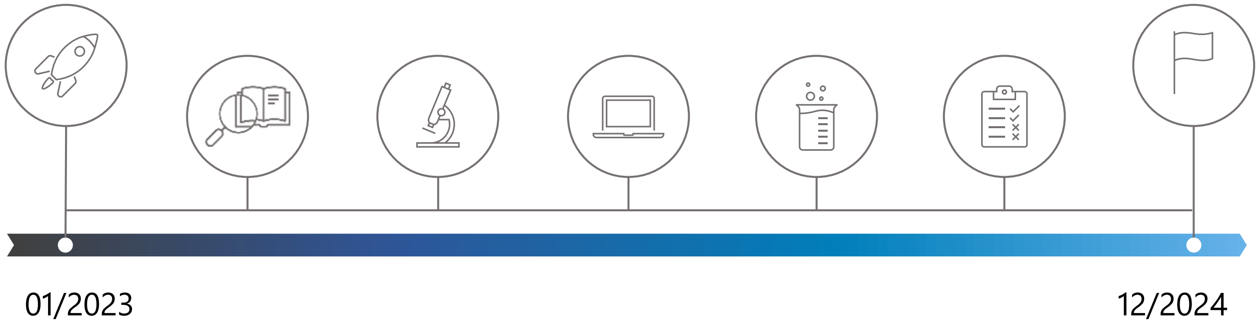
Newsletter n° 3 | July 2024

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.



PARAMETER VARIATION CAMPAIGN

The experimental study carried out on the leaching potential of chromium-nickel-containing dusts with various acids forms the basis for further experiments currently underway regarding extraction. Thus, an analysis of the extraction rates of the valuable metals like Cr and Ni was performed. The acids investigated for this task were hydrochloric-, sulphuric-, nitric-, vinegar- and citric-acid. The first three acids are mineral acids and show a strong acid nature, therefore easily reach lower pH values, which tends to lead to higher extraction. The other two acids (vinegar- and citric-acid) were examined because of their increasing usage in leaching operations and decreased environmental impact. The experimental setup has been already shown in Newsletter 2 and followed the schematic process flow depicted in Figure 1.

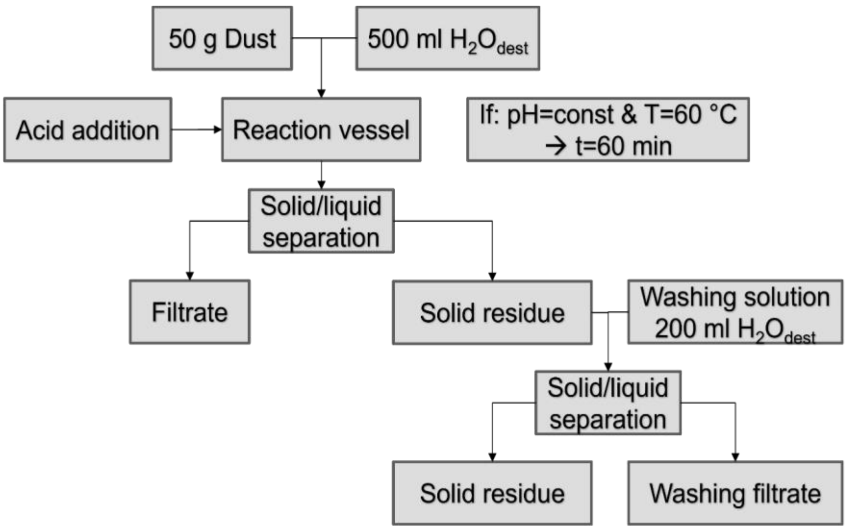


Figure 1: Flow sheet for the leaching experiments

For the experiments, a pH of 0.3, for the strong acids, and a pH of 2.5, for vinegar and citric acid, were decided. The different filtrates were analysed, and the extraction rates are visualised in Figure 2. As can be seen in both diagrams, hydrochloric acid performed best compared to the others, although sulphuric and citric acid both extracted a good amount of Ni and Cr as well. Nitric and vinegar acid malfunctioned in these tests, which is why HCl was chosen for the parameter variation for the follow-up experiments.

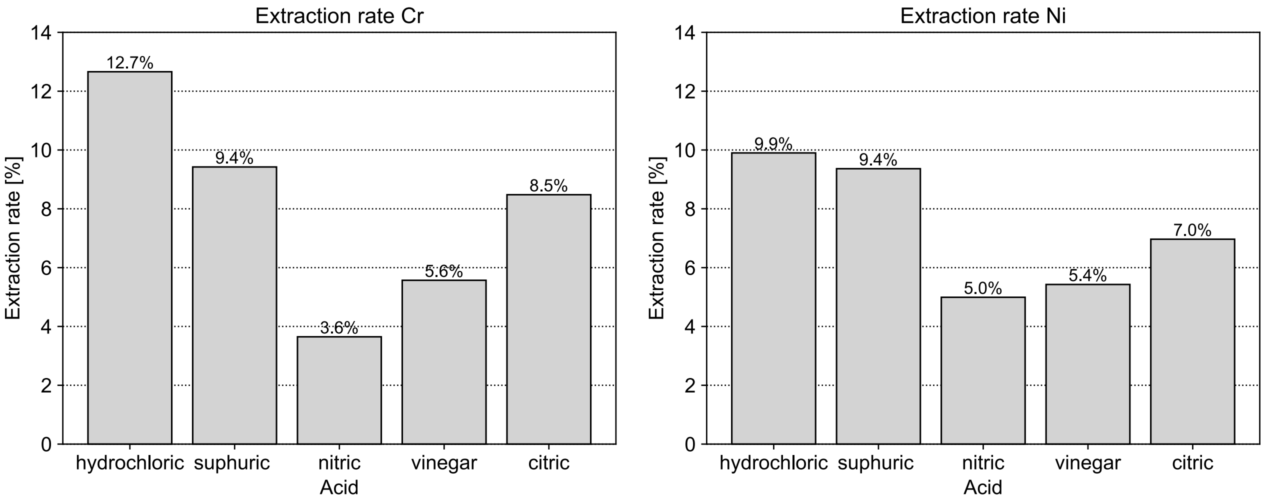


Figure 2: Extraction rates for chromium (left) and nickel (right)

The extraction rates of Cr and Ni were calculated as follows. The masses and volumes during and after the experiment were noted, and in combination with the afterwards conducted analysis with ICP-OES, a mass balance was generated. From this mass balance, the extraction rate could be calculated by dividing the mass of each element by the total mass brought into the reaction vessel via the dust.

A parameter variation campaign for HCl leaching is finished and being analysed already, a second parameter variation as well as a precipitation campaign with a synthetic filtrate are currently in progress.

COMPLEXITY OF SECONDARY MATERIALS

In secondary materials (residuals), metals and compounds are present in more complex combinations than those found in geological deposits, making recycling considerably more challenging. Additionally, certain elements cannot be recovered during the processing of residual materials for recycling purposes, as effectively illustrated by the expanded Metal Wheel (Figure 3). The recycling of these materials often involves the large-scale production of base metals with compatible thermodynamic properties, such as copper (Cu), iron (Fe), lead (Pb), lithium (Li), nickel (Ni), tin (Sn), titanium (Ti), and zinc (Zn).

Research into recovery processes and procedures is essential for returning valuable metals to the cycle as secondary raw materials, thereby improving the recycling rate. The quality of the residual material stream, which is mostly shredded and mechanically or physically processed, plays an important role in this process. For example, copper adhering to steel dissolves during pyrometallurgical processes and cannot be separated from the melt due to its more precious character. When impurity levels exceed contamination limits, the properties of the steel are adversely affected, which requires the dilution of impurities by adding virgin metals to fulfil the purity requirements.

Figure 3 illustrates the expanded Metal Wheel and the complexity of secondary resources, categorised by metallurgical treatment infrastructure to produce refined metals, high-quality compounds and alloys using Best Available Technology (BAT) according to M.A. Reuter et al. [1]. The innermost ring represents the flexible base metal processing infrastructure for recycling, the second ring the metal elements that primarily dissolve in the base metal (pyrometallurgy). The third ring displays elements and compounds that primarily accumulate in dusts, sludges or the feed (hydrometallurgy or pyrometallurgical refining treatment) and the outermost ring shows losses via lower-value building materials and dissipative loss.

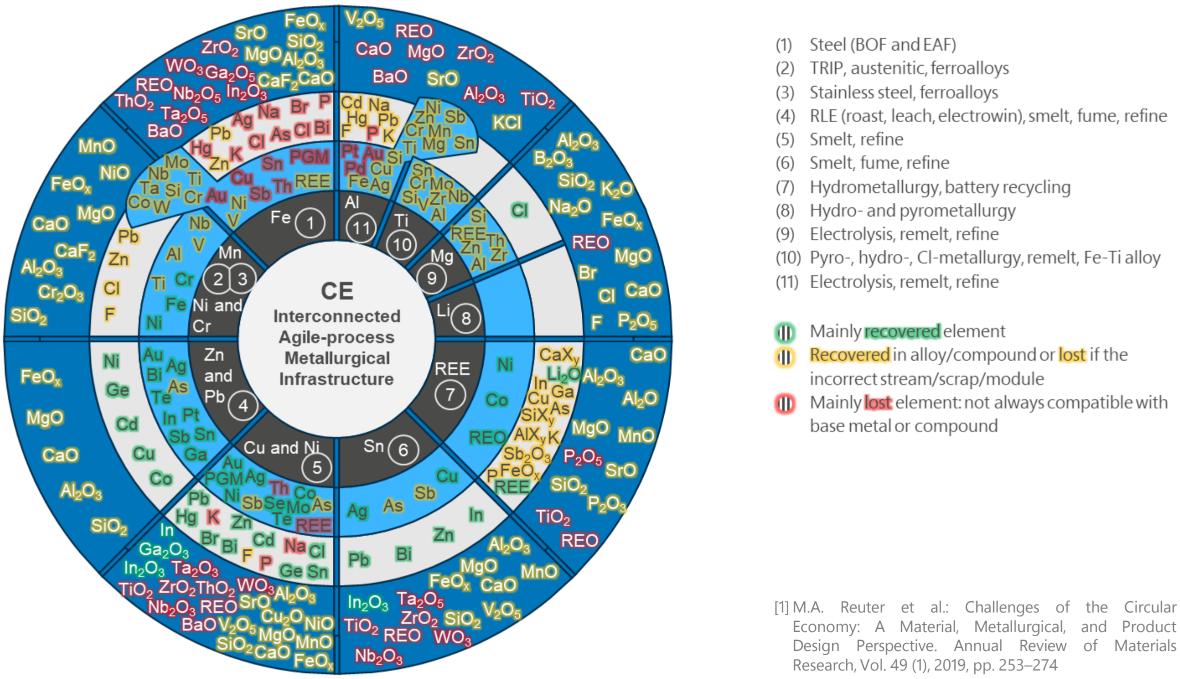


Figure 3: Complexity of secondary resources categorised by metallurgical treatment infrastructure to produce refined metals, high quality compounds and alloys using Best Available Technology (BAT) according to M.A. Reuter et al. [1]

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