Rare Earth Magnet Value Chain

VT-2026

FMH3929, 4 ECTS

Degree level: *Third-cycle studies (doctoral students)*

Description

This course is dedicated to rare earth (RE) permanent magnet value chain. The course gives an overview of the industry related to RE Magnets and Motors. The course has a modular structure. Each module includes teaching and learning materials on the following themes: Exploration of REE and Mining of REE containing ores; Extraction of REEs from ores and tailings; Magnet production; Desing of Magnet-based motor design; Recycling of magnets from EoL devices; Life Cycle Assessment (LCA) and Environmental aspects. To facilitate understanding of the content of the thematic modules content, training on the basic concepts of magnetism is also included. The course development is supported by EIT Raw Materials. Project No 21104, ExpSkills-REM, Expanding Knowledge and Skills in Rare Earth Permanent Magnets Value Chain.

Course contents

Module 0: Challenges of Rare Earth magnets. Basic concepts of magnetism

- What are Rare Earth Elements (REEs)?
- Introduction to magnetism.

Module 1 Ores containing Rare-Earth Elements and their mining

- REE Exploration: The main aspects of REE ores exploration are introduced, along with cases of study from both inside and outside the EU
- REE Mining: Economic aspects in REE Mining, underground and open pit mining techniques
- REE Extraction: Mineral Processing and Extractive Metallurgy Techniques
- Safety and Environmental Aspects and Social License to Operate of REE Mining.

Module 2 Current and Novel production methods of Rare-Earth Permanent Magnets (REPM)

- Fully dense REPM (Nd-Fe-B and Sm-Co) production techniques
- Corrosion protection of Nd-Fe-B magnets
- Bonded REPM production techniques
- Advanced REPM production techniques.

Module 3 Design and fabrication of magnet-based devices and components

- Introduction of electrical machines
- Fundamental theory for electrical machines

- Analysis of permanent magnet (PM)-based electrical machine performance
- Demonstration videos of manufacturing PM-based electrical machines
- Analysis of demagnetization problems in PM-based machines.

Module 4 Rare-Earth Permanent Magnets Recycling and REE extraction technologies

- Introduction to Rare Earth permanent magnets
- Recycling of REEs from permanent magnets: Economic and technical feasibility
- Pre-processing methods for REE recovery from PMs
- Hydrometallurgical recovery of REEs from PMs based on MONOLITHOS method.

Module 5: Life-Cycle Assessment (LCA) of magnets and environmental impact

- What is LCA? Types and benefits
- Sustainable magnet recycling: Insights from LCA case studies
- Life cycle assessment of magnets and environmental impacts

Intended learning outcomes

After completion of the course the student should have the knowledge and ability to:

- Assess critical factors affecting the development of raw material industry in Europe
- Describe technical, economic and societal challenges of building new and re-opening old mining and extraction facilities
- Describe the technology for fully dense and bonded RE permanent magnet production
- Discuss the advantages and drawbacks of different magnet production techniques
- Describe types, working principles and applications of electrical machines
- Describe the factors that influence the performance of permanent magnet-based electrical machines
- Describe the basic principles of different technological approaches to recycling permanent magnets from end-of-life products
- Describe the main techniques for extraction of REEs from ores and tailings
- Assess the environmental impact of raw materials industry and describe its improvement strategy.

Recommended Literature

1. Lecture materials.
2. J. M. D. Coey “Magnetism and magnetic materials”, Cambridge University Press, 2009.

Examination

Quizzes (Multiple choice questions) - 3 ECTS (0.5 ECTS per Module). Grading scale: P (≥ 75 % correct), F (≤ 74 % correct answers)

Project report and seminar presentation, 1.0 ECTS, Grading scale: P, F

Teachers:

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