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Method for obtaining iron concentrate from metallurgical slags

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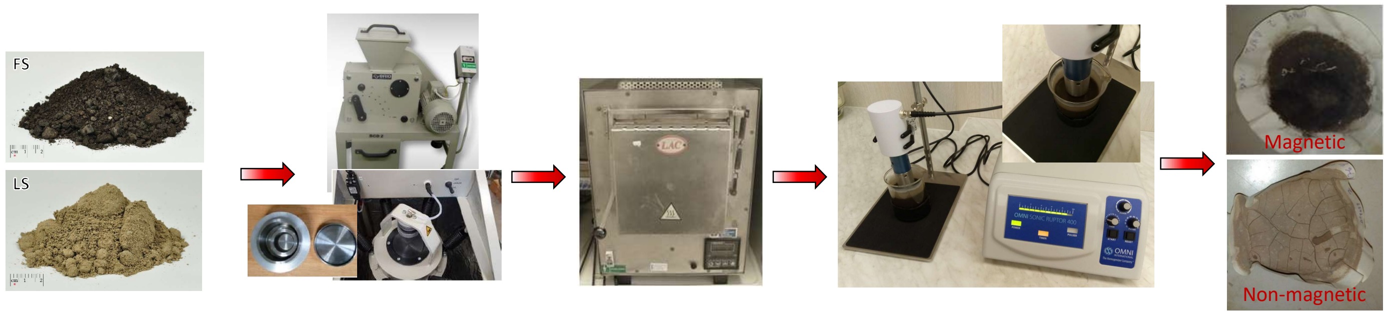
Introduction

A huge amount of furnace steel (FS) and ladle steel (LS) slag is produced as by-products during steel manufacturing. Not all the amount of produced steel slag finds appropriate utilization and is dumped in a landfill site. However, steel slags contain a reasonable amount of metallic elements such as iron, manganese, and magnesium. The objective of the present work is to investigate the possibility of iron recovery from milled slags. The proposed method is based on the disintegration of the slag grains in water environment using ultrasound. Magnetic particles in treated suspension are obtained using a wet magnetic separation process. Thermal treatment of the milled slags prior to ultrasound disintegration can be used to transform FeO into Fe_3O_4, with this step the magnetic fraction yield is significantly improved.

Application

Slags were crushed and grinded with vibrational mill and further subjected to sieving. The composition of milled slags is shown in **Table 1**. To increase the amount of magnetic fraction, FeO was converted to Fe_3O_4 (**Figure 1**) by calcination of the slags in a muffle furnace. The calcination temperature was optimized for each of the slags, whereas 800 and 1000 °C were used for FS and LS, respectively. In a next step, the slags were mixed with water in containers using overhead stirrer, and further disintegrated by ultrasonication. For magnetic separation experiments a belt with neodymium magnets was placed on the outside wall of container. The suspension was stirred for 10 minutes and during this process, the magnetic particles presented in slag adhered to the wall of container, and the nonmagnetic materials fall to the bottom part of the container. The non-magnetic fraction settled at the bottom and was separated by the filtration. After the removal of the belt with magnets, the magnetic fraction was obtained. Both, magnetic and non-magnetic fractions were dried at 70 °C and weighed.

Scheme of the separation process



Magnetic separation divides the individual slag into two fractions: magnetic (M) and nonmagnetic (NM), the yield of these fractions for both LS and FS, together with their chemical composition is shown in **Table 1**, the chemical composition of M and NM fractions is shown also in **Table 1**.

Table 1: Chemical compositions of original slags and magnetic (M) and non-magnetic (NM) part for wet magnetic separation.

Slag sample	LS			FS		
Oxides	w (wt%)					
	Original	Magnetic	Non-magnetic	Original	Magnetic	Non-magnetic
MgO	2.82	4.34	5.09	3.72	3.97	2.52
Al_2O_3	5.83	2.2	9.36	1.68	0.72	1.43
SiO_2	12.1	6.59	16.5	9.92	5.76	8.62
CaO	52.9	30.2	56.7	47.2	34.7	54.1
SO_3	1.2	0.66	1.46	0.12	0.12	0.25
MnO	2.76	6.72	1.36	4.4	7.08	3.5
Fe_2O_3	**16.9**	**48.3**	**8.7**	**30.7**	**45.7**	**26.5**
Yield	**-**	**53**	**47**	**-**	**31**	**69**

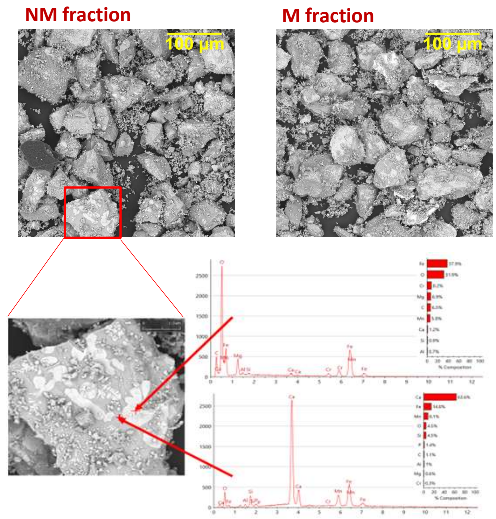


Figure 3: SEM micrograph of the selected particle of non-magnetic fraction of LS sample together with EDX spectra measured in marked points.

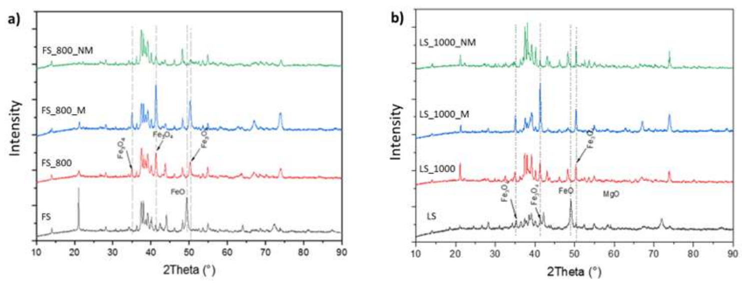


Figure 1: Phase composition of a) original and calcined FS slag, M and NM fractions obtained from FS slag; and b) original and calcined LS slag, M and NM fractions obtained form LS slag.

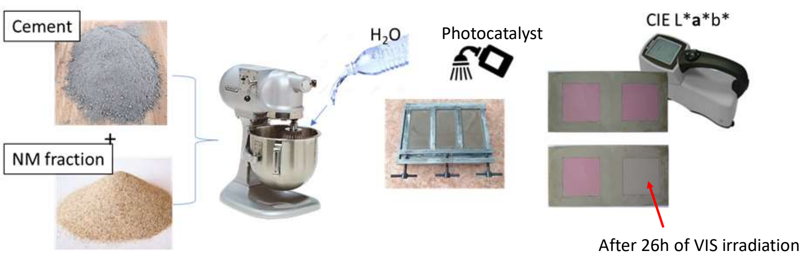


Figure 2: Utilization of the non-magnetic fraction as a filler for the preparation of building materials with self-cleaning properties

Summary

- Steel furnace and steel ladle slags represent a valuable source of iron.
- Using the tuned wet magnetic separation process, a reasonable part of the magnetic fraction can be separated.
- The separation process can be intensified by the transformation of iron and wüstite to magnetite using thermal treatment of the slags in the air environment.
- The magnetic fraction can be recycled in the metallurgical process, or can be used for other advanced applications, for example, magnetically separated carriers for sorbents or photocatalysts.
- Non-magnetic fraction can be used as a filler in cement-based building materials, this application is demonstrated in **Figure 2**.
- Further research should focus on the isolation of fine iron-based particles encapsulated in calcium-silicate based matrix (**Figure 3**).

Patent application

„Method for obtaining iron concentrate from metallurgical slags“ - registration number WO2022223061A1.

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