THE NON METALLIC INCLUSION STUDY IN CAR STEEL SAMPLES AND DETERMINATION OF ALUMINUM AND CALCIUM SOLUBLE/ INSOLUBLE PART

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Abstract. *This paper aims to present the results of the study of Al and Ca inclusions in three car steel samples by using the Spark-Dat method. The inclusional analysis of steel's purity was realized with the 21 NEOPHOT Metallographic Microscope. Also, are presented data obtained at determination of the Ca and Al soluble/insoluble parts in the same samples. The values for the fractions* Al_{insol} / Al_{tot} *(0.104; 0.067; 0.106) and* Ca_{insol} / Ca_{tot} *(0.10; 0.10; 0.10), prove the fact that in the steel elaboration the conditions have been created for an improper behavior at continuous pouring. The values of the account* $\frac{CaO}{Al_2O_3}$ *(0.00086; 0.00161; 0.00077) emphasize the fact that the steel from the samples forms the solid alumina at the temperatures of melted steel.*

Keywords*: spark diagram, inclusion, Spark-DAT, Ca insoluble, Al insoluble*

1. INTRODUCTION

In the steel industry, beside manganese, silicon and calcium, the aluminum is a strong deoxidizer agent. During the process of micro-alloying, aluminum is used as an element of acceleration for the deep drawing improvement. Therefore aluminum may be found in steel as a metallic aluminum (soluble aluminum), aluminum oxide and vibrate aluminum. The soluble aluminum and the nitrate can be dissolved in acid and this is simply called, soluble aluminum. During the steel elaboration process it is important to have a measure of the level of soluble aluminum in vinegar. Between the analysis and the obtained analytical result there must be a short period of time for the application of the imposed correction. The first analysis of soluble aluminum through the spectroscopy method of optical emission was developed in the 1960s. The manganese sulfide inclusion was realized in 1961.

In this paper aims to determine the concentration of Al soluble, Ca soluble, Al insoluble, Ca insoluble, through the Spark- DAT method for three car samples. Also, the analysis of non metallic inclusion of Al and Ca in the same samples is presented.

2. EXPERIMENTAL

Measurements were performed using optical emission with spectrochemical method – Spark DATA technique on three car samples S1, S2, S3. Technical data for Optical emission spectrometer owned by S.C. MECHEL Targoviste S.A. are presented in table 1.

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Table 1. Technical data for Optical emission spectrometer owned by S.C. MECHEL Targoviste S.A.

Diffraction order	Blase angle [nm]	Spectral range [nm]	The reverse of dispersion [nm/mm]
1	347	220÷528	0.60
2	173	160÷260	0.30
3	116	130÷176	0.20

The aim of the Spark-DAT option (Spark Digital Acquisition and Treatment) is to reach the intensity of each spark in the place of integrated value and to treat these signals with on-line fast algorithms. With the help of Spark DAT, the intensity emitted by the sample at each spark is measured and stored in 32 channels. The results are displayed as a spark diagram.

Inclusion is defined as the material with different composition (cinders, flux fondants, loam, products resulting from the chemical interaction which take place at the elaboration and pouring of the liquid metal) of the basic material, isolated in the continuous weight of the metallic material. The cast parts come from the elaboration and pouring technology, while the parts obtained through plastic decoration come from the ingot or the used semi-product.

The non-metallic inclusion has a strip form which produces local discontinuities in each part. These could be plastic (sulfides, silicates) and at the microscope they appear oblong, compact or fragile (oxides), and are divided into small pieces. In all cases, the inclusion reduces considerably the plasticity and the mechanic characteristics of the metallic material.

The calcium aluminates are dangerous, especially at contact during lamination. The effect of an inclusion over the properties of tiredness is dependent of the following: the size of the inclusion, shape, heat and elastic properties and the affiliation at a matrix. These factors are related to a form factor and to the tension distribution around the inclusion. The size of an inclusion has a major effect over the resistance of tiredness.

Calcium is a strong deoxidizer in steel and desulphurizer in steels . Calcium treatment can be used for steels to lower the sulfur and oxygen contents as well as to lower the number of inclusions and to modify the inclusion morphology. Calcium treatment modifies oxide and sulfide inclusion chemistry and morphology so that elongated inclusions become globular.

The aluminum oxides, which are normally of big sizes, with sharp rigs (even clusters appear), and very harmful for the devices, are in small number or are completely erased, being substituted by complex inclusion such $CaO - Al_2O_3$ or $CaO - Al_2O_3 - SiO_2$.

To determine the soluble/insoluble parts, one needs the static processing of the spark diagrams. The mathematical algorithm Ca_{tot}, Al_{tot} calculates the medium value associated to the total account from the sample, the algorithm Ca_{sol}, Al_{sol} calculates the median associated to the soluble calcium, and the algorithm Ca_{insol}, Al_{insol}, calculates the difference between the average and the associated median with the insoluble calcium.

Table 2 presents the results obtained for determined Al and Ca insoluble parts in car samples.

Table 2. Results obtained for determined Al and Ca insoluble parts in car samples

Probe	Al_{tot} (ppm)	Al_{insol} (ppm)	Al insol/tot	Ca_{tot} (ppm)	Ca_{insol} (ppm)	Ca insol/tot	$\frac{CaO}{Al_2O_3}$
S_1	410	43	0.104	1.0	0.1	0.10	0.00086
S_2	340	23	0.067	1.0	0.1	0.10	0.00161
S_3	450	48	0.106	1.0	0.1	0.10	0.00077

Knowing the total amount of the calcium from the sample, the relation is applied to the calibration curve [1]:

$$Ca_{insol} = \frac{Ca \cdot Ca_{-insol}}{Ca_{-tot}} \quad (1)$$

$$Al_{insol} = \frac{Al \cdot Al_{-insol}}{Al_{-tot}} \quad (2)$$

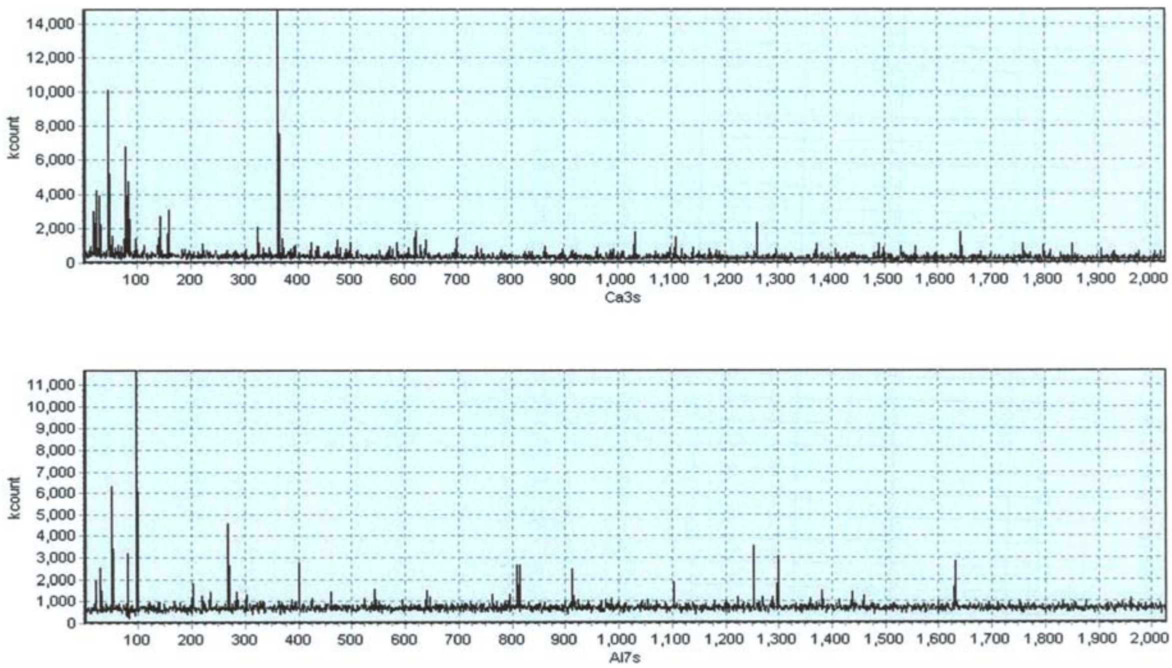

Fig.1. Spark diagram for sample 1.

The S1 sample has fourteen Al inclusions, fifteen Ca inclusions and zero Al and Ca inclusions. The first Ca inclusions are at surface, the most intense inclusion is at spark with number 400. For Al the most inclusions are at surface (sparks between [0-100], Fig. 1). The maximum intensity for this kind of inclusion is at spark with number 100. Therefore in this sample the inclusions are at the material surface.

Fig. 2. Image with metallographic microscopy for sample 1.

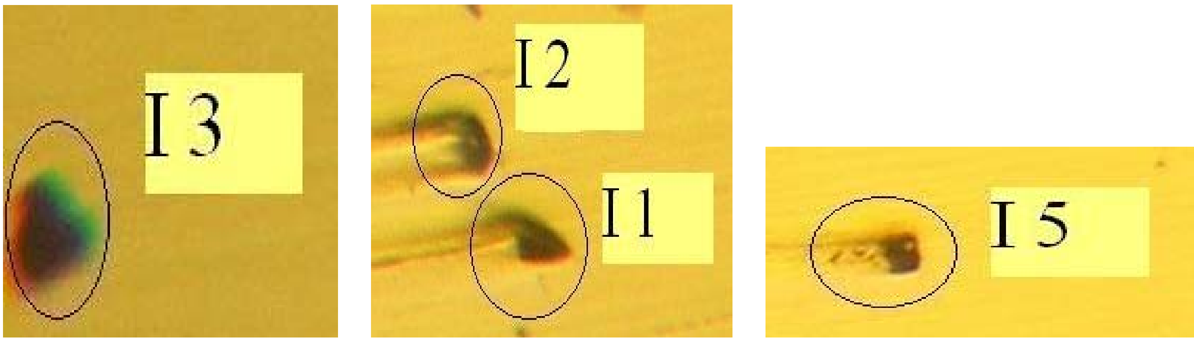

Fig.3. Metallographic microscopy for inclusions I1, I2, I4 from sample 1.

The metallographic images displayed in Figs. 2 and 3 show the following: I1, I2, I3, I5 are inclusions with irregular shape large size. This sample is unsuitable metallographic.

For the sample S_2, were recorded ten Al inclusions, sixteen Ca inclusions and one inclusion of Al and Ca (spark 50). For Ca the most intense inclusion is at spark number 450 and for Al at spark number 1400 (depth inclusion which can not been seen with metallographic microscope). With an irregular shape and quite dangerous for the structure of the material for which the sample was collected, is inclusion I1, while inclusions I2 and I3 are reduced as size, have globular, irregular shape and are distributed in the structure of the material. .

For sample S3, the Spark-DAT technique established 10 Al inclusions, 13 Ca inclusions, and one Al and Ca inclusions (Fig. 4). Out of the Spark diagram it can be concluded that the Ca inclusions are uniform distributed in the volume of the sample and the most intense was the spark number 420, while for aluminum the most intense one is at spark number 50 (surface inclusion). Almost all Al inclusions are displayed on the material surface.

From the metallographic analysis of sample S3, it can be noticed a globular inclusion of large size displayed at the surface I1 and a reduced irregular one I2.

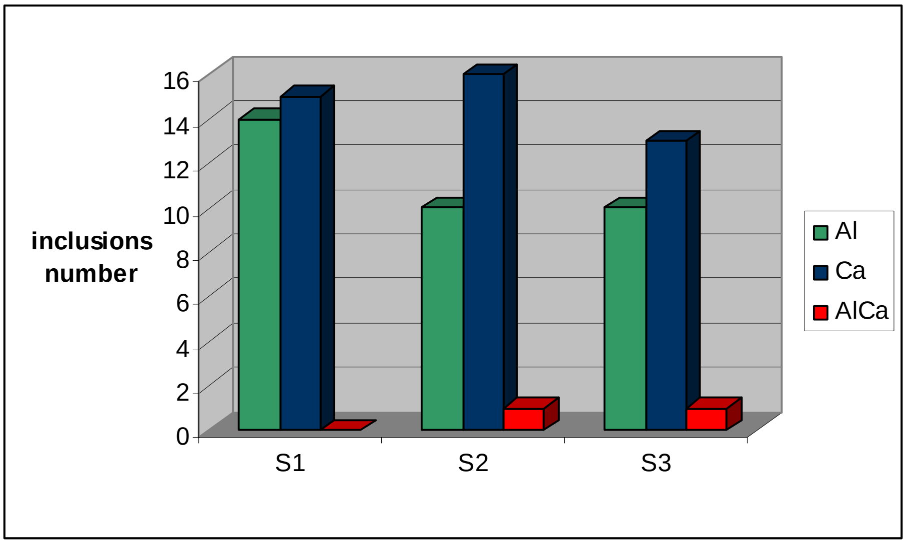

Fig. 4. The number of Al and Ca inclusions from the samples.

3. RESULTS AND CONCLUSIONS

The structural alterations, which are extremely important and take place within the industry with the main aim of updating its internal profile, had implications in the metallurgic industry in which qualitative and quantitative developments have been produced and are still being produced. The major demands of the world-wide economy imposed the intensification of the concern for the development of manufacture technology with the purpose of lifting the quality of metallurgic products, as well as the reduction of the price.

In 2009, the steel international market reached the lowest point and it will increase with 9, 2 % this year, since the demand has recovered in USA, Europe and Japan (according to the World-Wide Steel Association). In the future, the steel consumption could rise at 1, 2 milliard metric ton, from 1,104 milliards, which was the last year estimation. In the European Union, the demand for steel decreased with 33% in 2009, but will increase with 12.4% in 2010. Under these circumstances, when the steel remains a basic component for the majority of industry branches, it must be considered to increase the quality of development and to extend the research of compositional analysis.

The great variety of steel properties is determined by the chemical composition and the method of processing (plastic, chemical and thermo-chemical). The steel behavior at plastic distortion, at thermal treatment or mechanic processing is determined by mechanic composition, on the one hand, and by its method of processing, on the other hand.

The aim of Ca treatment is to change alumina with high heat temperatures in Al and Ca components, which are liquid at the temperatures of melted steel. The Al components which should be avoided are: CaO·6 Al_2O_3 with melting temperature 1833ºC and CaO·2 Al_2O_3 with melting temperature 1775ºC. The Al component which forms CaO· Al_2O_3 with melting temperature 1590ºC, is the temperature limit for melted steel [1].

The Al components corresponding from the technological point of view are: 3CaO· Al_2O_3 and 12CaO · 7 Al_2O_3, and they have the following melting temperatures 1539C, 1395C respectively.

The CaO/Al_2O_3 report for these components is: 1, 63; 0, 92 respectively. Analyzing the last column from chart 1, we notice that for all these 3 samples the values of the noted report are fewer than the 2 values. We may conclude that the steel from the car samples formed the solid alumina at the temperatures of melted steel.

From the diagram analysis of the Al, Ca and AlCa inclusions, it can be noticed that only the third sample has a calcium aluminates inclusion. This fact proves that all 3 samples are "clean" from the calcium aluminates point of view and each of them has a certain number (reduced from the technologic point of view) of Al and Ca inclusions. Knowing the distribution of Al, Ca and calcium aluminates inclusions, it can conclude over the properties of tiredness on the steel samples [2].

REFERENCES

[1] Vlaicu, Gh., Popescu, I. V., Parsan, F., Bancuta, I., Bahrim, M., *Romanian Reports in Physics,* **62**(2), 350, 2010.
[2] Anderson, C.W., Shi, G., Atkinson, H.V., *Acta Materialia*, **48**(17), 4235, 2000.

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