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ANALYSIS OF STRUCTURAL COMPONENTS EXISTING IN STEEL MAKING SLAG SAMPLED FROM STEEL MAKING-CONTINUOUS CASTING FLOW SHEET

Adriana PREDA[1], Ion IVAN[2], Florin ZĂMAN[3]
[1] S.C.UZINSIDER ENGINEERING S.A. GALATI,
[2] S.C. MITTAL STEEL S.A. GALATI
[3] ICEM S.A. BUCHAREST
email: research@uzineng.ro

ABSTRACT

Hereby paper work aims to identify and analyze the structural constituents from the steel making shop slag. Therefore, slag specimens sampled from different stages of steel making-continuous casting flow sheet in Mittal Steel Galaţi: after desulphuration, after converter tapping, from LF area, after continuous casting. By X ray difractometer analysis the existing phases in investigated stages based on diffracted crystallographic planes enhanced the variation graphs of lines intensity depending on diffraction angles drawn. The results achieved together with the followed technological parameters formed the data basis in order to perform a detailed analysis about progressing of each technological stage itemized (apparition conditions, effects) setting the requirements for optimization of steel making-continuous casting flow sheet in Mittal Steel Galati ferrous metallurgy area. The recorded information corroborated by values of physical-chemical characteristics of slag investigated should allow the making and testing of several technological solutions for capitalization and recirculating of these materials.

KEYWORD: slag, recirculating, capitalization.

Introduction

The lasting development program of the Romanian ferrous metallurgy includes as major task the establishing of the intensive capitalization and recirculating technologies for steel melting shop slag.

The slag has to be suitable to conditions required by dynamic trials and/or matched with weather conditions (temperature variations) in order to be recycled in ferrous metallurgy or roads manufacturing.

This is caused by physical-mechanical characteristics like granularity, content of impurities, density, water uptake, shape of grains, impact crashing resistance, wear resistance, freezing-thawing resistance, polishing resistance, binders stickiness.

Steel melting shop slag is a dense material with rough density >3.2 g/cm^3, lasting stickiness and erosion resistance which allow it to be used in roads manufacturing for lifting layers or asphalt layers submitted to high requests.

The main performances of the steel melting shop slag characteristics against the products made of crushed stone and those from pit ballast, mostly used in roads manufacturing, are submitted in table no.1.

Magnetic separation of metallic inclusions and granularity screening are compulsory before use (chemical and mineralogical one at the same time) getting:

- a ferrous product, recyclable in ferrous metallurgy;
- 0.8 ÷ 0.16 type named disaggregated slag recyclable in both ferrous metallurgy and roads manufacturing;
- >16 mm type named non-disaggregated slag recyclable in roads manufacturing only. Slag fragments have heterogeneous texture varying from porous - alveolar up to compact, varying suitable from light to dark gray color, even brawn. Visual separation reveals a mass content with ~ 70% porous fragments and ~ 30% compact fragments.

Structural constituents were found out during laboratory tests for estimating the possibilities of using these slags.

Table 1. *Characteristics of the steel melting shop slag*

Characteristics	*Slag*	*Crushed ag.*	*Pit ballast ag.*
Apparent density, kg/mJ	3300-3500	2500-2700	2600
Water uptake, % from mass	0,7-1,0	<0,5	<0,5
Grain shape – shape coefficient, %	<10	<10	<10
Crushing degree, % from mass	13-17	17	21
Wear by Los Angeles machine, %	18-22	12	21
Compression strength, N/mm^2	320-350	260	250
Freezing-thawing resistance, % from mass – frost cleftness coefficient	<0,5	<0,5	<1
Bituminous earth stickiness, %	>90	>80	>80
Polishing coefficient (PSV), %	58-61	48	45

Experimental results

Four dust slag samples were exposed in CoKα radiation, sampled from the manufacturing flux of OLD1 Mittal Steel Galați, codified as it follows: D code - slag resulted after iron desulphuration; OLD code - slag tapped after elaboration in LD converter; LF code - slag resulted after treatment in LF plant; TC code - slag resulted after bubbling in ladle;

Phases identified by X ray difractometric analysis and their specific difractometric parameters (diffraction angles, distances between planes, Miller coefficients of crystallographic planes) are submitted in table no. 2. Phase quantitative ratio values are estimated for each sample. Graphical representation of structural constituents identified in samples (lines intensity depending on diffraction angles) may be seen in fig. 1÷4.

Table *Difractometric parameters of analyzed samples*

Sample code	Identified phases	Phase quantitative report [%]	Miller coefficients of crystallographic planes (hkl)	Crystallographic system
D	$Ca_3Si_2O_7$ rankinit	40,3	(202); (112); (221); (121); (320); (124); (115);	M
	CaC_2	7,7	(101); (110); (111);	T
	Fe_2O_3	18,7	(112); (101); (202); (123); (224); (202); (134); (231);	R
	Feα	21,0	(110); (200); (211); (220);	C.V.C.
	MgO	12,3	(111); (200); (220); (400);	C.C.
OLD	$2CaO \cdot Al_2O_3 . SiO_2$ gehlenit	38,3	(111); (201); (211); (220); (311); (400); (323);	T
	Fe_2O_3	29,0	(101); (112); (101); (102); (202); (123); (103);(224);(134);(204); (235)	R
	CaO	22,5	(111); (200);(220); (222); (331); (400);(420);	C.F.C
	FeO	10,2	(111); (200); (220); (311); (222);	C.F.C
LF	$\beta CaO \cdot SiO_2$ wollastonit	38,0	(400); (310); (501); (203); (710); (313);(631);(322);(314);(223);(205)	Tr
	$CaO \cdot Al_2O_3 . 2SiO_2$ anortit	36,1	(220);(004);(204);(132); (130);(1**1**1)	Tr
	CaS	11,3	(111); (200); (220);	C.C.
	αAl_2O_3	14,6	(112); (102); (202); (123); (234); (20**2**); (131); (134); (225);	H
TC	$2CaO \cdot Al_2O_3 . SiO_2$ gehlenit	14,7	(111);(211);(212);(400);(410);(600)	T
	$\gamma\ Ca_2SiO_4$	33,9	(020); (103);(113);(121);(104);(311)	O
	αAl_2O_3	19,0	(112);(102);(202);(134); (231);(204)	H
	CaO	9,4	(200); (220); (332); (222); (400);	C.F.C
	$Al_2O_3 \cdot SiO_2$	23,0	(122); (230); (042);	O

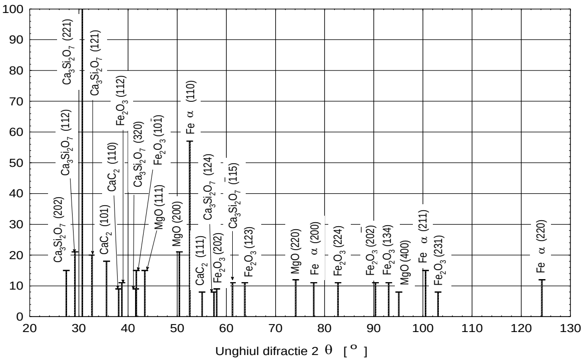

Fig.1. *Diffraction lines intensity variation depending on diffraction angle.* ***D*** *code sample.*

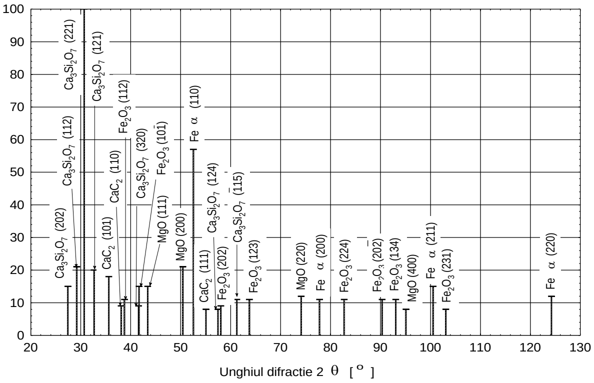

Fig.2*. Diffraction lines intensity variation depending on diffraction angle.* ***OLD*** *code sample.*

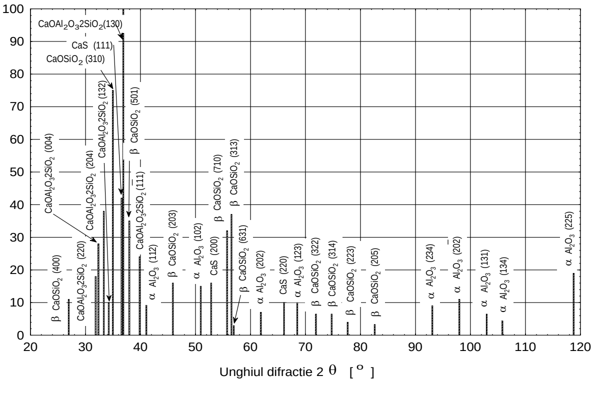

Fig.3. *Diffraction lines intensity variation depending on diffraction angle.* ***LF*** *code sample.*

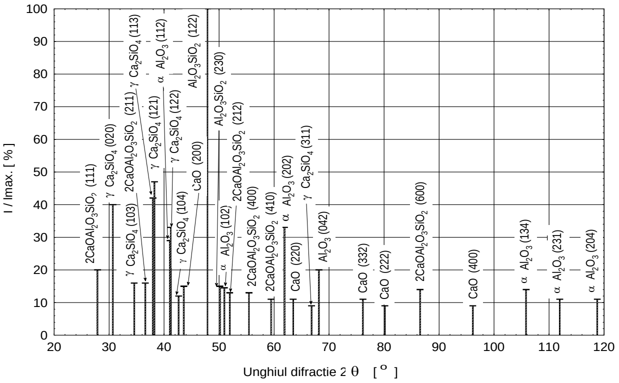

Fig. 4*. Diffraction lines intensity variation depending on diffraction angle.* ***TC*** *code sample.*

Difractometric analysis results enhanced the followings:

- **D** code slag beside the constituents specific for desulphuration plant reactions (calcium silicate $Ca_3Si_2O_7$, CaC_2, MgO) contain also ferrous as chemical element, in a non-allowed large quantitative ratio (**21,0%**) as well as Fe_2O_3 oxide in 18,7% quantitative ratio;
- **OLD** code slag has in composition, beside complex calcium silicate and calcium oxide, a significant ferrous content like FeO (10,2% quantitative ratio) and Fe_2O_3 in **29,0%** quantitative ratio;
- **LF** and **TC** code slag beside CaO, Al_2O_3 as well as simple or complex calcium and aluminum silicates **do not content ferrous oxides;**

Analyzing the results allowed characterisize the each technological stage running of the flow sheet in OLD1 Mittal Steel.

Iron presence in several of the investigated slags allowed finding out the deficiencies in the desulphuration process and converter steel making as well as stating the actions required in order to get rid of them.

Ladle iron desulphuration is considered to be an efficient process if it achieves the sulfur content decreasing up to the required values without increasing the iron content in slag. Several suitable desulphurating materials feeding in order to provide the making a slag with large sulfur absorption capacity and high flow ability to ensure the iron particles spreading in metallic bath may achieve this.

Shop steel making is achieved by combined blowing procedure (oxygen on the top side blown by lance and inert gases bubbling blown by nozzles located at the converter bottom side). This flow sheet performs as close as optimally possible when the slag is active and basic since the beginning of the oxygen blow providing the increase of iron quantity in the metallic bath.

- Based on the information received it passed to improving the technological flows of iron desulphurating and converter steel making, in order to significantly decreasing the iron losses and experimenting the methods of exploitation the steel melting shop slag.

Conclusions

X ray difractometric analysis found out the structural constituents existing in the steel melting shop slag, bringing information required for complete featuring of these materials.

The results allowed enlarging the data basis regarding:

- The finding out of eventual deficiencies on the investigated flow sheet and stating the actions required in order to get rid of them;
- The delimitation areas of using the steel melting shop slag and testing the several receipts in order to reuse these materials;

The drawing up and testing of some technological solutions intended for valuating and recirculating the steel melting shop slag.

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