MICA
Minerals Intelligence Capacity Analysis

FACT SHEET

Mineral processing

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Mineral and ores

Mineral processing is a part of science and technology dealing with treatment of mineral materials. It is covered by several physical and physico-chemical separation operation units and involved in performing and description of separations as well as their analysis, evaluation and comparison. This technology is very old, as old as human civilizations and the first mineral processing activities was started with cleaving, sharpening flint and sorting stones. Now, mineral processing is used for sorting of industrial and municipal wastes. The products concentrated are treated by metallurgical, chemical, civil engineering and other industries. See fig 1.

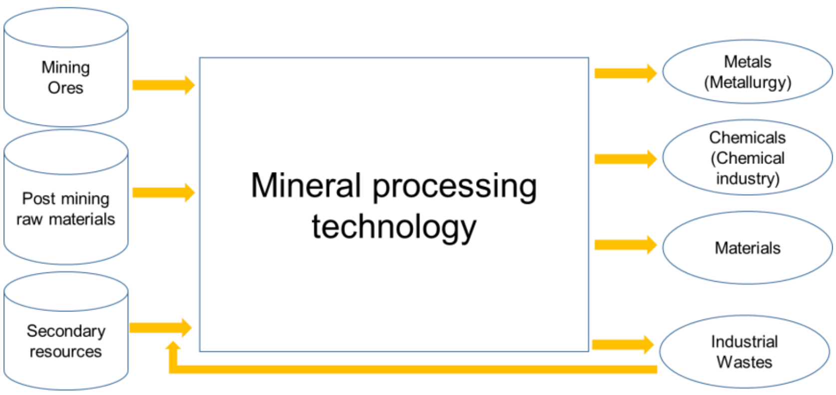

Fig.1. Uses of mineral processing technology

The extractive metallurgy gathers both mineral processing and metallurgy, which covers several materials and separation techniques see fig. 2.

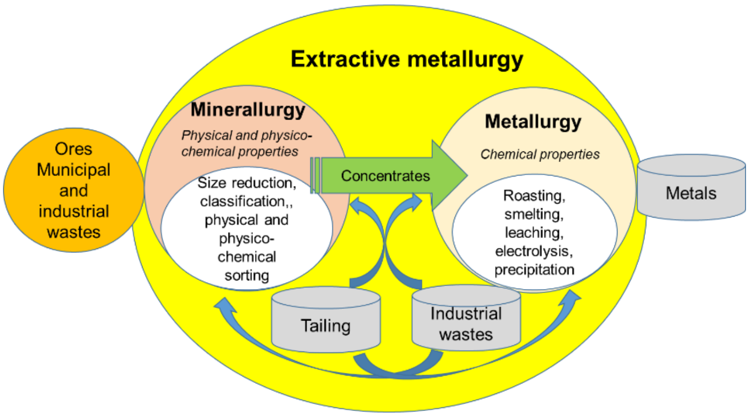

Fig.2. Technologies involved in extractive metallurgy

The usual operation techniques used in mineral processing is shown in Fig.3. The first step consists on pre-processing of mining raw materials, tailing or industrial wastes in order to liberate all particles contained (attend maximum Liberation degree). The input material to be beneficiated is crushed, grinded and classified until attending the liberation degree. In the second step, the techniques are chosen according to the physical and physico-chemical properties of particles contained. The techniques can be run in dry or wet processes. After the beneficiation, materials are dried, sampled and conditioned for being sold or being sent to metallurgical industries for refining and producing a marketable materials.

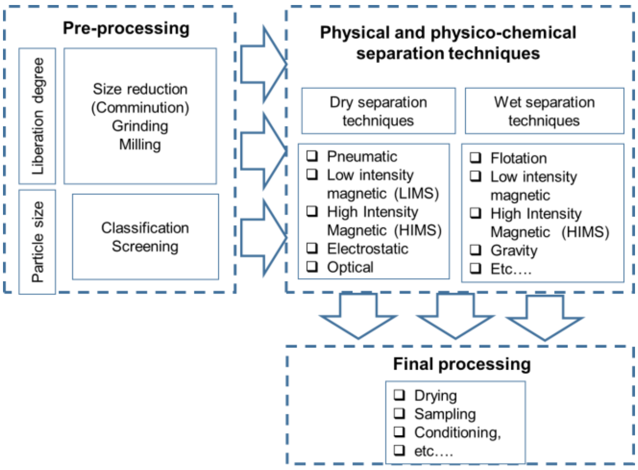

Fig 3. Techniques involved in mineral processing

Crushing, Grinding, screening

Comminution is a process which is performed for the reduction of particle size. The process requires application of forces. It can be accomplished in a mechanical or chemical way. This technique is almost used during the preparation of the material for separation operation. Comminution can be accomplished by crushing or grinding. Crushing is performed on large particles while grinding on small particles which is performed on mills and this operation consumes considerable amount of energy. The raw material is first subjected to size reduction before beneficiation. This step is very important in mineral processing and called comminution which can be selective, partially selective and nonselective as shown by figs. 4. The main objective of comminution of solid materials is to release useful particles from the gangue. If liberation is not complete, the product of comminution contains intergrowths. The mechanical comminution is usually used to recovery of metals, plastics, ceramics etc… from urban mine (end of life vehicles (ELV), waste of electric and electronic equipment (WEEE) and metallurgical by-products such as slags).

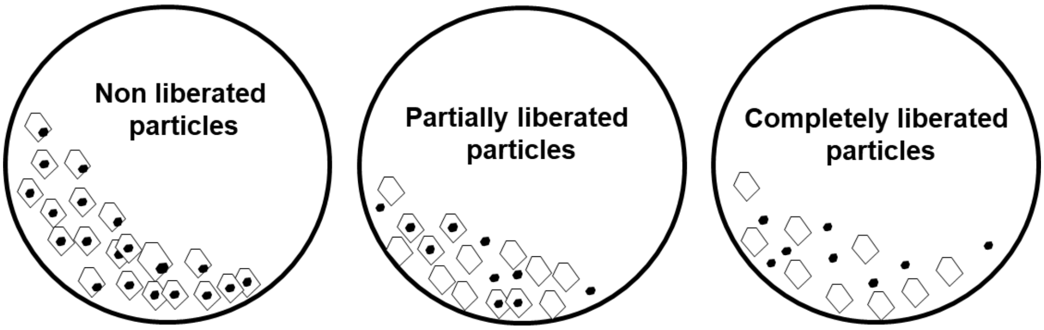

Fig.4. Liberation degree of raw material obtained from mechanical

The methods developed in mineral processing is depending not only on properties of the materials by also on the particle size. As shown by fig. 5, each method of separation requires optimal range of particle size.

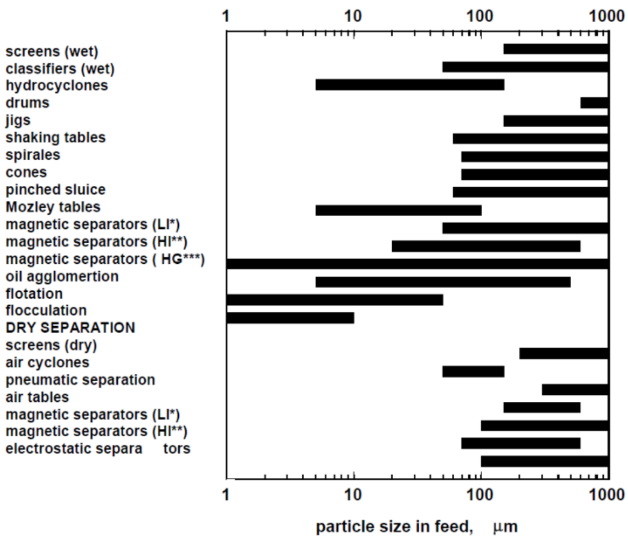

Fig.5. Particle size limit for each separation methods used in mineral processing

LI* Low intensity, HI** High intensity, HG*** High gradient magnetic field

*Mineral Processing (Foundations of theory and practice of minerallurgy) 1st English edition (*Wroclaw University of Technology, 2007)

Screening

The separation of the material by differences of particle size contained is performed by screening or mechanical classification. The particles which are smaller than screen opening pass through the screen while bigger particles either remain on the screen or fall off at a designated flow stream.

Scope (physical and physico-chemical sorting)

Separation methods developed in mineral processing are built depending on the differences of the physical and physico-chemical properties of individual minerals or materials such as shape, liability to size reduction, specific gravity, electro-magnetic susceptibility, surface chemical property, etc.:

- Physical sorting
- Gravity concentration
- Heavy medium separation (HMS)
- Froth flotation
- Magnetic separation (dry and wet)
    - Low Intensity Magnetic Separation (LIMS)
    - High Intensity Magnetic Separation (HIMS)
- Electrostatic separation
- Electronic sorting
- Dewatering
- Tailing deposal

Nowadays, mineral processing methods are used in the field of recycling of industrial wastes such as WEEE. As shown in Fig.6, the established process of WEEE recycling includes the following steps:

- ✓ Manual dismantling to recover all hazardous components (e.g., mercury in batteries, chlorofluorocarbon [CFC] in refrigerators). This step deals with depollution and recovers some valuable components before the shredding operation.
- ✓ Shredding of WEEE into small particles in order to liberate metals from plastics and wood.
- ✓ Low-intensity magnetic separation (overband) to recover ferrous metals.
- ✓ Eddy current separation to recover nonferrous metals.
- ✓ Wet density to separate different types of plastics.

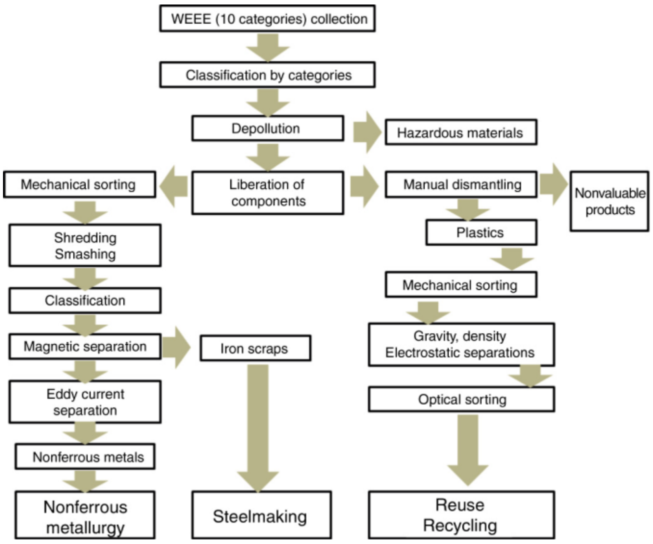

Fig.6. *General flowchart of mechanical and manual sorting of WEEE*

Contexts of use, application fields	-> contexts (e.g., environmental, economic, social assessment) -> which types of stakeholder questions are concerned? -> link to published studies that implement the method

Both mineral processors and extractive metallurgists have made considerable advances in the last few decades in developing new technologies, which make it feasible to recover metals from the secondary lower grade resources

Mineral processing gathers several methods which can be applied in different fields. In the field of extractive metallurgy, mineral processing for separating commercially valuable minerals from their ores. This technology is applied in agri-food, mining, household and industrial wastes. The purpose is to concentrate valuable commercial materials. Mineral processing may be used for depollution for environmental point view.

The context of use and application fields is very large and transverse. The flow sheet is elaborated depending to the feed material.

Input parameters	-> which parameters are needed to run the method

A proper set up for materials handling is needed to perform processing system. This can be done in different process stages may be In various locations with different feed conditions. The mineral processing is applied on ores, industrial wastes to beneficiate of minerals and to recover valuable materials from different types of wastes. Several parameters are identified depending on the input material, which can be adjusted.

Type(s) of related input data or knowledge needed and their possible source(s)	-> which types of data are needed to run the method, from which sources could they come… -> could be qualitative data or quantitative data, and also tacit knowledge, hybrid, etc.

The classification presented in this document is fully INSTIGATE compliant, and is thus the one which is used in several Knowledge base regarding mineral processing:

Model used (if any, geological mathematical, heuristic…)	-> e.g., geological model for mapping -> e.g., mathematical model such as mass balancing, matrix inversion, can be stepwise such as agent -based models, dynamic including time or quasidynamic specifying time series… -> can also be a scenario

- Not applicable

System and/or parameters considered	-> **the system can be described by its boundaries**. These can refer to a geographic location, like a country, or a city, the time period involved, products, materials, processes etc. involved, like flows and stocks of copper, or the cradle-to-grave chain of a cell phone, or the car fleet, or the construction sector, or the whole economy… -> **parameters** could possibly refer to geographic co-ordinates, scale, commodities considered, genesis of ore deposits and others…

The description of methods used in mineral processing is generic and therefore applied to a wide variety minerals in mining and for recycling of minerals and metals in urban mine in circular economy.

Time / Space / Resolution /Accuracy / Plausibility…	-> to which spatio-temporal domain it applies, with which resolution and/or accuracy (e.g., near future, EU 28, 1 year, country/regional/local level…) -> for foresight methods can also be plausibility, legitimacy and credibility…

- Not applicable

Indicators / Outputs / Units	-> this refers to what the method is actually meant for. Units are an important part but that is most of the time not sufficient to express the meaning. For example, **the indicators used in LCA express the cradle-to-grave environmental impacts of a product or service**. This can be expressed in kg CO_2-equivalent. But also in €. Or in millipoints. Or in m^2year land use. -> for foresight methods the outputs are products or processes

- Not applicable

Treatment of uncertainty, verification, validation	-> evaluation of the uncertainty related to this method, how it can be calculated/estimated

- Not applicable

Main publications / references	-> e.g. , ILCD handbook on LCA, standards (e.g. , ISO) -> can include reference to websites/pages -> references to be entered with their DOI

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D. Drzymala, Mineral processing: fundations of theories and practice on minerallurgy, Book, ISBN 978-83-7493-362-9, Wroclaw University of Technology, 2007. http://www.dbc.wroc.pl/Content/2070/Drzymala_mineral.pdf

Metso, Basics in Minerals Processing, handbook, Edition 10, 2015. **www.metso.com**

Related methods	-> List of comparable methods, their particularities… -> link to one or several other existing fact sheet(s)

- Not applicable

Some examples of operational tools (CAUTION, this list is not exhaustive)	-> e.g., software… Only give a listing and a reference (publication, website/page…) -> **should be provided only if ALL main actors are properly cited**

Modular simulator for mineral processing plants, http://www.mineraltech.com/MODSIM/

BILCO, Data reconciliation software for mass balance engineering**,** http://www.caspeo.net/bilco

USIM PAC, Digital simulation software for industrial processes http://www.caspeo.net/fr/USIMPAC

Key relevant contacts	-> list of relevant **types** of organisations that could provide further expertise and help with the methods described above.

Metso, http://www.metso.com/fr/francais/
GTK, mineral processing plant, www.gtk.fi
CTP, http://www.ctp.be/fr/expertises/mineral-processing/
MetNet, European Pilot Plant Network for Extractive Metallurgy and Mineral Processing, EU project https://eitrawmaterials.eu/project/metnet/
Prometia, Mineral processing and extractive metallurgyfor mining and recycling for innovation association: http://prometia.eu/

Glossary of acronyms /abbreviations used	-> Definition
CRM	Critical Raw Materials
HIMS	Hight Intensity Magnetic Separation
LIMS	Low Intensity Magnetic Separation
WEEE	Waste Electrical and Electronic Equipment