Lithium Processing - Spodumene

APPLICATION PAPER

PILITHCAPEN

Lithium Refining; Hard rock to Lithium Carbonate

Introduction

The Electrical Vehicle (EV) market is undergoing a revolution that is transforming the transportation landscape using Lithium-Ion battery technology. The demand for lithium ion battery is projected to increase to 4900 Gwh in 2030 as compared to 1500 Gwh in 2024[1]. To meet this challenge, high purity Lithium Hydroxide and Lithium Carbonate are required as essential materials to formulate these batteries.

The primary sources of Lithium are either brine lakes (Salars) or mineral deposits of mostly Spodumene ore. The Spodumene ore contains up to 6 % weight Lithium and is extracted from the ground in conventional mining operations (see Figure 1) that can be either underground pit excavation or surface strip mining depending on the location of the mineral lode.

Figure 1: Spodumene Mining Operations

Mining Applications

Mining operations typically involve the quarrying of the lithium rich ore from the surrounding rock followed by crushing & grinding operations, bulk separation by gravity difference or flotation and transport. Various mechanical operations are involved including crusher machines, mechanical shovels, large capacity haul trucks, transport belts, control systems, rotating equipment, and remote generators. Water treatment and fuel conditioning are also essential to the mining operation. Separation applications in mining are described in Table 1 for hydraulic fluids, lube oil fluids, diesel and process fluids, and water treatment.

Application	Filtration Value	Pall Product
Hydraulic	Prevent malfunction of hydraulic control systems due to contaminant fouling and fluid degradation	Particulate Filtration and Dehydration
Lube Oil	Reduce wear and reduced reliability of rotating parts due to contaminant abrasion and sluid viscosity losses	
Diesel and Process Fluids	Break emulsions and prevent damage to internal combustion engines and contamination of other process fluids	Liquid-Liquid Coalescers and High Flow Particulate Filters
Inlet Water, Recycle Process Water and Discharge (Waste) Water	Provide process water, environmental clean up and remote camp drinking water	MF System and High Flow Particulate Filters

Table 1: Mining Separation Applications

Lithium Refining: Spodumene concentrate to battery grade Li_2CO_3

The spodumene concentrate ore is converted into Lithium Carbonate for use as an essential component to make Lithium-Ion Batteries. The process for making Lithium Carbonate is illustrated in Figure 2.

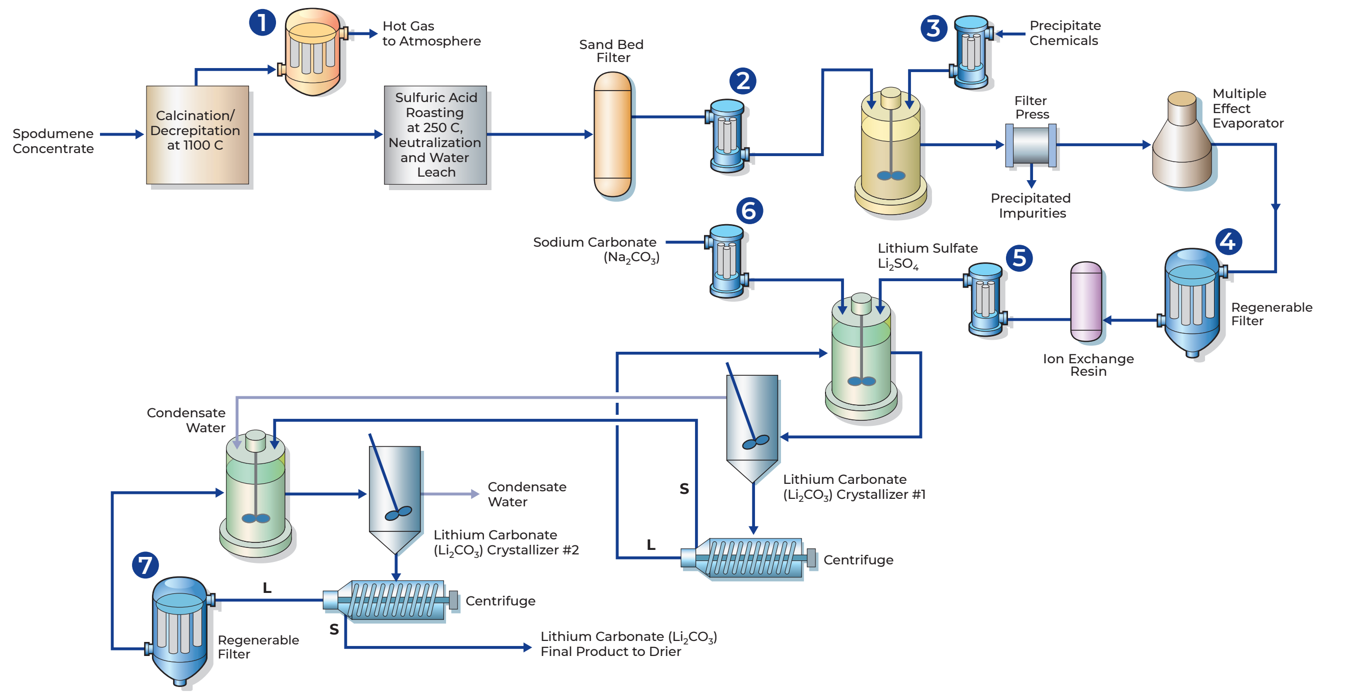
The first step is calcination / decrepitation of the spodumene ore performed at a high temperature of 1,100 °C. Here the crystal structure of the spodumene is changed to open the pore structure in the material to a format more easily extracted. To prevent fine particle emissions from the furnace, a hot gas blowback filter system (1) can be installed. The next step involves roasting with sulfuric acid at 250 °C followed by neutralizing and water leaching. The Lithium is now converted into a Lithium Sulfate salt solution and contains other dissolved impurities and tailings. A sand filter is typically used to remove bulk tailing solids followed by a cartridge type filter (2) to catch any remaining fine particulate. Undesirable dissolved contaminants are removed by the use of chemical precipitation. A cartridge filter(3) is used to treat the injected precipitation chemicals to prevent contaminants from entering the Lithium Sulfate stream.

The precipitated contaminants are separated from the Lithium Sulfate stream using a filter press. The stream is then concentrated using a Multiple Effect Evaporator. A regenerable (candle) filter (4) can be installed downstream of the evaporator to remove any remaining fine particulate that could adversely affect the ion exchange resin bed used primarily to remove divalent cations such as Ca+ and Mg+.

A cartridge filter (5) is also used downstream of the Ion Exchange resin to prevent any carryover resin or other particulates from contaminating the final product.

Sodium Carbonate is filtered by cartridge filters (6) before being mixed with the Lithium Sulfate solution. This causes a chemical reaction that creates the desired Lithium Carbonate and a byproduct of Sodium Sulfate that remains in solution. The process stream then goes to Lithium Carbonate crystallizers. The crystallizers incorporate vacuum dehydration to both concentrate and cool the solution leading to the crystallization of the Lithium Carbonate product. The Lithium Carbonate solids are separated out of solution by a centrifuge and then dissolved in pure condensate water for further purification. The Lithium carbonate solution is re-cooled and re-concentrated in a second Lithium Carbonate crystallizer to produce the final Lithium Carbonate product that is collected in a second centrifuge. A regenerable (candle) filter (7) can be installed to catch any fine Lithium Carbonate particles that pass through the centrifuge in the mother liquor and during any water washing of the product. The Lithium Carbonate is then dried and milled to a fine particle distribution and packaged for sale.

The process depicted here is based on conventional operating plants and there are many new methods in development in this emerging industry.



Filter	Filtration Value	Separation Product
1	Remove solid particulate from furnace flue gas to prevent emissions	Gas Blowback Filter
2	Prevent ingression of tailings impurities and carryover sand into system from upstream processess	1 - 5 Micron Filter
3	Prevent ingression of impurities into system from injected precipitation chemicals	1 - 5 Micron Filter
4	Protect Ion Exchange (IX) and crystallizer from carryover solids coming from the filter press	Regenerable Filter
5	Remove trace solids and Ion Exchange resin fines before the crytallizer	1 Micron Filter
6	Prevent ingression of impurities into system from injected Sodium Carbonate solution	1 - 5 Micron Filter
7	Recover fine particles of Lithium Carbonate from mother liquor recycle stream	Regenerable Filter

Figure 2. Lithium Refining Process

Material Purity Specifications

Lithium-Ion batteries have strict purity requirements for the materials used in their manufacture. Impurities can lead to poor charging performance including reduced vehicle range of operation, more frequent need to charge, problems with batteries starting at colder temperature and in some extreme cases to the batteries catching on fire. A major issue with the current Lithium conversion practice is reliable operation in producing the high-quality Lithium products. Battery grade purity specs are provided in Table 2 for Lithium Carbonate. For Lithium Carbonate the minimum purity requirement is 99.5 wt. %.

Product Name		Litium Carbonate Battery Grade
Li_2CO_3 content min. (%)		99.5
Impurities Max. (ppm)	Na	250
	K	10
	Fe	20
	Ca	50
	Cu	10
	Pb	10
	Ni	30
	Mn	10
	Zn	10
	Al	50
	Mg	100
	Si	50
	SO_4^{2}	800
	Cl	50
H_2O (%)		0.40
Average Granularity		≤6 µm

Table 2: Battery Grade Purity Specifications[2]

Improved filtration and separation can play an important role in improving both the process reliability for producing consistent high purity products and also for improving the product yields, reducing product re-work, and reducing operation costs.

EV Battery Value Chain

The various stages in the Electric Battery (EV) value chain are given in Figure 3. For each segment, filtration and separation play a vital role in meeting process goals for yield, purity, and reliability. For base materials, mining and unique material processing are required for Nickel, Cobalt and Aluminum as well as Lithium as described in this paper. Active materials involve treating of chemicals, specialty chemicals and polymers to make the essential battery components consisting of the separator, electrolyte, and anode/cathode. The battery cells also use chemicals and specialty chemicals that must be at rigorous purity levels for preparing the casing, filling operations, and preparing slurries. The battery pack will have micro-electronics and automotive components and require cleanliness monitoring.

Pall Corporation is your partner for filtration and separation needs and has experience throughout the EV battery value chain. Pall has over 400 qualified Engineers and Scientists that can provide: prototype testing, on site pilot testing, best practice training, process optimization, audits, contaminant analysis, application troubleshooting, validation services, presentations at scientific forums, and journal publications.

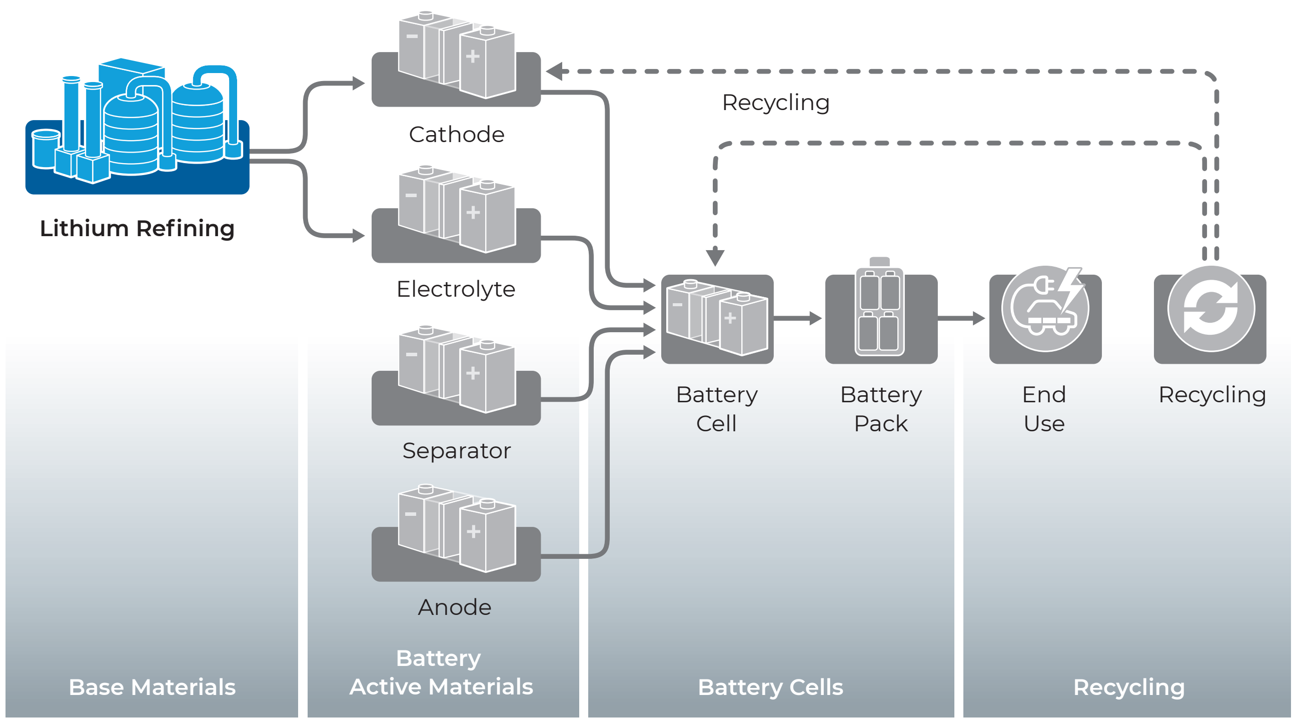


Figure 3: Applications in the EV Battery Value Chain

References

1. *Battery monitor 2023 (Roland Berger & RWTH Aachen university)*
2. *https://www.targray.com/content-data/mediafiles/images documents/pds-lithium-carbonate.pdf*

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