Leaching of metals in BOS slag via acid digestion

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ABSTRACT

Basic oxygen steelmaking (BOS) produces slag as a by-product which currently has limited low value use. Although there is a plethora of research conducted on recycling the material, due to the variability in composition from batch to batch, the scale-up on a single site, let alone multi-site solutions, is difficult. Metal extraction via acid digestion is a promising way of recycling slag due to its resilience and robustness. The initial stage of this project is focused on understanding the variability of both legacy & newly produced BOS slag, and leaching metals with different acids, conducting a comparison of effectiveness for further separation downstream. By using HCl, H_2SO_4 with slag and analysing the metal content afterwards, V extraction was higher with HCl, while Fe and Cr had higher values with H_2SO_4 after 48h.

BACKGROUND

The rising BOS slag production is between 100 to 200 Kg/T of steel production[1]. BOS slag is difficult to recycle due to the variability of the composition and the high lime content. Suggested uses of slag include fertilizer and aggregates in concrete. There is concern surrounding heavy metal leaching to the soil in both cases. Resulting in BOS slag being sent to landfill.

Research into minerals with similar composition to BOS slag (bauxite) suggests that acid can be used to leach metals [2]. Once the metals are leached into a solution, different methods can be used for separation, such as, electrodeposition. As suggested in Figure 1, Fe could be recovered and reintroduced back to the production of steel, reducing the environmental impact of iron ore mining. This would reduce blast furnace slag due to less impurities from the ore.

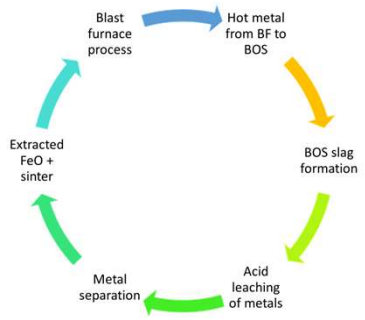

Figure 1. *Circular economy schematic of Fe recovery and reintroduction into the Steelmaking production*

METHODS

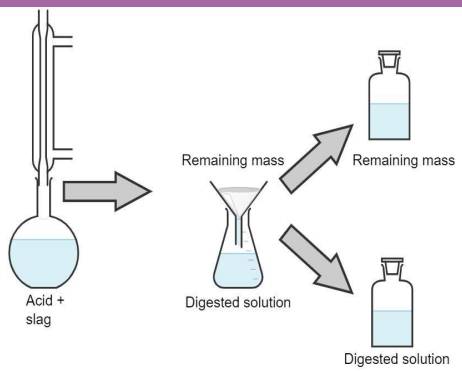

Figure 2.*Acid digestion and material separation method*

- Weathered slag was milled and digested with three different acids:
  - H_2SO_4 (1M, 75 °C)
  - HCl (1M, 75 °C)
  - CH_3COOH (1M, 50 °C, reduced temp due to fire hazard)
- After 4h, all samples were cooled down to room temperature.
- Aliquots were taken and tested using ICP-OES.
- XRF was used for the composition of the raw material.
- CH_3COOH is produced with the unburned gas in Port Talbot and a bioreactor, which would decrease the solvent cost.

RESULTS

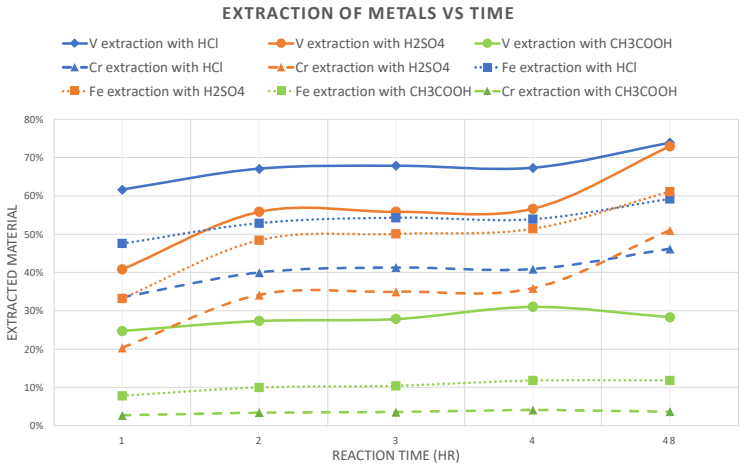

Figure 3. *Time progression for the extraction of V, Fe and Cr with H_2SO_4, HCl and CH_3COOH*

CONCLUSIONS

- The highest extraction yield was with H_2SO_4 for Fe and Cr whilst V has similar values in both H_2SO_4 and HCl.
- The fastest reaction was seen with HCl.
- Results show a progression of metal leaching after 48h but no evidence of a plateau reached.
- The metal with the highest leaching rates is V, followed by Fe and Cr.
- Some of the by-products of leaching are gypsum, de-icing salts and dye, the collection of which could decrease the environmental impact of mining.
- The residual heat from the plant (i.e. using hot slag) can reduce the energy requirements for acid digestion.

FUTURE WORK AND OUTCOMES

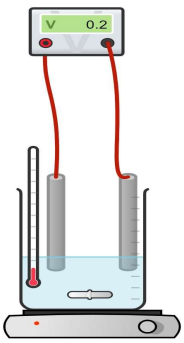

Figure 4. *Schematic of electrodeposition*

- Metals leached with acid will be separated using electrodeposition methods such as electrowinning and electrorefining[3]. A voltage is applied, first targeting the materials that need less energy to reduce deposition of unwanted materials.
- By obtaining pure metals with electrodeposition, mining emissions could be reduced whilst also reducing the risk of metal contamination in soils where BOS slag is landfilled.
- Vanadium concentration decreasing after 48h will be investigated.

REFERENCES

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3. Kim, K.; Candeago, R.; Rim, G.; Raymond, D.; Park, A.-H. A.; Su, X. Electrochemical approaches for selective recovery of critical elements in hydrometallurgical processes of complex feedstocks. *iScience* **2021**, *24* (5), 102374. DOI: https://doi.org/10.1016/j.isci.2021.102374.