RECYCLING AND METALLURGY

Summary/purpose of the thematic area

Processes for metal extraction from raw materials as ore, scrap and metal containing residues have high demands on low emission levels and low energy consumption as well as being competitive, cost and resource efficient. The process steps for extracting metals from primary and secondary resources are for many metals highly interconnected. A thorough understanding of the involved processes as well as a holistic view on ore based metallurgy and recycling is needed to increase the yield in metal extraction.

A flexible use of existing process steps, together with improved pre-/post-treatment of scrap, ores and residues through hydrometallurgical or physical separation methods, could increase the capacity for recycled scrap and ability to manage more complex scrap and ores.

All metallurgical processes generate residue materials such as slag, dust and sludge. The largest in volume is usually slag, in many cases with excellent technical properties for a.o. construction applications. However, tightened environmental regulations connected to the environmental goals formulated by the government influence the requirements for by-products and the use of residue materials in applications outside the plant. There is need for increasing the knowledge regarding how to adapt a slag to both environmental requirements and technical demands connected to the intended application.

Minor elements with high vapour pressures are often enriched in dust and sludge from the cleaning of process gases. There are considerable amounts of metal and carbon units deposited that could contribute to higher raw material efficiency if ways to recycle these materials are developed.

Scattered process information (measurements, camera images, product analyses, thermodynamic data, flow dynamics etc) is available which creates an opportunity for the metal extraction and recycling industry to improve flexibility, efficiency and working environment by further implementing digitalization and automation. This would improve process control and ensure an attractive and secure working environment.

One key factor for a sustainable industrial sector is the availability of competence. New/adapted approaches for education is needed to attract next generation to the field and to ensure life-long learning for industry and society.

Objectives and KPI

To provide the society with materials required for a sustainable modern life

- by combining novel pre-treatment and metallurgical operations to fully utilise ore concentrates, scrap and residues from ore and metal treating industries
- and minimizing the environmental impact for the entire process chain
- being technologically in the forefront, having safe and healthy working environment ensuring future competence by attracting young employees

To reach the objectives, development is needed in several areas:

- Metallurgical production routes in general
- Recycling of metals from scrap and secondary sources
- Recycling and utilization of industrial by-products
- Improved process control (modification and development of measurement technology, methods to treat large amount of data connected to metallurgical reactions, technology for automation).

To meet future demands, the challenge is to increase the yield of recovered metals and extract additional elements contained in the material streams (ore, scrap and residues) not extracted today. The strive is to utilize all by-products, e.g. slag, dust and sludge, depending on their properties through recycling and recovery of elements, in external applications or as raw material in other industrial sectors.

Research and innovation needs, and strategies and actions

To increase the metal recovery from ores and increase the recycling of metals it is necessary to have a holistic perspective where the whole processing and recycling chain is considered as well as the interaction with ore based metal production and the advantages from a combination of ore and scrap based production. Combination of suitable pre-treatment and post treatment methods, as e.g. bio- or hydrometallurgical processing, should be considered as a supplement to existing processes.

Research to utilise metal containing residue streams, understanding of their generation and how metal content can be enriched, should be encouraged. Examples are dust and sludge from gas cleaning that contain metals only in minor amount in the primary and secondary raw materials. Securing the quality of by-products such as slag requires research to assure environmental and technical properties of the material which may need modification in the extraction processes. This needs to be done without jeopardizing the overall outcome of the processes.

Models based on fundamental properties and chemistry of the materials, models that are also implemented in overall process models, will aid in optimising material, gas and energy utilisation, and predict consequences of e.g. changed material streams. Development of new process models should also be complemented with new innovative measurement techniques for online measurement of important process parameters and treatment of data.

Research and innovations will be needed within the following areas:

- Process development including pyro- and hydrometallurgical methods
- Fundamental understanding of distribution of elements between different process streams and their capacity to accept different elements.
- Separation techniques or combinations of such to more efficiently separate the metals contained in complex material streams.
- Innovative techniques for carbon free or carbon neutral reduction processes
- Innovative techniques to utilise waste streams from one industrial sector as raw material to another industry sector as for example carbon containing waste streams as reductant and energy carrier.
- Innovative measurement techniques and methods to evaluate large amount of data

Objectives

- To fully utilise the material and energy content in raw materials through enhanced extraction of metals from complex scrap, ores and residues, including extraction of elements contained in existing material streams but so far not extracted as well as securing the quality of products and by-products and securing a viable use of the by-products.
- To fully utilize flexibility in processes through implementing new measurement technology and processing of data for on-line process models as well as new automation systems
- Securing a minimal environmental impact by minimized emissions and transformation to carbon neutral processes.
- Securing the future competence and attractiveness through education and knowledge dissemination

Technology

- Adapting processing of raw material for increased product quality and simultaneously optimised gas and energy utilisation for minimised emissions, based on fundamental knowledge coupled to the processing and implemented in process models. (medium to long term)
- Develop and adopt measuring techniques for online measurements for enhanced process control. (short to medium term)
- Develop and adopt automation systems (medium to long term)
- Develop knowledge and technology to use by-products such as slag products in new applications. (short to medium term)
- Develop knowledge and technology to increase the yield in existing processes, considering the whole value chain for the raw materials. (medium to long term)
- Develop the technology needed to extract more elements from material streams already processed. (short to medium term)
- Develop technology for carbon neutral processing (medium to long term)

Resource efficiency and process control

- Optimise the existing process chains for simultaneous extraction of metals from ore concentrates and scrap, including the whole system from exploration, concentrating of ores and scrap, and processes for extraction of the metals, e.g. through improved process modelling. (medium to long term)
- Develop methods to enhance the metal content in and secure the quality of all by-product streams to increase the possibility to extract more metals from the material streams. (medium term)
- Dissipate knowledge about recycling possibilities and limitations to the designers of consumer products (design for recycling). (short to medium)
- Introduce new methods to more efficiently control the processes through new measurement techniques. (medium to long term)
- Develop the knowledge necessary to secure the product quality of the slag produced at the same time as processing consequences of varying slag composition can be controlled or purposely adjusted. (short to medium term)
- Develop methods to utilise waste materials from own processes or across business sectors to enhance effectiveness and the recovery of metals, e.g. the use of organic-containing waste materials as reductants or fuels in

the extraction of metals. (short to medium term)

Education

- Strengthen Swedish education of engineers and PhDs within all areas related to metallurgy and recycling.
- Carry out project assignments and thesis work in collaboration between universities and the companies connected to the research agenda.
- Introduce the knowledge gained within the research into the study materials at universities.

Knowledge dissemination

- Dissipate knowledge to increase the understanding of both benefits and limitations for recycling to plant people, designers, researchers and society.
- Dissipate knowledge about the need for metals, how they are produced and what the alternatives are.
- Exchange personnel between academy and industry.
- Collaborate and exchange with universities, research organisations and industries in other parts of the world.

Expected impact

Research within the given areas has the potential to have a large impact on a more efficient extraction of metals from ore concentrates, scrap, residues and waste, and result in increasingly environmentally safe use of generated residue materials.

Technical

- Optimised use of upgrading, pre-treatment and smelting operations.
- Advise for design of products to enhance recycling possibilities.
- Increased efficiency in process routes through new measurement techniques, process modelling and automation.
- New processing routes for complex ore and scrap materials.
- Adaption of slag properties with respect to new and existing uses for the slag products.

Economical

- Improved competitiveness of the industry through more efficient use of existing process streams.
- Known and new mineralisations are turned into ores.
- New, so far unused process streams are becoming economically viable.
- A market for by-products and slag.

Environmental

- Increased resource efficiency
- Lower amount of materials deposited.
- Decreased dependency on raw material availability.
- More environmentally friendly residue streams.
- Decreased energy consumption.

Social

- Increased employment opportunities and attractive sector for career opportunities.
- Higher awareness of sustainability issues connected to metallurgy and recycling among plant people, designers, recycling industry and society as a whole.