PhD offer

Metal recovery from the fine-fraction of incineration bottom ash by hydrometallurgy at pilot-scale

Key words: metal recovery, incineration bottom ash, percolation column, fluid flow, coupled reactive-transport modelling.

Context & objectives: Modern societies produce more and more waste, including municipal solid waste currently representing 2 billion tonnes per year worldwide, with a projection of 3.4 billion tonnes per year by 2050. A significant proportion of this waste is treated by incineration, which reduces its volume and mass and produces electricity. On the other hand, the two by-products of incineration, fly ash and Incineration Bottom Ash (IBA), are not systematically valorised. While the coarse fraction of IBA is widely reused, particularly in road sub-bases, the fine fraction, which contains approximately one third of the total leachable metal content, cannot be recovered in the current regulatory context and is therefore generally landfilled. The concentration of certain elements, such as copper, close to that of low-grade ores, encourages the use of IBA as a new resource of metals useful for the energy transition. Thus, IBA can be considered as an urban mine.

Extensive studies have been carried out in the past years on the development of a hydrometallurgical process for the recovery of metals of interest from the fine fraction of IBA at a laboratory scale. The process developed during Ms. Perrin's PhD thesis, allows the selective recovery of copper and zinc, through a pre-washing step, leaching, precipitation of Zn and its calcination, filtration, electrodeposition of Cu and its electrorefining. Recovery yields of 90% for Cu and 70% for Zn have been obtained at laboratory scale [1,2].

The main objective of this thesis project is to up-scale the hydrometallurgical process for the recovery of copper and zinc at pilot scale. Up-scaling from laboratory to pilot scale implies several challenges. In particular, the scarce control of global parameters, such as flow homogeneity, interactions between the solid and the leaching agent etc., as well as the transition from batch conditions to a continuous process.

Methodology & expected results: The first step of the up-scaling consists in the leaching of IBA in a percolation column. This step, being the most complex and difficult to control of the entire recovery process, will be implemented in two stages: (i) first in a small diameter laboratory column, in order to optimise the flow parameters and the coupling between "flow" and "speciation" (ii) next in a pilot column, in order to simulate leaching in conditions close to reality (heap leaching). Understanding the leaching mechanisms, in close connection with the flow characteristics, is the major challenge. The leaching mechanisms related to the leaching agent flow in the column can be studied, in parallel to the experimental part of the study, by a coupled modelling methodology. This approach is based on combining a speciation software in porous media (e.g., PhreeqC can model the mineral solubilisation in aqueous phases at thermodynamic equilibrium) and a software for modelling the flow (e.g., COMSOL allows coupling reaction and transport in porous media) [3,4].

The next steps of the recovery process, i.e., precipitation and calcination of Zn, filtration, electrodeposition and electrorefining of Cu will also be conducted at pilot scale. The challenge at this point will be to optimise the effluent recirculation and the energy consumption. Other specific experimental parameters could also need to be optimised.

In a second stage, the up-scaling of the whole recovery process will be modelled using the USIMPAC software for process engineering. The experimental data will be used to validate the up-scaled model. Numerical simulations will then be used to optimise the processes at pilot scale, as well as to up-scale at industrial scale.

Location and supervision: The research work will be performed at the Electrochemistry and Physical Chemistry of Materials and Interfaces laboratory LEPMI and the Rheology and Processes laboratory LRP, both located at Grenoble University Campus, Saint Martin d'Hères. The candidate will work under the joint supervision of researchers from LEPMI laboratory (L. SVECOVA and M. LUPSEA, specialised in process design and recycling processes development) and LRP laboratory (PX. THIVEL and H. BODIGUEL, specialised in process design and multiphysics flow).

The PhD is expected to start in October 2025, for a duration of 36 months.

Candidate profile: The candidate should be in master 2 - or equivalent, with a degree in process engineering. Numerical and modelling skills will be highly appreciated. The candidate should have a strong aptitude for experimental work and be able to work independently. Solid writing skills will also be required. A solid level in written English (>C1) is required.

How to apply?
Send your CV, motivation letter and master transcript (marks) to:
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Deadline to apply: April 30, 2025.