OPTIMISING THE USE OF EAF STAINLESS STEEL SLAG TO NEUTRALISE ACID BATHS

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Introduction

At KTH Royal Institute of Technology, a new application of slag recycling is currently tested in collaboration with several industrial partners, to reduce both waste and the use of raw materials. More specifically, previous experiments[1] proved viable the use of high-alloyed stainless-steel landfill slag to neutralise the acidic waste waters formed during the pickling process. Currently, lime is used to neutralise the waste wasters and the by-products of the chemical reactions are put in landfills. Meanwhile, slag is also put in landfills.

The present article publishes the latest experimental results on slag neutralisation carried out to gather more information about the neutralisation mechanisms. Specifically, trials have been performed to use a homogeneous particle size distribution across the samples, making possible a comparison based only on the mineral content present in the different slag samples.

Methods

Sample preparation

Previous experiments[1] proved that slag can raise the pH above neutral values, but it was hard to compare the behaviour between slag samples because of the different physical properties. For this reason, four slag samples coming from two different steel mills, already used in precedent trials[1] (O1, S1, O3 and S4), had been crushed *via* a milling machine and sifted through a 63 µm mesh. The lime samples, currently used at the steel plants (SL and OL), instead had not been ground nor sieved, because the median particle size was already well below 63 µm.

Experimental methods

The experimental setup remained unaltered from previous experiments[1]. As shown, in Figure 1, a beaker with 1 litre of waste wasters is agitated by a magnetic stirrer, while a weighted amount of slag is inserted in the beaker and the variation of pH is measured.

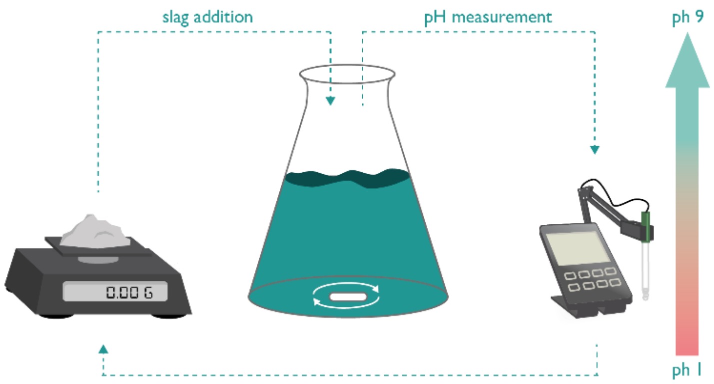

Figure 1: Experimental setup

Both the slag additions and pH measurements varied depending on the different investigations being conducted, while all the other parameters remained the same. Two experimental methods have been designed using the same setup:

Equilibrium trials (EQ): a small amount of slag is added and the variation in pH is measured. Once the pH stabilises around a certain value a new amount of slag is poured into the acidic waters, until a pH value of 9 or above is obtained. The total amount of slag poured is then summed up. This method was designed as a benchmark to understand approximately how much slag is needed to neutralise one litre of wastewater, independently from the kinetics.

All-in-one trials (AIO): Using the results from the EQ trials, all the slag is added at t = 0 s and the variation on pH is measured at t = 5, 10, 15, 20, 25, 30, 40, 50, 60 min. The goal was to find the amount of slag that makes it possible to reach a pH value of 9 by 30 minutes. The time and pH restriction were set in order to mimic the conditions of the industrial neutralisation plants that are currently being used to treat the acidic waters.

All the slag and lime samples used in the present investigation have been tested using both EQ and AIO trials.

Results and discussion

Both the final pH values and amounts of reactants being used in the EQ trials are shown in Figure 2. As expected, lime is more efficient than slag at neutralising the waste waters. In fact, 3 to 5 times less lime than slag is needed to obtain an even higher pH value. The results also show that, despite in previous experiments[1] the quantities were higher (around 10 grams more), S4 and O3 still maintain a similar behaviour. Also, O1 and S1 samples show a different trend compared to previous results[1]. In the earlier trials in fact, the samples could not neutralise the wastewaters while now they both reach a complete neutralisation with approximately 25 g.

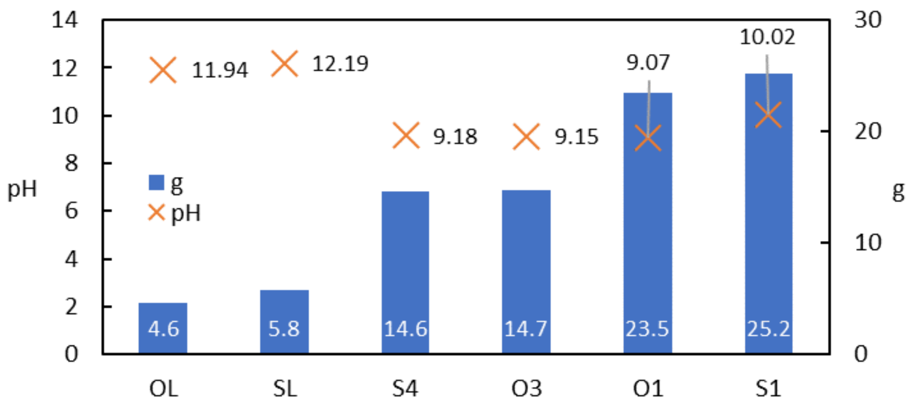

Figure 2: Equilibrium trials results

The explanation for this improvement is the decreased particle size distribution that enhances the neutralisation performance. Also, the results show that slag samples O1 and S1 can be used to neutralise the waste wasters, contrary to previous investigations. Since the only factor that had been changed is the particle size distribution, there is no doubt that it plays a major role in the neutralisation capacity of the slag samples. It is even possible that certain chemical reactions might not take place if the particles are too coarse.

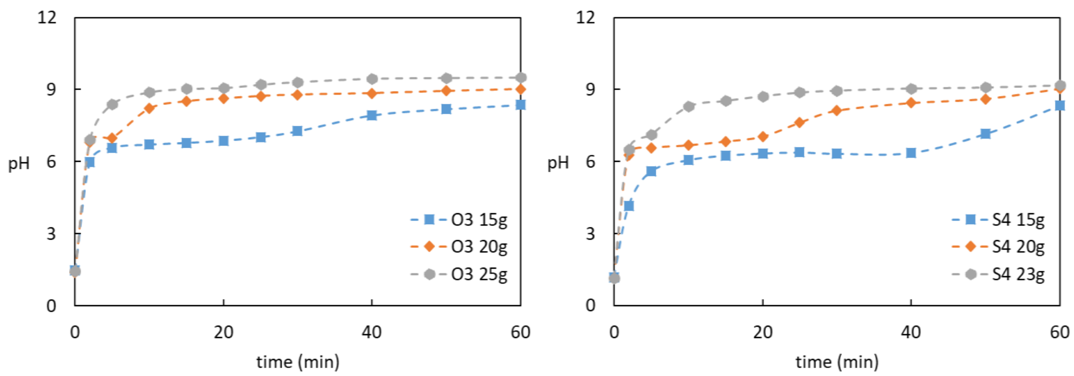

Figure 3: All-in-one trials of O3 (left) and S4 (right)

Figure 3 collects the results from the AIO trials conducted with slag samples O3 and S4. It is noticeable how there is a common trend across both graphs of a mass-dependent two-plateau system. In fact, in almost all the trials shown, there is a sudden surge of the pH value during the first minutes of the trial, followed by a period where the pH value remains quite stable, after which a secondary surge occurs. The trial with 25 g of O3 could be a degenerate case, where the second surge is pushed so much ahead in time that it happens simultaneously with the first. Once again, the results are in line with previous results[1], but the profile is neater due to a more homogenised particle size distribution.

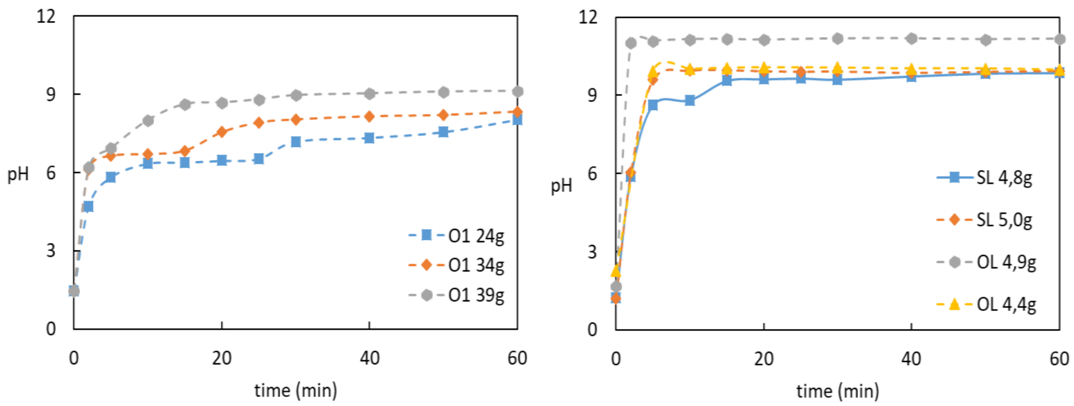

Figure 4: All-in-one trials with O1 (left) and all the lime samples (right)

The left part of Figure 4 consolidates the same trend visible in Figure 3. In fact, O1 behaves exactly as the other two slag samples. Sadly, the trials with S1 were interrupted prematurely due to a chemical reaction that made the slag powder coalesce together and deposit on the bottom of the beaker. Also, as for the EQ trials lime has been tested as a reference. Like previous results[1], it does not show a two-plateau system neither an increased amount of reactant needed compared to the EQ trials. Regarding the different quantities of slag samples needed to neutralise the acidic waste waters, the explanation probably lies in the different mineral composition. However, future experiments will be conducted to try to connect the mineralogy to the neutralisation capacity.

Conclusions

Compared to previous experiments, the particle size distribution of the samples used has been reduced and homogenised. This change led to two interesting effects: the quantity needed to neutralise one litre of wastewaters decreased, in the EQ trials by approximately 30% to 40% while In the AIO over 50%. The second effect is that when a homogeneous particle size is used, different slag samples can be compared by their mineral content. However, tests on the influence of the mineralogy on the neutralisation efficiency haven't been conducted yet. Overall, these preliminary experiments are a first stepping stone into building a solid theoretical background with respect to slag neutralisation of acid baths using recycled steel slags.

References

1. M. De Colle, P. G. Jönsson, A. Gauffin, A. Karasev, "The use of recycled stainless-steel slags to replace lime for neutralization of acid baths", in *Proceeding of European Oxygen Steelmaking Conference* (EOSC 2018), Taranto, Italy, 2018.