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Nuclear Minerals Plants in Brazil—Case Studies

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Abstract: This paper presents the process flow sheet of the main nuclear industrial units in Brazil and discusses some solvent extraction technical support required for these plants. The Center for the Development of Nuclear Technology—CDTN has been investigating alternative ways to supply the nuclear industry in order to improve the industrial processes. Some case study examples are presented, Emulsion from Uranium Solvent Extraction Plant and Itataia Uranium Developments. In Caitité industrial plant the water recirculation has caused continuous changes in the composition of pregnant liquor mainly in the sulfate and chloride concentrations. After some water recirculation cycles, a decrease in the uranium extraction efficiency was noted which was followed by the formation of stable emulsion at the uranium extraction stage. Itataia Uranium Developments were performed in a pilot plant for Itataia ore. This ore has the uranium mineral associated to the phosphate. The process consists of four main steps: 1) phosphate concentration, 2) chemical digestion of the concentrate to produce phosphoric acid with dissolved uranium, 3) uranium recovery, and 4) phosphoric acid purification by solvent extraction.

Key words: uranium recovery process; solvent extraction; nuclear plants

Introduction

The nuclear industry of Brazil—INB (Indústrias Nucleares do Brasil), a mixed economy Brazilian company connected with the Comissão Nacional de Energia Nuclear (CNEN) under the authority of the Ministry of Science and Technology is actively participating in the development of nuclear projects to generate nuclear-electric power. The projects encompass uranium exploration, mining and primary processing as well as the production and assembly of fuel elements that power in the nuclear power plant reactors. The company also provides technologies for heavy minerals including prospecting and research, mining, industrialization and marketing of monazite sand[1].

Three INB units are in operation and the industrial project of Itataia mines implantation is in its final phase.

The Mineral Department of the Center for the Development of Nuclear Technology—"Centro de Desenvolvimento da Tecnologia Nuclear"—CDTN/CNEN has worked with nuclear industries on research projects aiming at finding solutions for operating problems that occur during uranium ore processing.

This paper presents the process flow sheet of the main industrial units and discusses solvent extraction technical support projects for the plants.

1 Nuclear Minerals Plants

1.1 INB Caldas

INB Caldas, the first mineral-industrial complex of this nature in the country, was set up in the Municipality of Caldas, State of Minas Gerais, in 1982. Basically, INB Caldas meets the reload demands for the Angra I reac-

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tor and technology development programs.

The complex mineralogical formation and unique characteristics of the ore found in Caldas led to the development of an original process by INB technicians developed to extract uranium and associated elements. The open sky mining enabled better use of the uranium ore. The company started with development of nuclear fuel cycle technology to generate electric power with chemical processing of uranium to transform it into yellow cake.

Once the economically feasible uranium is exhausted, the work will shift to the extraction and processing of minerals at Caitité. From start-up, control operations have sought to minimize, reintegrate, and stabilize the potential pollution in the area through the development of environmental protection and control programs.

The mine is under decommissioning and its facilities, equipment, and especially the knowledge of its technical staff, are being used to develop new projects. The plant is now using sophisticated Monazite chemical treatment technology. The ore is obtained from the physical treatment in Buena-Rio de Janeiro[1].

1.2 INB Caetité—Mining and processing

One of the major uranium producing sites in Brazil is located in the Southeast Bahia State.

The site has reserves estimated to be 100 000 t of pure uranium oxide without any other minerals of interest so INB's is very interested in exploring the site. This quantity is enough to supply the Nuclear Power Station "Almirante Álvaro Alberto" (Angra I, II, and III Plants) for 100 years. The research and prospecting activities may increase substantially.

INB currently has a production capacity of 350 t/a of uranium concentrate, with the goal in the next few years to reach 800 t/a.

The uranium ore process uses leaching in piles (static). After being crushed, the ore is placed in piles and irrigated with a sulfuric acid solution to remove the uranium. Figure 1 shows a schematic diagram of the process. This technique leads to lower costs, due to the reduced amount of equipment and operational units involved. The uranium concentration is made using the extraction by organic solvents followed by precipitation separation, drying, and packing in drums.

This uranium ore processing unit is a modular

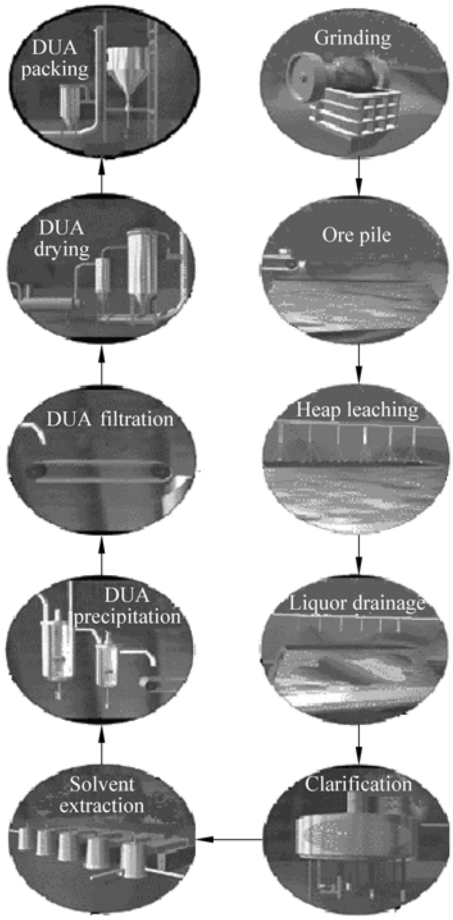

Fig. 1 INB Caetité—process flow sheet.

mineral-industrial enterprise designed with the purpose of developing the uranium use in approximately 33 occurrences forming the currently known reserve.

The environmental impact is reduced by the absence of fine solid waste so dams are not needed to contain the waste. The use of fewer chemicals further reduces the impact. However, the most important aspect is the possibility of recycling for the total return of liquid effluents to the process, ensuring no release of effluents to the environment[1].

1.3 INB Buena—Monazite sand treatment

The Buena Unit, located in the Rio de Janeiro state, is responsible for prospecting, research, mining, industrialization, and marketing of heavy minerals popularly known as "monazite sands". The physical processes for the ores treatment include mining and hydrogravimetric concentration followed by dry separation (physical separation through electrostatic, magnetic, and gravimetric processes). The ore is processed by hydrogravimetric concentration to obtain the heavy