



Process Mixing/Reaction, Solid-Liquid Separation and Drying For Battery Materials

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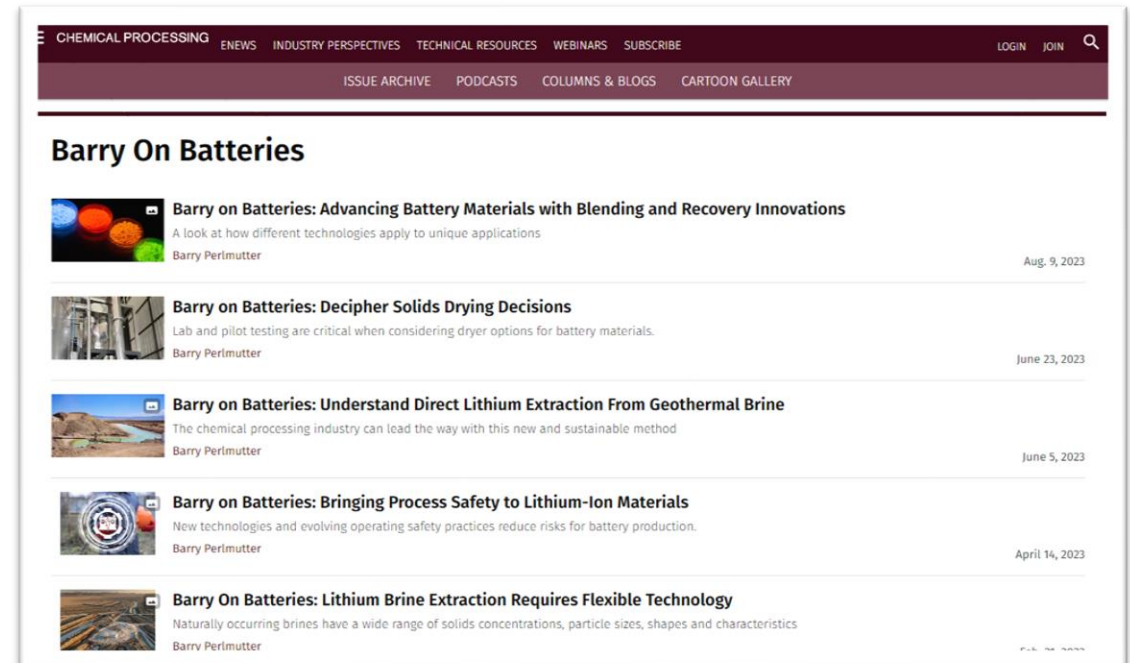
Barry A. Perlmutter

Overall Experience

- 40 years of international engineering and business marketing experience in the field of solid-liquid separation including filtration, centrifugation, drying, mixing & recycling
- Published & presented worldwide:
 - Author of [“Solid Liquid Filtration Handbook”](#) (Elsevier, 2015)
 - Editor of [“Integration & Optimization of Unit Operations”](#) (Elsevier, 2022)
- Professional skills focus on process solutions, innovation strategy, market expansion and business development.

Lithium Market Expertise & Experience

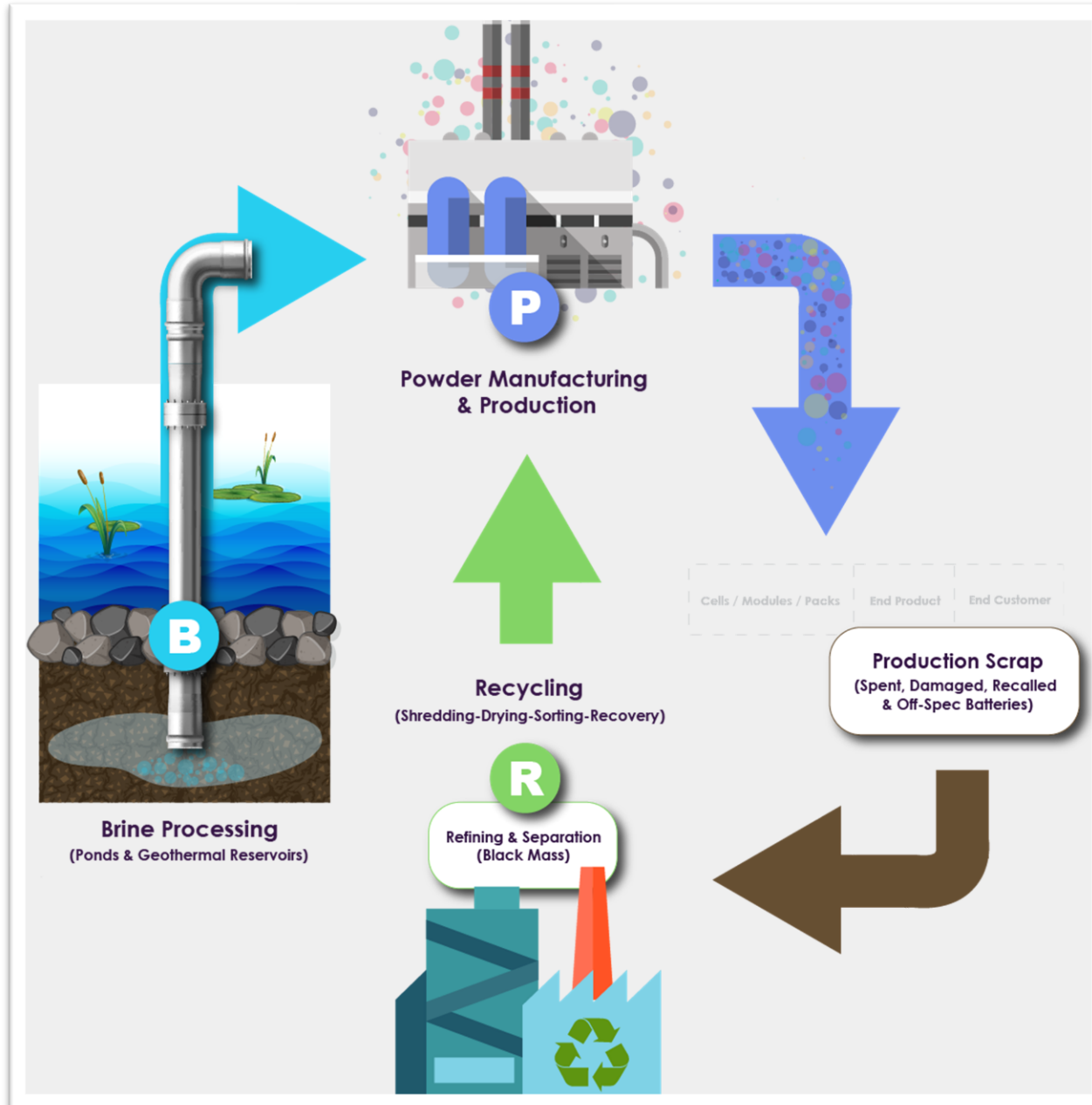
- <https://perlmutterideadevelopment.com/lithium-battery-materials/>
- [Chemical Processing Magazine and Columnist for “Barry on Batteries”](#)
- [International Battery Seminar Conference Presentation, March 2023](#)



The screenshot shows the website for 'Barry On Batteries' under the 'CHEMICAL PROCESSING' section. The navigation bar includes links for ENews, INDUSTRY PERSPECTIVES, TECHNICAL RESOURCES, WEBINARS, and SUBSCRIBE, along with LOGIN and JOIN options. Below the navigation, the site title 'Barry On Batteries' is displayed. A list of five articles is shown, each with a thumbnail image, title, subtitle, author name, and date:

- Barry on Batteries: Advancing Battery Materials with Blending and Recovery Innovations**
A look at how different technologies apply to unique applications
Barry Perlmutter
Aug. 9, 2023
- Barry on Batteries: Decipher Solids Drying Decisions**
Lab and pilot testing are critical when considering dryer options for battery materials.
Barry Perlmutter
June 23, 2023
- Barry on Batteries: Understand Direct Lithium Extraction From Geothermal Brine**
The chemical processing industry can lead the way with this new and sustainable method
Barry Perlmutter
June 5, 2023
- Barry on Batteries: Bringing Process Safety to Lithium-Ion Materials**
New technologies and evolving operating safety practices reduce risks for battery production.
Barry Perlmutter
April 14, 2023
- Barry On Batteries: Lithium Brine Extraction Requires Flexible Technology**
Naturally occurring brines have a wide range of solids concentrations, particle sizes, shapes and characteristics
Barry Perlmutter

PRESENTATION OVERVIEW



PRESENTATION OVERVIEW

Mixing-Blending-Reaction Options

- Cathode & Anode Materials
Main active components, conductive components, solvents, binders, etc.
- Chemicals
Hydroxide battery pastes, metal hydrides, lithium cobalt oxide paste, metal oxides, metal salts, etc.
- Electrolytes
- Hydromet & Downstream Processes

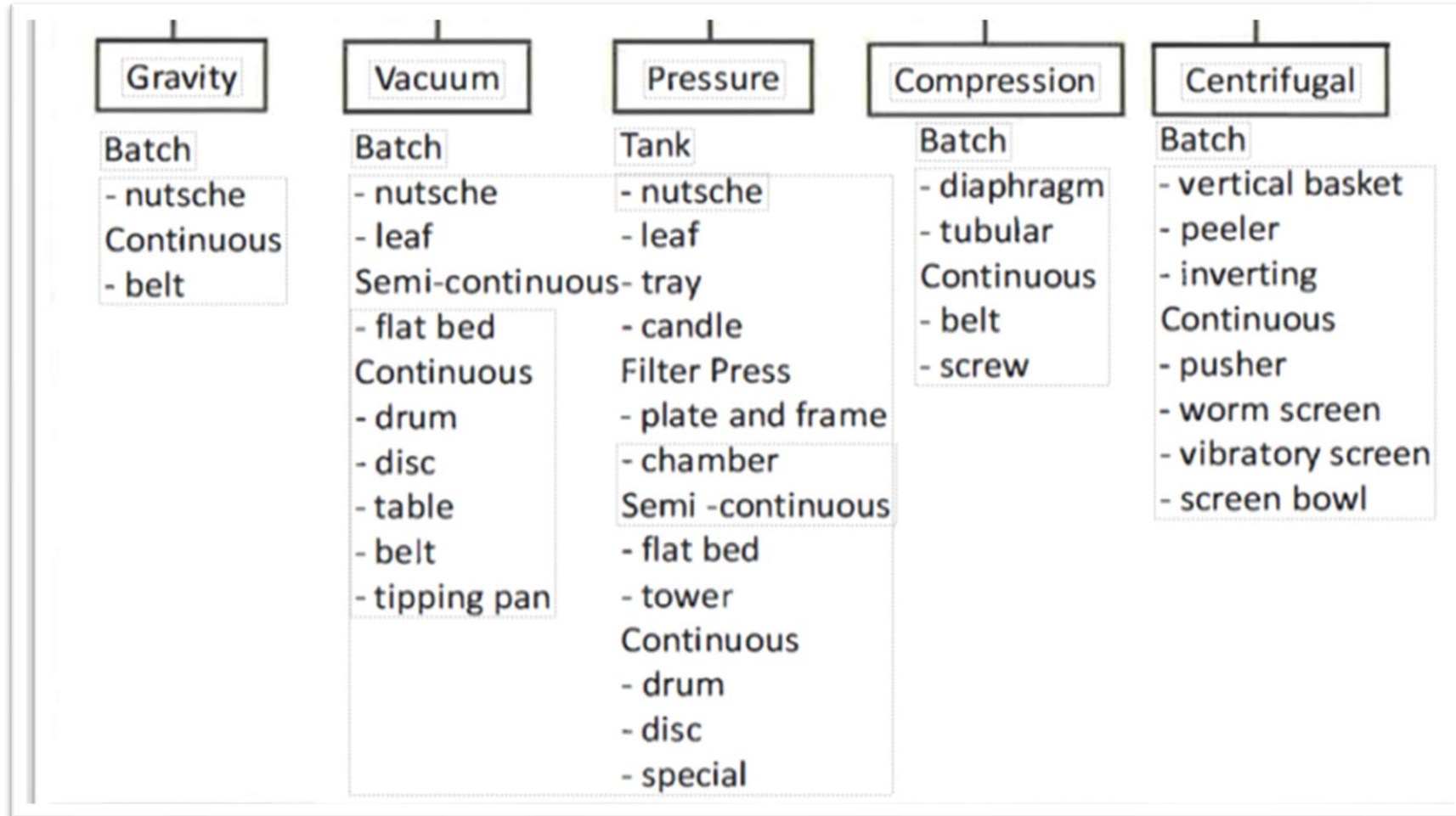
PRESENTATION OVERVIEW

Mixing-Blending-Reaction Options

- Volume of the slurry components
- Characteristics of the slurry components
- Crystallizer vessel geometry
- Orientation of the dosing nozzles for the slurry components
- Correct temperature and pressure control
- Selection of the appropriate mixing element set-up
- Correct speed optimum turbulence and flow in the mixing vessel
- Cycle times to match downstream operations-integration
- Mechanical reliability throughout the whole mixing process

PRESENTATION OVERVIEW

Filtration Options



SUMMARY & FILTRATION CRITERIA

1. **Typical Solids Content of Slurry (% Solids)**
2. **Process Characteristics (i.e., extraction/leaching)**
3. **Slurry Composition / Properties**
4. **Solids Description, Range of PSD, Shape**
5. **Cake Thickness/Structure/Formation**
6. **Cake Washing**
7. **Cake Pressing**
8. **Cake Moisture**
9. **Filtrate Quality**
10. **Filtrate Discharge / Separation of filtrates**
11. **Cake Discharge**
12. **Cloth and Overall Cleaning**
13. **Mechanical / Operational**
14. **Other (Performance/Installation/Utilities
/Ancillaries/ Filter Aid/Filter Media/MOC, etc.)**

PRESENTATION OVERVIEW

Drying Options

Batch dryers:

- Tray dryers
- Spray dryers
- Rotary dryers
- Vertical Vacuum dryers
- Pan dryers
- Spin Flash dryer

Continuous dryers:

- Conveyor dryers
- Belt dryers
- Fluid bed dryers
- Spray dryers
- Horizontal paddle dryers
- Tunnel dryers
- Rotary dryers

SUMMARY & DRYER CRITERIA

- 1. Dryer throughput; mode of feedstock production (batch/continuous)**
- 2. Physical & chemical properties of the wet feed and final product spec**
- 3. Variability in feed characteristics, process parameters and downstream impacts**
- 4. Upstream and downstream processing operations**
- 5. Moisture content of the feed and product (Wet and Dry basis)**
- 6. Drying kinetics-isotherms, drying curves, drying times**
- 7. Heat sensitivity - Melting point, - Glass transition temperature**
- 8. Quality parameters (physical, chemical, biochemical)**
- 9. Safety aspects, e.g., fire hazard and explosion hazards, toxicity**
- 10. Value of the product**
- 11. Need for automatic control**
- 12. Toxicological properties of the product**
- 13. Turndown ratio, flexibility in capacity requirements**
- 14. Type and cost of fuel, cost of electricity**
- 15. Environmental regulations**
- 16. Space in plant**
- 17. Dryer Materials of Construction, Seals, etc.**

LABORATORY & PILOT TESTING FOR TECHNOLOGY SELECTION

- **Feed Solids**
 - **Granular, particulate, sludge, crystalline, liquid, pasty, continuous flat sheets, sticky, lumpy**
 - **Size distribution, bulk density**
- **Mixing/Blending/ Reactions & Parameters**
- **Filtration: Pressure (or Vacuum) / Centrifugation**
- **Solids Washing & Dewatering**
- **Solids Drying & Drying Curves**
- **Cycle Times for the Complete Process**
- **Optimization for the Rate Critical Step**
- **Solids Discharge and Flows/Handling-Conveying**
- **Testing Provides For “Low-Risk” Scale-Up**

PDE-Stages

PDE-Stage 1: Preliminary Engineering

PDE-Stage 2: Detailed Engineering

P&IDs, PLC control philosophy and specification, detailed equipment specifications and other documents to allow client to issue purchase orders.

PDE-Stage 3: Project Execution

Assistance is provided, as necessary, to the client engineering teams and/or outside contractors, etc. to enable the project to be completed on-time within budget.

PDE-Stage 4: Commissioning and Startup

Supervision is provided to oversee vendors for cold and hot commissioning, startup, training and other on-site activities.

PDE-Stage 5: Support

Guidance is provided for on-going operation, optimization and other recycling plant activities along with assistance with vendor support.



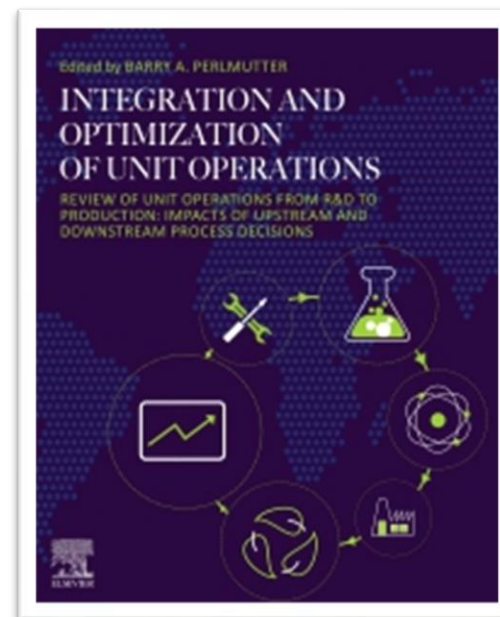
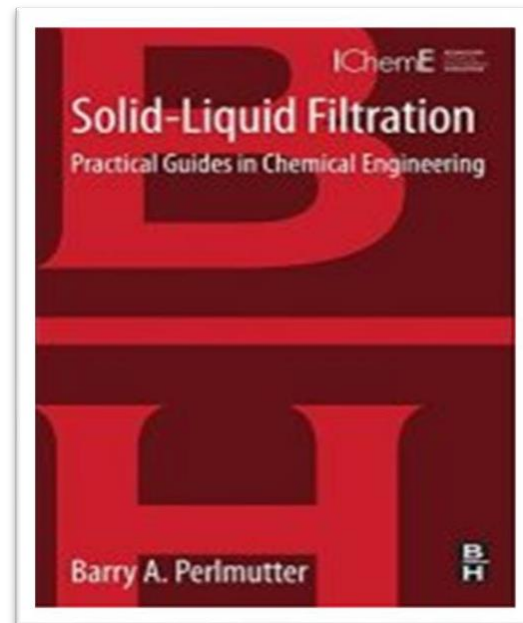
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