URANIUM ORE PROCESSING STILL ADVANCING

November 2016

Uranium ore processing technology continues to advance, driven by the need to reduce capital and operating costs, the move towards lower grade and more difficult ores, the need to improve the processing of saline leach solutions and the increasingly stringent environmental regulations.

Ore Preconcentration

U-pgrade™ Process

A physical beneficiation process developed by Marenica Energy, Australia (patent pending), for upgrading low grade surficial uranium deposits typically containing carbonates, clay minerals, and often sulphates. It involves the sequential removal of gangue minerals by commonly used unit operations to achieve a comparatively high grade concentrate without the use of chemicals. The initial step typically comprises wet scrubbing and screening to separate into fine and coarse fractions. The undersize fraction contains most of the uranium as an intermediate concentrate which may be further processed in a secondary beneficiation stage to produce a high grade uranium concentrate. Possible methods for secondary beneficiation include desliming, gravity separation, flotation, reflux classification and magnetic separation. Testwork indicates concentration to <3% of the mass and upgrading by >30 times. Initially developed for the Marenica Project in Namibia, the technology has been tested for a number of other projects(1).

In September 2016, Marenica reportedly entered into a technology license agreement giving Perth based Deep Yellow Limited the option to use the U-pgrade™ Process for the Tumas Project in Namibia(2). This follows promising testwork with a bulk sample which indicated that Tumas ore can be upgraded from 368 ppm U_3O_8 to a high-grade concentrate with excess of 13,000 ppm U_3O_8. This could be leached in a very small, conventional on-site standard acid leach plant, or safely and economically transported to third parties for final processing. The agreement allows Deep Yellow to rapidly move into next phase of development including further metallurgical testwork, a resource expansion drilling program and a fast track feasibility study program.

Ablation Process

A mechanical process invented by Ablation Technologies, Casper, Wyoming, USA, initially for gold then patented for uranium in 2012. Mineral Ablation, a joint venture with Black Range Minerals, Australia, was formed in 2012 to market the technology. Black Range were taken over by Western Uranium, Toronto, Canada in 2015. The process uses kinetic energy and water to force ore grains against each other through opposing pressurized nozzles to remove uranium in coatings and interstitial deposits from barren sand grains typically found in sandstone ores. The resulting fine material commonly contains a high percentage of the uranium and can be separated by screening into a high grade, low volume, concentrate. The concentrate may be further upgraded by removal of light barren fines by gravity separation. The final concentrate is dewatered and the water treated as required for recycling and reuse. Extensive testwork shows that typically more than 90% of the uranium mineralisation can be recovered into about 10% of the initial mass. Pilot scale tests with a 5 t/h pilot unit in 2013 reportedly achieved 94.5 % uranium recovery into the finest fractions(3). Western Uranium successfully tested the 5 t/h pilot plant on stockpiled ore at their Sunday Mine Complex in Colorado, and have constructed a 20 t/h with a view to moving into commercial operation(4). Also, GoviEx Uranium, Vancouver, Canada, have included Ablation in the proposed flowsheet for their Madaouela Project in Niger(5).

Up-Current Classification

Vimy Resources Limited are developing the Mulga Rock Project in Western Australia(6) to treat ore in which the uranium occurs mainly as uraninite associated with uranium-bearing lignite, lignitic clay/shales and carbonaceous shales. Up to 65% of the ore is coarse silica rich sand. In the proposed flowsheet, the beneficiation section consists of a mineral sizer and logwasher for ore slurrying and attritioning, then slimes removal using hydrocyclones. This is followed by upgrading of the resulting middlings fraction by rejection of about 50-60% of the mass, consisting of barren quartz sands, using two stages of upward current classification (UCC) to produce an upgraded concentrate and a low grade reject typically containing 60 ppm U_3O_8. The overall ore upgrading ratio for the combined slimes and concentrate is reported to be 2 to 2.5 with about 4% loss of uranium to the final tails. A successful pilot scale test program was carried out in 2016 as part of a DFS targeted at commercial production of 1350 tpa U_3O_8 commencing in 2019.

Nanofiltration

BMS Engineers/Paladin Energy(7)

A nano-filtration plant to recover and recycle sulphuric acid from uranium IX eluate, believed to be the first commercial operation of its type in the world, was successfully installed and commissioned at Paladin Energy's Kayelekera Uranium Mine in northern Malawi in 2013. It utilizes technology developed by Paladin Energy and BMS Engineers, Perth, Australia for which Paladin Energy have been granted a patent. The design has successfully demonstrated that a uranium-containing acid stream can be separated into a clean, uranium-depleted, acid stream containing the majority of the acid and a low-volume concentrated uranium stream. Apart from the significant acid savings (circa 40 t/day 98% sulfuric acid), it also resulted in significant savings in downstream neutralizing chemical requirements. A second plant has been designed, installed and commissioned at Langer Heinrich. This plant, designed to recover sodium bicarbonate from the IX eluate stream, was successfully commissioned in March 2015, and is continues to perform above design expectation. Paladin believe that the technology represents a new paradigm for uranium processing plants. For example, the nano-filtration step could be moved upstream of IX as in the case of Langer, where potentially it would be a building block to achieve greater cost savings than downstream of IX where it is at the moment(8).

Other Potential Applications

Vimy Resources are proposing to utilize nano-filtration to recover and recycle sodium chloride from the eluate from the resin-in-pulp circuit for the Mulga Rock Project(6). It has also been tested for a number of other uranium projects including Letlhakane in Botswana for A-CAP Resources, Michelin in Canada for Aurora Energy, and Mkuju River in Tanzania for Uranium One.

Application of IX to Strong Acid SX Strip or Eluate Solutions

Was developed and successfully tested for treating strong acid SX strip solution for A-CAP Resources' Letlhakane Project in Botswana(9). It is aimed at avoiding the need for partial neutralization of strong sulphuric acid SX strip or IX eluate solutions ahead of uranium oxide precipitation by using IX with a chelating resin to extract uranium and allow the acid to be recycled and reused. The loaded chelating resin is stripped with sodium carbonate/sodium bicarbonate solution. Sodium hydroxide is added to precipitate sodium diuranate which is separated and redissolved in sulphuric acid, followed by uranium oxide precipitation and drying. Based on the Letlhakane testwork, benefits include a saving of approximately 60% of the overall recovery cost from leach PLS to UOC product, and a high overall uranium recovery of > 99% from leach PLS to product by elimination of uranium loss in partial precipitation. A-CAP hold a patent for the process.

Development of SX and IX Systems for High Chloride Solutions

Honeymoon ISL Operation

The Honeymoon ISL Operation commenced in 2011 in South Australia and was suspended in 2014 due to declining uranium price. It included a novel SX system using a D2EHPA / tertiary amine synergistic mixture[(10)]. This system was found to give improved performance over the standard tertiary amine system in high chloride conditions, but requires the ferric iron content to be low. Stripping is with sodium carbonate. New owners Boss Resources have studied various SX and IX options for restarting and expanding the Honeymoon operation including an eluex (IX/SX) option with chelating resin being used in IX. A hybrid eluex configuration has been selected as the preferred option to be carried forward to the next phase of work in which pregnant leach solution is split between IX and the existing SX with the IX eluate also feeding the SX[(11)].

Other Developments

SX systems for uranium extraction from high chloride solutions are also being developed by other organizations including CSIRO in Perth, ANSTO in NSW, and BHP Billiton at Olympic Dam, South Australia[(12)].

Areva Fluid Bed Precipitation Process

Areva have developed and commercialized a patented continuous fluidized bed precipitation process for uranium oxide products, available in Australia from Adelaide Control Engineering (ACE), South Australia[(13)]. Claimed advantages over conventional tank precipitation practice includes lower cost of production and maintenance, increased recovery of uranium, increased uranium content of calcined product, larger particle size, reduced fines, less dust and lower risks to operators, increased calcined product bulk density, reduced transport costs, lower impurities and penalty costs and larger particle size. Improved dewatering is said to reduce calcining costs or allow increased throughput, and a horizontal kiln can be used for drying or calcining, which was not previously feasible. The system is applicable to both peroxide and ammonia precipitation.

For more information see ALTA Short Course *Uranium Ore Processing* at ALTA Publications.

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MetBytes are metallurgical commentary and insights written by Alan Taylor who has 40+ years' experience in the metallurgical, mineral and chemical processing industries. He has worked in metallurgical consulting, project development, engineering/construction, plant operations, plant start-up and technology development. Projects and studies have involved copper, gold/silver, nickel/cobalt, uranium, base metals, phosphates and alumina.