COMPARISON OF ELECTRODYNAMIC FRAGMENTATION AND CRUSHING OF CONVERTER SLAG AND EOL BRICKS

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Introduction

Electrodynamic fragmentation (EDF) was compared to conventional crushing in terms of liberation efficiency with two pyrometallurgical waste products, converter slag and end of life furnace bricks (EOL). EDF fractures material through the application of high voltage electrical discharge with high frequency pulses resulting in the formation of plasma along grain boundaries thus producing selective breakage[1]. Previous work has demonstrated the liberation efficiency of EDF in a range of materials[2,3,4].

Experimental Design

This paper is the preliminary results of an ongoing study of EDF of pyrometallurgical waste products. Samples supplied by Aurubis from the Pirdop copper smelting plant in Bulgaria. Figure 1 shows the intact texture for both of the materials that are the subject of this study.

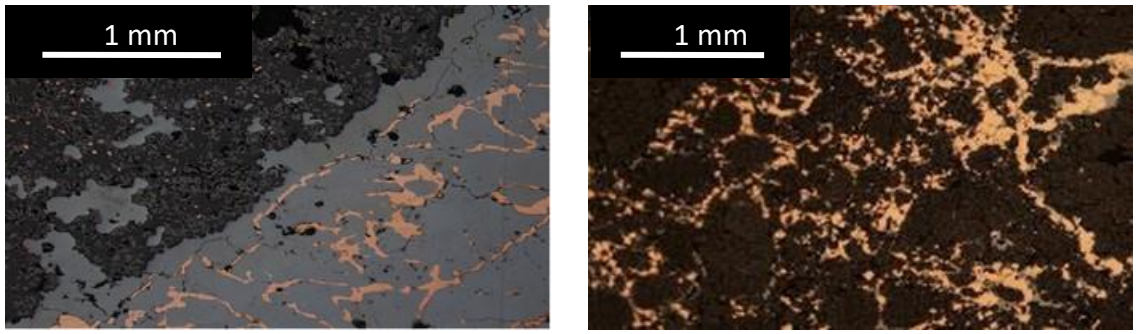

Figure 1: Copper slag (left) and End of Life (EOL) furnace bricks (right)

Both sample types were then representatively spilt into two groups by cutting into blocks on a trim saw. Each of these materials were subject to the following experimental design (Figure 2).

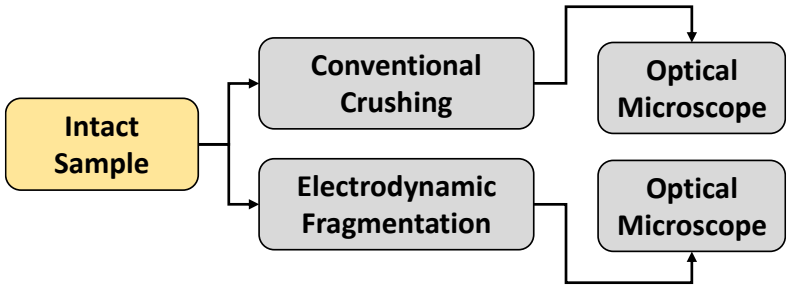

Figure 2: Experimental design for each material tested

An intact sample of copper slag was crushed in a jaw crusher and then collected. Another intact sample of the same material was put into the electrodynamic fragmentation instrument (Selfrag[2]) and broken according to parameters shown in Table 1.

Table 1: Experimental setting on EDF instrument

Sample Type	Sample Form	Voltage	No.	Frequency
		(kV)	of Pulses	(Hz)
Copper Slag	Intact texture	-	-	-
Copper Slag	EDF Breakage	180	250	5
Copper Slag	Crushed	-	-	-
EOL Furnace liner bricks	Intact texture	-	-	-
EOL Furnace liner bricks	EDF Breakage	180	150	5
EOL Furnace liner bricks	Crushed	-	-	-

Each broken sample was then mechanically sieved to collect sub-samples at set size fractions, which were mounted in polished blocks for further analysis. Each polished block mount was examined under an optical microscope and analysed.

Results

The results collected are as follows:

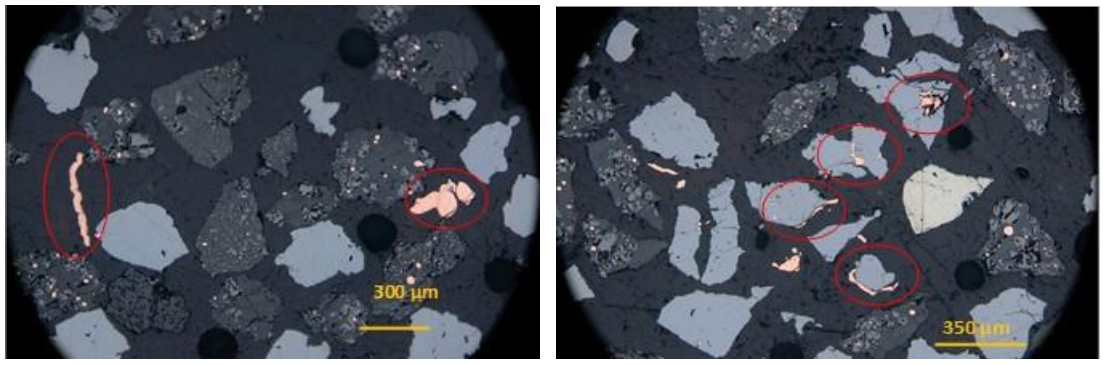

Figure 3: Copper converter slag EDF breakage -425 +300 µm fraction (left) and Copper converter slag crushed -425 +300 µm fraction (right)

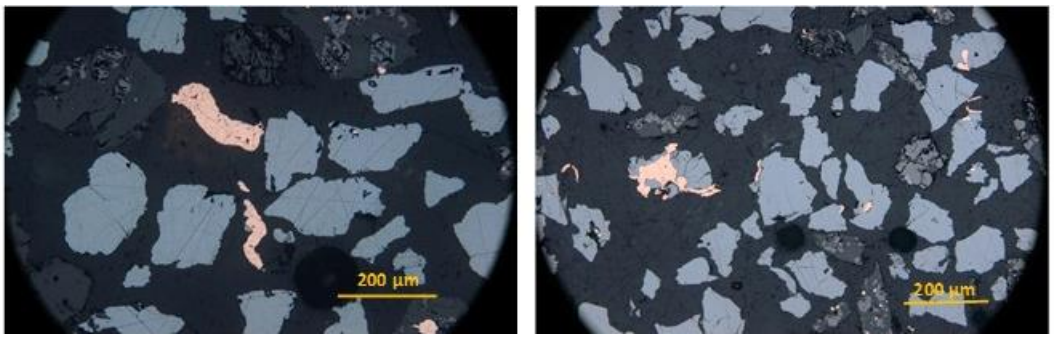

Figure 4: Copper converter slag EDF breakage -300 +150 µm fraction (left) and Copper converter slag crushed -300 +150 µm fraction (right)

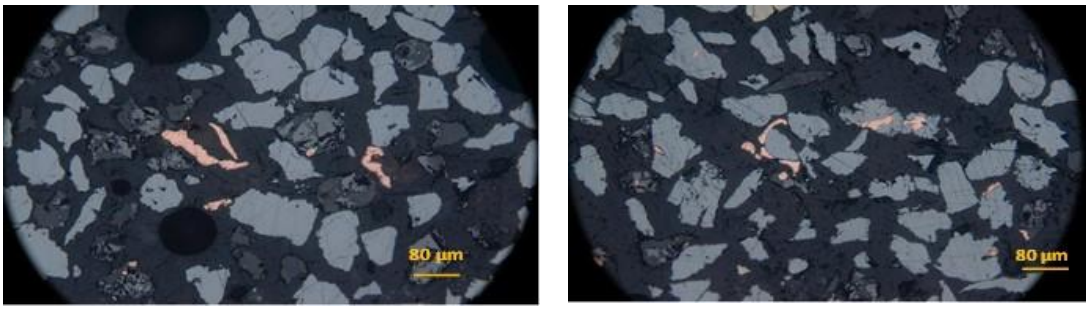

Figure 5: Copper converter slag EDF breakage -150+75 µm fraction (left) and Copper converter slag crushed -150+75 µm fraction (right)

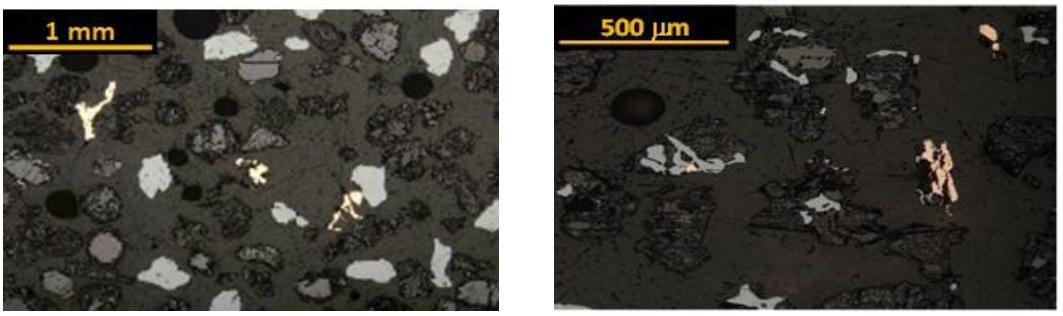

Figure 6: End of Life (EOL) furnace bricks EDF breakage -425 +300 µm fraction (left) and crushed -425+300 µm fraction (right)

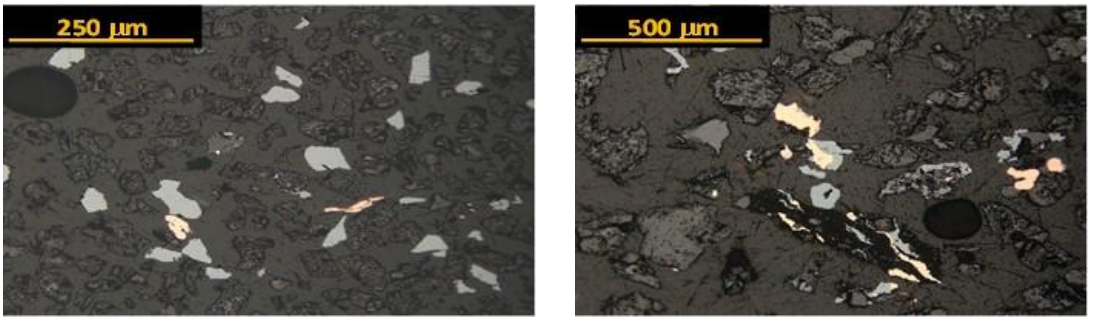

Figure 7: End of Life (EOL) furnace bricks EDF breakage -300+150 µm fraction (left) and crushed -300+150 µm fraction (right)

Discussion

The converter slag samples and the EOL furnace brick samples were examined under an optical microscope, for both EDF breakage and conventional crushing. There was a clear distinction between the breakage methods. The EDF had liberated the respective minerals at comparatively coarse grain sizes with a distinct preference to intact grains.

For converter slag, which contains a high percentage of pure copper and digenite (copper sulphide mineral: Cu_9S_5), minerals were fully liberated into mono phase particles. In comparison, the crushed samples had mostly binary and tertiary phase particles. In the crushed sample, most of the copper measured was associated with digenite. The copper particles seen in the crushed sample were smaller in size compared to the EDF broken samples. Fine fraction (5-10 µm) Copper droplets locked in Silicate-magnetite slag for both crushed and EDF samples.

The same distinct pattern was observed in the EOL furnace brick samples. The EDF samples were well liberated into mono phase particles at a comparatively coarse grain size when compared to the crushed samples. There was fewer observations of the fine droplets of Copper locked in other minerals. Most of the Copper observed was either completely liberated or partially liberated in both EDF and crushed samples.

Conclusions

EDF liberates intact mineral grains cleanly and a relatively coarse size fraction in comparison to conventional crushing. This phenomenon was observed at all size fractions compared between the breakage modes.

References

1. O'Dwyer. The Theory of Electrical Conduction and Breakdown in Solid Dielectrics. Press Oxford: n.p., (1973).
2. R. Martino and S. Gaydardziev, "Fragmentation électrodynamique des matériaux composites à haute valeur ajoutée contenant des substances récupérables", - EDF -HVC. ERA-NET ECO-INNOVERA Scientific & Technical Annual Report. (2015).
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