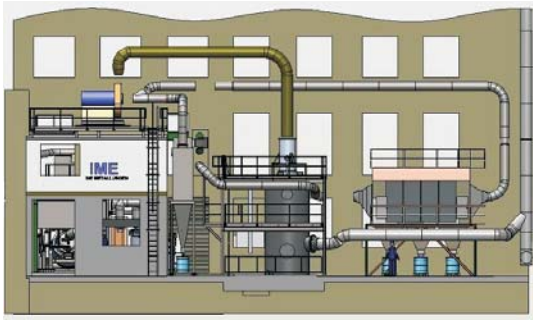
Process Sustainability

Pollution Control

The institute operates a high variety of test installations and most of them generate unavoidable solid, gaseous and/or liquid by-products. Like the industry our institute also undertakes strong efforts to minimize any emissions by the use of “state of the art” abatement technologies. We are in close contact to industry research centers for implementing the newest prototypes. In this way an electrostatic precipitator with hollow electrodes for absorbent injection catches most of the particles from the furnace off-gas and a high-tech bag filterhouse collects dust particles of all secondary gases from areas around the reactor as well as from the work floor. All such pre-cleaned gases pass a best available scrubbing unit, where the rest of remaining particles and all gas components are absorbed by acidic or alkaline solution injection. By online monitoring of the off-gas quality we are sure to avoid any bad/harmful impact of our research to the environment.



References & Services

Process Development in Lab & Pilot Scale

- recycling of spent batteries (Li-Ion, Ni-MH, Alkaline/ZnC) and catalysts (PGM, Mo, Ni containing) in a SAF process
- authothermal melting/converting of WEEE-scrap
- recovery of valuable metals from coatings (after electroplating, CVD/PVC and painting)
- recycling of complex aluminium scraps (compounds, foam, MMC’s) in a tiltable rotary kiln furnace
- improvement of the light metals (Al, Mg) recycling yield by flux/salt optimisation
- removal of ceramic particles from Al/Mg-salt slags by centri-fugation/filtration
- selective oxidation of impurities from secondary lead by controlled gas injection using rotor devices
- treatment of Pb/Zn-, WAELZ kiln- and copper-slags by magnetic stirring, DC-arc melting and carbon treatment using injectors and hollow electrodes
- conversion of hydrometallurgy waste (red mud, Jarosite, scrubber sludges) into valuable products
- carbothermic Co-reduction of iron-scrap/Al_2O_3-waste and SiO_2 into a FeSi- resp. AlSi-alloy

Small Scale Production & Customer-Oriented Research

The IME know-how and equipment allows for validation of production processes aiming on metal winning from ore and recovery from scap. New routes can be developed, synthetic minerals made from slags and waste/energy input minimized in lab and pilot scale can be tested e.g. by following process combinations:

- TBRC melting - slag reduction/skimming/converting
- EAF-melting - gas purging - segregation/metal filtration
- pelletizing - pre reduction - volatilization - hydrometallurgy

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06/2010

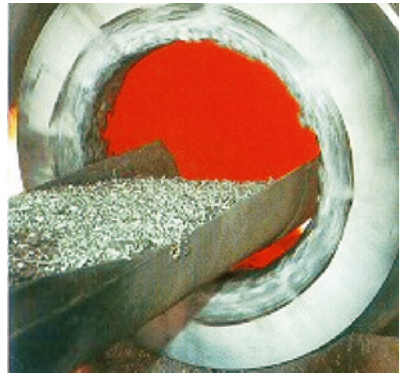
Recycling Equipment

- **Solo Resistance Furnace:**
  - heating power 14 kW, heat-treatment up to 1550 °C
  - different gas atmosphere possible
- **Tamman Furnace:**
  - application in high-temperature range (max. 2000 °C)
  - open and closed operation possible, camera observation
- **Mini VIM R Furnace:**
  - frequency 10 kHz, melting capacity 500 g copper
  - effective power 5 kW, vacuum up to 10^{-3} mbar,
- **Rotary Kiln Furnace:**
  - working temperature up to 1100 °C
  - rotation continuously variable from 0.75 to 7 rpm
  - charge volume up to 3000 g pellets
- **Melt Centrifuges**:
  - crucible volume 3.0 - max. 13.25 l, max. temp. 1200 °C
  - continuously adjustable number of revolutions 60-2000 rpm
  - maximum rotor head diameter 50 mm resp. 300 mm
- **Lab Scale EAF Furnaces:**
  - current: 120-700 A, voltage: 24-44 V
  - max. capacity 6 l, massive or hollow electrode
  - can be operated under inert/protective gas or under air
- **1 MW Electric Arc Furnace:**
  - AC or DC, 24 h operation mode
  - transformer power input 1 MVA,
  - max. 10 kA at 100 VDC resp. 5 kA at 200 VDC
  - hearth diameter 1.6 m, height of vessel 3.2 m
- **Lift Furnace:**
  - resistance heated by 9 SiC elements
  - crucible content 5 l, heat power 25 kW, max. 1550 °C
- **35 l Tilting Resistance Furnace:**
  - resistance heated furnace by 9 SiC elements
  - volume 35 l, max. 1550 °C, impeller
  - hydraulic tilting and lid with inert gas injection
- **Top Blown Rotary Converter (TBRC):**
  - rotation speed up to 10 rpm, max. 1550 °C
  - air or oxygen operated burner up to 500 kW
  - melting volume max. 1 m³, melt angle 0-90°
- **Electrostatic Precipitator:**
  - power 11 kVA, max. exhaust gas temperature 400 °C
  - hollow discharge and collecting electrodes
  - dedusting by surges of compressed air
- **Baghouse Filter:**
  - effective cleaning surface: 169 m², capacity 10000 m^3(STP)/h
  - guaranteed values for cleaned gas: 20 mg/m³ (standard)
  - working temperature: 50 °C, max. 130 °C
- **Scrubber:**
  - max. volume flow: 20000 m³/h (standard)
  - cooling in quench zone from max. 220 to 60 °C

Recycling Metallurgy

Metallurgie Prozesstechnik IME Recycling

DIE METALLURGEN



- **Fundamental Research**
- **Physical Conditioning**
- **Thermal Conditioning**
- **Melt Centrifugation**
- **Electrometallurgy**
- **Bath Smelting - Slag Metallurgy**
- **Pollution Control**

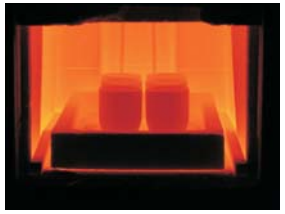
Department and Chair of

RWTH Rheinisch-Westfälische Technische Hochschule Aachen

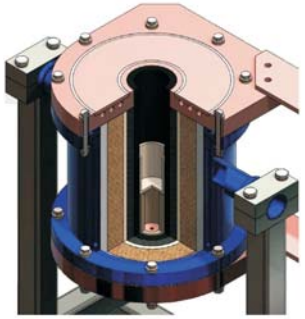
IME Opportunities in Recycling Metallurgy

Fundamental Research

In order to understand and predict the mechanisms which are controlling recycling processes, thermochemically modelling as well as experimental validation represents the start of many research projects. IME uses the commercial software



FactSage® and its databases for a forecast of expected equilibrium phases. As the input materials become more and more complex, suitable data are often missing and have to be recorded in systematical experimental investigations (activity coefficients etc.). The kinetics of the desired process will have a second strong impact on the success and economical feasibility which require optimized sets of fundamental studies. Tests comprise for example crucible screenings, metal-slag equilibria under defined atmospheres, optical and weight control of single pellets up to 2000 °C in a controlled gas flow and kinetic experiments to investigate the rate controlling step, to define necessary processing durations or to determine expectable efficiencies versus equilibrium. This research programme allows for a subsequent scale up through various equipment present at IME.



Physical Conditioning

Input material in form of powder (e.g. ore concentrate, offgas dust) must be often compacted before metallurgical treatment in furnaces like EAF, TBRC or rotary kilns as well in fundamental investigations. This can be done via pelletizing, cold briketting, pressing or sintering, where all methods are available at the IME. In this step neccessary additives like slag formers or reductants are preliminary mixed with the raw material and charged to the agglomerating equipment.

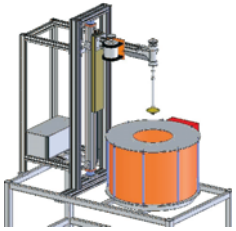
Thermal Conditioning

Many metallurgical processes need preliminary thermal treatment with respect to (partial) reduction of oxides, to a selective evaporation of specific metals and/or compounds as well as to remove organics via pyrolysis. By using defined atmospheres like hydrogen, nitrogen, air or CO the chemical reaction can be controlled in the desired directions.

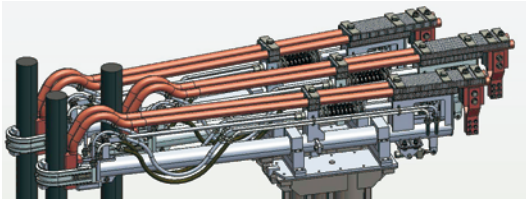
Applications are found for electric arc furnaces, hydrometallurgical leaching as well as metal powder sintering. Compared to static devices the rotary kiln furnace offers perfect conditions for full continuous operations.

Melt Centrifugation

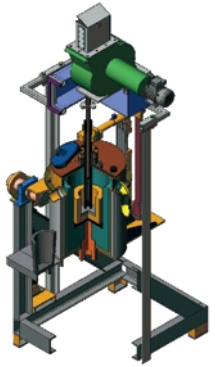
Metallurgical processes often create conditions where solids must be separated from a molten phase. This counts for oxide containing salt slags from Al-recycling, for removal of valuable ceramics from metal-matrix composite scrap or recovery of intermetallic compounds after segregation/cool crystallisation. One effective measure is to separate the solids by use of an immersed centrifugation rotor collector, developed at IME.

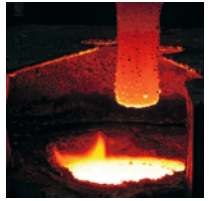


Electrometallurgy



EAF (electric arc furnaces) and SAF (submerged arc furnaces) are widely used for primary metallurgy of ferro-alloys, direct iron reduction, Mg-silicon production or slag treatment/battery recycling as well in recycling metallurgy like iron scrap, spent battery resp. catalyst or slag treatment. The high flexibility with respect to temperature, mode of electrical operation (DC, AC), mode of charging (open bath, slag layer, solid burden) and electrode position configuration offers best conditions for research when developing new/adjusted processes for complex residues, scraps and slag treatment/battery recycling. We run two lab scale furnaces of about 70 kW/6 l, for “proof of principle” experiments with lining material, electrodetype, slag former, and charging alternatives, screening. The world largest equipment operated by a university institute is connected to a 1 MW power supply for 3 phases. AC and DC operation allows for full continuous experiments and such throughputs in t/h scale.





In case of reduction processes an auxiliary injection device serves for accelerated reactions and improved homogenisation.

Bath Smelting - Slag Metallurgy

Many high efficient extracting processes rely on intensive metal-slag interactions and such quick and close to equilibrium conditions. The lift furnace operating up to 1600 °C allows for lab scale trials in 2 l crucibles of all kind of ceramic materials. Top as well as bottom gas injection and mechanical stirring allow for a simulation of larger units. Without lifting the heating hood show solidification and otherwise even quenching of the reaction products can be performed. A 35 l furnace, resistant heated and equipped with an impeller for gas injection represents the next upscaling sequence, where the 200 kg melt can be controlled cast by hydraulic tilting in customized moulds. This furnace has

been especially designed for reactive metal metallurgies like for magnesium by installing various cover gas devices. Our 1 m³ TBRC equipped with a 500 kW air/oxygen burner and vessels for Al/Mg as well as for Cu/Ni/PGM enables our customers to conduct test series in demonstration scale. This unit serves with revolutions up to 10 rpm for best mixing conditions and generates exact datas for mass flows and energy balancing. The reactor can also be used for Pb/Sb/Sn-systems, e.g. in primary or secondary smelting or in refining operation.