Metallurgy at RWTH Aachen University

The degree programm „Metallurgical Engineering“ comprises the fields of metallic and mineral materials, their production, processing and recycling. The academic studies include many practical experiences since they are accompanied by small group exercises, hands-on trials and excursions.

Essentially, the studies are arranged as a six semester long bachelor‘s study and a continuative four semester long master‘s study. The bachelor‘s study imparts subject-specific basics and gives aid to orientation for the major field, which has to be chosen during the master‘s study.

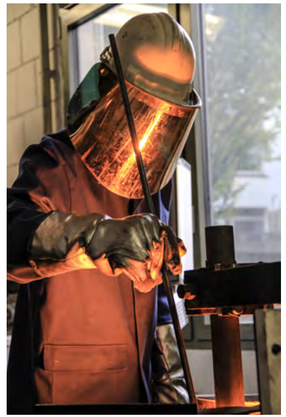
Sem.	Bachelor of Science		
1 2	**Area of Mathematics – Scientific Basics** • Mathematics • Physics • Chemistry	NTS	**Area of Subject-Specific Basics** • Engineering Mechanics • Materials Chemistry • Crystallography • Materials and Process Characterization • Drive Technology in Heavy Machinery • Process Measurement • Simulations Technics • Technical Systems and their Dynamics • Principles of Mechanics and Machinery Components
3 4 5	**Area of Specialization** • Material‘s Engineering • Material‘s Processing • Metallurgy and Recycling • Transportphenomena • Materials Physics		
6	**Internship**		**Bachelor‘s Thesis**

Master of Science			
1	**Major Engineering Science** • System Technology • General Process Technology • General Materials Engineering	NTS	**Major and Minor Field of Study (electoral)** • General Metallurgy and Metal Physics • Metal Forming • Materials Science of Steel • Casting Technology and Materials • Glas and Ceramic Composite Materials • High Temperature Engineering • Ceramics and Refractory Materials • Steel Metallurgy • Metallurgical Process Technology and Recycling of Metals
2 3	**Internship** – **Free Field of Study 1 and 2** These courses have to be chosen out of the catalogue of major and minor field or a selection of additional options.		
4	**Master‘s thesis**		

Academic knowledge is deepened during the master‘s study so that graduates are self-dependently capable to compile and solve complex problems. The scientific qualification is achieved by five exam-blocks: mutual obligatory area, electoral secondary major and NTS (non-technical subject), major and minor field of study and master‘s thesis.

The major field „Metallurgical Process Technology and Recycling of Metals“ at IME with the focus on non-ferrous metallurgy is one of nine possible major fields. In the two main courses „Thermal Recovery Processes of Non-Ferrous Metals“ and „Thermal Refining Processes of Non-Ferrous Metals“ individual process engineering steps of metallurgical processes, their theoretical basics and details of the technical plants are presented. Selected process lines from the ore or secondary raw material to semifinished products determine the focal point of the basis education. Lectures, exercises, seminars and practical courses define equivalently the training scope and are (like bachelor‘s and master‘s thesises) orientated towards up-to-date topics from industry and public research projects.
Besides the main courses, IME offers further secondary major courses and minor field courses:

- Metallurgy and Properties of Aluminum Melts
- Ressource Efficiency during Metal Recycling
- Hydrometallurgy
- Planning and Economic Feasibility of Metallurgical facilities



Our Service

Process Development in the Field of

- Electric arc furnace metallurgy
- Hydrometallurgy and applied electrochemistry
- Vacuum and inert gas metallurgy
- Microwave supported metallurgy
- Recycling of metal containing residues
- Pyrometallurgical refining technology
- Production technology of complex alloys

Service

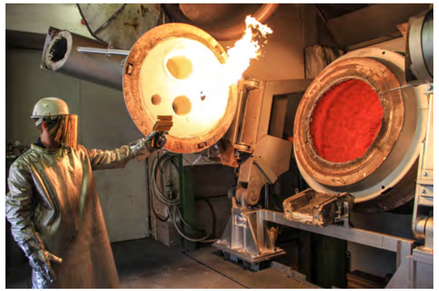
- Chemical analysis
- Energy balances and material flow analysis
- Process modelling and process simulation
- Technical advice and survey
- Studies to the state of the art
- Literature research

Education

- Bachelor or Master of Science of Metallurgical Engineering with focus on pyrometallurgical and hydrometallurgical process technology of the non-ferrous metals such as aluminum, copper, titanium, lead and zinc in consideration of resource efficiency during primary and secondary metal production.

Postgraduate Education

- For professionally experienced engineers with focus on new metallurgical technologies



Department Profile

Our Strengths

- Process development for metal production and metal recycling
- Applied electrochemistry of metals
- 750 m² laboratory and pilot plant area
- Extensive specialized library
- Practice orientated education and training of engineers
- Close collaboration with industrial partners
- Interdisciplinary projects using the research periphery of Aachen and the region

Our Customers

- Students and graduates
- Industry and associations
- Public research organisations

Our Targets

- Customer satisfaction through high-quality services
- Establishment as european center of excellence in non-ferrous metallurgy
- Continuous enhancement of our know-how and research areas

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Date 08/15

The Institute

IME Metallurgie Prozesstechnik Recycling
DIE METALLURGEN

IME Process Metallurgy and Metal Recycling

Prof. Dr.-Ing. Dr. h.c. Bernd Friedrich

Department and Chair of
RWTH AACHEN UNIVERSITY

Professional Description

Engineers provide technological progress and therefore ensure the basis of prosperity that has become self-evident to us. No mobile phone, no computer, no racing car, no space shuttle, no high speed train can be manufactured without using modern metallic materials able to meet the ever increasing requirements.

Here lies the chance for engineers in metallurgy and materials technology. At the beginning of a material's life cycle it is their job to design, develop, optimize and adapt the material. At the life cycle's end a suitable recycling concept must be established. In all cases the development of an environmetally friendly, low waste producing and economically feasible process is initially developed in the lab. Subsequently, scale-up in pilot equipment and finally testing in continiously working production plants is all part of a scientific engineer's job.

As a project manager the process metallurgist finds himself/ herself in a broad field of activities which combines many technical disciplines such as mechanical and electrical engineering, material science, chemistry, information technology and more. It is this team work, which presents the challenge of our profession.

Apart from the commodities aluminum, copper, zinc and lead, more than 40 other non-ferrous metals are constantly gaining significance in the industry. This is how, for example, titanium, magnesium, lithium, niobium, vanadium, chromium, silver, palladium, nickel, platinum or rare earth elements find their way into the key manufacturing areas automotive, aerospace, communication and engergy technology.

The field of process metallurgy and metal recycling incorporates a large number of metals and extends to the full broadness of engineering subjects based on wet-chemical and high-temperature chemistry. Protective gas and vacuum technologies are used to produce high-purity metals and smart materials. On the other hand, low-cost technologies must be employed for the selective and economic recovery of metals from scrap residues. Reflecting upon global resources, energy comsumption and prevention and follow-up environment protection technologies are a significant basis for the development of all materials flow analyses and ecobalances for metallurgical processes and their products.

As a metallurgical graduate you have excellent career options. Metallurgists are well-paid executives in the metal industry, plant engineering, consulting companies and public authorities.

Research Focuses at the Institute for Process Metallurgy and Metal Recycling

IME Metallurgie Recycling Prozesstechnik
DIE METALLURGEN

TBRC-/Air Injection Metallurgy

- Recycling of aluminum scrap with/ without salt
- (Autothermic) WEEE-Recycling
- Battery recycling

Vacuum and Inert Gas Metallurgy

- Vacuum destillation of heavy metal concentrates
- Synthesis of superalloys (Ni-, Fe-, Ti-basis)
  - Cycle of Ti-alloys
  - Parameter studies of ESR-steels

Refining Electrolysis

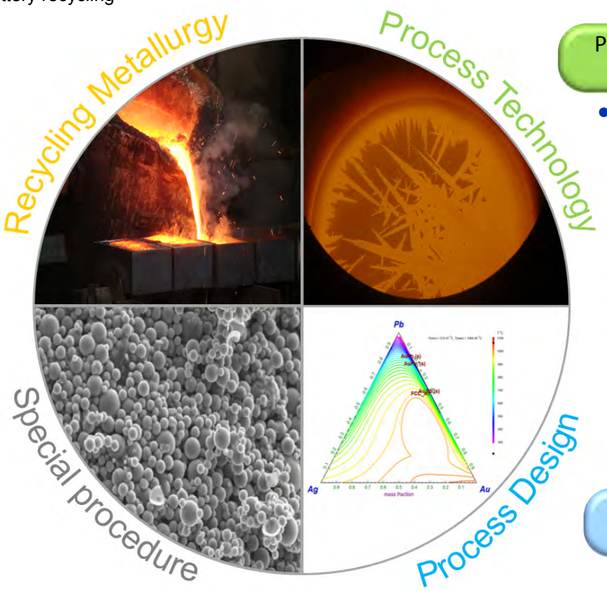
- Electrochemical fundamentals
- Parameter studies

Production Technology of Complex Alloys

- Triple-Melt (VIM-ESR-VAR)

DC/AC-Electric Furnace Metallurgy

- Direct processing of deep sea manganese nodules
- Direct metal reduction from slags
- Slag optimization in SAF-operations



Pyrometallurgical Refinement Technology

- Gas purging treatment
- Selective oxidation
- Pure metal production via cooling finger

Aluminothermic Reduction

- Production of master alloys on Ti-, Cr-, Ni-, Nb-basis
- Production of remelted electrodes for the ESR-process

Zero-Waste/Low-Emission Metallurgy

- Recycling of residues
- Slag cleaning

Synthesis of Nano-Scaled Powder

- Ultrasonic-Spray-Pyrolysis
- Milling and chemical precipitation

Thermochemical Process Modeling

- Volatilization processes
- Slag design

Molten Salt Electrolysis

- Rare earth winning
- Direct production of titanium alloys

Material Balance and Mass Flow Analysis

- Evaluation of non-ferrous metal concentrates from recycling streams

RWTH AACHEN UNIVERSITY

Department Equipment

Pyrometallurgy

- Electric Arc Furnaces (atmospheric, closed, inert gas atmosphere)
- Vacuum Arc Furnace (VAR)
- (High Temperature) Vacuum Rotary Furnace
- Vacuum Induction Furnaces
- Electron Beam Furnace
- Crystallization Furnace
- Hydrogenation-Dehydrogenation Reactor
- (Tiltable) Resistance Furnaces
- Top Blown Rotary Converter (TBRC)
- Zone Melting Furnace
- Vacuum Microwave Generator
- Pilot Pyrolysis Plant
- (Pressure) Electro Slag Remelting Furnace
- Pressure Induction Furnace
- Mini Tilt and Rotary Furnace
- Chamber Kilns

Hydrometallurgy

- High Pressure Leaching Autoclave
- Cascade Leaching
- Stirring Leaching Reactor (laboratory scale up to pilot plant scale
- 8 Column Heap Leach Test Station
- Ultrasonic-Spray-Pyrolysis
- Copper/ Silver Refining Electrolysis
- Molten Salt Electrolysis
- Solvent Extraction (multi stage mixer settler plant)
- Wet Chemistry Laboratory (for small scale trials)

Basics and Analytics

- Surface Tension Measurements of Liquid Metals, Salts and Slags
- Wetting Angle of Contact between Liquid and Solid Phase
- Density Measurement of Liquid Metals, Salts and Slags
- AAS/ AFS/ XRF/ DSC/ ICP-OES
- Portable XRF Device
- Portable FTIR Analyzer
- Ion (Exchange) Chromatography (IC/ IEC)
- Thermoanalysis (DTA/ TGA)
- Glow Discharge Optical Emission Spectroscopy (GDOS/ GDOES) for the Analysis of Coatings
- Microwave Assisted Digestion
- Determination of Gases in Solid Matter (C, S, H_2, N_2, O_2)