LITHIUM-ION BATTERIES

Powder processing systems for optimum battery performance

HOSOKAWA MICRON

HOSOKAWA
MICRON GROUP

Hosokawa Micron Test Centre in the Netherlands

Whether in e-bikes, smartphones or laptops, lithium-ion batteries have become an indispensable part of everyday life. With the planned expansion of electromobility, the importance of these batteries will grow even more in the years to come. Requirements for batteries are constantly increasing. End users want faster charging times, higher storage capacities and a long battery life in general. For manufacturers of batteries and accumulators, batteries should be as small as possible and at the same time have a high energy density. To meet these requirements, the Hosokawa Micron Group provides a variety of technologies that are used in the production of lithium-ion batteries.

- **COMPLETE SOLUTIONS FOR ALL RAW MATERIALS**
- **TWO PROCESSES FROM ONE SINGLE SOURCE FOR CATHODE AND ANODE MATERIAL**
- **EXCELLENT BATTERY PERFORMANCE: CHARGING TIME, STORAGE CAPACITY, SERVICE LIFE**
- **CONTAMINATION-FREE GRINDING**
- **ROUNDING OF GRAPHITE FOR HIGHER STORAGE CAPACITY**

5 TIMES COMPETENCE

Hand in hand for your success

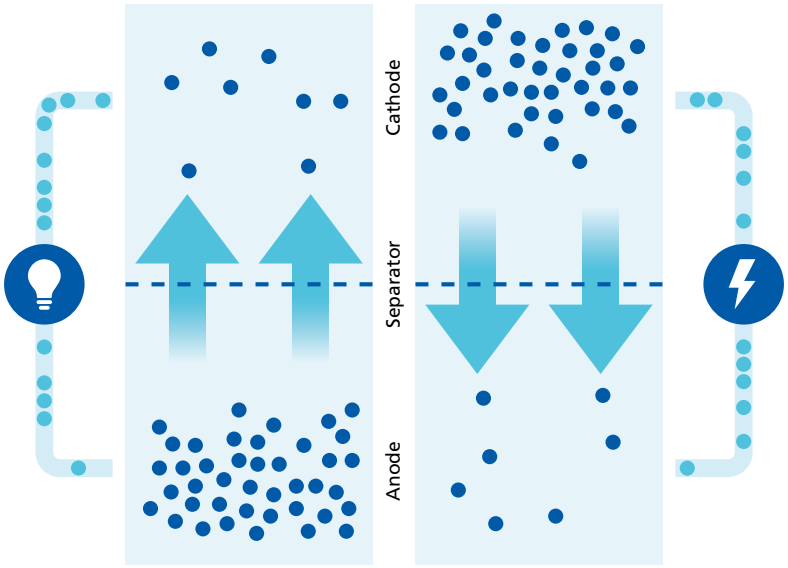
HOSOKAWA MICRON LTD.
Containment | Filling & Weighing | Size Reduction

HOSOKAWA MICRON B.V.
Mixing | Drying | Agglomeration

HOSOKAWA ALPINE AG
Milling | Classifying | Compaction

HOSOKAWA SOLIDS
Conveying | Weighing | Storage

HOSOKAWA MICRON CORPORATION
Group Headquaters | Milling | Classifying



The Hosokawa Micron Group, headquartered in Japan, has various locations around the world. Our European competence centres have combined their know-how to provide you with customised process technologies for optimum solutions. With more than 120 years of experience, we are a market leader in the development, design and manufacture of powder and particle processing machines and systems for rounding, drying, grinding and mixing.

With its wide range of particle processing technologies, the Hosokawa Micron Group still sets trends and standards in particle processing. Together we have developed special processes for the lithium compounds as well as the rounding of graphite. This is important for both cathode and anode of a lithium-ion battery.

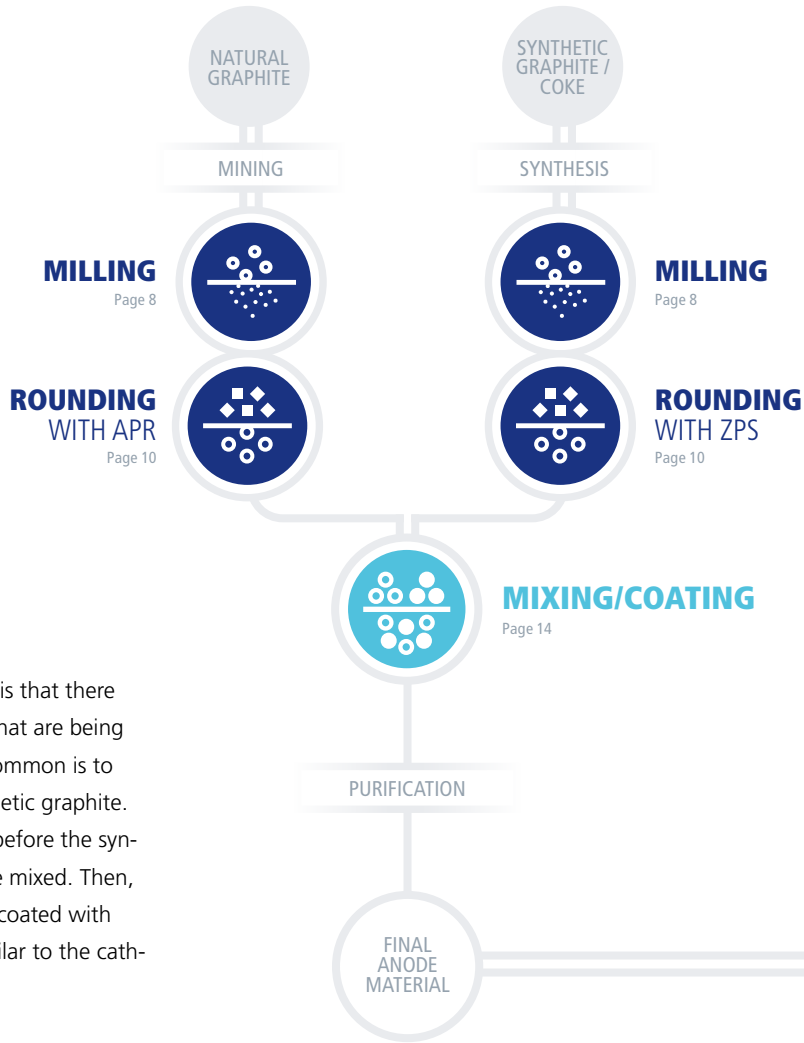
When charging and discharging a lithium-ion battery, the lithium ions move from the cathode to the anode and back again. The cathode and anode of a battery are made of different materials. A wide variety of lithium compounds (e.g. LCO, NMC, NCA or LFP) are used in the cathode. Graphite or lithium titanate form an essential component of the anode.

SYSTEMS FOR THE PRODUCTION OF **LITHIUM-ION BATTERIES**

Configurated according to your needs. *Do you have specific requirements for your processing system for cathode or anode material? Then contact us! Together, we will find the solution that suits you best.*

ALL FROM ONE MANUFACTURER

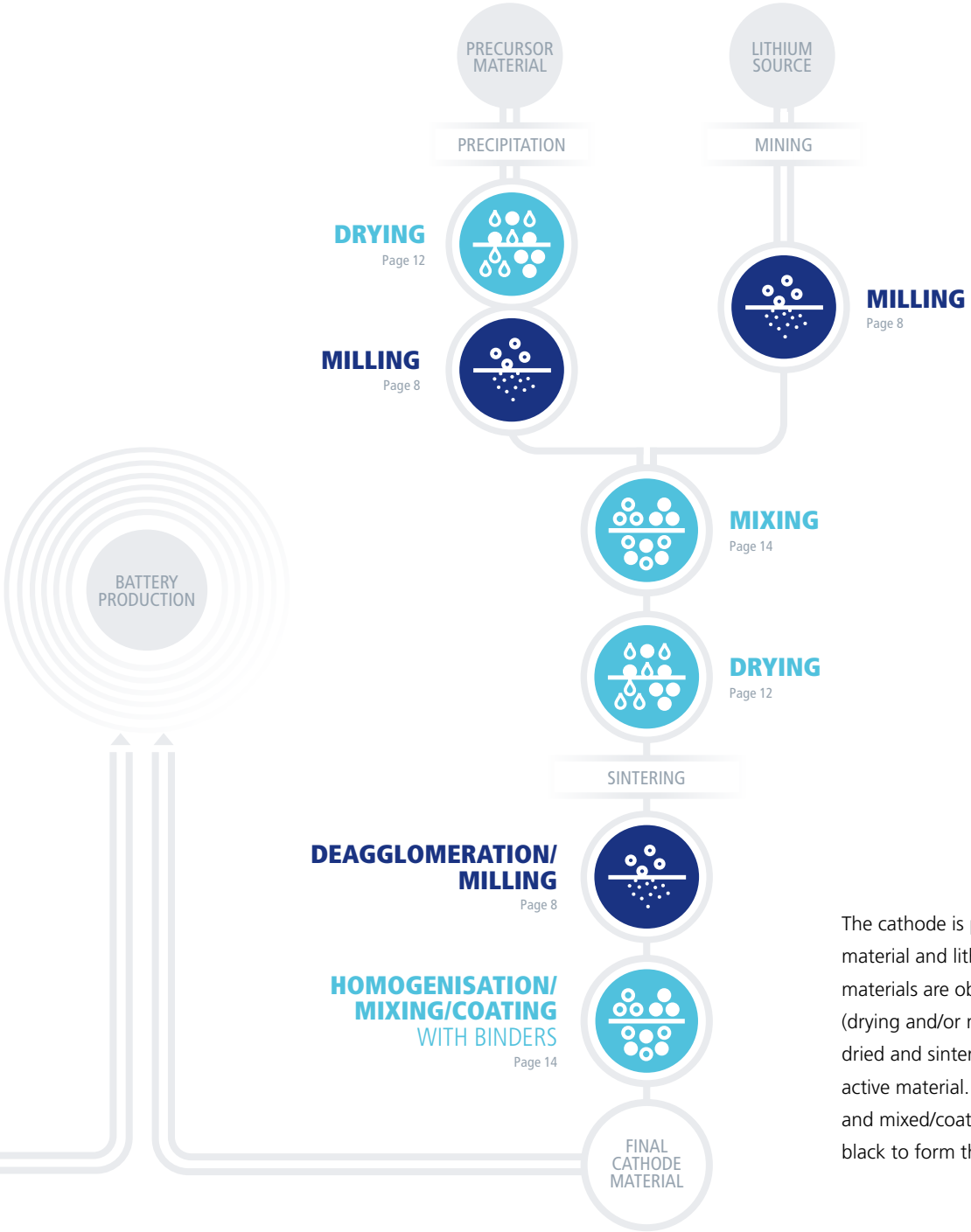
Two processes for a perfect result



The 'challenge' for the anode is that there is a wide variety of materials that are being used for this purpose. Most common is to use a mix of natural and synthetic graphite. Both need milling (rounding) before the synthetic and natural graphite are mixed. Then, the graphite mixture is mixed/coated with binders and carbon black (similar to the cathode process).

DURING THE WHOLE PROCESS:

PNEUMATIC CONVEYING
Page 16



The cathode is produced from precursor material and lithium sources. Both raw materials are obtained by different processes (drying and/or milling). Then they are mixed, dried and sintered to form battery/cathode active material. The material is then milled and mixed/coated with binders and carbon black to form the final cathode material.

STORAGE, CHARGE & DISCHARGE
Page 17

DOSING AND WEIGHING
Page 17

MILLING

For high-performance cathode material

One important step is ultra-fine grinding of the active substances. Two things are particularly important here, a precisely defined particle size and particle size distribution.
Ultra-fine grinding of the active powders creates particles with a larger surface area. This ensures optimum battery performance. The batteries can be charged faster, enjoy a longer service life and higher capacity. Two mills from Hosokawa Alpine are particularly suitable for ultra-fine grinding: the classifier mill ACM and the fluidised bed opposed jet mill AFG.

ADVANTAGES OF JET MILL AFG

The fluidised bed opposed jet mill AFG produces powders with steep particle size distribution and sharp top size limitation in the range of d_{97} < 10 – 15 µm.

- Classifier wheel is adjustable in design and speed
- Contamination-free grinding
- Easy cleaning by the hinge-back and removable classifier top section

› *AFG*

TECHNICAL SPECIFICATIONS

	AFG 100	AFG 200	AFG 400	AFG 630	AFG 710/4	AFG 800/3
Scale-up factor (F)	Lab	0.25	1	2.5	4	7.5
Nominal air flow rate (Sm³/h)	50	300	1,200	3,000	4,800	9,000

Several machine sizes available.

OPTIMAL WEAR PROTECTION

The special ceramic design of the classifier mill ACM ensures a high product purity and quality.

- Grinding and classifying in one machine
- Contamination-free grinding
- Steep particle size distribution
- Sharp and easily adjustable precision of fineness
- Easy cleaning and maintenance
- Low specific energy consumption

TECHNICAL DETAILS

	ACM-2HC	ACM-15BC	ACM-30/40BC	ACM-50BC
Drive – Grinding (kW)	3.7	11	22/30	37
Drive – Classifying (kW)	0.75	1.5	5.5/7.5	7.5
Total air flow rate (Sm³/h)	300	900	1,800/2,400	3,000

We design the perfect system for you and your needs! Please contact us.

› APR

GRAPHITE ROUNDING

For high-quality anode material

Graphite is the most important anode material for the production of lithium-ion batteries (LIB). To make optimal use of the valuable raw material graphite, it requires rounding. This offers crucial advantages: Rounding of the graphite increases tap density, thereby improving the storage capacity and the fast-charging capability of the battery anode. It also increases the service life of the batteries. In addition, it improves the intercalation kinetics – and thus the conductivity – of the lithium ions in the battery anode. Hosokawa Alpine has developed innovative solutions for rounding synthetic graphite and natural graphite: the classifier mill Zirkoplex ZPS and the Alpine Particle Rounder APR.

› ZPS Classifier Mill

ROUNDING OF SYNTHETIC GRAPHITE WITH THE CLASSIFIER MILL ZIRKOPLEX ZPS

- Low BET values
- Yields up to 90%: low loss of the valuable raw material
- High throughputs
- High tap densities for higher storage capacity
- Different target finenesses possible (d_{50} = 10 – 12 µm; d_{50} = 15 – 16 µm; d_{50} = 18 – 22 µm)
- Low specific energy consumption

ROUNDING OF NATURAL GRAPHITE WITH THE ALPINE PARTICLE ROUNDER APR

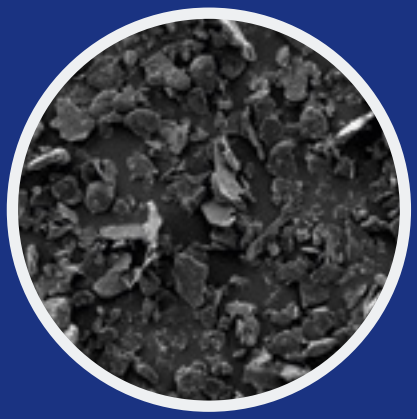
- Low BET values
- Short process times
- High throughputs
- Yields up to 80%: low loss of graphite
- Different target finenesses possible (d_{50} = 10 – 12 µm; d_{50} = 15 – 16 µm; d_{50} = 18 – 22 µm)
- Low specific energy consumption

ROUNDED GRAPHITE

For higher storage capacities

Normally, graphite particles are platelet-shaped. The spheroidisation of graphite brings decisive advantages: it increases the tap density and thus improves the storage capacity and the fast-charging capability of the battery anode. It also increases the service life of the batteries. Another advantage of graphite rounding: it improves the intercalation kinetics - and thus the conductivity - of the lithium ions in the battery anode.

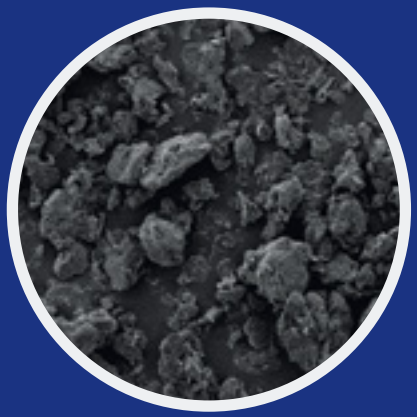
However, the existing processes for graphite spheroidisation only produce a low yield of about 30 to 50 %. Thus, a large part of the valuable raw material is lost. Hosokawa Alpine has now developed a new process for graphite rounding that requires fewer machines than was previously necessary. This not only reduces the space required, but also the effort required for maintenance and servicing.

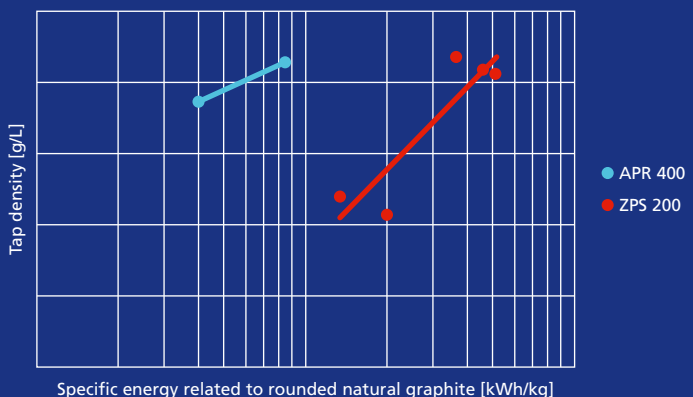


SPECIFIC ENERGY

Two methods for graphite rounding

The tap density is one of the target parameters to evaluate the quality of graphite for use in lithium-ion batteries. To produce a natural graphite with a certain tap density, rounding with an APR is more energy efficient than rounding with the conventional processes. Other particle properties such as fineness and BET surface area are comparable for both processes. In case of synthetic graphite/pet cokes the ZPS is more energy efficient.





DRYING

High flexibility during drying

Water is very undesirable in battery materials! Therefore, Hosokawa Micron has several dryers, both batch and continuous to get rid of this nightmare.

The first step where Hosokawa Micron machines can be used is in the process to dry and mill cathode precursor materials, such as nickel, manganese and cobalt oxides. The DMR flash dryer is ideal for the continuous drying of the active material. It can achieve end moistures of below 1% and unlike other dryers, it is flexible enough to handle both slurries and filter cakes.

In case extremely low end moistures need to be achieved, or in case the required capacity is small, batch dryers at low vacuum and/or high temperatures may be used.

For these applications the Nauta dryer can be used, which can handle slurries, filter cakes and powders, or the Conical Paddle Dryer (CPD). The CPD is excellent in handling base material at higher temperatures, resulting in high heat transfer rates.

RECYCLING OF BATTERIES

The CPD can be used to remove electrolytes from end of life batteries. The shear forces in this dryer help to separate the cathode and anode powders from the current collectors. Because the CPD operates under a vacuum, any flammable and/or toxic gasses are removed in a safe manner and can be recovered.

TECHNICAL SPECIFICATIONS

	DMR	*NAUTA DRYER*	*CPD*
Evaporation capacity	80 – 7,200 kg/h	1 – 600 kg/h	1 – 600 kg/h
Typical motor power	11 – 335 kW	0.5 – 80 kW	0.5 – 90 kW

FEATURES AND BENEFITS OF DMR

- Continuous operation
- High evaporation capacity
- Ultra fine regular end product
- Low energy consumption
- Compact design – small footprint
- Reduced contamination due to working principle

FEATURES AND BENEFITS OF NAUTA/CPD

- Batch operation
- Low end moistures
- Flexible in capacity
- Contained process
- Recovery of solvents possible

MIXING & COATING

From low shear to ultra-high shear

In battery production process, several mixer types are being used. There are two types, namely low/mid shear mixers and high shear mixers. Hosokawa Micron's portfolio contains both types of mixers, so the right mixer for your application can be selected.

NAUTA – LOW SHEAR

The Nauta mixer is often used as homogenizer or agitated feed hopper to create a consistent feed to the DMR or the mills. Another example is mixing of anode material, where the specific characteristics of natural and synthetic graphite need to be combined. This can be achieved by homogenizing these compounds in a Nauta mixer.

HIGH SHEAR

Several processes in the battery industry require high shear mixing. Small particle sizes of the precursors material means larger surface areas. This means there are more cohesive forces between the particles. Thus, more shear is required to mix these materials. This can be achieved using the Cyclomix and Nobilta high-shear batch mixers, or the continuous high-shear Modulomix. The high shear mixers do not only achieve a homogenous mixture, but also form a strong coating of other materials, such as carbon black and binders around the precursor to improve conductivity. Our mixers can be equipped with a wear resistance coating.

FEATURES AND BENEFITS OF NAUTA

- Low energy input
- Large batch sizes possible also in cantilevered execution
- Extremely homogenous mixing for free flowing particles
- Creating constant feed for continuous dryers or mills

TECHNICAL SPECIFICATIONS

	NAUTA MIXER	*CYCLOMIX*	*NOBILTA*	*MODULOMIX*
Shear	low	high	ultra-high	high
Product capacity	5 – 100,000 ltr	0.1 – 2,000 ltr	0.5 – 300 ltr	2.5 – 3,250 kg/h
Typical motor power	2.2 – 90 kW	0.75 – 240 kW	5.5 – 200 kW	1.6 – 15 kW

FEATURES AND BENEFITS OF CYCLOMIX

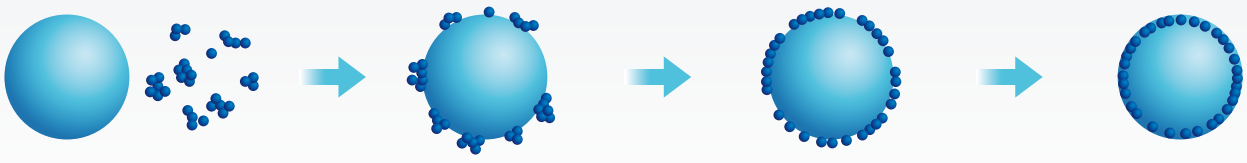
- Combined high shear and impact mixing
- Full coating
- Excellent temperature control
- Easy discharge
- Scalability

FEATURES AND BENEFITS OF NOBILTA

- Ultra high sear
- Full coating
- Particle design

FEATURES AND BENEFITS OF MODULOMIX

- Continuous operation
- Compact design
- High shear



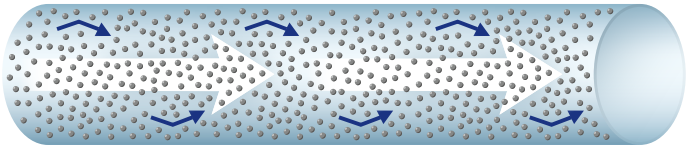
PNEUMATIC CONVEYING

Of various battery materials

In order to guarantee optimum product quality, the conveying methods have to be precisely matched to the product. For the cathode and anode materials, dense phase conveying is most suitable. This is done via Fluid Pneu dense phase conveying.

THE ADVANTAGES AT A GLANCE

- Dense phase conveying system with good price/performance ratio
- Loading 15 – 30 kg product/kg gas
- Low energy costs thanks to efficient use of pressure energy
- Gentle conveying of the product due to low conveying speed
- Reduced wear on the components



› *Solids Fluid Pneu: Fluided powders are carried as homogeneous material-/air mixture using thrust.*

STORAGE AND DISCHARGE

Product-specific stocking of battery materials

In the production process for batteries, it is necessary to stock raw materials, to buffer intermediate products and to store finished products. The subsystems have to match the bulk material and the process requirements. For example, a mass flow silo with the appropriate discharge aids is required for storing battery materials.

THE ADVANTAGES AT A GLANCE

- No adhesion or clumping of fine dusts
- No bridging
- Gentle treatment of the material to be discharged without grain destruction
- Low maintenance and low noise

Vibrating discharge base

WEIGHING & DOSING

Continuous dosing of raw materials into the mixer

The continuous and correct dosing of cathode and anode material plays a decisive role in the end of the process. In the battery production process, a loss-in-weight feeder is applied.

THE ADVANTAGES AT A GLANCE

- Safe and trouble-free automatic dosing for high process reliability
- Very good metering accuracy even with cohesive bulk materials
- Proven design with direct induction of tare and net weight to the load cells
- User-friendly dosing control based on Siemens components
- Simple connection to the main control system via standard interfaces

Loss-in-weight feeder

CONTAINMENT

Operator safety is an important consideration when handling battery materials. Depending on the product and the required OEB (Occupational Exposure Banding) level, the Hosokawa Micron Group offers a range of standard and bespoke containment equipment to complement its drying, mixing, milling and particle design equipment.

HOSOKAWA CONTAINMENT SOLUTIONS

- Downflow booths provide a versatile, open-fronted answer to containment needs
- Gloveboxes provide a higher level of protection

ADVANTAGES

- Operators benefit from high levels of ergonomic mobility
- Comfortable environment for extended work periods
- Suitable for a wide range of tasks

OPTIONS

- ATEX design
- FAT/SAT testing, IQ/OQ
- 3D modelling and full-size ergonomic assessment
- Manufactured to meet cGMP, FDA, EMA guidelines

SERVICE, VALIDATION, UPGRADES

- HEPA filter integrity testing (ISO 146443)
- OEL testing (ISO 146441)
- Pressure testing ISO 14644 and leak testing
- ISO10648-2 Airflow measurements

LABORATORY AND PILOT EQUIPMENT

As the batteries are developed and improved in the laboratory, Hosokawa Micron has a full range of equipment which can be used from small dryers, mills and mixers. These units are made in laboratory scale to pilot scale. Our equipment can finally be scaled up to industrial sizes.

ADVANTAGES

- Ergonomic design for any laboratory and pilot plant
- Results are comparable to industrial units
- Easy scale-up to industrial production capacities

INNOVATIVE TEST CENTERS

Our research and testing facilities can provide you with a wealth of machines and complete systems for the most varied plant configurations, all available on a global level. Precision, quality and innovative technologies: Do your testing with us.

YEARS OF EXPERIENCE

Profit from our many years of experience in the provision of solutions and our mastery of sophisticated processes. Well-known customers all over the world place their trust in the technology and know-how of the Hosokawa Micron Group.

GLOBAL SERVICE

Our service teams take care of repairs and maintenance, both on site and in our modern workshops equipped with the latest technology – smoothly, speedily and all around the world! The Hosokawa Micron Group – a partner you can rely on. Find out for yourself, you are sure to be impressed.

CONTRACT MANUFACTURING

The Hosokawa Micron Group is your professional and reliable partner for toll processing. We allow you to concentrate fully on your core business and to offset capacity bottlenecks without investment risks or long-term personnel commitment. Whether for a one-time project or a recurring job – our crew as well as our equipment are very flexible in adapting to your specifications!

ADVANTAGEOUS SYNERGIES

The know-how and experience of numerous specialists are bundled in the Hosokawa Micron Group to produce perfect solutions. Experience from a variety of customer segments in mechanical process engineering ensures that you, as the user, enjoy optimum solutions for practically every product – from an individual component to an entire plant.

HOSOKAWA MICRON GROUP

HOSOKAWA ALPINE AG
Milling | Classifying | Compaction

Peter-Doerfler-Strasse 13 – 25
86199 Augsburg
Germany

+49 821 5906-380 (Minerals)
minerals@alpine.hosokawa.com

+49 821 5906-572 (Chemical)
chemical@alpine.hosokawa.com

www.hosokawa-alpine.com

HOSOKAWA MICRON B.V.
Mixing | Drying | Agglomeration

Gildenstraat 26
7005 BL Doetinchem
Netherlands

+31 314 373-460
cmm@hmbv.hosokawa.com

www.hosokawa-micron-bv.com

HOSOKAWA SOLIDS SOLUTIONS GMBH
Conveying | Weighing | Storage

Lechwiesenstrasse 21
86899 Landsberg am Lech
Germany

+49 8191 3359-0
info@solids.hosokawa.com

www.solids.de/en

HOSOKAWA MICRON CORPORATION
Milling | Mixing | Particle designing

1-9, Shodaitajika
Hirakata-shi Osaka 573-1132
Japan

+81 72 855 - 2224
inquiry@hmc.hosokawa.com

www.hosokawamicron.com

HOSOKAWA MICRON LTD.
Containment | Filling & Weighing | Size Reduction

Rivington Road
Runcorn, WA7 3DS,
United Kingdom

+44 1928 755 100
info@hmluk.hosokawa.com

www.hosokawa.co.uk

LinkedIn Xing YouTube

0233-EN-2022-09_Batteries