ADVANCED MINERAL PROCESSING

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Work load75h: 45 h lectures and 30 h exercises
Number of credits: 8 ECTS
Course code: 8KUEVN22/8KUEVN29/8KUEVN30

► *Objectives :*

The objectives of this module are the following:

- based on the state of the art demonstrate the majors challenges in mineral processing,
- present the fundamental aspects of new separation concepts and equipment, like physical chemistry and kinetics of flotation,
- learn how to model and scale-up mineral processing equipment.

The courses will be held also as practice in the “Georesources” and “Environment” laboratories of Nancy as well as in Mineral Processing pilot plant.

► *Contents :*

The courses will be delivered to encompass the **three interrelated modules** listed below:

1. Material balance and scale-up of mineral processing equipment (3ECTS)

3. Modeling and kinetics of flotation (3ECTS)

2. Extractive metallurgy (2ECTS)

► *Prerequisites :*

Physics, chemistry, mineralogy, notions in hydrodynamics

1. Material balance and scale-up of mineral processing equipment

► *Objectives :*

Learn how to establish material balances of a separation process, scale-up equipment and flowsheets

► *Contents :*

1.1. Material balances:

- Definitions: solids percent, dilution, pulp density.
- Metallurgical results from separation, Weight% (yields) and "metal" Recovery.
- Sampling procedure: Reconstitution of material balance from chemical analyses, reconstitution of mineral composition of sample.

1.2. Scaling

- Application to different types of equipment: comminution, direct classification (screening) and indirect classification (classifiers, hydrocyclones).
- Scale-up of separations by gravity, magnetism and froth flotation.

3 Use of specific software to help material balance estimation (solid and water) and scaling : class work on software USIMPAC, Bilco, Echant.

► *Prerequisites :*

Knowledge of common mineral processing techniques, basic knowledge in mineralogy and of analytical mineralogy techniques

► *Form of Exam* : Written exam

► *Intended learning outcomes*

The student is expected to establish the material balance of a batch or continous sepatration process. They will be able to use the commerical software for reconcialtion of material balance and scale up of flotation equipment used for grinding and separation.

2. Modelling of flotation

Introduction to separation science. Modelling of separation as mass transfer phenomena, particle heterogeneity and distribution functions

2. Modelling and kinetics of flotation
2.1 Principle and microdynamic of flotation. Definition of interfaces
2.2 Bubble particle collision and attachments phenomena. Deteministic and stochastic models of collision
2.3 Flotation rate constants. Kinetics model of flotation: first order kinetics model, axial diffusion models,

2.4 Kinetics model of flotation equipment: conventional cell, column flotation, intensive flotation cell.
2.5 New developments in flotation equipments.

► *Prerequisites :*

Basic knowledge in hydrodynamic and physical chemistry

► *Form of Exam :*

1. Continuous evaluation during the training classes

2. Final written exam during 3 h with course documents authorized.

► *Intended learning outcomes*

After completion of the course, the students will know the various sub-processes/mechanisms and their key parameters that control the interaction between particle and bubble in flotation. They will be able to use this knowledge to identify the causes of problems in mineral flotation and propose practical solutions. The students is expected to know how to measure the rate of mineral flotation using several kinetics models of flotation in various flotation machines. They will be aware of new and recent developments in flotation equipment.

►*Assessement method for the three sub topics:*

The assessment method is a combination of the three. The students are expected to understand and remember or know how/where to find the facts, key points, basic principles (eg., BET equation for gas adsorption on a solid surface) in a particular topic and to use them for a specific problem (eg., use the BET equation to find the surface area of particles). They are also asked to use these facts, what they have learned to apply them to solve problems 'outside the box' (eg., identify/diagnose the possible causes of the low flotation of a particular mineral in an ore and propose some practical solutions to fix the problem).

3. Extractive Metallurgy

Teaching is only in the form of lectures. The physicochemistry of the processes and the major processes of extractive metallurgy are presented there.

► *Objectives:*

Extractive metallurgy is at the heart of the primary and secondary resource management processes. It draws on a wide range of knowledge. A global vision of the supply chain and the materials value chain is necessary to develop the processes of tomorrow capable of recovering increasingly complex ores and waste. A systemic vision is therefore necessary.

This course will focus on providing this vision by building on the skills already acquired by students in minerals engineering, mineralogy and in mineral processing processes. In particular, the following points will be addressed while ensuring a close link with the industrialization of processes which must be efficient, inexpensive and respectful of people and the environment

► *Contents :*

- Presentation of unit operations of extractive metallurgy processes

- Pyrometallurgical ore treatment operations: Principle and applications

- Hydrometallurgical treatment operations: Principle and applications (leaching, precipitation, liquid-liquid extraction, solid / liquid extraction)

- Electrometallurgical processes

- Analysis of industrial processes in extractive metallurgy

► *Prerequisites :*

Basic knowledge in chemistry and physics

► *Form of Exam :*

Final written exam during 3 h.

► *Intended learning outcomes*

After completion of the course, the students will:

Understand and interpret data to develop process diagrams for the extraction of metals contained in primary and secondary resources

Have a good command of the unit operations involved in extractive metallurgy and the physicochemistry associated with these unit operations

► *EIT Overarching Learning Outcomes (OLOs)*

OLO 3: Cross over between disciplines/subjects of physical chemistry, geology, resources and extractive metallurgy, and application of knowledge in each discipline to solve the problem of resources beneficiation and new ideas generation.

OLO 5 Improve the skills in Mineral characterization using the latest analytical and imaging techniques

OLO6: Set-up and perform the laboratory practical sessions for mechanical preparation, physical and chemical separation of rock samples