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Modernization of Electrolysis System at MagCorp Reduces Costs and Waste

Summary

Magnesium Corporation of America (MagCorp) has undertaken a modernization program at its Utah magnesium production facility. The modernization program is designed to improve the performance efficiency of the plant's electrolysis system and eliminate chlorine losses. The modernization program has resulted in operating benefits, including significant reduction in labor, energy, and maintenance costs, as well as reducing process waste emissions.

Plant/Company Overview

MagCorp (formerly Amax) is the oldest primary magnesium producer in the United States; the company has provided high-quality magnesium metal ingots to the world market since 1972. Headquartered on Utah's Great Salt Lake, MagCorp manufactures magnesium metal and its alloys for a variety of end-use applications.

Using primary solar energy, the natural brine of the Great Salt Lake is concentrated, purified, and dried into magnesium chloride ($MgCl_2$) powder. The powder is melted and introduced into electrolytic reduction cells to produce pure magnesium metal.

Producing magnesium metal historically has been successful because of its low cost and the flexibility of the casting system. The primary disadvantage of the process has been the use of older electrolysis technology, which leads to elevated labor and energy expenses. Older electrolyzers also cause increased loss of chlorine to the environment.

Project Overview

To improve the $MgCl_2$ cell-feed purity and electrolyzer performance, MagCorp initiated two separate upgrade projects during the 1990s. A feed purity improvement project was directed toward cost-effective reduction in levels of oxygen, iron, and carbon in the $MgCl_2$ cell feed. The electrolysis improvement project was aimed at reducing energy consumption, eliminating excessive chlorine losses, and reducing the operating labor required.

Project Implementation

Cell-feed purification project. Electrolytic production of magnesium can be simplified into two primary steps: preparing $MgCl_2$ powder, and the subsequent electrolysis of the salt. Electrolyzers must be designed to handle the specific chemical compositions resulting from the feed preparation step. MagCorp historically averaged

Benefits

- Improves process efficiency
- Reduces energy consumption
- Reduces labor requirements by up to 83 percent
- Increases productivity
- Reduces maintenance costs by up to 60 percent
- Reduces emissions

Applications

Older electrolytic reduction processes often have elevated labor and energy expenses and increased environmental losses of chlorine. Application of updated technologies can help reduce levels of oxygen, iron, and carbon in the cell feed while reducing energy consumption, eliminating excessive chlorine losses, and reducing the operating labor required.

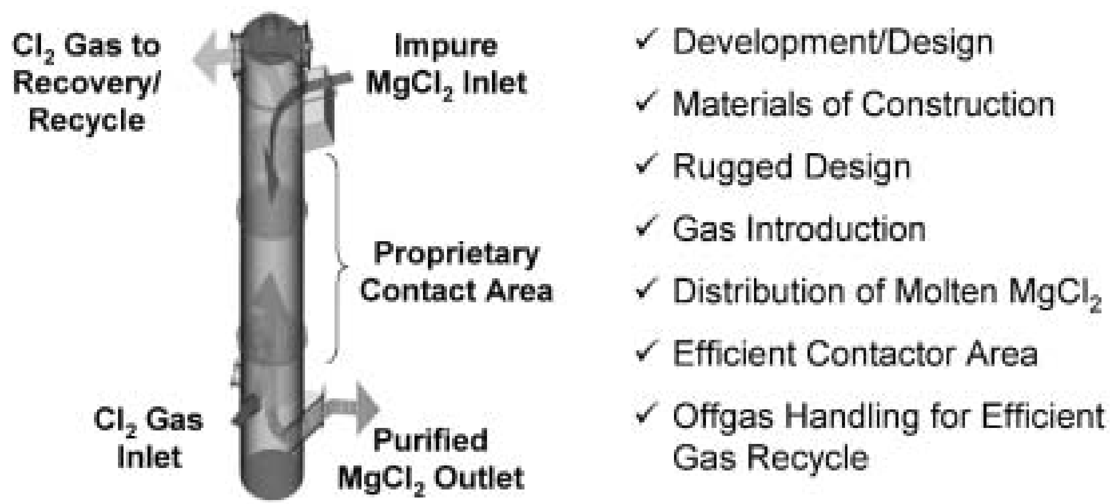
0.70 percent non-electrolyte impurities, which is significantly higher than the 0.20 percent maximum designed for most high-efficiency electrolyzers. The project objective was to significantly reduce impurity with minimal changes in infrastructure.

The existing chlorination system used refractory-lined cells arranged in a primary and secondary process scheme. These units used chlorine sparging tubes to introduce gas into the reactors. Process kinetics were driven by reactant control, reactant contact (control of chlorine vapor bubble size), residence time, and mixing.

After extensive experimentation, a tertiary chlorination step was added to the existing system. This modification involved installation of a proprietary vertical chlorinator for removal of residual oxygen and iron. Additional modifications included installation of an electronic control scheme for reactant, power, and gas handling. Chlorinators were modified to eliminate air introduction into the reactors and to accept a vertical electrode design that improved the refractory layout. These modifications dramatically improved reliability, cleanliness, and control of the system. Other equipment modifications included installation of additional product surge capacity and new mobile feed-hauling equipment for $MgCl_2$ transport to the cell rooms. These modifications resulted in a substantial reduction in the introduction of $MgCl_2$ impurities through handling.

Electrolysis improvement project. Because of the labor, energy, and maintenance expenses associated with the equipment, magnesium electrolysis is the most cost-intensive processing step in the electrolytic method of production. Historically, MagCorp used both diaphragm and diaphragmless electrolyzer designs. Although the diaphragmless designs enjoy the benefits of increased productivity and improved chlorine collection capability, both types of electrolyzers suffer from an excess labor burden, unfavorable chlorine recovery, and limited unit productivity.

TERTIARY VERTICAL CHLORINATOR



The success of the cell feed purity project, along with extensive testing of experimental equipment, helped in the design of a new electrolyzer that was compatible with the improved $MgCl_2$ feed. The new electrolyzer was also designed to provide:

- Reduction in energy consumption of 30 percent
- Productivity improvement of 300 percent
- Significant reduction in labor and maintenance requirements
- Improved environmental and hygiene performance
- Increased ability to absorb process upsets

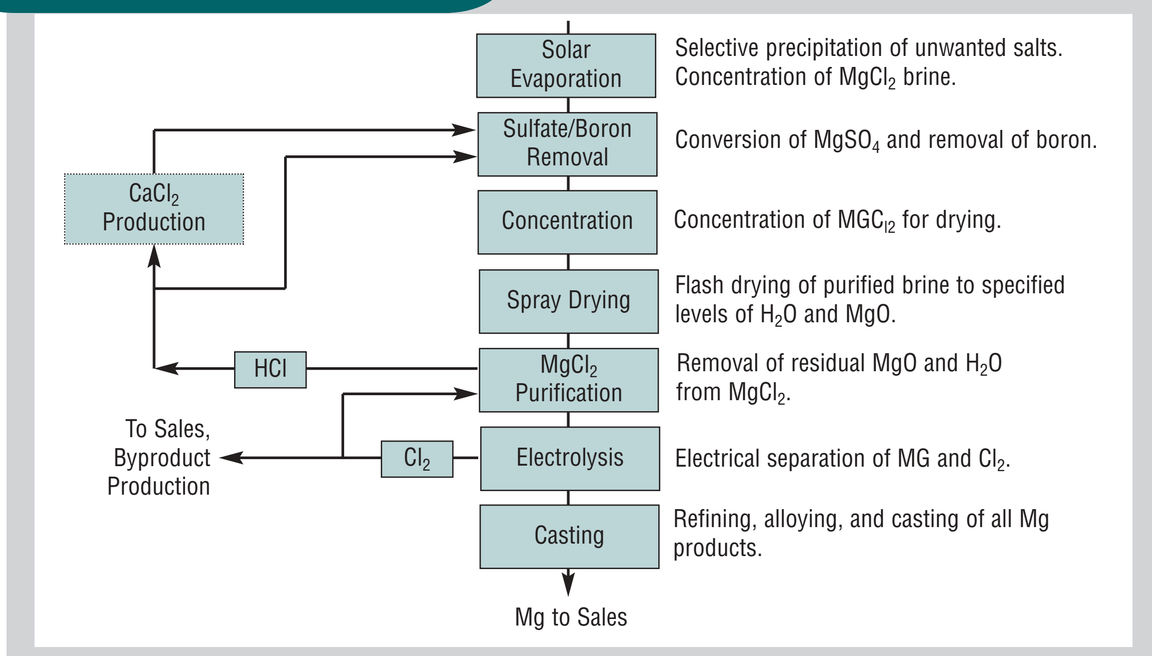
The technical challenges of installing an advanced electrolyzer in an existing facility were met with minimal process interruption.

Results

High levels of impurities in the $MgCl_2$ have been shown to have an adverse effect on the efficiency of the electrolysis process. Modifications to the $MgCl_2$ feed preparation process resulted in significant improvement in product purity. This was accomplished with the added benefit of an overall decrease in area operating costs of 10 percent. The success of this project enabled the project team to design a high-efficiency electrolyzer for the magnesium cell rooms. The new cell design has improved and had significant impact on the MagCorp electrolysis system.

- Replacing the existing electrolyzer direct-current (dc) power system with new rectifier and busbar capacity, coupled with the new electrolyzer design, has resulted in improved efficiency. Actual performance levels of 6.03 kWh/lb magnesium (including all busbars) have been demonstrated. In-cell power consumption has also decreased.
- The increased scale of the new electrolyzers has provided a framework for reduced operating labor. Historically, MagCorp electrolyzers averaged 1.0 to 1.5 tons/day of magnesium, whereas the new cell design produces up to 3.1 tons/day of magnesium. This change, combined with the improved feed delivery system, has reduced area labor requirements by 83 percent.

MagCorp Process Flow Chart



- Maintenance costs of the new electrolyzer system are dramatically improved from those of older designs because of the ruggedness, simplicity, and improved electrode cooling of the new system. Maintenance requirements have been reduced by 60 percent. “Rebuild” expenses have also decreased.
- Emissions have been significantly reduced. Worker exposures to chlorine and thermal emissions have been reduced by 45 percent and 30 percent, respectively. Collection of chlorine has been significantly improved, with more than 99.9 percent capture because of the proprietary metal collection system.

Lessons Learned

Modernization of the MagCorp electrolysis system has demonstrated that it is technically and economically feasible to retrofit existing production facilities with equipment that provides world-class performance. The installed cost of the feed purification system and electrolysis equipment upgrades was approximately $1,100/ton of annual magnesium production. This approach to performance improvement can provide older magnesium producers with the efficiencies required to compete in the high-quality magnesium market with reasonable rates of return on facility investments. The technological approach can also provide the framework for significant volume expansions should market growth require future increases.

Industry of the Future—Mining

In mid-1998, the National Mining Association reached an agreement with the U.S. Department of Energy’s Industries of the Future Program to join in creating research and development partnerships to develop and deploy new technologies that will improve environmental performance and enable the industry to meet increased global competition. The mining industry supplies the minerals and coal essential to the infrastructure of virtually the entire U.S. economy: glass, ceramics, metals; cement for buildings, bridges, roads, and equipment; and coal or uranium to generate more than 70% of the nation’s electricity.

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BestPractices focuses on plant systems, where significant efficiency improvements and savings can be achieved. Industry gains easy access to near-term and long-term solutions for improving the performance of motor, steam, compressed air, and process heating systems. In addition, the Industrial Assessment Centers provide comprehensive industrial energy evaluations to small- and medium-size manufacturers.

Project Partners

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