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THE VARIATIONS OF THE CARBIDE AND GRAPHITE FORMATION ELEMENTS OF THE MILL ROLLS CASTED OF HYPEREUTECTOID STEEL

Ana Josan
University "Politehnica" of Timisoara, Faculty of Engineering Hunedoara
331128 Hunedoara, Revolutiei street, no.5, tel. +40254207532, e-mail: ana_j@fih.upt.ro
Romania

Vasile Putan
University "Politehnica" of Timisoara, Faculty of Engineering Hunedoara
331128 Hunedoara, Revolutiei street, no.5, tel. +40254207536, e-mail: putan.vasile@fih.upt.ro , Romania

ABSTRACT
In order to point out to their chemical composition upon the hardness in exploitation we carried out a critical analysis of the Adamit-type charges at mettalurgical company, out of which, several rolls were cast. We took into account the chemical compositions and the hardness of these rolls, as well as the hardness recorded in exploitation. Thus, we pointed out to a series of correlations between the chemical composition and the hardness we obtained.
Keywords: hardness, Adamit steel, cylinders, chemical composition

1. INTRODUCTION
The required technical conditions imposed to the rolling cylinders are very different and, often, contradictious. Thus, the high hardness of the crust correlated with mechanical resistance and at high temperature, and also often with higher resiliency of the metal from core, journals and wobblers, are rather difficult to obtain. Therefore, it must be taken in consideration the chemical composition, this having a determinant role for obtaining the wished structure [1]. The chemical composition of alloy for casting of rolling cylinders is one of the main facets which contribute to obtain the using properties. This determines the macro and micro structure after an eventually processing in liquid state, alteration in guidable conditions of solidification and cooling and, in some cases, after a thermal treatment. In cast cylinders from cast irons and steels, there are also: chrome, nickel, molybdenum, boron, and also composite of cerium, calcium, aluminum, boron and titanium.
In the fast cooling conditions, the *carbon* from Fe-C alloys makes calcium carbide (cementite), and in slow cooling conditions, it dissociates himself in free carbon (graphite). Similarly, manganese, chrome, sulphur, molybdenum drives to the dissociation of cementite, and nickel, aluminum and, especially, the silicon force up fashioning of graphite (it is a hard graphitizing, in slow cooling conditions and also in fast cooling conditions).
The influence of *manganese* in the used alloys for casting of rolling cylinders mark out, chiefly, by his acts of desulphuration and deoxidation. As a carburizer element, the manganese forms, in Fe-C alloys, the stable carbides at high temperatures, like $(Fe,Mn)_3C$.
From common elements, *sulphur and phosphorus,* are limited at a lowest content possible, depending on the available row materials or on cast irons used (Fgn). Only in case of Fgl, non-alloyed, it is used, rarely, the increasing of percent of P up to 0,5%, in order to avoid the cracks and for obtaining a clear surface of panels.

The *molybdenum* takes part of the group of carburizer elements, almost all cylinders being alloyed with Mo in the rate of 0,3 – 0,5% [2]. The casting of cylinders containing molybdenum under 0,25% is not rationally, because it does not drive to a visible improvement of its structure [1].
In the case of rolling cylinders casting, the *nickel*, having an unlimited solubility in cast irons, allows the improvement of ferrite resistance from pearlite and improve the mechanical resistance at wear of cast irons [1,2]. The *chrome*, in the alloys for cylinders casting, forms stable carbides, improve the hardness and the depth of hard scales in the condition of development and deepening favoring of passing zone, and decreasing, thus , the mechanical characteristics and its resistance at thermal shock cylinders [1]. The contents of nickel and chrome, are in the limits of low and medium alloyed cast irons. By improving of these contents, grow also the cylinder hardness.
In Table 1, are presented some estimative chemical compositions of rolling cylinders [3].

Table 1. Estimative chemical compositions of rolling cylinders [%].

No.	Alloy type	Hardness	Chemical composition [%]							
		HSC	C	Si	Mn	P max	S max	Cr	Ni	Mo
1	Cast iron non-alloyed with lamellar graphite	45-60 60-70	2,5-3,0 2,8-3,0	1,2-1,6 0,4-0,7	0,4-0,8 0,4-0,8	0,5 0,5	0,05 0,05	sub 0,4 sub 0,4	sub 0,5 sub 0,5	- -
2	Cast iron alloyed with lamellar graphite	45-60 60-80 80-95	2,8-3,2 3,2-3,5 3,2-3,7	0,8-1,0 0,3-0,7 0,3-0,7	0,7-1,0 0,4-0,6 0,4-0,6	0,1 0,1 0,1	0,05 0,05 0,05	0,5-1,0 0,7-1,2 0,8-1,6	0,3-0,6 1,2-1,6 3,0-5,0	0,3-0,5 0,3-0,5 0,3-0,5
3	Cast iron with indefinite structure	55-60 60-80 80-95	3,1-3,4 3,1-3,4 3,1-3,4	1,0-1,3 0,8-1,1 0,6-0,9	0,2-0,6 0,3-0,8 0,3-0,6	0,1 0,1 0,1	0,05 0,05 0,05	0,6-1,0 0,8-1,2 1,4-2,0	2,5-3,0 3,0-4,0 4,5-5,0	0,3-0,5 0,3-0,5 0,3-0,5
4	Cast iron with graphite nodule	45-60 60-80	3,3-3,5 3,3-3,5	1,5-2,5 1,2-1,5	0,5-0,7 0,5-0,8	0,1 0,1	0,02 0,02	sub 0,5 sub 0,5	sub 0,3 sub 0,3	- -
5	Cast iron with graphite nodule A	45-60 60-80 80-95	3,3-3,5 3,3-3,5 3,3-3,5	1,8-2,2 1,2-1,8 1,0-1,5	0,5-0,8 0,5-0,8 0,5-0,8	0,1 0,1 0,1	0,02 0,02 0,02	max 0,5 0,4-0,8 0,6-1,6	1,8-2,2 2,0-3,0 3,6-4,4	0,3-0,5 0,3-0,5 0,3-0,5
6	Hypereutectoid steel, non-alloyed, type Adamit	30-50	1,2-1,8	1,2-1,5	0,7-1,0	0,04	0,02	max 0,5	max 0,2	0,3-0,5
7	Hypereutectoid steel, alloyed, type Adamit)	45-50 50-60 60-70	1,6-2,0 1,6-2,0 1,6-2,0	0,6-0,9	0,6-0,9	0,04	0,02	0,8-1,2 0,6-1,2 0,8-1,2	0,5-0,8 1,5-1,8 2,5-2,8	0,3-0,5 0,3-0,5 0,3-0,5

2. EXPERIMENTAL DATA

In terms of cooling speed of cylinders barrel rolls, on its section, it may present a hard coring of alloyed elements (especially that carbonizes), because the diameter of barrel rolls were ϕ > 450 mm and it cannot assure high speeds of solidification and cooling during and after casting. Taking in consideration the cooling speeds like the same, due to high thickness of walls (the cylinders diameter ϕ ≥ 500mm), the cylinders structures could be evaluate also by medium values of carburized elements, graphitisants and detrimentals [3]. The performed studies, regarding the variation of chemical composition on the cylinders section type Adamit, after it was brought out of using, lead us that carburized alloyed elements like Mo, Cr, Mn are the elements which governs the appearance of carbides (especially from ledeburite) which drives to the growing of the resistance at wear mainly at hot-rolling [2,4]. Therefore, and also due to the fact that the cylinders type Adamit have a similar chemical composition, which put them in the zone of hypereutectoid, it takes in account the equivalent carbon C_E , considered by [5] :

$$\%C_E = C + \left(\frac{S+P}{3}\right) \quad (1)$$

$$\%C_E = C + \frac{Mo}{4} + \frac{Cr}{5} + \frac{Mn}{6} + \frac{V}{14} + \frac{Si}{24} + \frac{Ni}{40} \quad (2)$$

In the Table 2 are exposed the chemical compositions and variation of carburized and graphitizing elements by equivalent carbon C_E [5] according to formula:

$$\%C_{E\_carb} = C + \frac{Mo}{4} + \frac{Cr}{5} + \frac{Mn}{6} \quad (3)$$

$$\%C_{E\_graf} = C + \frac{Si}{24} + \frac{Ni}{40} \qquad (4)$$

Table 2. Chemical compositions, respective variation of carburized and graphitizing elements by equivalent carbon of studied rolling cylinders.

No.	No. cyl.	Chemical composition [%]										Variation of carburized and graphitizing elements by equivalent carbon (C_{E_carb}, C_{E_graf}), obtained with the formula:	
		C	Mn	Si	S	P	Cr	Ni	Cu	Mo	Ti	$\%C_{E\_carb} = C + \frac{Mo}{4} + \frac{Cr}{5} + \frac{Mn}{6}$	$\%C_{E\_graf} = C + \frac{Si}{24} + \frac{Ni}{40}$
1	*0952*	1,99	0,8	0,7	0,005	0,003	1,2	1,61	0,2	0,35	0,06	2,4508333	2,0594167
2	0954	1,99	0,8	0,7	0,005	0,003	1,2	1,61	0,2	0,35	0,06	2,4508333	2,0594167
3	0955	1,99	0,8	0,7	0,005	0,003	1,2	1,61	0,2	0,35	0,06	2,4508333	2,0594167
4	0957	1,89	0,83	0,74	0,008	0,035	1,08	1,7	0,18	0,32	0,06	2,3243333	1,9633333
5	0958	1,89	0,83	0,74	0,008	0,035	1,08	1,7	0,18	0,32	0,06	2,3243333	1,9633333
6	*0959*	1,89	0,83	0,74	0,008	0,035	1,08	1,7	0,18	0,32	0,06	2,3243333	1,9633333
7	0946	1,86	0,83	0,68	0,008	0,029	1,03	1,66	0,16	0,3	0,04	2,2793333	1,9298333
8	*0947*	1,86	0,83	0,68	0,008	0,029	1,03	1,66	0,16	0,3	0,04	2,2793333	1,9298333
9	0961	1,85	0,83	0,67	0,005	0,039	1,05	1,6	0,17	0,3	0,03	2,2733333	1,9179167
10	0949	1,82	0,86	0,68	0,006	0,025	1,12	1,7	0,18	0,3	0,04	2,2623333	1,8908333
11	*0951*	1,82	0,86	0,68	0,006	0,025	1,12	1,7	0,18	0,3	0,04	2,2623333	1,8908333
12	*0965*	1,82	0,81	0,78	0,01	0,032	1,05	1,62	0,19	0,3	0,03	2,24	1,893
13	0944	1,86	0,83	0,68	0,008	0,029	1,03	1,66	0,16	0,3	0,04	2,2793333	1,9298333
14	0945	1,86	0,83	0,68	0,008	0,029	1,03	1,66	0,16	0,3	0,04	2,2793333	1,9298333
15	0960	1,85	0,83	0,67	0,005	0,039	1,05	1,6	0,17	0,3	0,03	2,2733333	1,9179167
16	*0962*	1,85	0,83	0,67	0,005	0,039	1,05	1,6	0,17	0,3	0,03	2,2733333	1,9179167
17	0948	1,82	0,86	0,68	0,006	0,025	1,12	1,7	0,18	0,3	0,04	2,2623333	1,8908333

Using the data presented in tab.2 were made the bar charts of the variation of carburized and graphitizing elements obtained by equivalent carbon, using the relations 3 and 4.

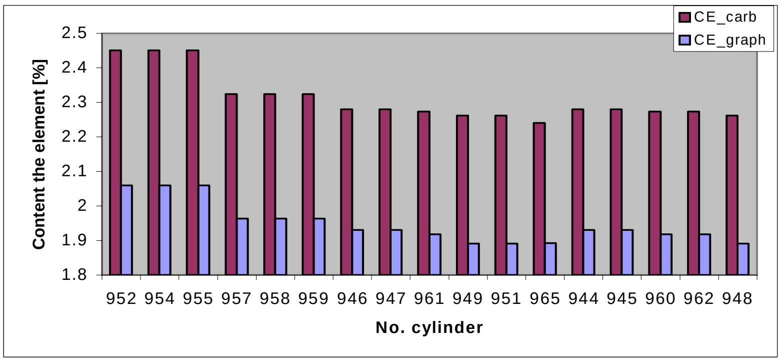

Figure 1. Variation of carburized and graphitizing elements by equivalent carbon, registered for the 17 studied cylinders.

A particular influence over exploitation durability of rolling cylinders is presented by variation of hardness on barrel rolls height, that could govern the site establishing of the gauge which are most stressed, according to profile of rolled metal, number of getting through, speed of rolling, rate of reduction, temperature, etc. For that, for 6 cylinders (0952, 0959, 0947, 0962, 0951, 0965), were performed hardness measurements on barrel rolls height. The registered hardness are presented in the Table 3.

Table 3. Value of the hardness, HB, on the barrel roll height.

	Cylinder No.	$C_{E\ carb.}$ [%]	Height of barrel roll from under journal [mm]					Difference of hardness on height [HB]
			15	250	450	650	875	
1	0952	2,4508333	384	376	366	358	350	34
2	0959	2,3243333	376	368	364	357	346	30
3	0947	2,2793333	372	361	350	346	339	33
4	0962	2,2733333	370	356	342	331	328	42
5	0951	2,2623333	343	338	330	326	312	31
6	0965	2,24	376	362	358	346	335	41
Average			370,16	360,16	351,66	344,00	335,66	35,16

4. CONCLUSIONS

Analyzing the table 3, it results that the differences of hardness registered on the barrel roll of cylinders for the six studied cylinders enters in the field 30…42 HB.

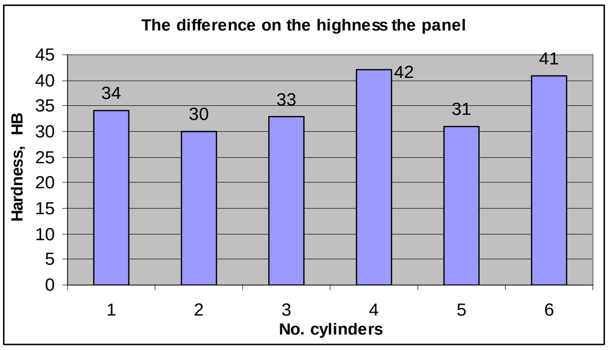

Figure 2. The differences of hardness registered on the barrel roll of cylinders.

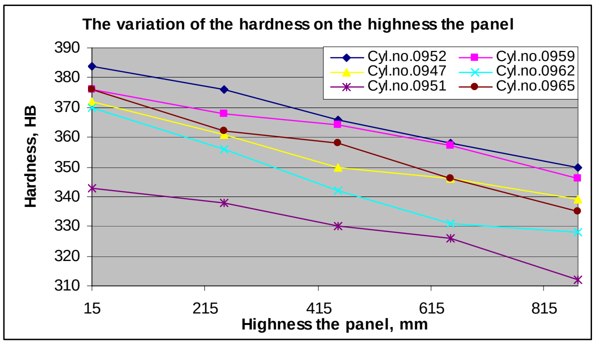

Figure 3. Variation of the hardness on the barrel roll height.

Thus, the maximum values of the hardness on the barrel roll of cylinders are registered at the low part of this, irrespective at the part from inferior journal, being explicable due to the fact that due to direct casting, the inclusions are accumulated at the upper part of barrel roll. As a result of, during the exploitation is recommendable the positioning of most stressed gauges at the inferior part of the barrel roll.

Conclusions:

- ➢ The carburized alloying constituents Mo, Cr, Mn are that govern the appearance of carbides (especially from ledeburite); these drives to the growing of wearing resistance, mainly on hot-rolling.
- ➢ The maximum values of the hardness on the barrel roll of cylinders are registered at the low part of this, irrespective at the part from inferior journal.
- ➢ Due to direct casting, the inclusions are accumulated at the upper part of the barrel roll
- ➢ During the exploitation is recommendable the positioning of most stressed gauges at the lower part of the barrel roll.

5. REFERENCES

[1] BUDAGHIANŢ, N. A., KARSSKI, V.E.: Casting rollers, Bucureşti: Editura Tehnică, 1986

[2] SPOREA, I. ş.a.: 74. Variation of chemical compositions on the section of rollers type Adamit - Vol I - ”Universitaria ROPET 2000”, p.361, Petrosani, 2000

[3] * * * Surveyance on the process flux of rollers made from Fgn and type Adamit, at Siderurgica S.A Hunedoara - Research – design center, Research section, Hunedoara 1998

[4] SPOREA, I., ş.a.: Considerations about rollers using made from casting steels - Sesiune de Comunicări Ştiinţifice Hunedoara, Analele Facultăţii de Inginerie Hunedoara, 2000

[5] Sporea I., Josan A, Mihuţ G. - Studies and tests on rollers type Adamit, R-A2 quality - Analele Universitătii "Valahia", Târgovişte, 2003, pg.41- 44.