NEW LOGIC INTERNATIONAL, INC.

Case Study

Lanthanide Mining and Milling Effluent Treatment

A cost-effective and environmentally-sound solution

Overview

New Logic International installed its Vibratory Shear Enhanced Processing (VSEP) system in March, 1998 at a major California rare earth mining and manufacturing facility. The VSEP is used for treatment of mine tailing pond effluent at this facility with no pretreatment required. The VSEP system uses nanofiltration followed by ultrafiltration membrane modules and is able to treat the mine tailing pond effluent, reducing suspended and dissolved solids below the required limits for process recycling or discharge. The economics of installing this system are extremely attractive with a 35% reduced capital cost combined with a 53% reduced operating and maintenance costs when compared with conventional treatment technology. The application of VSEP membrane technology to mining and rare earth metals manufacturing facilities (such as lanthanide mining) is found to be an attractive economic alternative to conventional wastewater treatment technology.

Background

The mining and commercial production of rare earth elements began at Mountain Pass, California, in the mid-1960's. Rare earth elements are refined from bastnasite ores that are mined, crushed, concentrated, and further separated into individual lanthanide compounds. The separation processes developed at Mountain Pass are highly proprietary, however, the upgrading of the bastnasite ore is fairly common within the mining industry.

The mine tailing waste water at this facility needs to meet the requirements for recycle or discharge and thus requires prior treatment. For treatment of the mine tailing wastewater, the client considered two treatment schemes, as follows:

- Use traditional technologies, namely a vapor compression evaporation system.
- Use a VSEP Treatment System.

The use of vapor compression evaporation system was evaluated to be much more expensive than the use of VSEP system for treatment of mine tailing wastewater. The use of a VSEP system results in substantial savings in operating costs primarily due to elimination of the energy requirements for evaporation.

The use of a conventional two-step ultrafiltration and reverse osmosis filtration system was also considered. However, the conventional membrane systems require pretreatment using chemical treatment to reduce turbidity followed by a sand filtration unit and a thickener. A preliminary economic assessment showed much higher operation and maintenance costs than the VSEP treatment system.

Upon installation of the VSEP, the concentrated ligon sulfonate stream is recycled to the process. Clean water permeate generated from the first stage VSEP is also recycled to the process, while the permeate generated from the second stage is sent to the evaporation ponds. This rare earth mining and manufacturing facility has installed the VSEP system to allow the treatment of tailing pond wastewater more efficiently and allow the treated permeate streams to be recycled to the process or discharged.

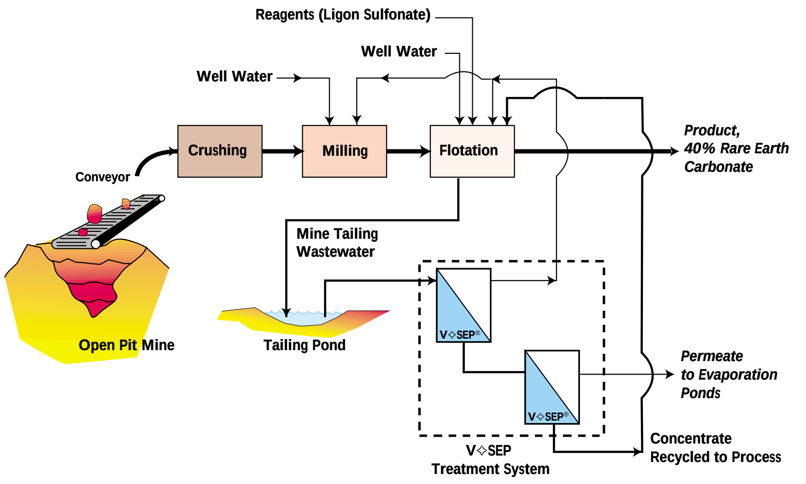
The rare earth mining and manufacturing facility where the VSEP is installed operates 24 hours a day, 350 days per year. The maximum mine tailing flow rate to be treated in the process is approximately 100 gallons per minute (gpm).

Using nanofiltration and ultrafiltration membrane modules in the VSEP has been shown to be a commercially viable option for treatment of mine tailing wastewater. More than 65% of the feed waste water is recovered as clean water suitable for recycle or discharge, while 32% is discharged to evaporation ponds and 3% is recycled as a ligon sulfonate reagent. The permeate electrical conductivity is reduced well below the design requirements. This project summary describes this application of VSEP process, discusses the expected process performance, and presents the economic advantages of VSEP compared to traditional technologies.

System Description

An overall simplified flow chart for the lanthanide mining and manufacturing process, including the VSEP treatment system, is presented in Figure 1. The ore is removed from

Figure 1
Integration of V✧SEP with Rare Earth Mining and Milling Facility



the pit at an average grade of approximately 8 percent rare earth oxide. The ore is crushed and ball-milled prior to flotation. During flotation, ligon sulfonate, a flotation agent, is added to separate the bastnasite (rare earth-bearing carbonate) from the carbonate host material. The flotation process upgrades the raw ore to approximately 40% rare earth oxide. The waste from the flotation process, the gangue material slurry and process fluids from the separation plant are deposited in a "dry" tailings pond. Over the years, the "dry" tailings pond has become "wet" and it now requires dewatering.

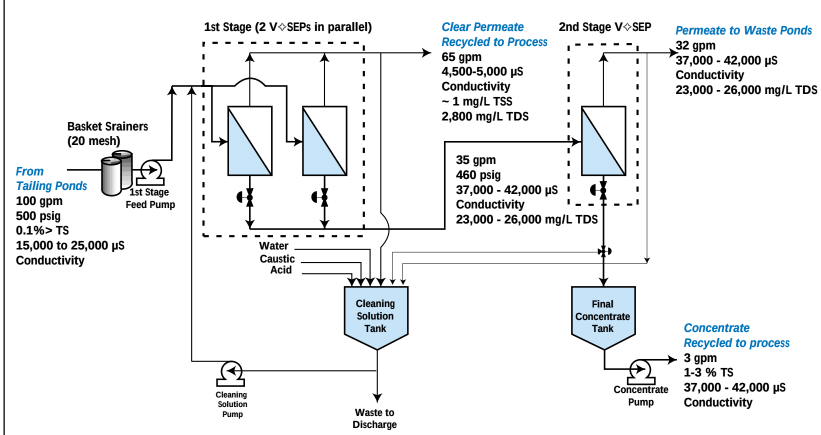
The tailings water contains abundant ligon sulfonate (brown colloidal material), clay- and silt-sized particles with a turbidity of > 21 NTU, and is highly saline (15,000 to 25,000 µS). Conventional dewatering to produce recycle water (4,500 µS) for the mill would typically require clarification, ultrafiltration, nanofiltration, and reverse osmosis or a vapor compression evaporation system including a heat recovery exchanger.

In early 1998, a single-stage, 100 gpm VSEP filtration system using "tight" nanofiltration membranes was installed to dewater the tailings pond and produce recycle quality water for use in the milling operation. A second-stage VSEP was added to recover the ligon sulfonate reagent from the concentrated wastewater. The only pretreatment provided were 20 mesh basket strainers used to keep pipe-scale from damaging the high-pressure pumps.

The introduction of VSEP results in the production of clean water which is suitable for recycle as process water for milling and flotation operations. The concentrated ligon sulfonate stream is also recycled to the process.

A process schematic for this application of the VSEP is presented in Figure 2. This diagram includes the overall material balance for the lanthanide mining and milling effluent treatment system and illustrates the performance of the VSEP unit. Mine tailings from the tailings pond is fed to the VSEP treatment system at a rate of 100 gpm. Two industrial scale VSEP units, using nanofiltration membrane modules with 85% salt rejection membranes, process the mine tailing wastewa-

Figure 2
Process Schematic for Effluent Treatment at the Rare Earth Mining and Milling Facility



ter. A second stage VSEP unit, using an ultrafiltration membrane module with an 8,000 Molecular Weight Cut-Off (MWCO) membrane, processes the concentrate from the first stage to recover flotation reagent and eliminate color agents from the waste stream. The produced concentrated stream at a flow rate of 3 gpm is recycled to the flotation process.

Stage #1 VSEPs also generate a permeate stream of about 65 gpm which is recycled to the process. The permeate stream from the second stage is about 32 gpm and is sent to the evaporation ponds. Electrical conductivity of the feed to the VSEP units ranges from 15,000 to 25,000 µS and the feed concentration is less than ~ 0.1% total solids (TS). In the first stage, the permeate concentration is reduced to ~ 1 mg/L of total suspended solids (TSS), ~ 4,500 µS of conductivity, and about 2,800 mg/L of total dissolved solids (TDS), all well below the design requirements for process recycling. The permeate is reused as process water for the flotation and milling processes. All permeate from second stage VSEP is discharged to the evaporation ponds.

The concentrate discharge of the second stage VSEP unit is controlled by an automatic timed control valve. This valve is set such that the concentration of the dissolved solids fraction from the VSEP is held at the desired level. A multi-stage feed pump supplies the mine tailings to the VSEP unit at a flow rate of about 100 gpm at a pressure of about 500 psig. Constant frequency drive positive displacement pumps are used in conjunction with flow restricting valves to set feed pressure.

The VSEP field tests for treatment of mine tailing effluent were successfully conducted in early 1998. At a temperature of 25°C, permeate flux ranged from 30 to 50 gallons per square foot per day (GFD) at a feed conductivity concentration of about 15,000 µS. The effluent permeate concentration levels averaged 4,500 µS and about 1 mg/L TSS. These test results are based on data from a pilot unit at a feed pressure of 500 psig. The actual commercial installation has been able to achieve similar performance and meet or exceed the project objectives.

Project Economics

Fresh water and wastewater disposal costs are high at Mountain Pass due to its remote desert location. Well water from two separate locations is pumped from a combined distance of twenty-seven miles and to an elevation of three thousand feet. Estimated water costs are approximately $3.75 per thousand gallons. Past liquid wastewater disposal practice included large evaporation ponds located 13 miles to the east of the mining facility. Recent environmental concerns and legislation is forcing the Mountain Pass operation into a zero discharge situation. VSEP filtration equipment originally implaced to dewater the "dry" tailings pond and secure the integrity of the tailings dam are increasingly needed to limit sources of "new" water at the operation.

The cost of installing and operating the VSEP system when compared with the alternative conventional treatment technology have been calculated.

For the VSEP treatment system, the operating costs are calculated based on the power costs to operate the filter unit (30 HP), power to the filter feed pump (90 HP), filter cleaning costs, membrane replacement costs, and the operating labor that would be required. The alternative conventional treatment technology costs include power costs for feed pump (10 HP) and the conventional vapor compression evaporator.

VSEP Technology and Its Applications

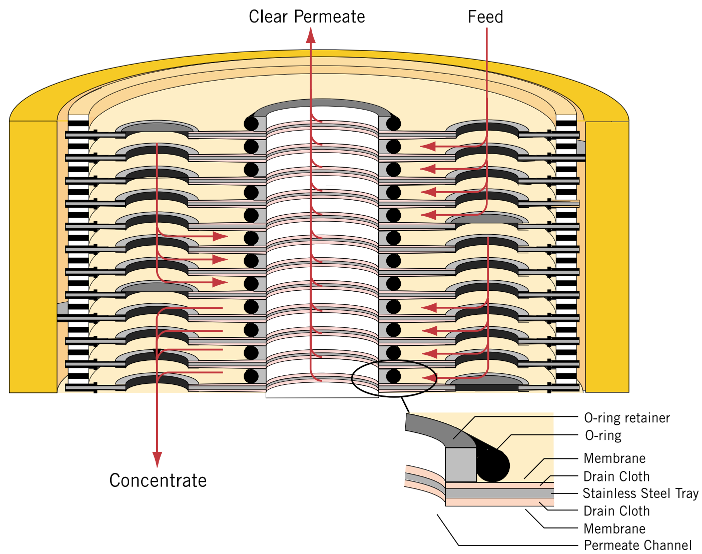
VSEP (Vibratory Shear Enhanced Processing) technology is being in-

Table 1
Estimated Construction, Operation, and Maintenance Costs and Savings - VSEP Treatment System vs. Alternative Conventional Treatment Technology

Item		Alternative Conventional Treatment Technology Costs (b)	Savings
Equipment/ Installation Cost, $			
o VSEP System, freight, filter cleaning system, feed pump, holding tank, piping and control (a)			
o Alternative Conventional Treatment Technology, feed tank, pumps, piping and controls (b)			
Equipment/ Installation Cost Saving, $			
Operation and Maintenance Cost, $/Year			
Power Cost			
90 KW @ $0.04/KWh	-		
20 KW @ $0.04/KWh	-		
System Maintenance and Cleaning			
Thermal Energy Required, 97 gpm water evaporated, Vapor compression Evaporator, Diesel fuel use 75 Btu/lb of water @ $0.80/gal of diesel (Heating Value = 136,068 Btu/gal)			
Labor Cost (c)			
1-full time operators	-		
1/2-time operator	-		
Total O&M Cost /Savings, $/Year			

(a) The VSEP system consists of three industrial scale VSEP units operated in two stages and is able to process100 gpm of mine tailing waste water and produce near 97 gpm of clean water suitable for discharge.
The VSEP system is operational 24 hours per day, 350 days per year.
(b) The alternative conventional technology consists of a vapor compression evaporator, pumps, and storage tanks.
(c) Labor costs include raw salary as well as company paid benefits.

Figure 3
Filter Pack Cross Section



corporated into the treatment schemes for recycled effluent and/ or water/wastewater treatment, and product concentration/dewatering in various process industries. Developed by New Logic International, Inc. of Emeryville, California, a VSEP system can filter streams containing a variety of materials or contaminants without the fouling problems exhibited by conventional membrane systems. The process not only filters suspended solids, but it also reduces or eliminates BOD, COD, conductivity and color bodies. The result is a crystal clear, reusable water stream and a concentrated product stream or sludge.

Rather than simply preventing fouling with high-velocity feed, VSEP reduces fouling by adding shear to the membrane surface through vibration. This vibration produces shear waves that propagate sinusoidally from the membrane's surface. As a result, the stagnant boundary layer is eliminated which increases the filtration rates.

As shown in Figure 3, the industrial VSEP machines contain many sheets of membrane which are arrayed as parallel disks separated by gaskets. The disk stack is contained within a Fiberglass Reinforced Plastic (FRP) cylinder. This entire assembly is vibrated in torsional oscillation similar to the agitation of a washing machine. The resulting shear is 150,000 inverse seconds, which is ten times greater than the shear in traditional crossflow systems. High shear has been shown to significantly reduce the fouling of many materials. The resistance to fouling can be enhanced from a selection of over 200 membranes where materials such as polypropylene and Teflon can be used.

Figure 4 presents a photograph of an industrial scale Series i system. Each Series i system contains up to 1450 square feet of membrane filtration area. A single VSEP unit is capable of processing up to 150 U.S. gallons per minute while producing a crystal clear filtrate and a concentrated sludge in a single pass. This large throughput capability is accomplished by a system which occupies only 20 square feet of floor space and consumes between 5 and 20 hp.

The VSEP system can offer a very economical solution to control water and waste water streams within the chemical manufacturing processes. Traditional membrane separation capabilities coupled with the unique characteristics of VSEP, make it possible to successfully concentrate product streams and handle a variety of contaminants at high flux rates. This provides opportunities for VSEP use in the treatment and/ or recycling of raw water, boiler feed water, mining and chemical plant effluent, filtrate treatment and condensates.

Figure 4
Photograph of an Industrial Scale Series i Unit

Operational savings generally can be attributed to the following areas:

- chemical treatment (reduction or elimination)
- retained BTU value
- reduction of fresh water usage and effluent flows
- improvement in filtrate quality
- pumping energy reduction
- reject concentration improvements
- eliminate fouling of heat exchangers & evaporators
- reduce BOD, COD, TSS, TDS and color
- lower labor and maintenance costs due to one step process

The industries and applications for VSEP are quite diversified and include: **Mining** (mine tailings), **Industrial Laundries** (wastewater treatment & water recycling), **Pulp & Paper** (black liquor, whitewater, box plant effluent, end-of-pipe), **Industrial Water Pretreatment** (ultrapure, boiler feed, surface water R.O.), **Pigments & Paint** (latex emulsions, product recovery), **Solids Dewatering** (calcium carbonate, kaolin clay, TiO_2) and **Metal Working** (oily wastewater, metal hydroxides).

References

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