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Studies Concerning the Possibilities of Manganese Recovery from Steel Slag by HCl and HNO_3 Extraction

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Abstract: In this paper, we studied the possibilities of manganese recovery from steel slag, which is a result of steel manufacturing in Siemens-Martin furnace, on Metallurgical Plant Resita. Steel slag was put into acid extraction in HCl and HNO_3 with various concentration, at different values of liquid : solid ratio and extraction time. During lab experiences, it comes out conclusions and we settled the optimal conditions for manganese recovery.

Keywords: steel slag, manganese recovery, acid extraction, optimal conditions.

1. Introduction

Residues decontamination has an important role in solving problems concerning environment protection. Thus, concepts of decontamination were introduced, in which residues are avoid or turn to goods, so only a small part of them need processing.

The most part of recovered materials, cant be used as they are in collected form, so these are potential reused.

Converting them into direct usefull materials need an advanced technological processing, which bring them value [1-8].

2. Experimental

Steel slag was put into drilling and sorting process, and, for experimental determinations we used fraction F_6 (<90μm)< with the following percentage content of metals: Ca 21.54%; Mg 8.70%; Fe 21.03%; Mn 11.76%.

In lab experiences, manganese recovery was made by steel slag dissolving in HCl and HNO_3[9].

For settling optimal conditions, extraction from steel slag was realized in 15% and 32% HCl, and 25% and 54% HNO_3, at different values of time (5; 10; 15 and 30 minutes) and extraction liquid:solid ratio (liquid = volume of acid used in extraction; solid = steel slag mass, mixes with acid).

Manganese content determination in acid extracts, was realized by atomic absorption spectrophotometry method, in the following conditions [10, 11, 12]:

- flame type: air – acetylene;
- air flow: 3.5 L/min;
- acetylene flow: 1.5 L/min;
- lamp current: 3 mA;
- wave length λ = 279.5 nm;
- slith width: 0.2 nm.

3. Results and discussion

Manganese separation degree from steel slag, calculated following extraction in HCl and HNO_3 at different liquid:solid ratio values, and time of extraction, are presented in Table 1 and Figure1.

Analyzing results from table 1 and fig.1, it comes out that:

- manganese separation degree – α_{Mn}, calculated following extraction in 15% HCl took values in 18-85% domain. α_{Mn} raise significantly with liquid : solid ratio increasing, values calculated for α_{Mn} at liquid : solid ratio = 10:1 are twice higher than those calculated for liquid : solid ratio = 4 : 1;
- in the case of 32% HCl extraction, manganese separation degree took values in 34-83% domain. Values which exceed 70%, were calculated starting from liquid : solid ratio = 8:1 and extraction time = 15 minutes;
- α_{Mn} values, calculated in case of 25% HNO_3 extraction, are very low, taking values in 28-45% domain. In this case, neither liquid : solid ratio raising or extraction time increasing, don't bring significant raising of α_{Mn} values.
- In case of 54% HNO_3 manganese extraction, α_{Mn} took values in 30-75,5% domain. Values that exceed 70%, were calculated for liquid : solid ratio = 10:1 and extraction time values of 10, 15 and 30 minutes.

For determination the way in which manganese separation degree is influenced by other parameters of process, we calculated by mathematical regression method, the answer curves of α_{Mn} variation, as a function of liquid : solid ratio, at different values of extraction time. The mathematical expressions are presented in Table 2

TABLE 1. Manganese separation degree - α_{Mn} from steel slag, during acid extraction in HCl and HNO_3

Liquid:solid ratio	time (min.)	Manganese separation degree α_{Mn} (%)			
		HCl 15%	HCl 32%	HNO_3 25%	HNO_3 54%
4:1	5	18.5	34.8	28.3	30.3
	10	29.1	35.9	28.6	35.2
	15	35.5	37.3	29.4	37.6
	30	36.1	37.2	29.4	37.9
5:1	5	25.7	45.9	30.2	41.5
	10	34.8	45.9	31.4	41.9
	15	42.8	46.9	31.3	42.2
	30	44.0	48.1	34.2	44.2
6:1	5	55.2	54.1	29.3	43.2
	10	54.9	58.1	32.6	48.6
	15	56.2	57.2	34.9	49.2
	30	56.2	59.0	35.7	55.2
8:1	5	61.6	51.0	30.7	60.3
	10	66.1	65.7	32.4	65.3
	15	69.2	75.8	37.3	69.0
	30	71.0	74.9	39.0	69.1
10:1	5	81.0	79.0	38.0	69.2
	10	81.2	81.8	38.9	72.1
	15	84.1	82.2	39.4	72.2
	30	84.8	83.0	45.1	75.5

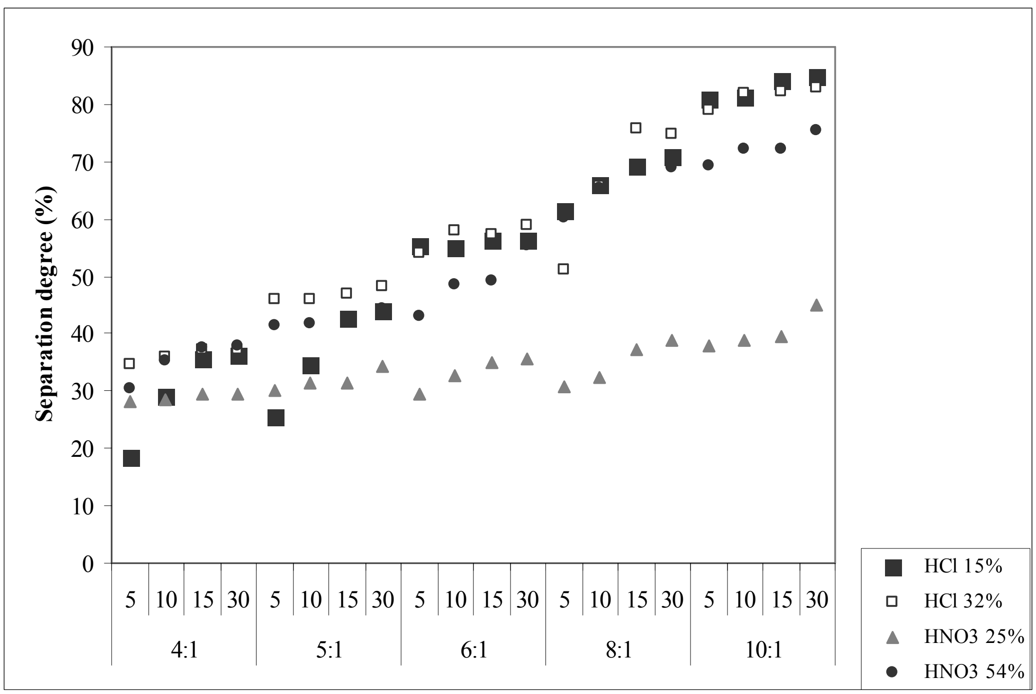

Figure 1. Manganese separation degree variation as a function of liquid : solid ratio and time of extraction

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TABLE 2. Mathematical expressions of manganese separation degree α_{Mn} answer curves as a function of liquid : solid ratio, at different values of extraction time

Liquid : solid ratio	Equation	Correlation coefficient r
HCl 15%		
4:1	y = 3.32 lnx + 21.76	r = 0.939
5:1	y = 4.07 lnx + 26.93	r = 0.961
6:1	y = 5.78 lnx + 40.86	r = 0.990
8:1	y = 7.07 lnx + 49.16	r = 0.998
10:1	y = 8.64 lnx + 60.82	r = 0.993
HCl 32%		
4:1	y = 3.82 lnx + 26.84	r = 0.994
5:1	y = 4.87 lnx + 34.31	r = 0.992
6:1	y = 5.98 lnx + 41.96	r = 0.995
8:1	y = 7.25 lnx + 48.94	r = 0.980
10:1	y = 8.50 lnx + 59.91	r = 0.993
HNO_3 25%		
4:1	y = 3.021 lnx + 21.28	r = 0.993
5:1	y = 3.34 lnx + 23.35	r = 0.967
6:1	y = 3.52 lnx + 24.33	r = 0.998
8:1	y = 3.73 lnx + 25.56	r = 0.996
10:1	y = 4.27 lnx + 29.63	r = 0.997
HNO_3 54%		
4:1	y = 3.75 lnx + 25.86	r = 0.996
5:1	y = 4.44 lnx + 31.20	r = 0.998
6:1	y = 5.23 lnx + 35.97	r = 0.998
8:1	y = 6.96 lnx + 48.41	r = 0.997
10:1	y = 7.57 lnx + 53.08	r = 0.995

During steel slag manganese separation by acid extraction, it comes out that α_{Mn} has an increasing tendency with liquid : solid ratio increasing, at the same values of extraction time, and with the extraction time increasing, at the same values of liquid : solid ratio, independent of acid type.

The highest values of manganese separation degree in all studied cases, were calculated for liquid : solid ratio = 10:1 and extraction time = 15 and 30 minutes.

Significant values of α_{Mn} were calculated in case of 15% and 32% HCl extraction and 54% HNO_3 extraction. α_{Mn} calculated for 15% HCl extraction had values near close to those calculated for 32% HCl extraction, and a little higher than values calculated for 54% HNO_3 extraction.

Manganese separation degree exceed 80% for 15% HCl extraction at a liquid : solid ratio = 10:1 and extraction time = 5-30 minutes; and for 32% HCl extraction at a liquid : solid ratio = 10:1 and extraction time = 10-30 minutes. In case of manganese separation from steel slag by HCl extraction, increasing HCl concentration don't bring significant variation of separation degree.

TABLE 3. Optimal conditions of manganese recovery process from steel slag, by acid extraction

Type of acid	Liquid : solid ratio	Extraction time	α optimal value (%)
HCl 15%	10:1	15 minutes	84.1
HNO_3 54%	10:1	30 minutes	75.4

Answer curves of manganese separation degree variation, calculated as a function of liquid : solid ratio at different values of extraction time, are characterized by logarithmic equations, with values of correlation coefficient higher than 0.9.

4. Conclusions

Based on experimental data, we settled optimal conditions of manganese recovery by acid processing of steel slag.

Experimental data processing by mathematical regression method, permitted the settlement of mathematical model of manganese acid extraction process, respectively equations of manganese separation degree dependence on parameters of process (acid concentration; liquid : solid ratio; extraction time).

References

1. Angelescu, A., Ciobotaru, V., *Impactul unor activităţi poluante specifice asupra mediului*, Economia 2, **2003**, 41-45.
2. Iovi, A. Iovi, C., Negrea, P., *Chimia şi Tehnologia îngrăşămintelor cu microelemente*, Ed. Politehnica, Timişoara, **1999**.
3. xxx., *What is Slag,* National Slag Association, USA, **2002**.
4. *** *Raport de mediu 2002, Europa Centrală şi de Est*, Heidelberg Cement, Bucureşti, **2003**.
5. Van Oss, G.,H.., *Iron and Steel Slag*, U.S.Geological Survey, Mineral Com-modity Summaries, USA, **2005**.
6. Ziemkiewicz., P., *Steel Slag: Application for AMD Controll,* Proceding of the **1998** Conference on Hazardous Research.
7. *** *New Uses for Steel Mill Slag – Available Resources from Waste,* Built Environment Innovation & Construction Technology, Nr.21, USA, Oct. **2001**.
8. Wilburn, D., R., Goonan, T., G*., Aggregate from Natural and Recycled Sources*, U.S.Geological Survey Circular 1176, SUA , **1998**.
9. Dobrescu, L., Socolescu, A., Vişan, S., *Folosirea reactivilor anorganici pentru extragerea metalelor din soluţii acide rezultate în procese hidrometalurgice*, Metalurgia 36, **1984**, nr.9, 368-370.
10. Lupu, I., Grigorescu F., Lupu L*., Analiza instrumentală în metalurgie şi construcţii de maşini,* Ed. Tehnica, Bucureşti, **1986**.
11. Cristurean, E., Marinescu, D., Antoniu, A., Olar, R., Badea, M., *Chimia metalelor – lucrări practice de laborator*, Editura Universităţii din Bucureşti, **1998**.
12. AOAC 965.09. *Official Methods of Analysis of the Association of the Official Analytical Chemists*, SUA, **1990**.