Process Development and Technology for Battery Materials

Bēpex

Beyond: Expectation

A message from our President

Welcome to Bepex International. We greatly appreciate the opportunity to work with you.

I have been with Bepex for many years, starting as a laboratory engineer in our Process Development Center. I have always been fascinated by the materials and challenges that we see in working with companies like yours.

We take pride in innovation by developing a process to transform your raw materials into finished products. We have an exclusive range of unit operations and solids processing technologies available to meet the most challenging applications.

We are committed to your success from initial inquiry and product development to ongoing commercial operation. We work with you to meet your clients' changing material performance requirements and provide a robust operation that minimizes downtime.

Integrity is at the core of our values as we protect your confidential information. This means the process developed for you is just that, for you and no one else.

We are confident that we can provide the answers you need very quickly, even if your needs aren't a fit for our capabilities.

We hope you'll make us your first call and see for yourself what makes Bepex special.

Greg Kimball, CEO

5,000 +
ACCOUNTS ACROSS
65 COUNTRIES

20,000 +
SUCCESSFUL
PILOT SIMULATIONS

30 +
TRANSFORMATIONS AVAILABLE
FOR DEVELOPMENT

< 3
WEEKS FROM EVALUATION TO
SYSTEM RECOMMENDATION

125
YEARS AT WORK

1
CALL IS ALL IT TAKES

MORE THAN MEETS THE EYE

Who we're not.

We are not a catalog. We are not an engineering firm. We are not rigid. We are not too big, nor too small. We are not hard to work with. We are not cookie cutters. We don't copy and paste. We don't walk away. We don't waste time.

So, who is Bēpex?

We are the Material Transformation People™. We deliver custom-configured processes and systems that make your innovative products possible. We do so quicker than anyone else while offering the most precisely matched technology for your application.

What we value.

We value integrity, first and foremost. Our customers rely on us to develop custom solutions for their product needs. It is our job not only to develop a custom process, but to make sure that it remains custom for you.

We value innovation, never passing up an opportunity to explore and broaden our knowledge. Every new application, technology, material, and development provides growth, further positioning us as experts in material transformation.

We value commitment. The type of commitment that doesn't disappear in adversity. And we know our customers do too. We built our legacy on remaining committed to the success of our customers, even when it wasn't easy.

Trace our Roots

Our foundation stretches as far back as the 19th century. Nearly 125 years of compounding experience, building on each success, translating new ideas and successes to the industries we serve.

Though Bepex as a name has only been around since 1975, we continue to draw on the experience and learnings developed well before our time.

1897 Strong Scott established in Minneapolis, MN

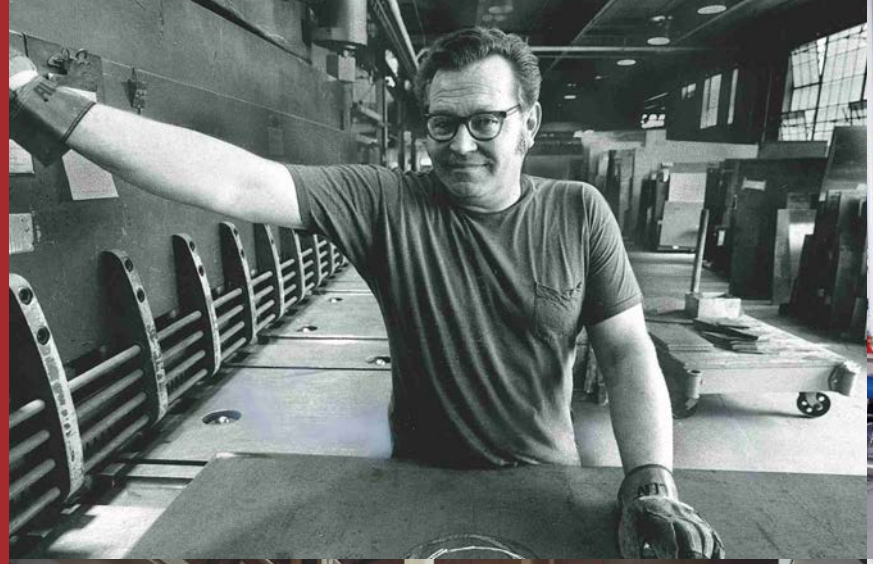
1908 Komarek Greaves established in Chicago, IL

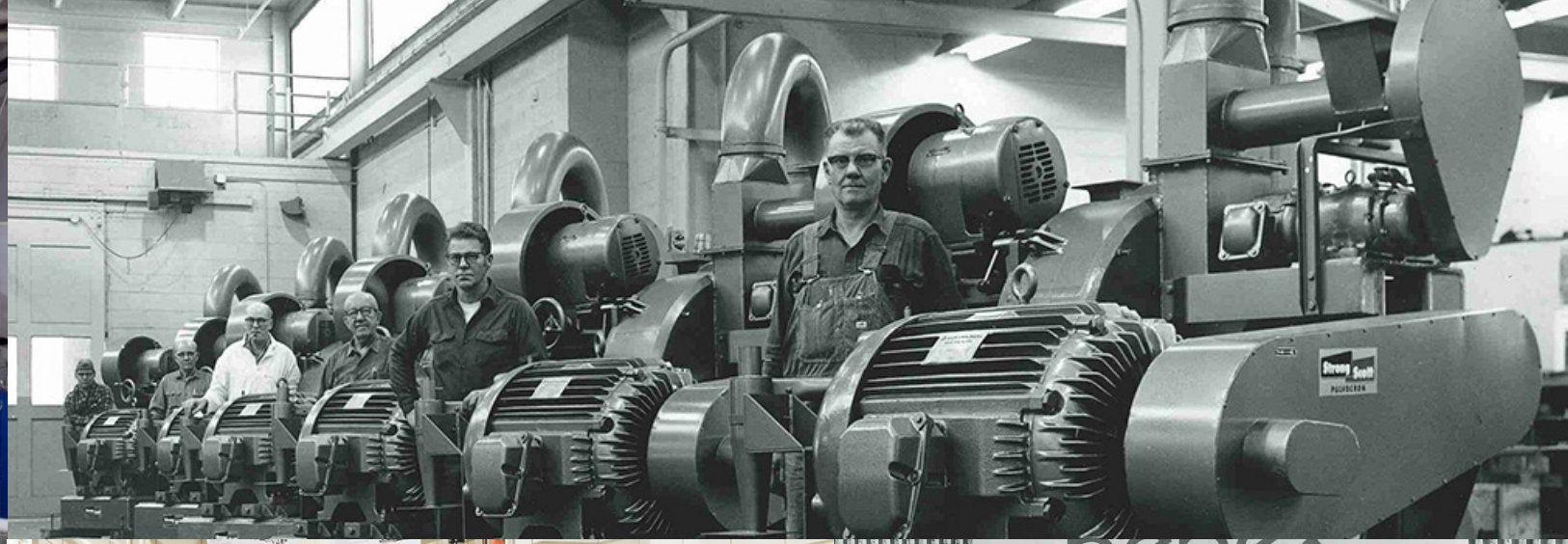
1933 Rietz Manufacturing established in Santa Rosa, CA

1975 Bepex Corporation formed by the merger of Strong Scott, Komarek Greaves, and Rietz

1992 Hosokawa Micron Group purchases Bepex Corporation

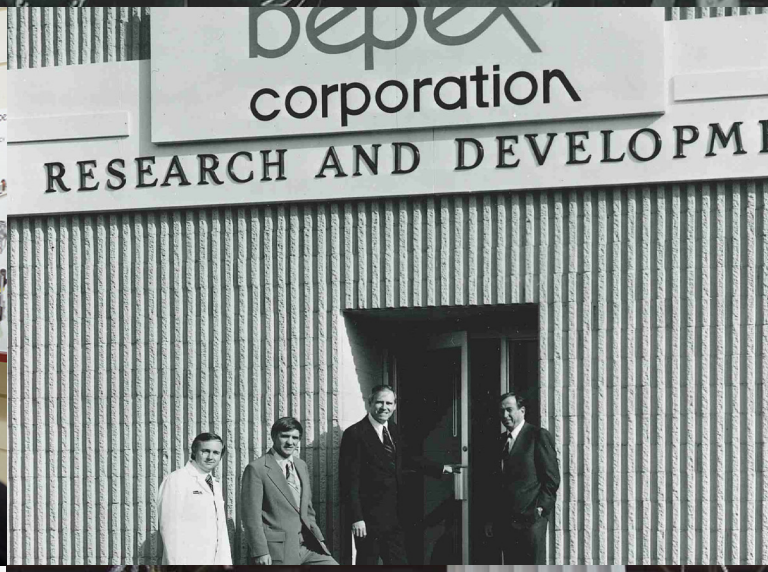
2004 A group of senior managers involved in the day-to-day operation purchases Bepex back from Hosokawa, establishing Bepex International.




Strong Scott


RD-8
SINTEGRATOR
TENTS
NDING


Bepex
SOLVENT RECOVERY
PULVOCRON SYSTEM


bepex
corporation
RESEARCH AND DEVELOPME

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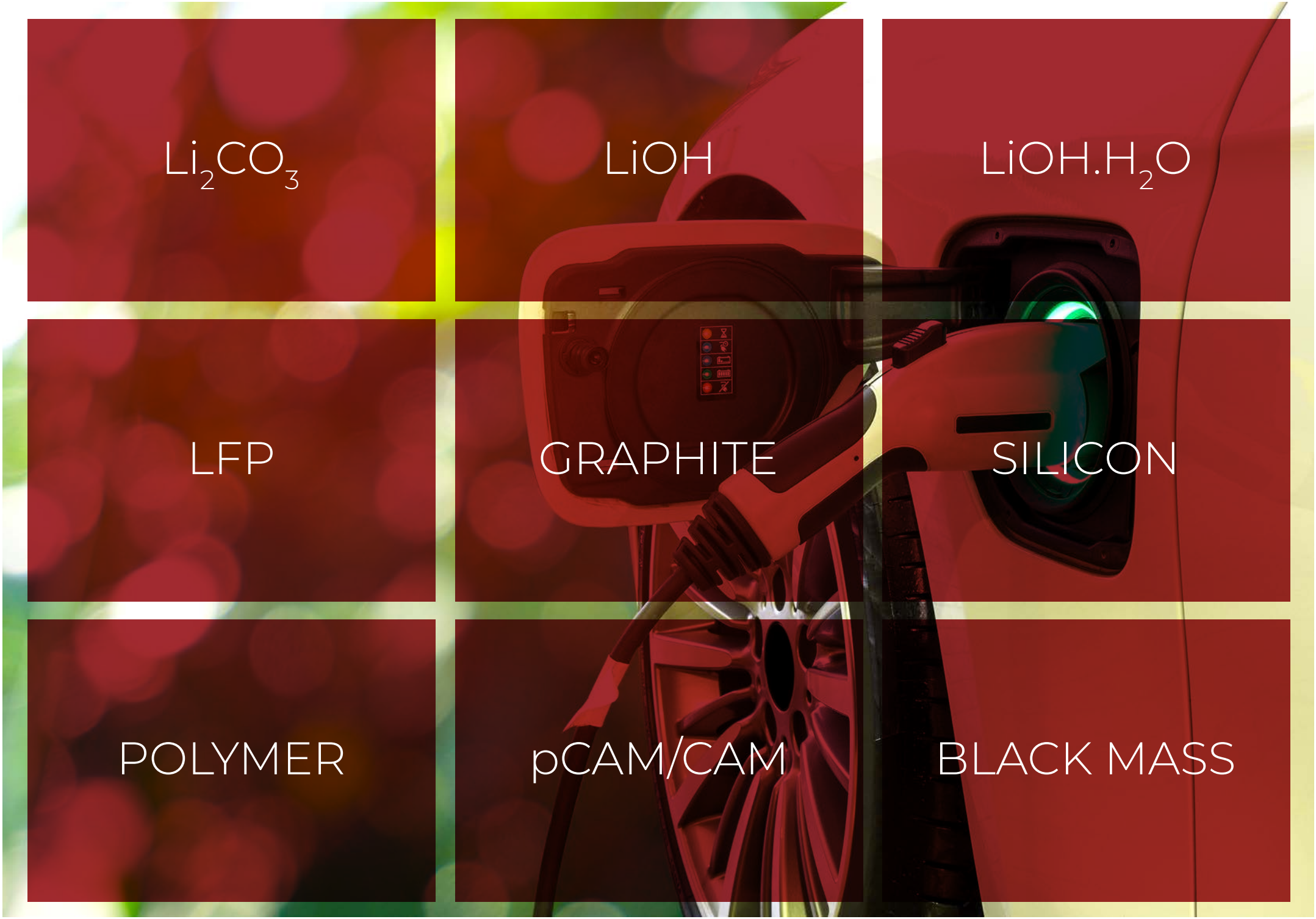
Solutions for Advanced Materials

Bepex has experience in developing, testing, and commercializing various chemistries and materials, both in raw material processing and in recovering critical minerals in recycling.

We partner with manufacturers early in product and process development, marrying the two to design the most appropriate commercial solution for each application.

Key Technologies & Processes

- Direct flash drying and micronizing of wet cake materials from a filter press or centrifuge.
- Indirect inert drying, solvent recovery, and heating using electric elements.
- Indirect cooling following high-temperature drying or calcining
- High-shear mixing with optional heating
- Densification of fine powders into granules or briquettes, either for efficient transportation or downstream processing.
- Micronizing to produce fine (3-5µm) battery-grade material

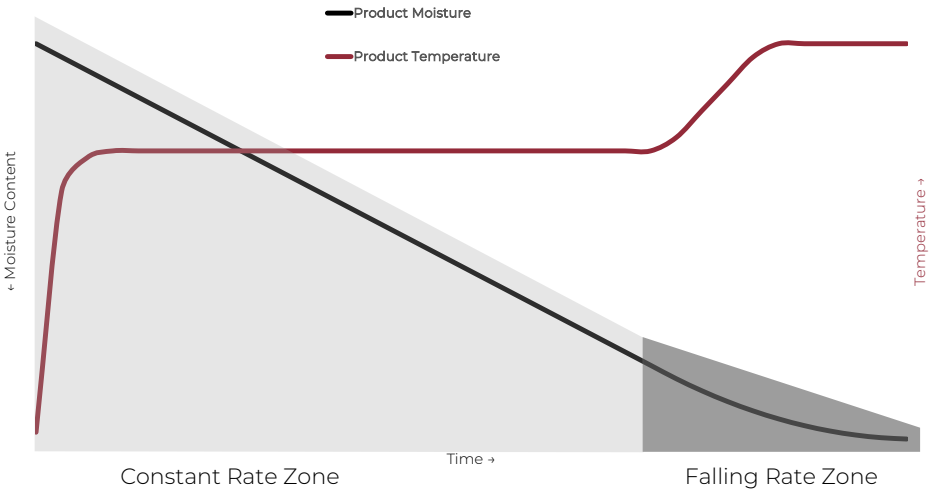

Li_2CO_3
LiOH
$LiOH.H_2O$
LFP
GRAPHITE
SILICON
POLYMER
pCAM/CAM
BLACK MASS

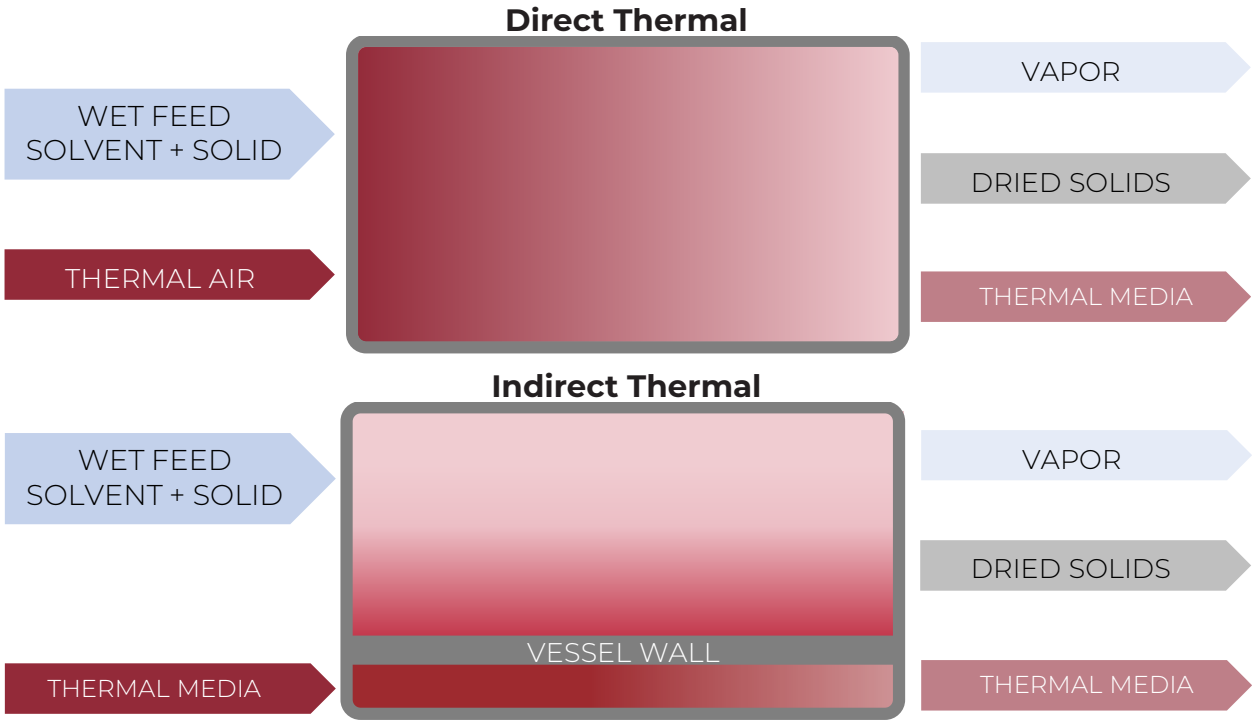
Battery Industry

Thermal Technologies

7 Unique Thermal Technologies

- Indirect Thermal Technologies
  - Heating via steam, hot oil, or partial or full electric design
- Direct Thermal Technologies
  - Heating via burner or indirect heat exchanger
- Operate atmospheric, inert, under vacuum, or at pressure
- Capable of heating or cooling, from -10°C to 800°C
- Residence times ranging from 10 minutes to multiple days



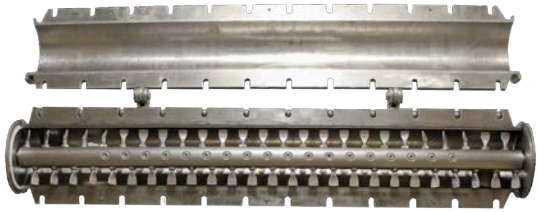


FACTORS FOR IMPLEMENTATION

- Used primarily when water is the solvent
- Capable of higher evaporation rates
- Able to combine drying and micronizing
- Higher gas flows make inerting difficult
- Evaporative cooling lowers product temperature
- Lower CAPEX / Higher Opex

- For special environments (inert, vacuum, pressure)
- Higher thermal efficiency than direct
- Used when the solvent is a volatile
- Capable of recovering solvent
- Smaller gas flow reduces emissions treatment
- Higher CAPEX / Lower OPEX

PCX
Dispersion Flash Dryer



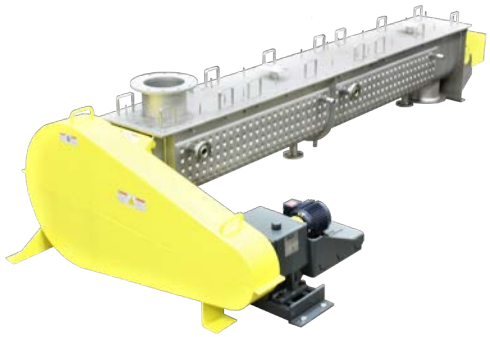
SOLIDAIRE
Thin-Layer Paddle Dryer

TORUSDISC
Bed-Level Paddle Dryer

Fluid Bed
Stationary Fluid Bed Dryer

HOPPER DRYER
Long-Residence Dryer

CONTINUATOR
Pressure Reactor



THERMASCREW
Gentle Thermal Screw

Key Technologies & Processes

- PCX | Direct flash drying and micronizing of wet cake materials from a filter press
- SOLIDAIRE | Fully electric indirect inert drying, solvent recovery, and heating
- SOLIDAIRE | Indirect rapid cooling following high-temperature drying or calcining

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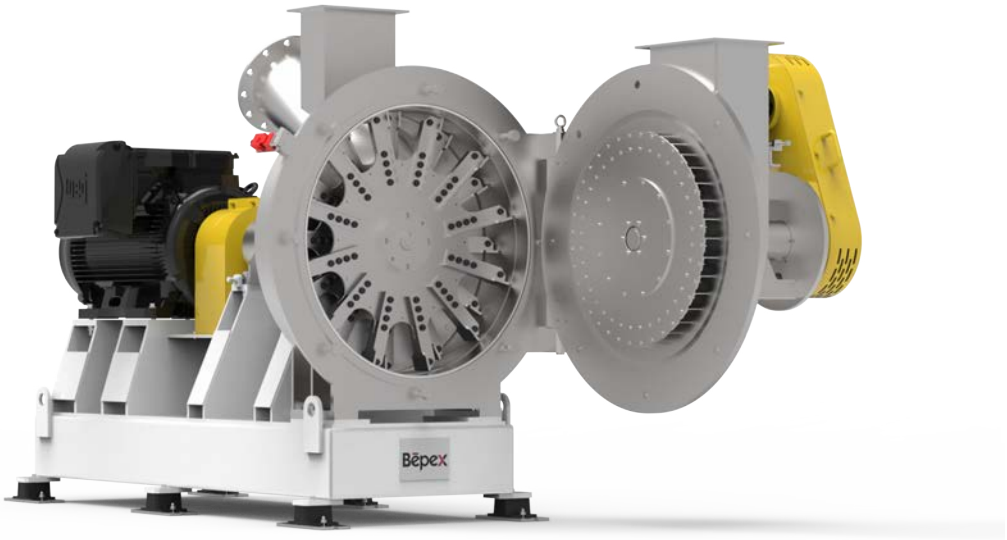
PCX | Dispersion Flash Dryer

- Dry, and optionally micronize, wet cakes from filter presses or centrifuges
  - Proprietary Wet Cake Feeder design for tough-to-convey solids
- High-speed dispersion plates increase drying efficiency
- Capable of fine milling to d(50) of 3-5µm
- Direct contact between hot process air/gas and wet solids
- Process air/gas heated via burner or indirect heat exchanger



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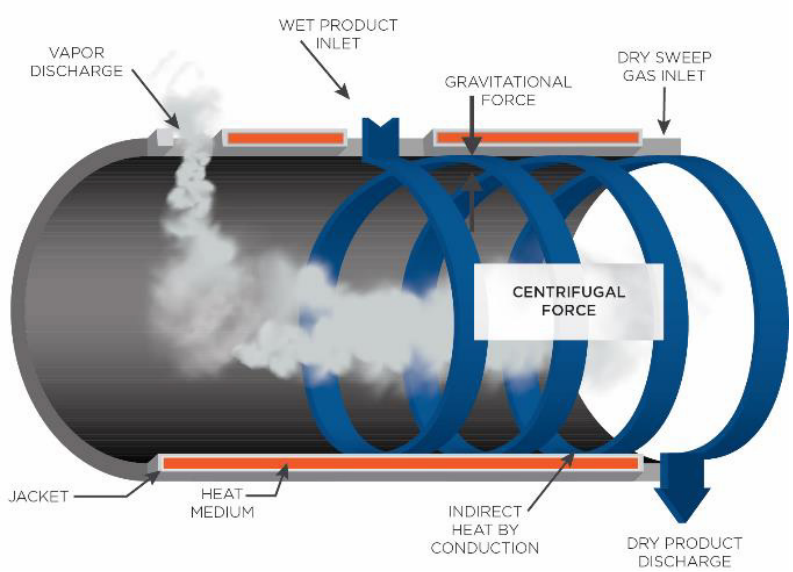
SOLIDAIRE | Thin-Layer Paddle Dryer

- Thin working layer delivers the most efficient heat transfer available
- Heat media options include steam, hot oil, or fully electric heating
- Capable of rapid indirect cooling of solids with chilled glycol or water
- Operate under an inert environment, vacuum, or pressurized states
- Strict control over temperature and residence time
- No backmixing and quick reaction to process changes



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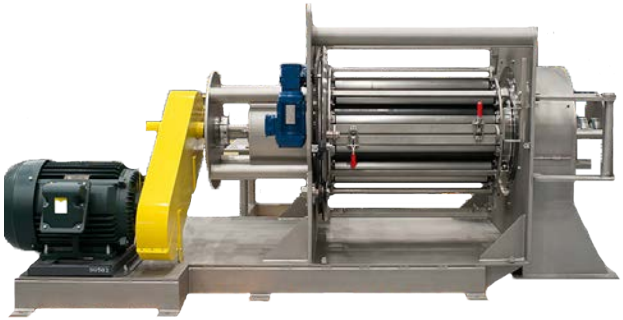
Mixing & Agglomeration Technologies

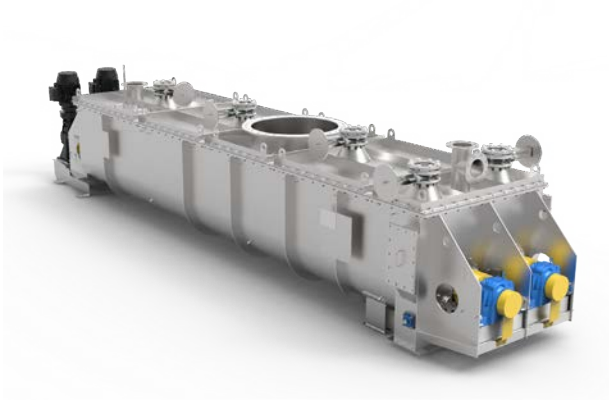
6 Unique Mixing & Agglomeration Technologies

- Wet Mixing and Agglomeration
  - Processing solids and liquids, or multiple liquids via agitation, variable shear, and extrusion.
- Dry Mixing and Agglomeration
  - Densifying, granulating, or briquetting dry powders via pressure, or mixing dry powders.
- Some technologies are capable of heating or cooling material while processing
- Able to produce discrete particles from 100 mesh to 5-inches
- Complimentary upstream and downstream process technologies

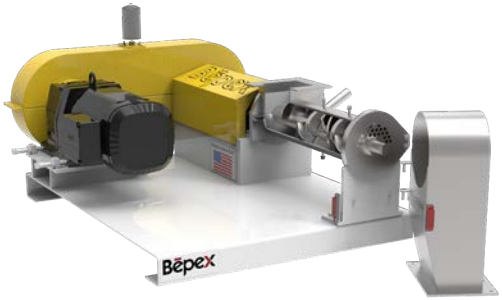
TURBULIZER
High-Shear Paddle Mixer



FLEXTURBULIZER
Self-Cleaning Paddle Mixer



HYDRAMIX
Twin-Rotor Paddle Mixer



EXTRUD-O-MIX
Low-Pressure Mixing Extruder

TURBOFLEX
Vertical Instant Mixer

ROLL COMPACTOR
High-Pressure Roll Press

Key Technologies & Processes

- TURBULIZER | High-shear mixing with optional simultaneous heating
- ROLL COMPACTOR | Densification of fine powders in granulation or briquetting

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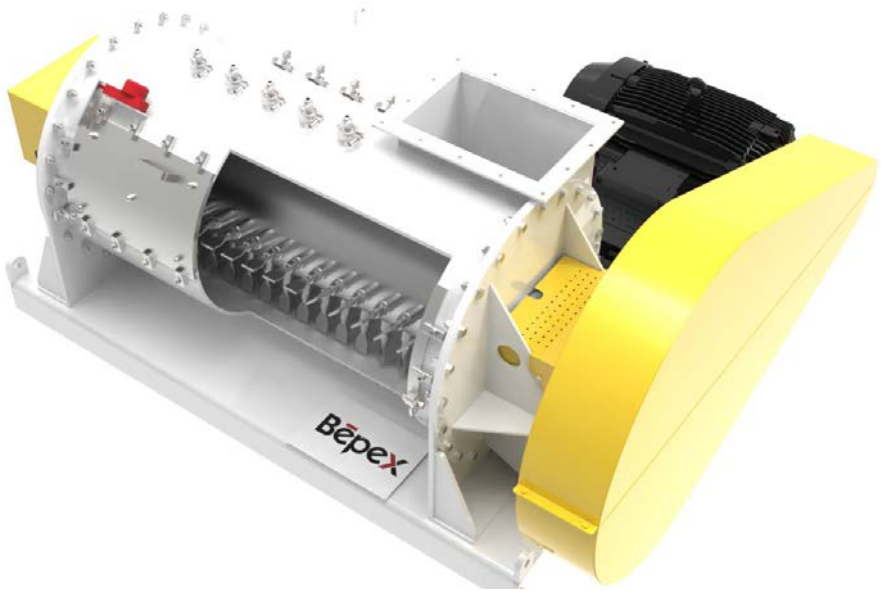
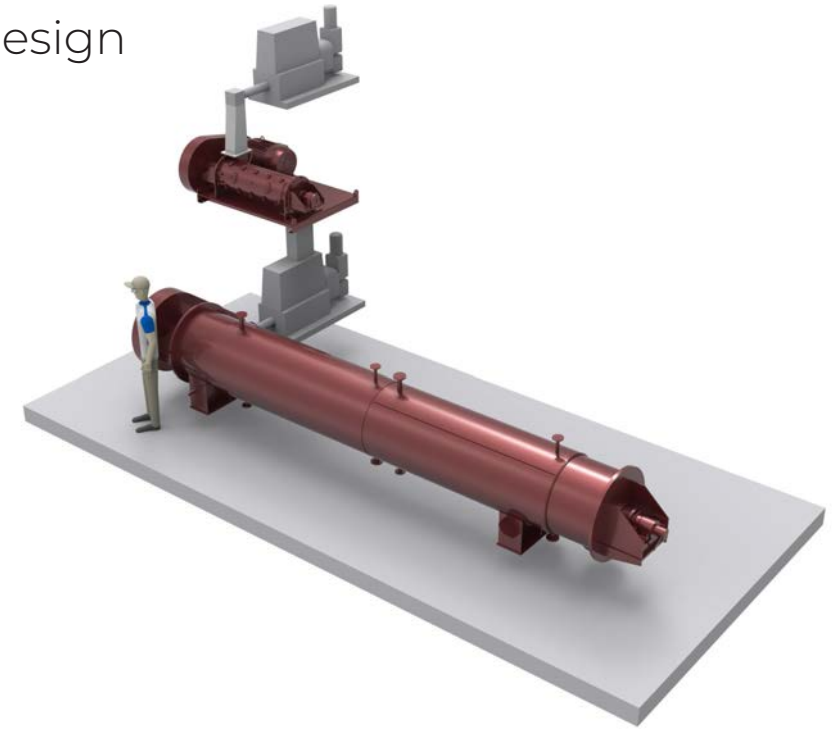
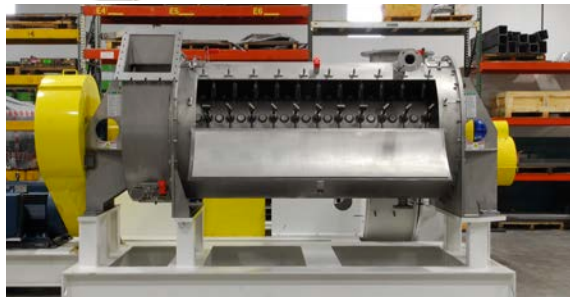
TURBULIZER | High-Shear Paddle Mixer

- Continuous paddle mixer for high-shear mixing or agglomeration.
- High-shear produces controlled and consistent mixing and particle growth
- Adjustable paddles provide strict control over residence time and shear
- Capable of heating or cooling the vessel to control material temperature
  - Heating possible via hot oil, steam, or electric design
- Optional split-body design for easy cleanout







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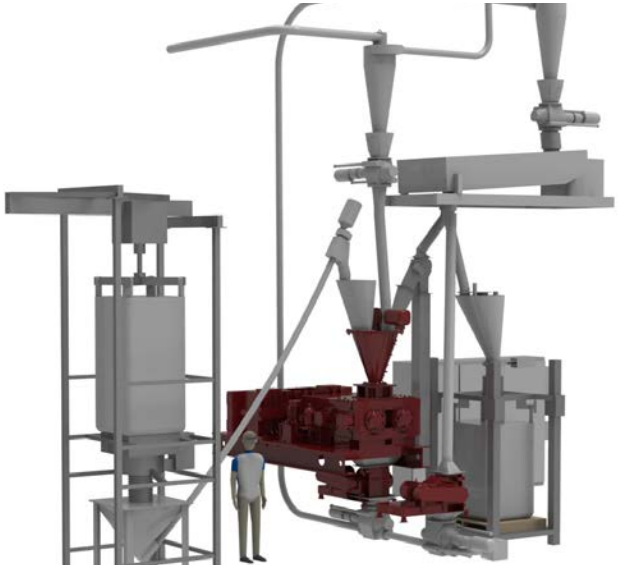
ROLL COMPACTOR | High-Pressure Densifier

- High-pressure roll press for densifying fine powders to granules or briquettes.
- Densify fine powders up to 10x, improving handling, transportation, and dusting.
- Variety of pocket designs and MOCs to design for specific applications.
- Optional gas-tight design available to operate an inert environment.
- Proprietary milling technologies for high-yield granulation.
- Up- and downstream thermal and mixing technologies for process development.



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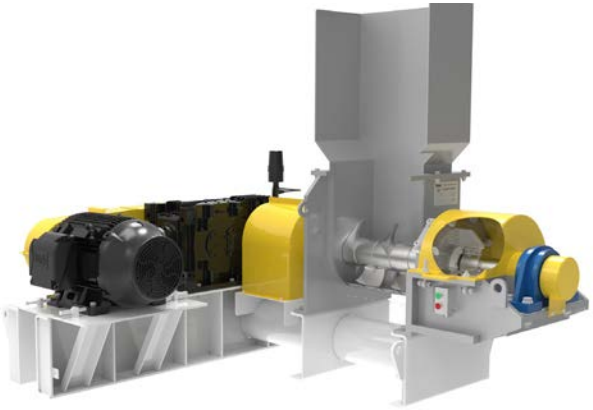
Size Reduction Technologies

7 Unique Size Reduction Technologies

- From fine grinding/micronizing to large bale reduction
- Technologies suitable for wet or dry milling
- Some technologies are capable of heating or cooling material while processing
- Applications include micronizing, coarse grinding, bale grinding, and delumping
- Customized wear elements to meet high purity standards in battery materials

PULVOCRON
Air Classifying Mill

GRANULATOR
High-Yield Granulating Mill



RUBBER CHOPPER
Rubber Bale Grinder

RP DISINTEGRATOR
Angled Hammer Mill

RI DISINTEGRATOR
Inline Wet Mill & Delumper

RD DISINTEGRATOR
Hammer Mill With Separation

Key Technologies & Processes

- PULVOCRON | Micronizing and optionally drying to a d(50) of 3 µm.
- RI DISINTEGRATOR | Inline wet milling or delumping to homogenize a slurry.
- GRANULATOR | High-yield mill in compaction granulation system.

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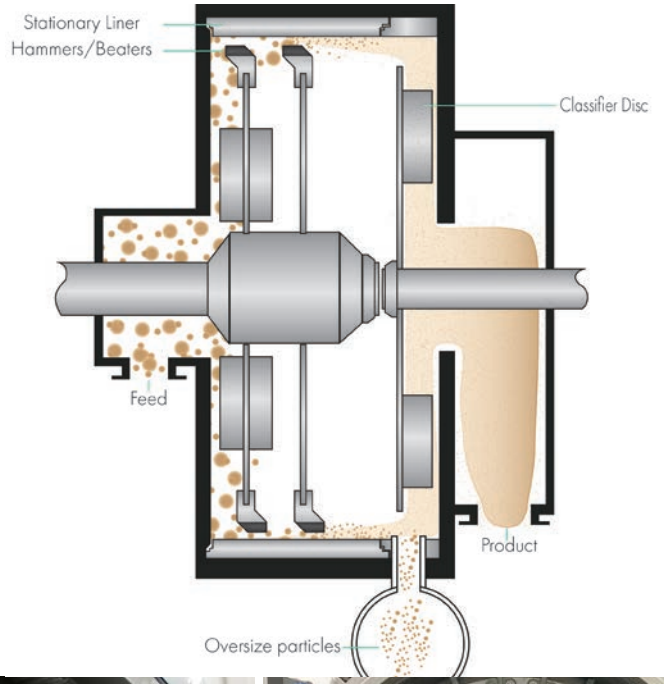
PULVOCRON | Air Classifying Mill

- High-speed impact mill to achieve down to a d(50) of 3-5µm
- Independent control of mill and classifier speeds, resulting in narrow PSD
- Forced vortex dynamic classifier for in-line sizing
- Optional heating or cooling of process air for simultaneous drying or cooling
- Wear resistant designs and components to maintain strict purity requirements



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PROCESS DEVELOPMENT AND DESIGN

1 With new materials or chemistries, we typically begin with a bench-scale feasibility analysis. These studies allow our team to run small tests to determine potential operation and develop a preliminary estimation for a viable commercial process.

2 In our Process Development Center in Minneapolis, MN USA, we put together custom systems to demonstrate pilot scale operation for your process. This helps you derisk your path to a solution while providing us scale-up data to provide a process guarantee on a commercial system.

3 Once we are awarded a purchase order for new equipment and systems, we begin custom engineering our equipment for each application. This includes design, fabrication, assembly, and testing. On systems, this includes PFD, P&ID, stack-ups, safety, and operational criteria.

4 Once equipment is installed, our engineers will come onsite to perform a mechanical checkout, followed by true system commissioning. We provide dedicated onsite support until the process guarantee is achieved, and your operations team is comfortable taking over.

Bēpex

THE MATERIAL TRANSFORMATION PEOPLE™

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