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THE REDUCING OF THE GAS CONTENT IN METALLIC SMELTS – SPECIAL REQUIREMENT FOR PRODUCING STEELS WITH ADVANCED PROPERTIES

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There are not sufficient information related to the correlation of gaseous inclusions in steels with their properties. Therefore, in this paper report is given on the experiments carried out on the modification of steel properties (fracture strength, elongation and resilience) as a function of gas content and on microporosity as a function of gas content, including its influence on the quality of steels.

Key words: Characteristics, Steels, Degassing, Hydrogen, Nitrogen and Oxygen gasses in steel

1. INTRODUCTION

The making of steels having advanced properties requires the using of modern steelmaking technologies, a very important one being degassing, namely the removal of gas as hydrogene, nitrogene, oxygene [1, 2]. At present, the steel industry is confronted on this field with two problems, namely that of finding a new method to exhaust gas from metallic smelts[4 – 6] and retechnologization by upgrading the existent installations in metallurgical plants [3].

The last mentioned aim is of great importance in countries that use old technologies, thus, one has to undertake researches which shall generate efficient measures of improving the performances of the current equipment, especially of vacuum degassers of VAD-VOD type.

2. PURPOSE AND RESEARCH CONDITIONS

The gas content minimizing as the main target of durable steel making has to be connected with the knowledge about the influence of gas on the steel quality assessed on the base of the values of various characteristics.

One can observe at this moment that literature doesn't show either sufficient nor systematized data on this subject. Due to such a context, one considers that the study of a possible quantitative correlation between the gas content and the characteristics of steels becomes necessary.

That is why the experiments were planned due to the importance of the connection between gas content and materials characteristics.

Practically, it is analysed the influence of hydrogen [H], nitrogen [N] and oxygen [O] on the fracture strength, R, elongation, A and resilience KCU for a lot of smelts from continuous production streams within a metallurgical plant.

The researched steel groups, their grades and chemical compositions are shown in Table 1.

3. EXPERIMENTAL DATA AND DISCUSSION

The numerical processing of information carried out in the frame of the experimental resarches is shown in **T**ables 2-4 and Fig.1-3.

In Fig. 1 is shown the behaviour of the main mechanical parameters of a typical steel (with the composition specified on the graph), as a function of hydrogen content. The fracture strength, R, decreases abruptly, while elongation shows a slower decrease. The resilience, KCU, exhibit a variation with hydrogen content similar to the elongation.

Table 1 shows the three groups of steels investigated in this paper. Tables 2-4 shows the experimental digital data illustrating the properties of steels as a function of hydrogen, nitrogen and oxygen content of the steels.

Table 1. Smelts researched as concern "gas inclusions – steel quality".

Group	Specific grade	C, %	Mn, %	Ni, %	Cr, %	Mo, %
A	42MoCr11 42MoCr11X 645H 35CD4 30HGSA 30HRA	0.40-0.43	0.68-0.86	0.18-0.28	0.96-1.12	-
B	18MoCrNi17 34MoCrNi15X 32NCW06.604 25CD4-S 48H3	0.16-0.20	0.42-0.58	1.42-1.68	1.52-1.78	0.25-0.35
C	16CrMo44 X18S 50RA 65G OCS90PF 45HNMFAS	0.13-0.18	0.52-0.70	0.22-0.30	0.90-1.10	0.40-0.50

Table 2 – Experimental results concerning the influence of hydrogen (steels belonging to group A).

Crt. no.	H [ppm]	R [ppm]	A [%]	KCU
1	0.82	1240	12.4	58
2	1.12	1255	-	-
3	1.17	1210	11.8	-
4	1.93	1205	10.6	57
5	2.14	1220	12.0	61
6	2.67	1105	-	60
7	2.88	1105	11.8	-
8	3.24	1035	10.9	-
9	3.53	1055	9.9	54
10	3.96	1075	10.2	42
11	4.52	1050	9.8	43
12	4.48	1055	9.6	-
13	4.63	1045	9.9	49

Table 3 – Experimental results concerning the influence of nitrogen (steels belonging to group B).

Crt. no.	N [ppm]	R [ppm]	A [%]	KCU
1	80	1045	-	-
2	88	1075	11	62
3	98	1015	10.1	64
4	104	1025	8.8	52
5	116	995	9.2	-
6	138	1020	8.8	-
7	151	995	8.8	66
8	170	950	8.5	71
9	193	925	-	-
10	212	955	8.6	68

Table 4– Experimental results concerning the influence of oxygen (steels belonging to group C).

Crt. no.	O [ppm]	R [ppm]	A [%]	KCU
1	112	820	9.2	64
2	136	832	-	-
3	152	828	9.4	66
4	170	842	8.2	72
5	204	772	7.8	70
6	214	741	-	-
7	232	738	8.2	68
8	241	695	7.9	58
9	314	715	8.2	-

Figures 1-3 show the evolution of the steel properties when the gas content in steel increases. As easy to see the main mechanical properties of the investigated steels become weaker, the parameters R, A, and KCU decreases with gas content. Excepting the resilience, the other parameters significantly decreases.

We have tried to find the correlations, as expressed by mathematical processing of the experimental data, related to: 1. the fracture strength and [H] and [N] contents; 2. elongation and [H] and [N] contents.

The mathematical processing led to the following mathematical equations, which can be used as tools for the characterization and even prediction the quality of steels as a function of the composition parameters (see equations 1-3).

$$R = 1.38[H]^2 - 39[H] + 1310 \quad (1)$$

$$A = -0.0017[H]^2 - 0.2[H] + 12.44 \quad (2)$$

$$R = 0.13[N]^2 - 15.8[N] + 10.78 \quad (3)$$

$$A = 0.063[N]^2 - 1.02[N] + 12.54 \quad (4)$$

The deviations from these correlations could be explained as follows:

- It is possible to have the simultaneous influence of three types of gases and not of a single one.
- The chemical compositions of steels, although they are highly restricted, still are spread in a range of values;

One of the main conclusions is that resilience is one of those characteristics, which react in the most sensible way to the negative influence of gas entrapped in steels.

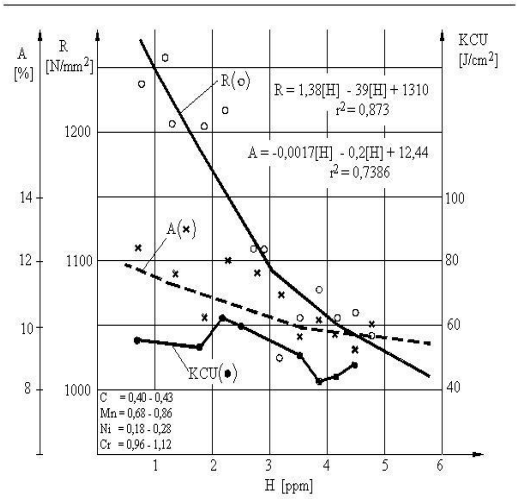

Fig. 1. Steel quality modification of hydrogen content (group A).

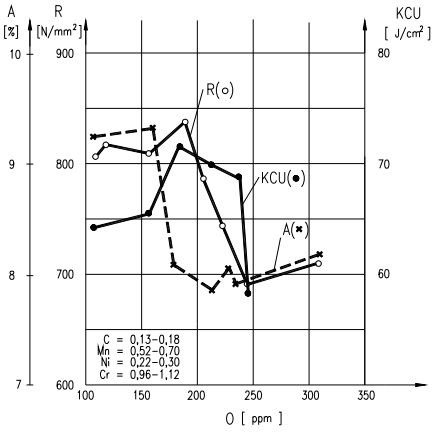

Fig .2.The influence of nitrogen on steel characteristics (group B).

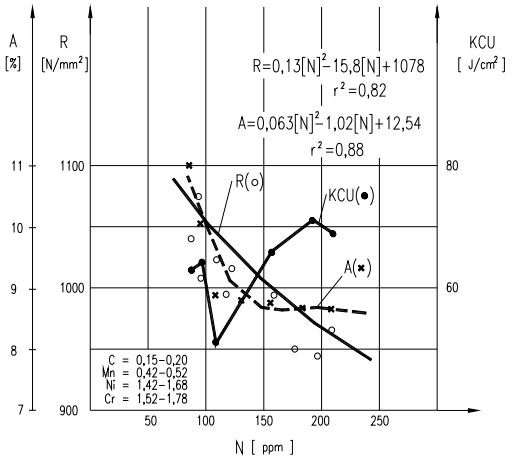

Fig. 3. The influence of oxygen on steel characteristics (group C).

CONCLUSIONS

The steel properties are significantly dependent on the gas content in the sample. The modification of the properties with the gas content has been modelled in order to get the mathematical functions that lay at the basis of the processes that take place in the material.

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