Wise process routes for varying feedstock in base metal extraction

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Introduction

In Sweden, there are several large but low-grade ore deposits that have not been extracted so far. The main reason is the presence of impurities such as arsenic and antimony that increase the overall cost of the process and make the extraction uneconomical. In-depth experimental studies, plant data and theoretical modelling are needed to develop new techniques for an efficient use of the resources. Besides, recycling of metals from end of life scrap and metal containing waste, e.g. waste electric and electronic equipment (WEEE), is an important part of a metal production plant. Most of these secondary raw materials contain mixtures of different metals together with various plastics and ceramics that may adversely affect products and by-products of the metallurgical operation. Therefore, a thorough study on how to control possible changes of properties is required. The aim of the research is to develop an optimum combination of hydro- and pyro-metallurgical pathways to bleed impurities from the metal extraction chain and convert them into valuable by-products.

In-depth studies are carried out in three PhD projects; hydrometallurgical methods, slag capacity and thermodynamic modeling. The PhD projects include experimental investigations in bench scale, characterization of materials, theoretical modeling and evaluation. Extensive sampling and experimental studies are carried out by industrial partners.

Results and discussion

Antimony is one minor element that is considered a problematic element for smelters, due to difficulties to bleed it from smelter processes. Thus a pretreatment step for selective removal of antimony from complex concentrates containing high levels of antimony is investigated. The aim is to test and optimize a complete hydrometallurgical step for leaching and extraction of antimony from complex concentrates. Leaching tests have been performed to dissolve antimony and arsenic from a complex copper concentrate. Alkaline sulphide leaching gives the best selectivity to remove the impurity elements from the concentrate with high yields of antimony and arsenic into the leach liquor. Further studies on the alkaline sulphide leaching efficiency were conducted in order to ascertain the optimum conditions for antimony and arsenic removal. The results showed that alkaline sulfide leaching could be a feasible way to treat the concentrate for elimination of both elements. In the continuing work, extensive leaching tests of complex concentrate in laboratory scale equipment have been carried out. In addition, fundamental kinetics studies of the dissolution of the antimony mineral, tetrahedrite, has been carried out. The results so far are promising. Further studies on the purification of the pregnant leach liquor with the aim to produce antimony metal through electrowinning are in progress.

At the Rönnskär Smelter electric and electronic scrap is an important raw material. Along with valuable elements impurities such as alumina enters the smelter through scrap material. Alumina will be distributed to the slag phase during processing. Major parts of the slag generated from copper processing units at the Rönnskär smelter are treated in the slag fuming process in which a.o. zinc is recovered and a slag is produced which mainly is used as construction material. For efficient operations a slag with appropriate properties are essential. Experimental studies in laboratory scale have been carried out to investigate the influence of alumina on melting and leaching properties of slag from the fuming plant. Results shows that increased alumina content of the slag will cause formation of a new phase (anorthite) and rises the liquidus temperature, while its leaching properties are not adversely affected.

Thermodynamic modeling can be used as a tool to understand the chemical reactions occurring in different processes; as in this case, for copper smelting. It can further be used to predict smelter capacity for impurities and potential to recover valuable elements. SimuSage, which is based on ChemApp and its rigorous Gibbs energy minimization technique, together with the extensive collection of thermodynamic data from FactSage is used to simulate the mass and heat balances for the various process units. The models are complemented with data from literature for elements not included in the databases. The models are verified with information obtained from extensive sampling campaigns at different process units at the Rönnskär smelter of Boliden Mineral AB. Currently a model for the converting process is verified against process data.

In addition, options to remove impurity elements from different process units at the smelter are investigated.

Finally, an evaluation of different options, including hydrometallurgical and pyrometallurgical process routes with the aim to remove impurities as well as the potential to turn them into valuable by-products will be made.

Concluding remarks

The close cooperation between University and Industry has formed a strong research and development base. The experience within this research program confirms the importance of looking at the extraction chain as a whole to consider different process routes and combinations of methods for efficient extraction of metals.

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