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International Journal of
Materials Technology and Innovation

DOI: 10.21608/ijmti.2022.277913

Online ISSN 2682-4299

Workshop " The Role of Mineral Resources in Sustainable Development in Egypt : Challenges and Solutions "

ورشة عمل " دور الثروة المعدنية في التنمية المستدامة في مصر : التحديات والحلول"

8-7 سبتمبر 2022 بفندق بيراميزا -الدقي - القاهرة

Workshop on

"The Role of Mineral Resources in Sustainable Development in Egypt : Challenges and Solutions "

Abstract Book

Under the Auspices of

Prof. Dr. Mohamed Ayman Ashour

Minister of Higher Education & Scientific Research

Organized by

Minerals Technology Institute

Central Metallurgical Research & Development Institute

7-8 September 2022

Pyramisa Hotel – Dokki – Egypt

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Conservation of Mineral Resources for Sustainable Development

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Abstract

The paper describes the need for conservation of mineral wealth with a view of utilizing existing resources efficiently, discovering new deposits, finding substitutes & recycling. The focus for the conservation of mineral resources must be on extraction practices of the mineral itself. The role of State is significant for optimizing mine life and implementation of royalty regime that encourages the user of low-grade minerals. The main assumptions presented in this paper are that relate to the conservation of minerals for achieving sustainable growth, the ones that will significantly shape the development of mining in the future while minimizing the impact on the environment. Sustainable growth requires balancing long-term economic, environmental and social objectives. What makes this challenging is that the solutions lie beyond the traditional areas of engineering design and industrial ecology, encompassing the ecological and social implications of technological decisions. In the minerals sector, sustainable development means that investments in mineral projects should be financially profitable, technically appropriate, environmentally sound and socially responsible. Businesses involved in extracting non-renewable resources have come under growing pressure to embed the concept of sustainability into strategic decision-making processes and operations. Economic development, environmental impact and social responsibilities together with the conservation of minerals can be done in many ways including:

- Minerals should be used in a planned and sustainable manner.
- Technology should be upgraded to allow the use of low-grade ore at low costs.
- Using the mineral resources with great efficiency.
- Avoid the over exploitations of minerals.
- Recycling of metals also results in the conservation of mineral resources.

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Mineral Fillers

"Types, Upgrading, Surface Modification and Applications"

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Abstract

What caused fillers to be added to materials in the first place was probably quest for lower costs. Fillers are inexpensive, thus using them would make the material cheaper. Fillers are defined as materials that are added to a polymer formulation to lower the compound cost or to improve properties. Such materials can be in the form of solid, liquid or gas. By the appropriate selection of these materials, not only the economics but also the other properties such as processing and mechanical behavior can be improved. Fillers produced today are manufactured by sophisticated processes. There are numerous examples of surface modification which changes filler's properties. Mineral additives are widespread in industrial manufacturing processes. In more recent years, minerals have frequently been used for their functionality and other mineral specific qualities. The effect of addition of mineral fillers depends on the mineralogy, particle size, particle shape, refractive index and many other mineral properties. Although these fillers retain their inherent characteristics, very significant differences are often seen, depending on the molecular weight, compounding technique, and the presence of other additives in the formulation. Therefore, once the basic property requirements are established, the optimum filler type and the loading level for cost and performance balance must be determined. The addition of fillers also requires a balance of formulation for optimum processing properties. Therefore, before making a final decision on a filled compound, it is critical to establish the following:

1. **Optimum loading level for property and benefit.**
2. **Optimum formulation for processing and production output.**
3. **Economics of filled formulation.**

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Improving the Competitiveness of Some Egyptian Mineral Resources in View of Sustainable Development Plans

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Abstract

Egypt, like the rest of the world countries, are facing large challenges since few years such as Covid 19 and the current war between Russia and Ukraine. These international problems affected adversely on the global economy and caused an economic recession for most of the world countries. As a result of that, Egypt took many economic and social actions to minimize the consequences of these global problems in view of the vision of Egypt 2030 that help the sustainable development plans.

The revenues from mining sector in Egypt is very low (~ 0.5 % of national income) and below the expectation (~ 5 % of national income) of the state, due to many reasons that makes developing the mining sector is a must. One of these reasons is selling the Egyptian ores as run-of-mines (ROM) without beneficiation or any treatment to improve their grade, and in turn, increase their competitiveness in the markets.

Egypt has large reserves of many industrial materials (e.g. phosphate ore, white sand, kaolin, etc.) in many localities among the country. Such natural ores can satisfy not only the local demand for production of fertilizers, glass and ceramics, but also for exportation. However, these ores are of low grade so that they need beneficiation before their application in different industries. Beneficiation of such raw ores, from different localities both on bench and pilot plant scale at CMRDI, indicated their technical and economical viability, which, in turn, encourage the investment in upgrading these industrial minerals.

This paper presents the ready to implement technologies at CMRDI to upgrade the quality of Egyptian white sand and kaolin ores as well as improving the specifications of phosphate ores and their fine wastes which are discarded during mining process due to their low grade, to produce cheap fertilizers.

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New Trends in Mineral Beneficiation Using Bio-Processing

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Abstract

The field of mineral processing depends on the conventional separation techniques (from crushing, grinding, gravity separation, magnetic separation and flotation) to separate the important minerals from the associated impurities to obtain the specifications required for the industry. It is known that these methods are inadequate in the subseive range, these large amounts of valuable minerals are discarded as fines and ultrafines. Treatment of fine particles presents a difficult problem in the chemical industry and raw materials processing and its solution is required. Among the promising techniques that have been applied in the field of mineral processing is the use of biotechnology, Biotechnological processing routes are sought to solve the problems associated with lean grade ores, recently, employing microorganisms and their metabolites as a potentially low-cost and environmentally friendly alternative for the synthetic compounds in many of the current mineral beneficiation techniques is receiving increasing attention. Economic considerations and the industry's attention to reducing the environmental impact of mining and mineral processing have led to significant advances in the application of biotechnology in mineral processing. In the mineral processing industry, surface-modifying chemicals such as collectors, depressants, activators, frothers, and various flocculants are commonly used, which are generally expensive, toxic, and non-biodegradable. Therefore, they cause soil and groundwater pollution. So, bio-beneficiation of minerals such as bio-flotation and bio-flocculation has been introduced as a novel, more flexible, a non-toxic method that not only preserves the physical and chemical structure of minerals and has few environmental hazards but also expresses promising results in the enrichment of minerals. Also, attempts have been made to use microorganisms in the disposal of harmful elements in the field of water purification or in the extraction of precious elements from ores. Twenty-one years ago, CMRDI started to study the possibility of using microorganisms in the field of mineral processing. Specially, to beneficiate difficult to-treat ores when the gangue minerals are finely disseminated in the matrix or when the minerals in the ore matrix have similar physico-chemical properties that make their separation processes become extremely difficult by the conventional physical separation methods. A considerable work was done in this field including scientific theses (7 master's theses and 6 doctoral theses) as well as several published papers, and more than 21, in different international journals and conferences and six internal and international projects. As a part of its program to increase the involvement of CMRDI in this novel technology, CMRDI, with the assistance of expertise from University of Florida, USA and Lulea University, Sweden, has established a bio-technology laboratory. This new Lab. was supported and well-equipped with all facilities, personnel (three microbiologists), needed in this domain. The biological laboratory has a long history in upgrading most of the industrial ores in Egypt such as phosphate ores, iron, talc, calcium carbonate, kaolin and manganese. Also the biological lab has good results in waste water treatment where toxic elements have been eliminated in the industrial effluent treated with bacteria.

Surface Modification of Egyptian Calcium Carbonate to Produce Value Added Products

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Abstract

Egypt is endowed with a huge reserve of high-grade calcium carbonate (as limestone and calcite), which is being utilized in some applications that do not require such high purity such as dimensional stone for construction and aggregate for road construction. In the meantime, its use in other industries such as fillers in pigments, plastics, etc. is limited due to lack of fundamental and practical experience in preparation of such materials for these applications. A large number of surface treatment technologies have been attempted to endow mineral particles with new properties for many industrial applications. Therefore, the objective of the study is to develop such knowledge related to preparation of fine powders and slurries, surface modification techniques, and dispersion that can be applied on the Egyptian calcium carbonate to produce value-added products. Specifically, bench scale development of methodologies for production of both powder and slurry of natural and surface coated calcium carbonate for plastic, paints and paper production are included. The results are helpful to both public and private sectors since they involve not only academic studies, but also applied research that can help in achieving the goal of maximum utilization of our natural resources. The results cover the occurrence and reserves of calcium carbonate in Egypt including microscopic observations and mineralogical composition. The establishment of the criteria to control rheological properties and the physical stability of suspensions so as to attain a solid volume with adequate fluidity. New Technology for coating calcium carbonate powder was established.

Manipulate The Value of Some Mineral Resources (not scarcity) That Have Valuable Elements

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Abstract

Mineral resource/reserve is the composite of useful concentration of minerals that may or may not exceed the input cost for obtaining the target valuable minerals. The technological process, the needs of the economy, and prices in the market depend on whether and when the rock/mineral becomes raw material. For example, for road construction the mineral raw material is stone mined from the quarry, and the stone blocks broken away from the rock mass for the construction of stone structures or processing into polished slab. The rock bauxite is a mineral raw material for obtaining aluminum, hematite for iron, and kaolin for porcelain. The pure clay is mineral raw material for manufacture of ceramics, and impure clay for production of tiles or bricks. The mineral/ore deposits are formed in the Earth's crust by different geological processes over time, and accumulates minerals in such quantities and qualities that it is technologically possible to mine and economically profitable to designate it as "Ore" and "Orebody." In such condition the mineral resource becomes mineral or ore reserve. This talk will through light on mineral resource (not scarcity) that can be considered as Ore or Ore body such as serpentine and serpentinite minerals, celestine or celestite, cassiterites, … These ores are considered sources of metals e.g. Mg, Sr. Si, Al, Ni, Tin, …

Effect of Marble and Granite Dust Addition on the Strength and durability Properties of Concrete

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Abstract

The marble and granite industry leaves behind about 20% of the total production in the form of ultra-fine particles that are not biodegradable, which is estimated at 448,000 tons annually in the Torah area, which must be disposed of in a safe manner such as concrete which leads to a green environment. Therefore, this study aims to use fine powders of granite and marble as an alternative to cement in different proportions, and to measure the strength and durability of the resulting concrete and compare it with conventional concrete. Therefore, concrete mixtures containing fine powders of granite and marble in proportions ranging from 5% to 25% were prepared. The mechanical properties such as compressive strength, tensile strength, bending strength, etc were measured to determine their efficiency. Durability properties such as water permeability, chloride penetration, sulfate resistance and electrical resistance were also determined. It was found that replacing cement with fine granite powder in proportions up to 15% leads to suitable concrete without negatively affecting the strength and durability parameters.

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NEW HORIZONS FOR THE EGYPTIAN METALCASTING INDUSTRY:

A Vision Based on Technologies Developed at CMRDI

Prof. Adel Nofal

Central Metallurgical R&D Institute (CMRDI)

Abstract:

The metal casting industry is the cornerstone of industrial development. The demand for metal components is expected to change as new markets and products emerge and others disappear. The Egyptian metal casting industry will need to anticipate emerging industry and consumer needs and provide innovative products, that are superior in quality, competitively priced and still with high added-value. New processes will be needed to cast metal components, that meet the demanding material specifications and designing of new products. Learning how to meet the technical demands of new products and markets will be essential to the future viability of the metal casting industry itself.

The Egyptian imports of castings reached alarmingly high figures, meanwhile the idle capacity of this industry in 2012 exceeded 200,000 ton. The main reasons include: lack of investments in new technologies and initiatives for new casting products, and hence as inadequate quality levels of local production.

Since its establishment in the early 1970's, the Metal Casting Group of CMRDI has been instrumentally engaged with R&D programs together with the Egyptian foundry industry, aiming at introduction of new technologies and developing of new casting alloys to the Egyptian market, as well as development of human resources working in that field. This report highlights those efforts and explains how they can serve as outlines for a road-map for the development of the metal casting industry over the coming years; to fill the gap between production and demand.

Examples are:

- Introduction of ductile iron technology and the subsequent production of castings of vital importance such as spare parts for textile machinery and rolls for steel rolling mills.
- Production technology of the revolutionary material; the austempered ductile iron (ADI) and exploring its potential applications in automotive, agricultural, earthmoving, and transmission parts.
- Optimization of abrasion resistance/toughness properties combination of grinding media alloys used in cement and mineral processing industries.
- Production of strategic castings with applications in deface industries.
- Introduction of investment casting and its implementation in medical implants and turbine-blades production.
- Another technology under development that should be tackled soon is the prediction of iron melt quality before casting of large castings used in Wind Turbines, which will represent an essential input to the Egyptian Wind Energy development program.

The potential implementation of the above-mentioned technologies for the production of high- added value castings to the existing foundries or for the establishment of new production facilities will be discussed as a base for a road-up of the metal casting industry.

The possible role of the experimental foundry at CMRDI in development of human resources and provision of continuous training programs for foundry personnel on different levels will be elaborated. Moreover, higher specialized courses on technological and metallurgical aspects of the metal casting industry will be suggested, based on more than 40-years experience in R&D interaction with the metal casting industry in Egypt and abroad.

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Potentials for the Production of Titanium Metal and Pig Iron for Different Industries

Dr. Heba Hussien *
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Abstract

The titania rich slag containing 68% TiO_2 and pig iron with purity of 97% iron were produced from smelting reduction of Abu Ghalaga illmenite concentrate (42% TiO_2). The Smelting process was carried out using homemade submerged electric arc furnace (125 kW). The produced titania rich slag was up-graded by leaching with hydrochloric acid to produce buff synthetic rutile (88% TiO_2) which can be used in welding rods industry. Furthermore, the titania rich slag was chlorinated to produce titanium tetrachloride (98% $TiCl_4$) using fluidized bed reactor. The prepared titanium tetrachloride was reduced by magnesium metal using a locally fabricated reactor to produce Ti metal with purity 99%. Moreover, the obtained pig iron was casted to produce special spare parts for automotive industry.

Production of Phosphoric Acid from Egyptian Phosphates: Challenges and Solutions

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Abstract

Production of phosphoric acid from Egyptian phosphates via Dihydrate Process was reviewed. The difficulties facing this technology regarding each phosphate were demonstrated and their solutions were discussed as well. For example, enhancing the filtration rate of phosphoric acid from phosphogypsum were discussed in details. The applied techniques were physical and/or chemical routes. In industry, better filtration rate of phosphoric acid from phosphogypsum means higher production as well as less capital and operation costs. Physical technique is related to decreasing the cake thickness via increasing rotation speed of filter under the standard applied vacuum. Chemical techniques lead to modification of crystals by different additives which added individually. This include but not limited to surfactants, polymers, aluminum bearing materials, oxidizing agents, blending of two phosphate ores, …etc. At CMRDI, phosphoric acid is prepared using standard continuous unit simulating Dihydrate process of single tank reactor. The specific optimum conditions of reaction and crystallization of the tested phosphate ore were applied. Also, purification techniques of phosphoric acid from impurities were reported. CMRDI team supervised the test of phosphoric acid production from underground New Valley phosphate using surfactant at Abu Zaabal Chemicals and Fertilizers Company. The filtration rate was increased by 30-40% using Crysmod surfactant.

Spent Catalysts Recycling for Valuable Metals Recovery

Dr. Sabah M. Abdel Basir *

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Abstract

Catalysts used in various industrial processes deactivate over time. When the catalyst activity falls below an acceptable level, it is usually regenerated and reused, but this process is not always possible. After a few regeneration and reuse cycles, the activity of the catalyst may decrease to very low levels, and further regeneration processes may be economically unfeasible. Due to the gradual depletion of high-grade ores, the recovery of valuable metals such as molybdenum, nickel, cobalt, and vanadium from spent catalysts has received a lot of attention. Several hydrometallurgical methods for recovering these metals from spent catalysts have been investigated. Leaching (acidic or basic), precipitation, adsorption, and solvent extraction are the main methods. Because of the high dissolution of valuable metals, acid leaching is generally preferred in the industry over basic leaching. Due to the gradual depletion of high-grade ores, the recovery of valuable metals such as molybdenum, nickel, cobalt, and vanadium from spent catalysts has received a lot of attention. Because of their effectiveness, selectivity, and biodegradability, different organic acids are gaining attention as a promising green leaching method for spent catalysts. Nonetheless, despite these advantages, organic acid-based leaching has yet to be widely adopted. This is due primarily to a lack of a clear knowledge about the potential of organic acids, as well as the slightly costlier associated with some commercial organic acids. However, the higher leaching costs associated with organic acids can be offset by their higher selectivity and positive environmental effects.

Keywords: Spent catalysts; Valuable metals; Leaching; Recovery; Organic acids;

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Electrolytic Industrial Refiner Improvement and Development of Companies Electrode Monitoring as well as Technology Transfer Fields.

Dr. El Sayed Mostafa El Sayed *

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Abstract

The chemical and electrochemical processing department has a variety of useful facilities used to develop and solve difficulties in the industrial copper electrorefining from secondary scrap best guide electrolytic refiners. It was noted that the produced cathodic copper has an uneven surface in addition to the morphological defects (spheres and tree precipitates), which affect the possibility of exporting it abroad. Decreasing the oxygen content in the produced copper is another goal to satisfy the requirements of some special clients. The improvement of electrolytic copper production with identical ideal specification for exportation from electrolytic refiners was performed and developed by CMRDI. Copper cathode of Grade A with a flat and smooth surface and reduction of power consumption to reach the world standards are goals of our study (that satisfied the ideal standards for export). The goals of increasing current efficiency and lowering power consumption of the electrolysis unit were achieved. All of these factors increased the efficiency of copper refining plants. With regular supervision and continuous workplace consultations, CMRDI researchers created a management system for electrolytic copper manufacturing that fulfill the ideal standards for export (fine and smooth copper cathodes) for Alexandria Copper Works Co (2000-2010). Moreover, CMRDI researchers successfully synthesized and optimized metal alloys and metal iron oxide films which produce highly efficient renewable energy, Solar and Fuel Cells by different electrochemical routes.

Keywords: Copper, copper refining, fire refining, electro refining, copper anode, copper cathode, current density, bath composition, organic additives, anodic passivation, cell development, dissolved gases, cathodic quality, current efficiency.

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Utilizing Phosphogypsum by-Product Produced from New-Valley Phosphate by Dihydrate Wet-Process for Sustainable Applications

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Abstract

Abu-Tartur phosphate mine is the biggest phosphate mine in Egypt. The estimated phosphate ore reserves in the area may reach up to billion tons, phosphate rock is the main source for production of phosphoric acid. Phosphoric acid (H_3PO_4) is produced by two commercial methods: wet process and thermal process. Wet process phosphoric acid is used in fertilizer production. Thermal process phosphoric acid is of a much higher purity and it is used in the manufacture of high-grade chemicals, pharmaceuticals, detergents, food products, beverages, and other nonfertilizer products. Phosphogypsum by-product produced from a phosphoric acid plant is mostly stacked on land, and some countries like (Morocco, Tunisia and South Africa) discharged into the sea. Less than 5 % of production is used commercially, usually deposited in large stockpiles, without any treatment, but there are different applications after treatment which include (i) for use as soil conditioning or as fertilizer in agriculture (ii) in cement manufacturing to control the setting time of cement and (iii) small quantity is used in the production of plaster, plaster boards, gypsum fiber boards, and gypsum blocks. In this work, the effort is being directed to purification phosphogypsum by using different methods. We use phosphogypsum, after purification and design ratios of different additives to work as soil amendment. In addition, phosphogypsum and commercial phosphoric acid is utilized to produce hydroxyapatite as advanced fertilizer.

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Bioleaching of Copper from Electronic Waste Using *Aspergillus niger*

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Abstract

The recycling of printed circuit boards (PCBs) causes environmental problems by releasing dioxins and furans. The objective of this study is the recovery of copper from PCBs through the bioleaching process using *Aspergillus niger* which was isolated from the surface of Abu Tartur phosphate ore. In the bioleaching process, the optimum conditions were used to modify ammonium medium with inoculum spore size of $2X10^6$ SFU/50 ml for 5 days at 30 ºC in a pulp of 0.5% solid 150 mesh particle size and aeration at 200 rpm. Different carbon and nitrogen sources were used. Glucose (1.5%) and ammonium chloride (0.2%) were the best source of carbon and nitrogen, respectively. Also, the optimum initial medium pH was 7. Under these conditions, about 100% of Cu was extracted. The mechanism of bioleaching was studied by detecting the production of organic acid using brome cresol green as an indicator and HPLC analysis. The color change of agar medium of the incubated plate with *A. niger* from blue to yellow, and HPLC analysis showed detection of malic and citric acids in the sample in presence of e-waste higher than samples without e-waste. E-waste before and after the bioleaching process was investigated using SEM. The surface of e-waste becomes smoother and more porous due to the bioleaching process.

Extraction of Rare-Earth Elements from Egyptian Phosphogypsum with Efficient Water Recycle Using Membrane-Based Technique

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Abstract

Phosphogypsum (PG, $CaSO_4.2H_2O$) is a by-product produced in large amounts during phosphoric acid (H_3PO_4) production from phosphate rock [$Ca_5(PO_4)_3OH$] via reaction with sulphuric acid (H_2SO_4). The annual production of PG is 100-280 Mt/year all over the world, 85% of which is stockpiled for long-term storage without further treatment. Only a limited amount of PG is able to be reused in different applications due to the presence of rare earth elements (REEs) and heavy metals. Worldwide, 90% of phosphoric acid produced via dihydrate process, about 70% of the rare earth concentrates pass to PG and the remainder to phosphoric acid. The separation of REEs and heavy metals from PG to produce purified PG is a must to be able to reuse it in soil amendment, or other applications. The most suitable and economical process is the use of diluted H_2SO_4 solution as leachate because it is one of the raw materials used in phosphate rock digestion and would add minimal capital costs based on the low percent solution required for leaching. Herein, we worked on purifying PG produced from DH process from (El-Nasr for Intermediate Chemicals Co., Kom Oshim - Faiyum, Egypt) via leaching with diluted H_2SO_4 solution (7 – 15 %) to extract REEs and heavy metals. Then, the purified PG can be safe to use it for wide range of applications. Furthermore, reverse osmosis (RO) technique has been implemented to concentrate the pregnant solution with REEs to save energy of conventional evaporation and avoid environmental pollution from evaporated gases. This led to short the time of conventional evaporation notably; and generate pure water that can reuse it again.

Nanobubble enhanced flotation in minerals technology with a case study feasibility

Dr. Ahmed Sobhy *

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Abstract

Froth flotation is an extensively used, cost-effective particle separation process, but its high efficiency is limited to 10 µm and 100 µm for minerals and 50 µm and 500 µm for coal. Nanobubbles technology integrated into froth flotation expands this size limitation by increasing both the collision and attachment probabilities of fine particles and by reducing the detachment probabilities of coarse particles. Furthermore, nanobubbles enhance the flotation performance of ultrafine and relatively coarse particles. Besides, nanobubbles increase froth stability by increasing particle hydrophobicity. Also, nanobubbles increase the kinetic flotation rate by shortening the induction time of attachment, ensuing in a larger process capacity. In addition, nanobubbles reduce the reagent and air consumption and act as a secondary collector, resulting in considerably lower operating costs. Thus, nanobubbles enhanced flotation can be applied to a wide variety of minerals profitably, and detailed technical performance and economic evaluation are given on coal preparation as a case study.