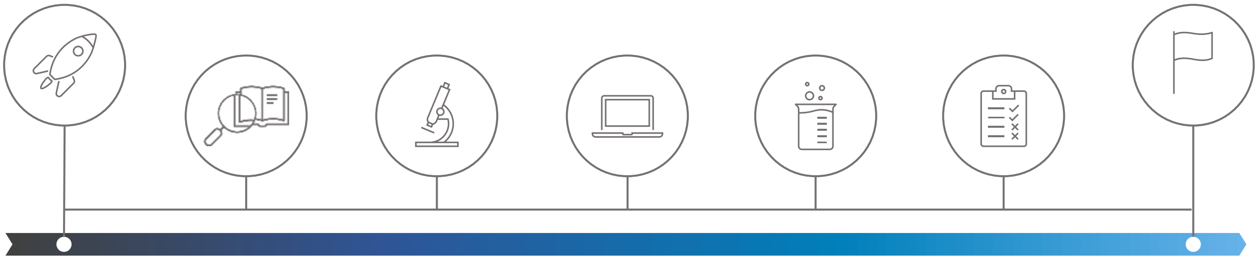
Hydro Stäube

Hydrometallurgische Rückführung von versorgungskritischen Metallen aus Stäuben der Eisen- und Stahlindustrie

Hydrometallurgical recovery of supply-critical metals from dusts of the iron and steel industry

The current research project HydroStäube analyses various hydrometallurgical leaching steps or combinations thereof for the treatment of steel mill dusts. Most dusts from metal production undergo pyrometallurgical treatment in high-temperature processes. In general, these involve the addition of carbon carriers and hence contribute to CO_2 emissions. To return metals contained in the scrap which are partly transferred to the dusts of the steel mill, back into the supply chain in terms of circular economy, sustainable processes are required to be climate neutral, resource-saving and energy-efficient. Subsequently, the HydroStäube method should also allow the recovery of other dusty residues produced in steel mill processes in best case which currently lack a specific treatment process.



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EFFECTIVE LEACHING OPTIMISATION

As mentioned in the last newsletter, several campaigns were being worked at that time for optimizing the leachability of Cr and Ni with HCl from stainless steel dusts as well as a precipitation campaign for recovering these metals from a synthetic filtrate similar to the leachate one. Regarding the first two mentioned, two different dusts were chosen to conduct the experiments with. One of those dusts (Dust_1) high in Cr and Ni, and low in Zn, the other one low in Ni and higher contents of Zn and Cr (Dust_2). The first set of experiments with Dust_1 shows a relative dependency of the extraction, towards higher temperatures, as can be seen in Figure 1. Regarding leaching time, the impact was observed to be rather low compared to other parameters. The second leaching experiments with Dust_2 though show a factor 5 to 7 lower Cr extraction from the dust itself. Nonetheless, the Zn extraction of Dust_2 was in every experiment quite high .

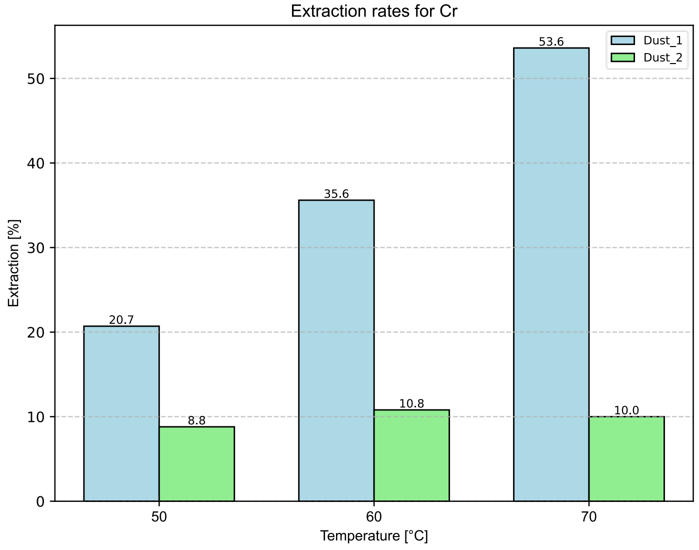

Figure 1: Extraction rates for Cr

PRECIPITATION EXPERIMENTS

Among other things, a neutralization-precipitation campaign was carried out to recover the leached metals. A 25% by weight NaOH solution was used to precipitate the metal ions. Although the thermodynamic calculations carried out in the planning phase showed that precipitation with Cr should begin at a pH value of around 4, the actual precipitation of Cr together with Fe was observed from a pH value of around 4.5. Subsequently, it was investigated whether it is possible to obtain three different precipitation products, i.e. a filter cake rich in Fe, Cr and Ni. However, due to the close thermodynamically calculable stability ranges of the precipitates, a sum precipitate was defined as the target, in which Fe and chromium should collect together. As can be seen in the exemplary illustration of one of the experiments, almost all of the Fe and Cr precipitated in the first precipitation step (Figure 2), while Ni and Mn were kept in solution at over 60 % of the original concentration. Only in the further steps Ni and Mn precipitated until the solution changed from a greenish-yellowish color at the beginning to an almost clear solution without any coloration after precipitation. In summary, the leaching of valuable metals such as Cr and Ni with hydrochloric acid and neutralization precipitation are promising but need to be further investigated to reach a level where they can be applied on industrial scale.

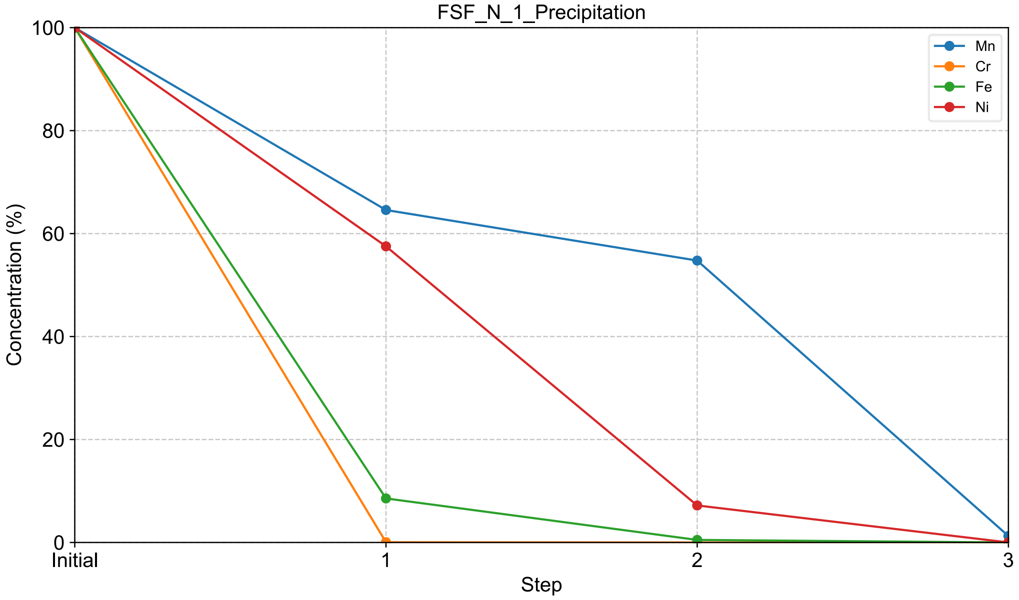

Figure 2: Elemental distribution over precipitation steps

SPEAKING AT SIPS CONFERENCE

In the week of 20th to 24th of October the Stelter International Symposium for non-ferrous metallurgy, in honour to Prof. Dr. Ing. Michael Stelter took place as part of the "Sustainability though Science and Technology" conference on the island of Crete in Greece. At this conference, Dipl. Ing. Thomas Howard presented and discussed the findings in form of a conference proceeding as a presentation on the leaching campaign of Dust_1 in an academic environment with fellow metallurgists and company representatives.

RECYCLING OF CR-, NI- OR MN-CONTAINING PRECIPITATES

As the industrial steelmaking dusts are high in iron content, the leaching solutions contain the desired elements like Cr and Ni but also Fe to a certain extent. Due to the chemical similarities of the mentioned metals in hydrometallurgy, iron containing compounds are part of the precipitates after pH adjustment too. Consequently, a literature study regarding potential markets for recyclates was carried out.

In general, more than 90% of chromite mining go to ferrochrome production. Besides, two thirds of primary produced nickel (EU with a share of 13.5% representing the second biggest market after China) are used in stainless steels, as about 70% of stainless grades contain Ni as an alloying element. Additionally, 90% of extracted Mn is used as ferromanganese and silicomanganese in steel industry. Therefore, ferroalloys for special steels produced from circulated materials are of high interest.

The recycling of Cr-, Ni- or Mn-containing precipitates in steelmaking has the potential of reducing the dependency of the EU on extra-European imports. Moreover, the ferroalloy production is very cost-intensive; thus, recovery of alloying elements from process residues may save expenses. In particular, the costs attributed to separate reduction of oxides or hydroxides cease if directly charged into steel bath under reducing conditions. Nonetheless, the risks associated with impurities need to be considered. As Cu cannot be removed from liquid steel melts, there is a limit of 0.2% in ferroalloys for steelmaking. Moreover, the contents of tin and molybdenum should be kept low.

Further application areas for mixed recyclates are inoculants of complex chemistry used in solidification of metallic melts, metal salts for preparation of electrolytes in galvanisation, magnetic materials, welding additions, wires or electrodes as well as alloys with specific thermal expansion values.

CONCLUSION AND OUTLOOK

The HydroStäube project is now at the end of its duration and looking back the project consortium successfully developed a hydrometallurgical process for the recycling and recovery of the metals contained in steel mill dusts. The experimental setup was optimised for future campaigns and after determining the optimum leaching parameters, high leaching rates could be achieved. The effectiveness of precipitation with NaOH was demonstrated, producing precipitates containing the targeted elements. These products can be used further in the steel industry. However, further optimisation of the precipitation step is necessary to minimise unwanted accompanying elements and increase the output. Additionally, a step-by-step adaptation from synthetic precipitation solutions to the industrial solution should be performed. The process offers promising environmental benefits as it minimises landfilling and conserves primary resources by recovering other metals like Cr and Ni.

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