincts and, with the help of a tool microscope , two perpendicular diameters of the same stamp are being measured. Varying with the medium diameter of the stamp, the hardness of the test-bar material is being established.



Picture 1. Set of test rods made of OLT 35K, unused material, tried at high temperatures



Picture 2. Set of test rods made of OLT 45K, unused material, tried at high temperatures

In the paper, you are presented the experimental testing on two types of thermal resistant steel, from the category of those used in the manufacture of steam tubes, that is: OLT 35K and OLT 45K.

The normalized test-bars have been tested at ambient temperature and at high temperature up to +500°C.

Picture 1 shows OLT 35K test-bars and Picture 2 OLT 45K test-bars, after hardness testing at high temperature: +20°C; +100°C; +200°C; +300°C; +400°C; +500°C.

After the test rods were tried, we measured two perpendicular diameters to each print, calculating the mean diameter and out of the standard we obtained the value of Brinell hardness.

4. THE RESULTS EXAMINATION AND CONCLUSIONS

The results of the measurements, the calculated values and the magnitude of the hardness are given in table 1 and 2, for each type of steel.

Table 1. Brinell hardness at high temperature of OLT 35K steel, after tempering

No.	Trial temperature [^{0}C]	Diameter [mm]					**Brinell hardness HBS]**			
		d	Print 1	Print 2	Print 3	Mean	Print 1	Print 2	Print 3	Mean
1	+20	d_1	5,14	5,18	5,16	***5,18***	134	132	133	***132***
		d_2	5,18	5,22	5,20		132	130	131	
		d_m	**5,16**	**5,20**	**5,18**		**133**	**131**	**132**	
2	+100	d_1	4,71	4,67	4,69	***4,676***	162	165	164	***164,33***
		d_2	4,73	4,61	4,65		161	170	167	
		d_m	**4,72**	**4,64**	**4,67**		**161**	**167**	**165**	
3	+200	d_1	4,54	4,51	4,61	***4,533***	175	178	170	***176***
		d_2	4,48	4,52	4,55		180	177	174	
		d_m	**4,51**	**4,51**	**4,58**		**178**	**178**	**172**	
4	+300	d_1	4,78	4,80	4,76	***4,765***	157	156	158	***158***
		d_2	4,75	4,78	4,74		159	157	161	
		d_m	**4,476**	**4,79**	**4,74**		**158**	**156**	**160**	
5	+400	d_1	4,92	4,86	4,98	***4,923***	148	152	144	***147,66***
		d_2	4,95	4,90	4,93		146	149	147	
		d_m	**4,935**	**4,88**	**4,955**		**147**	**150**	**146**	
6	+450	d_1	5,17	5,17	5,18	***5,156***	133	133	132	***133,66***
		d_2	5,14	5,10	5,20		134	137	131	
		d_m	**5,15**	**5,13**	**5,19**		**134**	**135**	**132**	

Table 2.Brinell hardness at high temperature of OLT 45K steel, after tempering

No.	Trial temperature [^{0}C]	**Diameter [mm]**					**Brinell hardness HBS]**			
		d	Print 1	Print 2	Print 3	Mean	Print 1	Print 2	Print 3	Mean
1	+20	d_1	5,25	5,24	5,30	***5,263***	128	129	126	***127,66***
		d_2	5,25	5,28	5,26		128	127	128	
		d_m	**5,25**	**5,26**	**5,28**		**128**	**128**	**127**	
2	+100	d_1	4,65	4,82	4,79	***4,705***	167	154	156	***162,66***
		d_2	4,57	4,71	4,69		173	162	164	
		d_m	**4,61**	**4,76**	**4,74**		**170**	**158**	**160**	
3	+200	d_1	4,52	4,47	4,46	***4,520***	177	181	182	***177***
		d_2	4,58	4,56	4,54		172	174	175	
		d_m	**4,55**	**4,51**	**4,50**		**174**	**178**	**179**	
4	+300	d_1	4,73	4,75	4,73	***4,738***	161	159	161	***160,33***
		d_2	4,76	4,63	4,78		158	164	157	
		d_m	**4,745**	**4,71**	**4,755**		**160**	**162**	**159**	
5	+400	d_1	4,92	4,92	5,05	***4,94***	148	148	140	***146,33***
		d_2	4,90	4,92	4,94		149	148	146	
		d_m	**4,91**	**4,92**	**4,99**		**148**	**148**	**143**	
6	+450	d_1	5,34	5,22	5,21	***5,245***	124	130	130	***128,66***
		d_2	5,30	5,20	5,20		126	131	131	
		d_m	**5,32**	**5,21**	**5,205**		**125**	**130**	**131**	

The curves of hardness variation have been drawn with the values of hardness from the chart, depending on the testing temperature for each type of steel, shown in fig. 3.

An analysis of figure 3, the point graph, shows that Brinell hardness increases with temperature, and stays constant for values ranging between 200^{o}C and 250^{o}C, after which it decreases again.

If we draw the graph of 2nd degree polynomial function for the values we obtained, we obtain the equation of this function, the correlation coefficient being R^2 = 0.8856 for OLT 35K steel and R^2 = 0,9314 for OLT 45K steel. We can therefore conclude that hardness depending on trial temperature observes a law of 2nd degree polynomial variation.
It is also to be noticed that all the values we obtained are higher than 132 HBS for steel OLT 35K and 127 HBS for steel OLT 45K. For the steel under study it is particularly useful to know these values, because it is used in making parts that work under high pressure and temperature
From the data obtained for hardness testing, as well as from the analysis of the figure 4 diagram, one can notice that for the tested steel, hardness shows a variation similar to the drive breaking resistance R_m, that is Brinell hardness increases in the same time with the temperature increase, up to 200°C, and the starts to decrease.

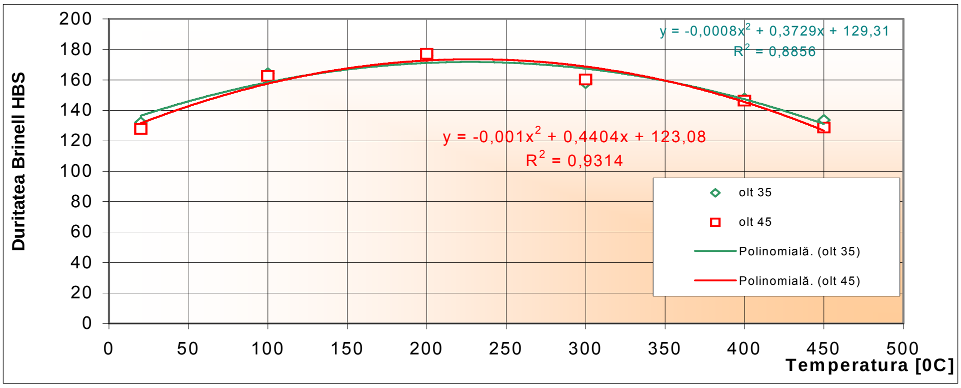


Figure 3.

This makes us conclude that the drive breaking resistance of steel can be established, by knowing its hardness and vice versa. The specialized literature also provides relations between the two characteristics.

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