U.S Department of Energy
Mining Industry of the Future

Round III Projects

Alternative Anode Reaction for Copper Electrowinning

- **Principal Investigator:** Jerry May- INEEL
- **NETL Project Manager:** Mike Mosser
- **Partners:** Bateman Engineering, Bechtel, Phelps Dodge Morenci, Phelps Dodge Miami
- **Total Project Cost:** **$960K**
  - DOE Share: $367K
  - Participant Share: $405K + additional $188K
- **Project Period:** **24 months**
- **Project Start Date:** **March 2002**

Alternative Anode Reaction for Copper Electrowinning

Project Objectives

- Devise an electrolyte inject manifold that will replenish ferrous ions at the anode surface without damaging the cathode deposit and minimize the pump energy.
- Design anodes to enhance ferrous ions diffusion and maximize cell voltage reduction
- Study and recommend alternative reductants to replace SO2
- Devise a process that will produce SO2 from sulfur, react the SO2 with ferric ions in copper electrolyte and only emit environmentally acceptable amount of So2 to the air.
- Devise a process that will economically extract H2SO4 from copper electrolyte and produce H2SO4 stream that approaches a concentration of 300 g/l
- Provide an economic evaluation of this process versus conventional copper electrowining
- Demonstrate the fully integrated process at large pilot plant scale.

Milestones and Status

Major Milestones Planned to Date/Status

Planned Milestone	*Scheduled*	*Completed*
– Manifold design/tests	02/28/2003	01/16/2003
– Anode selection/tests	06/30/2003	01/16/2003
– Alternative reductants	12/15/2003	03/14/2004
– SO2 regeneration system	12/31/2003	03/31/2004
– The acid recovery system	04/30/2003	05/30/2003
– Economic evaluation	01/31/2004	
– Pilot plant testing	12/31/2003	06/30/2003
– Final report	02/29/2004	

Key Accomplishments

December 2003 – INEEL

Administration

- Final laboratory data is in and economic evaluation is under way.
- Project POP was moved to May 31 to allow time to evaluate data before economic modeling is completed.

Key Accomplishments

September 2003 – Bateman
Acid recovery system

- Developed template for Design criteria – 100%
- Prepare operating cost estimate – 100%
- Final report – 100%

September 2003 – Versitech
Activated Carbon Regeneration

- Preliminary design and economical evaluation of ferrous regeneration system – 99%

Key Accomplishments

March 2004 – Bechtel
Economic evaluations

–Technical-economic model established

–Several test runs have been made. Evaluating test data

March 2004 – INEEL
Ferrous regeneration system

–Hydrogen gas is most effective in ferric reduction reaction

–Availability of hydrogen production on site needs more investigation.

Key Accomplishments

September 2003 - Phelps Dodge
Pilot plant testing

- Pilot plant continuous testing completed – 100%
- Estimated energy savings of 50% have been realized in pilot plant work.
- Elimination of Acid Mist achieved in test work

March 2004 – Phelps Dodge

Phelps Dodge plans on construction of new Alternate Anode Process in 2005

Smart Screening System in Taconite Processing

- **Principal Investigator:** Dr. Daryoush Allaei-QRDC
- **NETL Project Manager:** Mike Mosser
- **Partners:** Albany Research Center, ISPAT Inland Mining, U.S. Steel-Minntac, S3i
- **Total Project Cost:** $2,300K
  - DOE Share: $1,150K
  - Participant Share: $1,037.5K
  - Albany Research Center $ 112.5K
- **Project Period:** 36 months
- **Project Start Date:** September 9, 2002

Smart Screening System in Taconite Processing

Figure 1 Full Smart Screen System with PZT-based motor

Figure 1 PZT system setup on field-ready supporting structure

Smart Screening System in Taconite Processing

Figure 1A Close-up of the full S3 with PZT-based motor

Figure 1A PZT system setup with control box to individually control each motor

Smart Screening System in Taconite Processing

Figure 1B Close-up of the full S3 with PZT-based motor

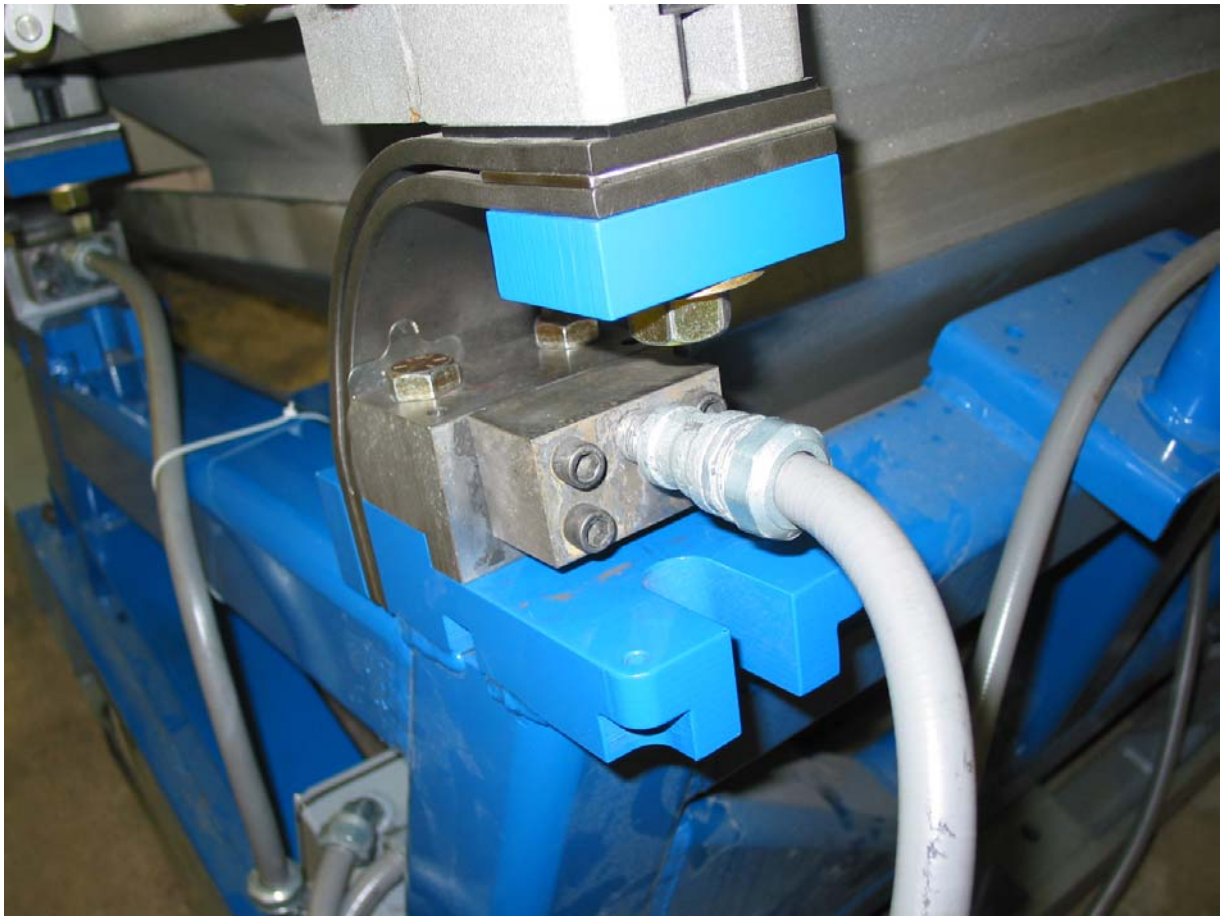
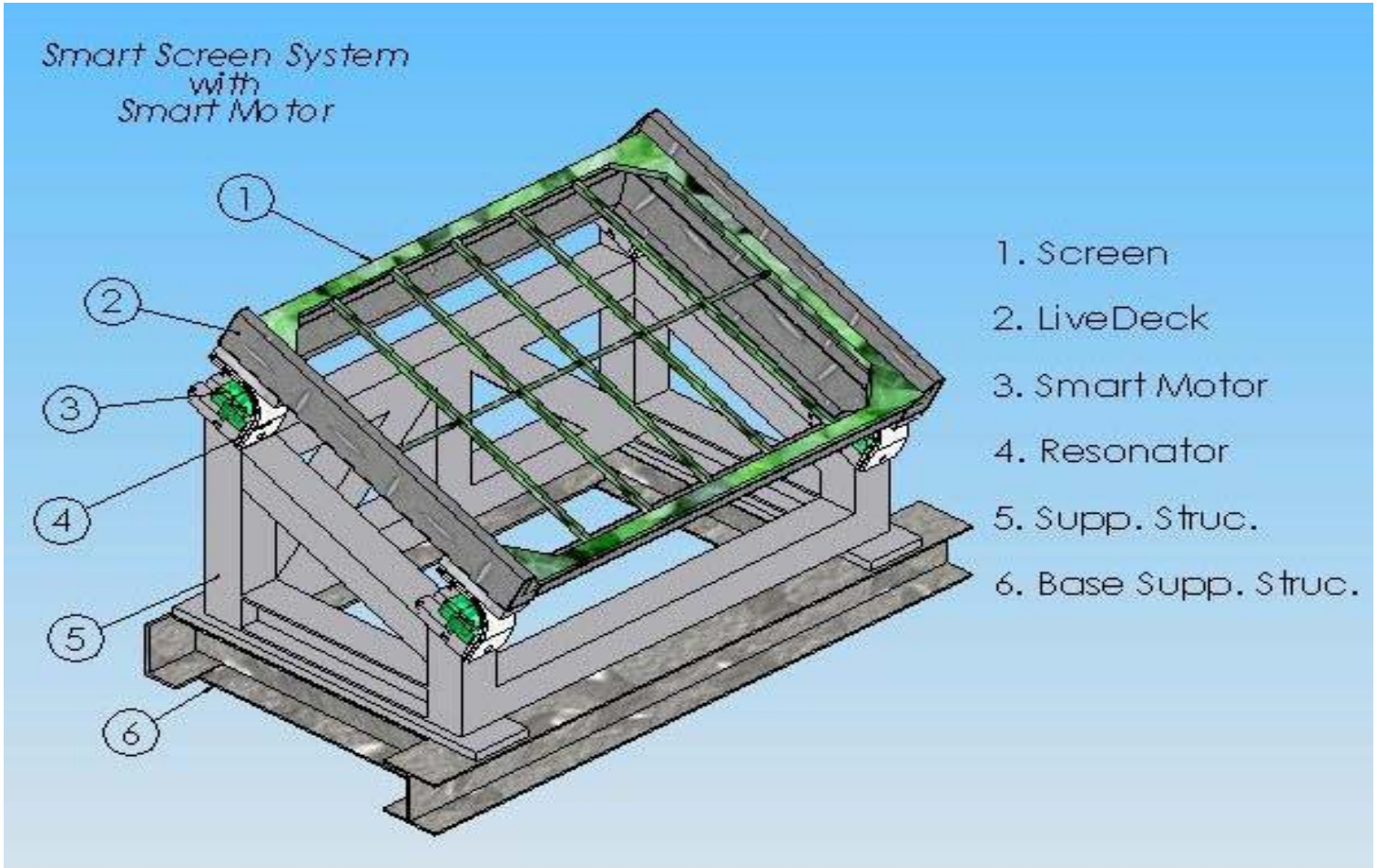


Figure 1B Close view of Smart Motor with conduit wiring

Smart Screening System in Taconite Processing

Figure 2 Part description of Smart Screen System with PZT-based motor



Smart Screening System in Taconite Processing

Figure 3 Full Scale Prototype of the PZT-based Smart Screen System

Figure 3 PZT system setup for wet test at QRDC lab

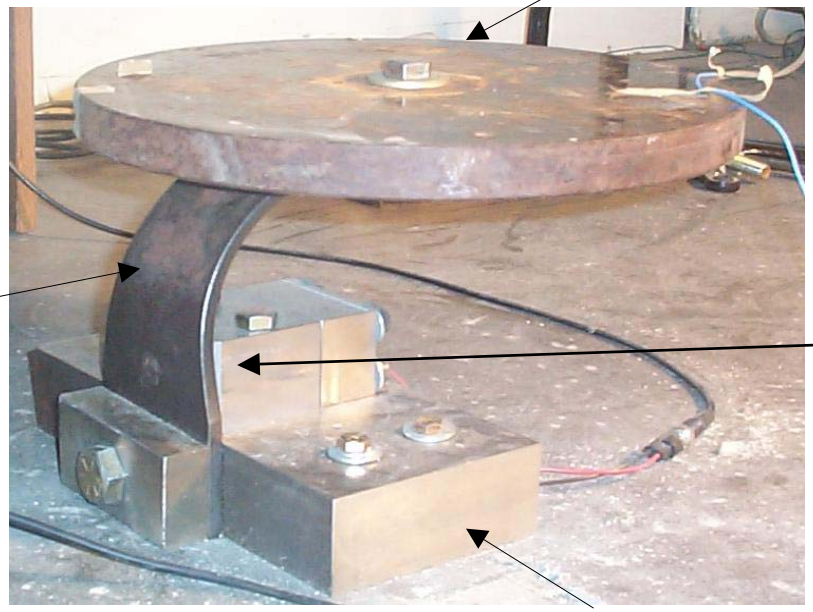
Smart Screening System in Taconite Processing

Table 1 Performance of the PZT-based S3 under dry and wet conditions

Location	DRY TEST			WET TEST		
	Flow Direction	Vertical Direction	Resultant	Flow Direction	Vertical Direction	Resultant
Stroke [mils] measured on screen center at feed end						
QRDC lab	29	30	41	24	26	35
S3i lab	57	68	89	-	-	-
CMRL	17	12	21	10 - 11	13 – 16	16-19
Stroke [mils] measured on screen center at output end						
QRDC lab	26	12	29	-	-	-
S3i lab	52	36	63	-	-	-
CMRL	16	5	17	-	-	-

Smart Screening System in Taconite Processing

Figure 4 Experiment setup used to evaluate the longevity of PZT Motors



To date we have 5,000 hours (more than half of a year) of continuous run at QRDC laboratory.

Project Objectives

- To reduce the current energy requirements in fine screening operations by at least 75%
- To reduce the maintenance the maintenance cost in the screening operations by at least $500,000 per year
- To improve throughput of material by 5% to 10%
- To reduce noise and vibration levels in the screening area to that of the background

Milestones and Status

Major Milestones Planned to Date/Status

Planned Milestone	*Scheduled*	*Completed*
– End-task evaluation of initial design	Q3/03	100%
– End-task evaluation of prototype study	Q3/03	100%
• **Go/No-Go Decision Point**	Q3/03	Go
– Mid-task evaluation of initial S3 units	Q4/04	95%
– Summary of evaluation of initial field investigations	Q4/04	90%
• **Go/No-Go Decision Point**	Q4/04	
– Summary evaluation of final field investigations	Q2/05	45%
– Summary of business development and feasibility	Q2/05	90%

Key Accomplishments -1

- Successfully tested PZT system under dry and wet condition in QRDC laboratory.
- Longevity tests of PZT-based Smart Motors have shown promising results.
- One full PZT system was developed and ready for field installation and evaluations.

Key Accomplishments -2

- Commercialization has been successful
- Eleven Magnet-based Smart Screen Units was installed in 3 taconite plants in 2003.
- Five additional units to be installed in 4/04.
- One PZT system is on standby for field installation & evaluations

- 8, 2, 1 units installed in Minntac, Keetac, & Ispat Inland Plants in Minnesota, respectively.
- 4 additional units in Keetac Plant in 4/04.
- 2 additional units in Ispat Inland Plant in 4/04.
- 1 PZT unit will be installed in Minntac or Ispat.

Project Recognition – 1
Published in "Rang View" in early 2004

Good vibrations

Chisholm company introduces "controlled energy flow" screening technology

"Achieving the noise and maintenance objectives was nice, but meeting capacity needs was key. But demonstrating its potential for meeting capacity needs has really given us some momentum."

Good vibrations

Chisholm company introduces "controlled energy flow" screening technology

In the mining industry, vibrations in equipment typically mean a noisy work environment and costly maintenance. But some Iron Range mines are tuning in to a new technology that makes vibration a good thing.

The screening machine developed by Smart Screen Systems Inc. (S3i), a Chisholm-based company, uses carefully targeted energy in the form of vibration frequencies to process iron ore slurry and, where necessary, reduce silica, an impurity, from the final product. And it does so with no excessive and harmful noise, using significantly less energy than conventional screens.

"Smart Screen™ technology is a completely different approach to materials separation," said Rob Scarlett, S3i's director of new business, sales and marketing. "Our goal is to focus vibration energy on the places where it can be used to deliver a positive result."

Smart Screens™, as the S3i units are called, are the first commercial application of two patented technologies, "energy flow control," or EFC™, and "vibration control by confinement," or VCC™. Dr. Daryoush Allaei, a nationally recognized expert in vibration technology, developed these technologies to improve the performance of U.S. military equipment such as helicopters and other aircraft, spacecraft, marine vehicles, and ground vehicles and systems. One recent application is noise reduction in mobile command vehicles.

"Achieving the noise and maintenance objectives was nice, but meeting capacity needs was key. But demonstrating its potential for meeting capacity needs has really given us some momentum." **Rob Scarlett, S3i's director of new business, sales and marketing**

The first link between military research and mining process improvements was made in 1997, when staff from an area mine attended a conference at which Dr. Allaei was a guest speaker. During the next several years, Allaei and others worked to craft a new type of screen that would adapt vibration technology for mining applications. S2i was formed in February 2001 to accomplish this mission.

The resulting SmartScreen™ unit stands about four feet high, five feet wide and about eight feet long. The screening surface, known as the live deck, sits at a 28-degree angle. Two small electromagnetic motors vibrate resonators attached to the live deck to agitate the screen and separate particles as they flow down the face of the screen. The motors create a specific vibration frequency that separates materials most effectively. A feedback loop between the live deck and the motor allows the unit to restore the target frequency as the amount of material on the screen varies.

The first S3i production model was installed in an area taconite plant in March 2003. With the Smart Screen installed, noise levels near the screening unit dropped to a level equivalent to plant background noise. Before installing the S3i equipment, the noise level had been reported to be substantially higher than the background noise in the plant.

In addition, electricity consumption dropped about 75 percent, because the Smart Screen™ system uses 120-volt electromagnetic "smart" motors to move the 145-pound live deck of the screen. The old system used a 440-volt, three-phase motor to move the entire screening unit — almost 2,000 pounds of steel.

In addition, Smart Screens™ have no bearings to lubricate, which means more production time and less time and money in maintenance.

"Achieving the noise and maintenance objectives was nice, but meeting capacity needs was key," Scarlett said. "And the fact that our pilot project demonstrated its potential for meeting capacity needs has really given us some momentum."

The results caught the attention of seasoned mining professionals.

"I believed the technology is very promising; because, theoretically, force input goes to zero as a machine reaches resonance," said Dick Lohry, a 32-year veteran of U.S. Steel's Minntac mine, concentrator and pellet plant who now serves as S3i's chief operating officer.

Word about the new technology is getting around the industry. As of December 2003, S3i systems are now in operation at three Iron Range mines. The S3i team has been closely monitoring performance at all locations and is making adjustments as needed.

Above: The Smart Screen™ unit, which stands about four feet high and five feet wide, is a new application of vibration technology in the mining industry. The unit helps separate impurities out of taconite slurry. It uses less energy and produces less noise than conventional separation equipment.

Officials gain insights, build relationships on Indiana visits

Commissioner Sandy Layman recently led a delegation, including state Senators Tom Bakk, David Tomassoni, and Tom Saxhaug, to meet with top officials at three Indiana companies considered strategic to future development in northeastern Minnesota. High-level meetings at two steel making facilities and an energy plant in Indiana provided the delegation with invaluable insights into mining and energy projects that are either in process or under consideration for the Iron Range.

First, the Minnesota delegation met with officials at Steel Dynamics, Inc. (SDI), in Butler, Ind. Although interested in SDI's steel making capabilities, the group's primary focus was Iron Dynamics Inc. (IDI), an SDI subsidiary. IDI produces direct reduced iron (DRI) briquettes on a 50-meter rotary hearth furnace, the largest in the world.

They also visited PSI Energy, Inc./Dynegy Wabash River coal gasification facility in West Terre Haute, Ind.

Finally, the delegation visited International Steel Group's (ISG) Burns Harbor Division in Burns Harbor, Ind. ISG is the newest integrated steel making facility in the United States. This company annually consumes up to six million tons of the pellets produced by Hibbing Taconite Company, making it Hibtac's largest customer.

"SDI is a major partner in the Mesabi Nugget project in Silver Bay," Layman said. "They buy most of the nuggets produced by the Mesabi Nugget pilot demonstration plant at Northshore Mining Company. If the nuggets perform well in SDI's process, it will provide an excellent testimonial for their commercial viability."

Bakk agreed, "If Mesabi Nugget successfully proves its process, it will open a new market for Minnesota taconite concentrates, including companies that employ electric furnaces like SDI's, and foundries. Currently Minnesota pellets can only be used by blast furnaces employed by integrated steel makers."

SDI's rotary hearth furnace in Butler, Ind.

Tomassoni said he was impressed by the visit to PSI Energy. This power plant utilizes an integrated gasification process, similar to the technology that will be used in the Excelsior Energy plant proposed for the LTV site in Hoyt Lakes.

"It was extremely interesting to observe firsthand how this revolutionary clean coal technology produces electricity in a manner that both decreases air emissions and increases plant efficiency," Tomassoni said.

Saxhaug said that he gained a better understanding of these subjects that will enable him to converse more knowledgeably about important mining and energy projects with both his legislative colleagues and his constituents.

"We also established good working relationships with key executives that will be advantageous to future economic development efforts," said Saxhaug.

Project Recognition - 2

- Eriez, one of the leaders in vibrating machines for food and chemical plants is negotiating a license to manufacture and sale Smart Screen Systems.
- Taconite Processing Plants in Michigan have expressed a strong interest to purchase smart Screen Systems in 2004.
- Hylsa, a large Mexican steel and mining company, is negotiating marketing and sales agreement in Mexico.
- Sales agents are set up in Brazil.
- Has received much attention from related industry in the general field of vibrating machinery.

Good News

- 11 magnet-based systems have been sold to mining plants in Minnesota.
- The PZT-based system is ready for field tests in 2004.
- 5 more magnet-based and one PZT-based S3 machines will be installed in taconite plants in 2004.
- Based on the results obtained to date, the magnet-based systems have surpassed our expected performance.
- Estimated annual savings are estimated to exceed $7,000,000 when the entire Minntac plant is changed to Smart Screen System.

Good News (continued)

- Based on the full line of Magnet-based Smart Screens (8 units) in Minntac, the noise/vibration levels are below the background levels. No more MSHA citations.
- Our screen efficiency and weight recovery are expected to be higher than conventional systems.
- Smart Screen is expected to do a much
- Better job in silica improvement.
- Operators love the S3 machines due to their simplicity and low maintenance.
- Our energy savings are expected to be met.