Processtechnology for Battery Applications

One Step ahead with us!
Lithium ion batteries store and supply electrical energy in mobile telephones, laptops and tools. Electrical vehicles, such as bicycles, scooters and other hybrid concepts are also creating a steadily rising demand for batteries.

The goal is to develop ever more powerful batteries that feature increased capacity, a longer lifetime, shorter charging times, lower weight and size. Lithium ion batteries are basically comprised of a negative electrode (anode), a positive electrode (cathode) and a separator membrane. The individual electrodes are made up of conductor foils that are coated with a mixture of binders, active materials and additives (battery slurries).

In addition to the mechanical and thermal resistance of the separators, the key factors for the quality and safety of the batteries are the chemical composition, the shape and particle size distribution of the active materials, the homogeneity and the absence of defects in the coatings on the conductor foils of the electrodes. Based on many years of experience, NETZSCH offers an extensive portfolio of machines and equipment for dry and wet grinding, mixing, homogenization, dispersion, delamination, separation and deaeration, as well as analysis.

Trust NETZSCH Solutions for Battery Materials

Proven Excellence.
One option for the synthesis of cathode and anode materials is the so-called solid-state process. In this process route, the active material is created from the raw materials through a chemical transformation in suitable furnaces. Depending on the raw materials used, a wet grinding stage with dry pre-grinding processes can be required for the raw materials prior to the synthesis.

The CGS and s-Jet® fluidized bed jet mills can be used for the dry grinding. For the wet grinding, the Zeta®, Neos or Zeta® RS agitator bead mills are used, depending on the required target fineness. Synthesis via a furnace process can result in the formation of undesired agglomerates. In order to separate these, a dry dispersion with a CSM classifier mill is usually carried out after the synthesis furnace, without change of the original size and shape of primary particles.

Typical compounds for cathode materials are:
- LCO (Lithium Cobalt Oxide, LiCoO₂)
- NCA (Lithium Nickel Cobalt Aluminum Oxide, LiNiCoAlO₂)
- NCM (Lithium Nickel Manganese Cobalt Oxide, Li[NiCoMn]O₂)
- LMO (Lithium Manganese Oxide, LiMn₂O₄)
- LFP (Lithium Iron Phosphate, LiFePO₄)

Some examples of active materials for anodes are:
- Amorphous Carbon
- Graphite
- Lithium Titanate (LTO, Li₄Ti₅O₁₂)
- Metallic Anode Materials (Silicon, Tin)

The conductor foil is usually made of aluminum.
APPLICATION TASKS, which we have successfully mastered

**DRY PROCESSING**

<table>
<thead>
<tr>
<th>Product</th>
<th>Machine</th>
<th>Working capacity [kg\text{solid}/h]</th>
<th>Fineness [μm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lithium Cobalt Oxide (LCO)</td>
<td>CSM 165</td>
<td>250 - 350</td>
<td>$d_{50} = 10 - 12$</td>
</tr>
<tr>
<td>Lithium NiCoMn Oxide (NCM)</td>
<td>CSM 165</td>
<td>250 - 350</td>
<td>$d_{50} = 10 - 12$</td>
</tr>
<tr>
<td>Lithium NiCoMn Oxide (NCM)</td>
<td>CSM 260</td>
<td>400 - 450</td>
<td>$d_{50} = 4 - 5$</td>
</tr>
<tr>
<td>Lithium Iron Phosphate (LFP)</td>
<td>CGS 71</td>
<td>1000</td>
<td>$d_{50} = 1$</td>
</tr>
<tr>
<td>Pitch Cokes</td>
<td>CGS 16</td>
<td>5 - 10</td>
<td>$d_{50} = 5$</td>
</tr>
<tr>
<td>Artificial Graphite</td>
<td>CGS 16</td>
<td>4</td>
<td>$d_{50} = 5$</td>
</tr>
</tbody>
</table>

Working capacity depends on required fineness and product characteristics.

**WET PROCESSING**

<table>
<thead>
<tr>
<th>Product</th>
<th>Machine</th>
<th>Working capacity [kg\text{solid}/h]</th>
<th>Fineness [μm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lithium Manganese Oxide (LMO)</td>
<td>$\text{ALPHA ZETA}^\text{®} 25$</td>
<td>110</td>
<td>$d_{50} = 0.15$</td>
</tr>
<tr>
<td>Lithium Iron Phosphate (LFP)</td>
<td>$\text{NEOS} 150$</td>
<td>200 - 300</td>
<td>$d_{50} &lt; 0.2 - 0.4$</td>
</tr>
<tr>
<td>Lithium Titanate (LTO)</td>
<td>$\text{ALPHA ZETA}^\text{®} 25$</td>
<td>20</td>
<td>$d_{50} = 0.10$</td>
</tr>
<tr>
<td>Metal Silicon</td>
<td>$\text{ZETA}^\text{®} 25 + \text{ZETA}^\text{®} RS 60$</td>
<td>3 - 4.5</td>
<td>$d_{50} = 0.09$</td>
</tr>
</tbody>
</table>

Working capacity depends on required fineness and product characteristics.
In order to prevent an internal short-circuit in the cells, a separator is inserted between the electrodes. The separators, which are typically made of polymer (e.g. PE, PP), are perforated to allow the ions to pass through.

For increased thermal stability and the prevention of shrinkage, so-called inorganic composite separators (ceramic-coated foils) are more and more used.

The ceramic suspensions used here typically have particle sizes in the submicron range. Wet mills, such as the Discus, Zeta®, Neos or the Zeta® RS are used for the production of these coating systems.
### APPLICATION TASKS,
which we have successfully mastered

**WET PROCESSING**

<table>
<thead>
<tr>
<th>Product</th>
<th>Machine</th>
<th>Working capacity [kg\text{slurry}/h]</th>
<th>Fineness [\text{μm}]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alumina (Al\textsubscript{2}O\textsubscript{3})</td>
<td>\textit{ALPHA ZETA} ® 10</td>
<td>50</td>
<td>(d_{95} = 1.0)</td>
</tr>
<tr>
<td>Alumina (Al\textsubscript{2}O\textsubscript{3})</td>
<td>\textit{ALPHA DISCUS} 20</td>
<td>580</td>
<td>(d_{50} \leq 1.0)</td>
</tr>
</tbody>
</table>

Working capacity depends on required fineness and product characteristics.
The majority of active materials are in the electrode with limited electrical conductivity additionally the polymer matrix in the electrode needs to be electrical conductive. That is why additives are used also to reduce the required charging time of the battery when being added to the battery slurries. Here it is primarily the carbon-based raw materials that are used, such as carbon black, graphite and carbon nano tubes (CNTs), which should be characterized by the highest possible aspect ratio.

The materials must first be carefully dispersed or delaminated in preliminary stages. Here the size of the primary particles, the properties of the bulk solids and the purity requirements usually present particular challenges, which NETZSCH solves with the EPSILON, OMEGA® and the s-JET®.

Battery Slurries

PMH/ PML planetary mixers have established themselves as state of the art for the production of so-called battery slurries.

With PMH/ PML planetary mixers a combination of different processes like dissolution of binders, the premixing and the alloying of the dry components, the mixing, kneading and homogenization as well as the degassing of the high viscose pasty slurries can be realized with an excellent temperature control.

However, depending on the material system used, the binder can also be dissolved first and very gently mixed after addition of the active materials. To prevent defects in the coating due to gas inclusions, the mixing process is typically carried out under a vacuum. This way, pockets of air that have entered via the raw materials can be removed from the product.

The key aspects for selection of the PMH/ PML planetary mixer are the excellent temperature control and the broad viscosity range for which this machine is suited.
APPLICATION TASKS, which we have successfully mastered

WET PROCESSING

<table>
<thead>
<tr>
<th>Product</th>
<th>Machine</th>
<th>Working capacity [kg slurry/h]</th>
<th>Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>MWCNTs in NMP</td>
<td>OMEGA® 500</td>
<td>50</td>
<td>Pass operation</td>
</tr>
<tr>
<td>SWCNTs in Water</td>
<td>OMEGA® 500</td>
<td>15</td>
<td>Re-circulation operation</td>
</tr>
<tr>
<td>SWCNTs in Water</td>
<td>OMEGA® 500</td>
<td>25</td>
<td>Re-circulation operation</td>
</tr>
<tr>
<td>SWCNTs in NMP</td>
<td>OMEGA® 500</td>
<td>25</td>
<td>Re-circulation operation</td>
</tr>
<tr>
<td>Acetylene black in Water</td>
<td>OMEGA® 500</td>
<td>90</td>
<td>Pass operation</td>
</tr>
<tr>
<td>Acetylene black in NMP</td>
<td>OMEGA® 500</td>
<td>90</td>
<td>Pass operation</td>
</tr>
</tbody>
</table>

Working capacity depends on required fineness and product characteristics.
The NETZSCH Business Unit Grinding & Dispersing offers an extensive machine program for process-engineering, providing solutions for wet and dry grinding, mixing, dispersing and deaeration. Long-term experience, consistent development work, daily contact with our customers and developments with more than 100 patents ensure our technical competence and further attest to our quality-consciousness.

The bundling of process-engineering expertise and the extensive machine program, ranging from laboratory to production machines to complete production lines, is unique worldwide. Whether for dry or wet preparation, we offer the best machine solution, customized to suit to your particular application.

<table>
<thead>
<tr>
<th><strong>ANODE &amp; CATHODE MATERIALS</strong></th>
<th><strong>SEPARATORS</strong></th>
<th><strong>CONDUCTIVE ADDITIVES &amp; BATTERY SLURRIES</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>OMEGA® Dispersionizer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PMH / PML Planetary Mixing &amp; Kneading Machines</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EPSILON Inline Disperser</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Wet Grinding</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>ALPHA® Lab Laboratory Mill</td>
</tr>
<tr>
<td>ALPHA® DISCUS® Agitator Bead Mill</td>
</tr>
<tr>
<td>ALPHA® ZETA® Agitator Bead Mill</td>
</tr>
<tr>
<td>ALPHA® NEOS Agitator Bead Mill</td>
</tr>
<tr>
<td>ZETA® RS Nano Mill</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Dry Grinding</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>CSM CERAMIC Classifier Mill</td>
</tr>
<tr>
<td>S-JET® Steam Jet Mill</td>
</tr>
<tr>
<td>CGS Fluidized Bed Jet Mill</td>
</tr>
</tbody>
</table>

NETZSCH Technologies in Li-ion Batteries
Production Process

Mixing and Dispersing Technologies

The aim of dispersing and mixing for material preparation
- Producing a homogeneous distribution of a fine disperse phase
- Easy mixing and dispersing in an enclosed, emission-free and time-saving process

Your benefit of high quality dispersing and mixing
- Slurry preparation without grinding media
- Homogeneous mixing process for improved product quality

Possible machines
- Economic Dispersionizer OMEGA®
- Inline-Disperser EPSILON
- Planetary Mixer PMH/PML

Wet Grinding Technologies

The aim of wet milling for material preparation
- Creating a large specific surface
- Homogeneous mixing of the individual raw material components
- Producing a narrow particle size distribution

Your benefit of high quality wet milling
- Control diffusivity in the furnace process
- Avoid unreacted raw materials after synthesis
- Exact scale-up from laboratory to production-sized machines
- High reproducibility

Possible machines
- Agitator bead mill DISCUS for pre-grinding
- High Efficiency Mill ZETA® and NEOs for fine grinding down to sub-micron
- Nano Mill ZETA® RS for super fine grinding down to nano range

Dry Grinding Technologies

The aim of dry milling for material preparation
- Producing a narrow particle size distribution with exact verification of the upper particle size of the product

Your benefit of high quality dry milling
- Metal-free grinding process
- Exact scale-up from laboratory to production-sized machines
- High reproducibility

Possible machines
- Classifier Mill CSM CERAMIC
- Steam Jet Mill s-Jet®
- Fluidized Bed Jet Mill CGS
NETZSCH Technologies in Li-ion Batteries
We offer a Tailored Solution for Every Specific Product Requirement

Mixing and Wet Grinding Process
Heat Treatment, Chemical Processing
Wet Grinding and Deagglomeration
Dry Grinding and Deagglomeration including Classification
Active Material
Drying
Lithium Source
Precursor

- Agitator Bead Mill \textit{Alpha}®\textit{Discus}
- Agitator Bead Mill \textit{Alpha}®\textit{Zeta®}
- Classifier Mill CSM \textit{Ceramic}
- Fluidized Bed Jet Mill CGS
- Steam Jet Mill \textit{s-Jet}®
- Nano Mill \textit{Zeta® NS}
- Agitator Bead Mill \textit{Alpha}®\textit{Zeta®}

NETZSCH Technologies in Li-ion Batteries Production Process
Production Process
Every Specific Product Requirement
NETZSCH Technologies in Li-ion Batteries

Agitator Bead Mill Alpha® Discus

Our technology
- Horizontal agitator bead mill with TetraNex® disk grinding system
- Activation of the grinding media with high intensity through the entire grinding chamber by the disk agitator shaft
- Use of grinding media from approx. 0.5 mm to 5.0 mm

Your benefit
- Optimum grinding chamber material – normally ceramics or wear-resistant polymers – for requirement of LIB
- The grinding media are evenly distributed in the grinding chamber and intensively activated by the optimal designed TetraNex® grinding disks
- Grinding media separation system (DCC) with classifying rotor for the safe use of very small grinding media even with highly viscous products

Applications
- Pre-grinding of
  - Lithium NiCoMn Oxide (NCM)
  - Lithium Manganese Oxide (LMO)
  - Lithium Iron Phosphate (LFP)
  - Lithium Titanate (LTO)
  - Metal silicon

- Pre- and fine-grinding of
  - Ceramic material for separator coating
Agitator Bead Mill \textit{ALPHA® ZETA®}

Our technology
- Agitator bead mill with peg grinding system with optimized volume specific power density
- Use of grinding media down to 0.2 mm
- Highest productivity

Your benefit
- Optimum grinding chamber material – normally ceramics or wear-resistant polymers – for requirement of LIB
- Highly efficient centrifugal separation system for a safe production
- Highest productivity at lowest specific energy
- Control of particle size distribution by setting of process parameters
- Simple process control and excellent reproducibility
- Easy operation with high degree of automization
- Optimized temperature control
- Different machine sizes available – exact scale-up and optimal adaption to your requirements
- Excellent cooling efficiency

Applications
- Fine-grinding of
  - Lithium NiCoMn Oxide (NCM)
  - Lithium Manganese Oxide (LMO)
  - Lithium Iron Phosphate (LFP)
  - Lithium Titanate (LTO)
  - Metal silicon
  - Ceramic material for separator coating

![LiFePO₄ – Feed material](image1)

![LiFePO₄ – after grinding](image2)
NETZSCH Technologies in Li-ion Batteries

Proven Wet Grinding Technology for New Products in the Nanometer Range

Nano Mill \textit{ZETA}\textsuperscript{®} \textit{RS}

Our technology

- Further development of system \textit{ZETA}\textsuperscript{®}
- Designed for the use of grinding media from 0.03 mm to 0.3 mm
- Easy handling

Your benefit

- Optimum grinding chamber material – normally ceramics or wear-resistant polymers – for requirement of LIB
- Highly efficient dynamic centrifugal separation system
- No screen blocking due to \textit{Open Dynamic Classifying system (ODC)} or \textit{Separate driven open Dynamic Classifying system (SDC)}
- Highest productivity at lowest specific energy
- Use of smallest grinding media for the production of finest end products at lowest specific energy demand

Applications

- Super fine-grinding of
  - Lithium Iron Phosphate (LFP)
  - Metal Silicon

Metal silicon – Feed material

Metal silicon – after grinding
## Production Process

### Dry Grinding Technologies

#### Classifier Mill CSM CERAMIC

<table>
<thead>
<tr>
<th>Our technology</th>
<th>Your benefit</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combination of a mechanical impact mill with an integrated dynamic air classifier for a steep particle size distribution</td>
<td>Highest product quality without metal contamination</td>
<td>Lithium Cobalt Oxide (LCO)</td>
</tr>
<tr>
<td>Latest classifier technology with vertical classifier wheel and exchangeable, simultaneously rotating immersion tube</td>
<td>Easy control of moisture content</td>
<td>Lithium NiCoMn Oxide (NCM)</td>
</tr>
<tr>
<td>Closed-loop system to prevent moisture content</td>
<td>Minimal warming of product due to the controlled gas stream</td>
<td>Lithium NiCoAl Oxide (NCA)</td>
</tr>
<tr>
<td>Completely wear protected</td>
<td>Steep particle size distributions with exact verification of upper particle size of product</td>
<td>Graphite</td>
</tr>
<tr>
<td></td>
<td>Load can be set exactly to suit the requirements of the product (variable speed), to achieve highest finenesses, unlimited adjustment</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reproducible results</td>
<td></td>
</tr>
</tbody>
</table>

![Image of Classifier Mill CSM CERAMIC](image1.png)

![Image of NCM after grinding](image2.png)

![Image of NCA after grinding](image3.png)

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**NETZSCH Technologies in Li-ion Batteries Production Process**
NETZSCH Technologies in Li-ion Batteries

Fluidized Bed Jet Mill CGS

Our technology
- Combination of an air jet mill with a dynamic air classifier
- Patented integrated classifier design
- Entirely autogenous grinding
- Grinding with cold gas
- Hot gas up to 250°C
- Inert gas
- Various construction materials available including wear protection

Your benefit
- Metal-free grinding process: grinding by particle – particle impact, no contamination
- Precise control of the fineness through integrated dynamic air classifier
- Significantly lower compressor capacity as opposed to comparable jet mills (ε-Jet*)
- Highest finenesses and maximum throughput achievable with just one classifier wheel
- Close and steep particle size distribution

Applications
- Lithium Cobalt Oxide (LCO)
- Lithium NiCoMn Oxide (NCM)
- Lithium NiCoAl Oxide (NCA)
- Lithium Manganese Oxide (LMO)
- Lithium Iron Phosphate (LFP)
- Lithium Titanate (LTO)
- Si-alloy
- Metal silicon
- Graphite (Natural, Artificial)
Production Process
Dry Grinding Technologies

Steam Jet Mill *S-JET*®

Our technology
- Jet mill using superheated steam as its milling gas (process gas)
- Highest Fineness (submicron range for dry grinding)
- Double the throughput capacity than air
- Considerably higher efficiency
- Steep particle size distribution
- Process gas temperature > 300°C
- Drying and grinding possible

Your benefit
- Easily control the fineness by classifier wheel
- Metal-free grinding process (autogenous grinding)
- Highest fineness below 1 micron
- Exactly defined maximum particle size through integrated dynamic air classifier
- High energy saving process
- High reproducibility
- Different machine sizes available – optimal adaption to your requirements

Applications
- Carbon Nano Tubes (CNTs)
- Graphite (natural, artificial)

![Steam Jet Mill Image](image-url)
NETZSCH Technologies in Li-ion Batteries

Mixing and Dispersing Technologies

Inline Disperser Epsilon

Our technology
- Unique inline dispersing technology
- Fully equipped for process control and monitoring
- Less wear compared to conventional inline disperser
- Significantly less temperature increase
- Ability for degasing of product

Your benefit
- Best dispersion quality
- Repeatable process
- Reduction of manual influence
- High operational availability

Applications
- Dispersing of
  - Carbon black
  - Carbon Nano Tubes (CNTs)
  - Graphene
  - Electrode slurries
Production Process

Homogeneous Mixing Process for Improved Product Quality

Planetary Mixer and Kneader PMH / PML

Our technology
- Machines operate according to the planetary system
- The mixing elements rotate on a central axis in a fixed tank, with each element simultaneously rotating on its own axis as well
- The double rotary motion of the mixing elements covers the entire mixing zone and guarantees optimal dispersion
- The revolving wall/floor scrapers support the mixing/kneading process while also providing for good heat transfer to the tank wall

Your benefit
- Homogeneous mixing of a wide variety of components
- Vacuum-tight and explosion proof models
- Easily exchangeable mixing tools
- Excellent temperature control
- Broad viscosity range
- Operation under inert gas possible
- High flexibility in product viscosity

Application
- Mixing, homogenization and dearation of electrode slurry
NETZSCH Technologies in Li-ion Batteries

Innovative Dispersion Concept for Slurry Preparation without Grinding Media

Economic Dispersionizer OMEGA®

Our technology

- Machine with the novel NETZSCH Dispersion Device (NDD) that ensures a maximum product quality and reproducible dispersion result by optimal utilization of the factors turbulence, cavitation and shearing forces
- The unique geometry of the NETZSCH Dispersion Device ensures an optimized conversion of the pressure into dispersion forces
- The pressure is generated from piston pump (up to 700 bar)
- After the nozzle module the product being dispersed is accelerated to jet speeds of 200 m/s to 300 m/s

Your benefit

- Easy cleaning and fast product change
- Processing of low to high viscosity products
- Reduced energy consumption compared to standard dispersion technologies
- High efficiency, high productivity
- Easy temperature control
- No metal contamination
- Low wear and long service intervals result in low maintenance costs
- Determination of the dispersion forces by the working pressure (gentle dispersion)
- Minimal operational noise
- Different machine sizes available – exact scale-up and optimal adaption to your requirements

Applications

- Dispersing of conductive material with binder system
- Delamination and dispersing of graphite or FLG (Few Layered Graphene)
- Carbon Nano Tubes (CNTs)

Graphite – Feed material

Graphite – after dispersing
Production Process
Solutions for Plant Engineering
NETZSCH applications laboratories are equipped with state-of-the-art technology and are part of our comprehensive service program.

These laboratories allow us to accurately test customer products in order to obtain the maximum grinding, dispersing and mixing efficiency according to customer specifications for the battery materials. After testing is complete, a comprehensive test report, including a sample of the final product, is prepared and sent to the customer.

Customers are welcome to take part in the testing of their product, guaranteeing that all tests are run exactly according to their requirements. During the trials, customers will also learn more about our company, its manufacturing abilities and staffs.

Wet Grinding and Mixing Laboratory
NETZSCH-Feinmahltechnik GmbH
Selb, Germany (wet processing)

Dry Grinding and Classifying Laboratory
NETZSCH Trockenmahltechnik GmbH
Hanau, Germany (dry processing)

Battery Application Laboratory in Asia
NETZSCH Korea Co., Ltd.
Goyang, Korea (dry and wet processing)
Technical assistance must arrive quickly and work perfectly. That’s why we offer an extraordinary range of services, with the assurance that highly-qualified NETZSCH personnel perform these services all over the world. Our specialists provide quick and reliable assistance. We advise you in your own language, wherever you are.

The NETZSCH service network extends to all corners of the globe. As a result, we strengthen the competitive capacity of our customers, facilitate trouble-free, efficient processes and ensure maximum machine availability.

Our range of services includes

- Procedural commissioning
- Inspection
- Maintenance
- Modifications
- Overhauls
- Process optimization
- Spare parts
Comprehensive Battery Testing Using

Successful Characterization of Battery Components

The energy density and the lifetime of the batteries are strongly related to the type and quality of the materials used.

Areas of Application
- Raw material characterization
- Cell design studies
- Generating input data for mathematical modeling of thermal processes
- Gathering parameters for scale-up
- Developing QC procedures
- Battery recycling

Suitable Thermal Analysis Methods for Material Testing
- Differential scanning calorimetry (DSC) to investigate phase transitions (e.g., melting, crystallization), specific heat or the compatibility between various components
- Multiple Mode Calorimetry (MMC) for isothermal charging / discharging experiments
- Thermogravimetric analysis (TGA) to study the thermal stability
- Simultaneous thermal analysis (STA) as a combination of TGA and DSC
- Evolved gas analysis (EGA), coupled to TGA or STA, for identifying released gases
- Light or laser flash analysis (LFA) to determine thermal diffusivity and thermal conductivity
- Dilatometry or Thermomechanical Analysis (TMA) to investigate expansion/shrinkage
Ingenious Investigation of Complete Batteries or Battery Stacks

For application in daily life, energy storage systems should be mechanically, thermally and electrically stable and safe while providing easy charging and discharging capabilities. Such information can only be obtained by testing entire batteries.

Determination of Potential Hazards

The risk of thermal runaway is still an issue for lithium ion batteries. But worst-case-scenario tests of charged batteries in adiabatic calorimeters can help design inherently safe cells in heat-wait-search mode. The right choice here is the accelerated rate calorimeter (ARC) rate calorimeter ARC for pouch cells, 18650 cells as well as D-cells.

Charging/Discharging Cycles

The number of possible charging/discharging cycles a battery is able to undergo (associated with the remaining capacity) is a clear evidence for its performance and lifetime. Isothermal measurements (in an MMC or ARC) in combination with an external cycler provide heat output data of the battery in normal operation which is essential for the design of an adequate thermal management system.
Business Unit Grinding & Dispersing –
The World’s Leading Grinding Technology

NETZSCH-Feinmahltechnik GmbH
Selb, Germany

NETZSCH Trockenmahltechnik GmbH
Hanau, Germany

NETZSCH Vakumix GmbH
Weyhe-Dreye, Germany

NETZSCH Lohnmahltechnik GmbH
Bobingen, Germany

NETZSCH Mastermix Ltd.
Lichfield, Great Britain

NETZSCH FRÈRES S.A.R.L.
Arpajon, France

NETZSCH España, S.A.U.
Terrassa/Barcelona, Spain

ECUTEC S.L.
Barcelona, Spain

Tramega
Terrassa/Barcelona, Spain

NETZSCH Premier Technologies, LLC.
Exton PA, USA

NETZSCH Indústria e Comércio de Equipamentos
de Moagem Ltda.
Pomerode, Brazil

NETZSCH (Shanghai) Machinery and Instruments Co., Ltd.
Shanghai, China

NETZSCH Technologies India Private Ltd.
Chennai, India

OOO NETZSCH Tula
Tula, Russia

NETZSCH Makine Sanayi ve Ticaret Ltd. Sti.
Izmir, Turkey

NETZSCH Korea Co., Ltd.
Goyang, Korea

The NETZSCH Group is a mid-sized, family-owned German company engaging in the manufacture of machinery and instrumentation with worldwide production, sales, and service branches. The three Business Units – Analyzing & Testing, Grinding & Dispersing and Pumps & Systems – provide tailored solutions for highest-level needs. Over 3,500 employees at 210 sales and production centers in 35 countries across the globe guarantee that expert service is never far from our customers.