LITHIUM PRODUCTION WITH VALVE STANDARDISATION

Rebecca O'Donnell, Baker Hughes, USA, and José Maluenda Llantén, RPM, Chile, details how standardising control valves in the lithium extraction processes can improve efficiency, reliability, and cost-effectiveness.

Lithium plays a pivotal role in the advancement of clean energy technology, with demand poised to surge dramatically as the world transitions to more sustainable energy sources. As innovations like

Figure 1. Traditional lithium ponds in Chile.

direct lithium extraction (DLE) reshape the processing landscape, this article will underscore the importance of standardising control valve usage. By doing so, it highlights how current technology in brine extraction can lower inventory levels, boost run time, and maintain output. The optimisation strategies discussed can also be implemented into other types of lithium processing facilities recognising similar benefits and offering comparable advantages.

What is lithium?

Lithium (Li) is the least dense solid element and lightest metal on the periodic table, belonging to the alkali metal group. With an atomic weight of 6.939 and known for its chemical reactivity, it is highly sought after and deemed essential in clean energy technology. Due to its high electrochemical potential, lithium is crucial for several industrial applications. Historically used in heat resistant glass, metal alloys, and medication, the most notable new energy use of lithium is in rechargeable batteries for electric vehicles, as well as renewable energy storage. It is forecasted that the demand for lithium, and the unique properties it holds, will rise as new energy transition technology advances and the global shift towards renewable energy is accepted in the market.

Where is it found and in what form?

Lithium can be found all over the world in different chemical compositions and forms with varying concentrations. There are two economically viable ways of extracting lithium. The first is by opencast mining lithium rich ore, known as spodumene. The second primary method of obtaining lithium is by extraction from saltwater pools found underground, known as brine deposits, predominantly from regions with high evaporation rates. The focus of this article will be on the latter, extracting lithium from underground saltwater pools or brine deposits. This method is commonly used in South America in an area known as the 'Lithium Triangle' – which includes Chile, Bolivia, and Argentina, where some of the world's highest concentrations of lithium are found.

How is lithium extracted?

In Northern Chile, the Salar de Atacama is a sedimentation basin whose central depression is occupied by a crust consisting of essentially halite, or core measuring 1100 km^2 in area and 900 m deep, surrounded by a marginal zone of saline silt measuring approximately 2000 km^2 in area, where concentrated salt pools are found in a process known as 'brine pumping'. The reservoirs of salt water are pumped up from underground to the surface and brought to 'ponds', where the water is evaporated for up to 18 months. As water evaporates, the concentration of lithium and other salts in the brine increase. While location and concentrations vary, lithium concentrations typically start below 1% prior to evaporation, and after become approximately 6%.

A typical brine is composed of:

- Boron (0.5 – 1.5%).
- Chlorine (30 – 38%).
- Magnesium (1 – 2.5%).
- Lithium (5 – 7%).
- Sodium (0.01 – 0.15%).
- Potassium (0.01 – 0.02%).
- Calcium (0.02 – 0.05%).
- Sulfate (0.01 – 0.03%).
- Water (50 – 60%).

The following process claims the benefit of priority under 35 U.S.C. §119, from Chilean patent application 484-96, filed 28 March 1996, the entire contents of which are hereby incorporated by reference.

The brine solution, after evaporation, is made up of several minerals and is then taken to a processing plant for a treatment known as 'purification'. The first step is to remove unwanted elements, such as boron, by adding hydrochloric acid or sulfuric acid, regulating temperature at -5°C – 20°C, and maintaining a pH of 0 – 4 to form boric acid. During the chemical precipitation, control valves regulate the addition of chemicals to ensure precise reactions and successful separation, while also maintaining the correct pH of the brine. The boric acid is then removed by separation and filtration and dried for commercial sale. A second process is required to remove the rest of the boron using an organic solvent, which takes several steps. It is important to remove as much boron as possible in the beginning of the purification process as it affects purity of the final product. Throughout the

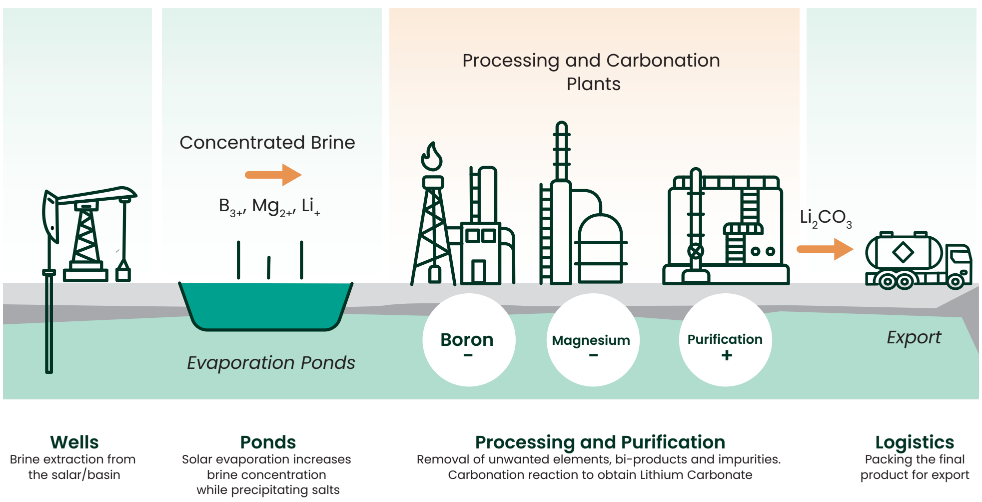

Figure 2. Traditional lithium brine extraction process.

evaporation and purification processes, control valves regulate the transfer of brine between states to ensure consistent processing conditions and maintain the necessary temperature and pressure requirements for efficient lithium concentration. The solution should contain around 5 ppm of boron after removal.

Examples of chemical reactions using HCL:

- $Na_2 B_4 O_7$ +2HCl+5H_2O -> 4$H_3 BO_3$ +2NaCl (1)
- $MgB_4 O_7$ +2HCl+5H_2O -> 4$H_3 BO_3$ +$MgCl_2$ (2)
- $Li_2 B_4 O_7$ +2HCl+5H_2O -> 4$H_3 BO_2$ +2LiCl (3)
- $K_2 B_4 O_7$ +2HCl+5H_2O -> 4$H_3 BO_3$ +2KCl (4)

The lithium-rich brine is then diluted with mother liquor in a reactor to decrease the lithium content from 4 – 6% to 0.9 – 1.5% to prevent lithium precipitation. Sodium carbonate (soda ash) 20 – 30% by weight is introduced to increase pH to 7 – 9 at 15 – 95°C for 5 – 120 minutes. Under these conditions, 60 – 95% of the magnesium will precipitate by undergoing the following reaction:

- $MgCl_2$ +$Na_2 CO_3$ -> $MgCO_3$ +2NaCl (5) – At 80°C, the solubility constant of magnesium carbonate is 3.5 × 10-3 with a pH of 8.

After several separation and filtration steps, the brine contains 0.01 – 0.05% magnesium. It is then sent to a reactor with calcium hydroxide (milk of lime) for the final steps to bring magnesium levels below 0.002%.

- $MgCO_3$ +$Ca(OH)_2$ -> $Mg(OH)_2$ +$CaCO_3$ (6)
- $MgCl_2$ +$Ca(OH)_2$ -> $Mg(OH)_2$ +$CaCl_2$ (7)
- $CaCl_2$ +Na.sub$_2$ CO_3 -> 2NaCl+$CaCO_3$ (8)

The brine consists of 0.8 – 1.2% lithium after this step and is combined again with sodium carbonate (soda ash) to maintain a pH level of 8 – 12 at 50 – 98°C for 5 – 180 minutes. Control valves precisely manage the addition of soda ash as a reagent to achieve the desired chemical reactions, which is critical for efficient precipitation and high-purity product formation.

This step enables lithium carbonate (final product) to precipitate out at 40 – 90%, but typical conversion is 80 – 90% following this reaction:

- 2LiCl+$Na_2 CO_3$ = $Li_2 CO_3$ +2NaCl

Further solid/liquid, mechanical, and chemical separation techniques are needed to increase total recovery of lithium, and will depend on brine composition and conversion to lithium. In the final step, pure lithium carbonate is dried, granulated, and packaged.

The description of lithium extraction can deviate based on brine composition and the processes used are always evolving for better more economical production. Regardless, control valves remain part of the process as an intricate piece that helps to maintain the requirements of temperature, flow, and pH. Each of these components are vital to provide consistent and reliable production of lithium.

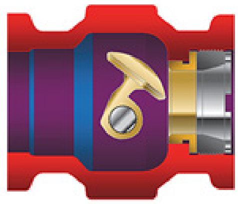

Figure 3. Cutaway of Masoneilan Camflex.

Figure 4. Masoneilan Camflex with SVI3 Digital Positioner.

Throughout the process, there are many corrosive and erosive applications that require correctly sized and specified control valves to ensure optimal production. Because control valves must function consistently over time, no matter how corrosive or erosive the process flow may be, they must be sized to handle conditions and perform optimally until scheduled maintenance can occur.

The challenge then becomes differentiating between hundreds of valves with varying sizes, models, and materials in plants that operate under harsh conditions and must be replaced at an estimated six months to two years. Most are replaced with body sub-assemblies or complete valve replacements to maintain production and decrease maintenance time. Keeping the right inventory is very important. With so many valve choices, Masoneilan™ offers a versatile valve solution that can be utilised in many applications with minimal changes and excellent performance.

What is the most economical solution for a high performing, reliable control valve?

Masoneilan's Camflex is a widely accepted eccentric plug valve that works well in services found in processing facilities. It is not a new valve to the market. Harnessing over five decades of experience and development, the Camflex has shown its ability to cover a wide range of applications as a reliable solution to erosive and corrosive applications.

How does it work?

Masoneilan's Camflex has a simple yet effective design that includes a compact body with a plug, seat, and seat retainer exposed to process media. It has a straight through flow path that allows for 100:1 rangeability and bidirectional flow, without impingement points leading to erosion or dead zones inside the body. The plug is specifically made to move away from the seat when the valve is opened so there are no close contact points in conjunction with the seat, preventing wire draw or high velocity wear. The design allows reduced friction required by the actuator. When the valve closes by rotating, which is the only time the plug contacts the seat, the plug arms 'flex' the plug into the seat providing consistent tight shut off.

Available features

The Camflex offers many available customisable options to meet application requirements. This enables the user to pick only the applicable options, while not being forced to buy unnecessary extras.

Available options include:

- Slurry style bushings which are out of the flow path and contain an O ring that prevents particles from entering the shaft area causing sticking.
- Exotic materials are an option for compatability to media.
- Venturi seat to mitigate damage due to flashing applications.
- Hardened trim materials to offer protection from media.
- Ceramic trim for severe applications.
- Body coatings/treatments for erosion protection.
- Fugitive emission packing.

Standardising control valves at a lithium processing plant makes sense

For most processing plants, keeping control valves online for as long as possible and functioning optimally is key to staying on top of production. Most sites keep body sub-assemblies on hand versus changing out spare parts for quick replacement. For this reason, large amounts of inventory may be required, becoming a challenge to manage. Since Camflex can be used in several applications across the plant, it is possible and has been shown to reduce overall inventory for certain Camflex sizes and materials.

For example, the Camflex 1 – 4 in. Hastelloy can be used for applications containing sulfuric acid, but can also be used elsewhere in the plant. Therefore, if similar sizes and Cvs can be used, it would be efficient and effective to keep strictly Camflex replacement valves on the shelf, instead of many different valves for various uses.

Conclusion

The value of a valve product like Camflex begins with its reliable and robust performance. Whether it is required for repeatable tight shut off, erosive resistant design, versatility, or a combination of these attributes, the Camflex offers high-level performance across multiple applications, and can be standardised throughout an entire plant. This standardisation leads to a longer product lifespan, reduced inventory requirements, and streamlined maintenance operations – ultimately enhancing overall efficiency and the cost effectiveness of all operations. GMR