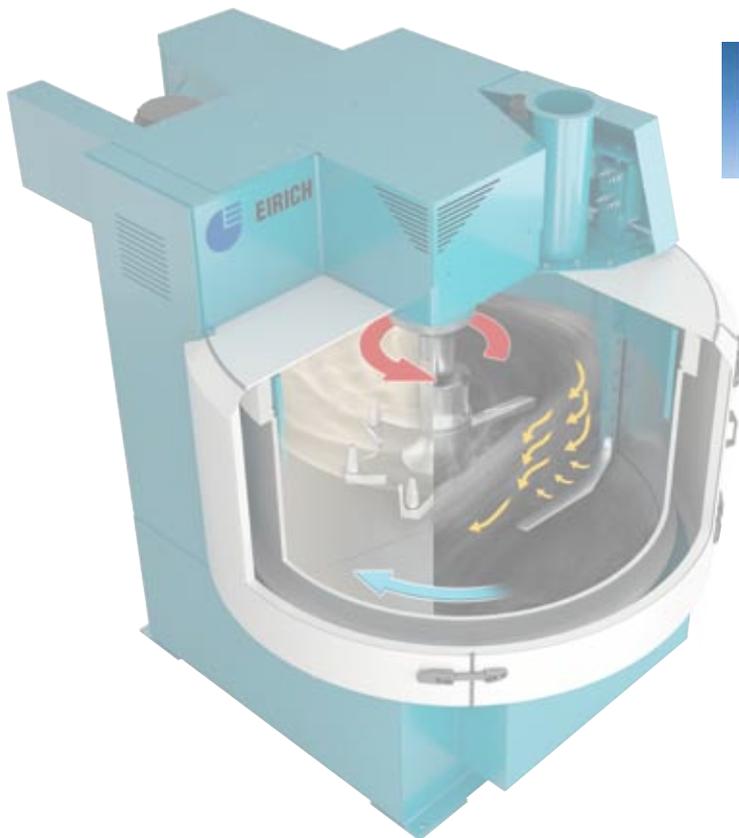


Preparation Technologies for Lithium-Ion Batteries

very short preparation times
higher efficiency of electrodes
flexible and compact systems



Preparation technologies for lithium-ion batteries

From the world-market leader for preparation systems in the lead-acid battery field

The preparation of battery pastes ranks among the most demanding of tasks in the mixing technology field. For this very reason, technologies from the EIRICH company are regarded as indispensable by top-name battery manufacturers all over the world. Nowhere else can producers and consumers alike benefit in such high measure from the advantages of EIRICH mixing technology.

EIRICH – trend-setter in the field of preparation systems for batteries

At the beginning of the 1990s, EIRICH kicked off an enduring technological trend with its EVACTHERM® process for the production of lead-acid batteries. It was thanks to this innovative preparation process that the lead-acid battery was successfully developed into the AGM* battery.

The planetary mixer now widely used in the battery industry was invented by EIRICH at the beginning of the last century. It was further developed into the EIRICH mixer with its unique mixing principle, which has been regularly optimized on the basis of decades of experience and successfully incorporated in new areas of application.

It offers fascinating possibilities, including for manufacturers of lithium-ion batteries.

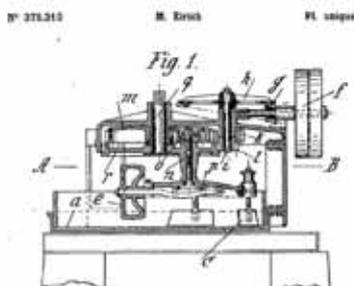
Gaining a competitive edge with the right technology

The right preparation technology is a major precondition for advanced battery systems with very high energy densities, endurance and safety. And the right partner is indispensable for anyone wishing to offer modern and environmentally friendly products on a long term basis. At the same time you benefit directly from our research and development activities. Because EIRICH and renowned companies, universities and competence networks have been working jointly for decades on future battery concepts. Regardless of whether you are active in the electromobility field or in the

development of stationary energy storage concepts, EIRICH will always be able to offer you the best preparation solution for your future battery concepts.

The global battery market holds unimagined possibilities for companies. With our tailor-made technical solutions we would be glad to help you make in the most of these possibilities.

Place your trust in a strong partner and strengthen your competitiveness now and for the future!



Planetary mixer from EIRICH's patent dated 1907

Innovative EIRICH preparation technology

No matter which energy storage systems ultimately prevail, the key to your success will always be the right preparation technology

*Absorbent Glass Mat (AGM)

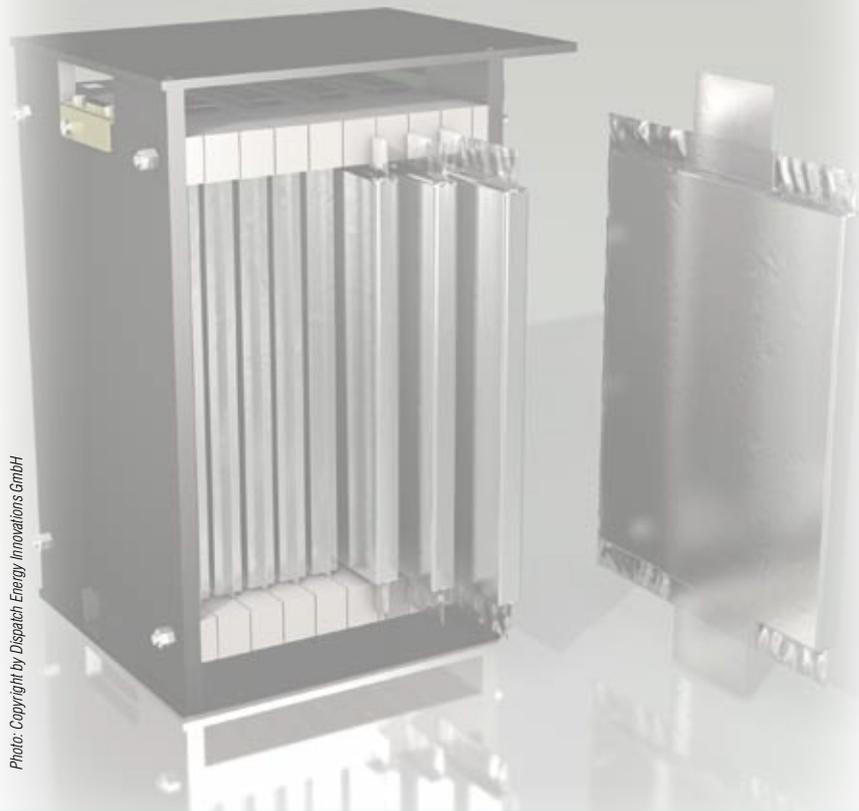


Photo: Copyright by Li-Tec Battery GmbH

The highlights of EIRICH preparation technology:

- just one machine for all process steps
- excellent dry and wet dispersion
- homogeneous distribution of binder without demixing
- EVACMIX® vacuum technology for degassed coating mixes
- very short preparation times
- higher efficiency of electrodes
- flexible and compact systems



Photo on front cover, right / Photo on page 3, bottom right
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Raw material and particle design for battery systems

The EIRICH mixer with its unique working principle offers fantastic possibilities along the entire process chain, from the production of raw materials and the preparation of system mixes to particle design for many different electrical energy storage systems.

Often it is possible to integrate complicated and expensive process chains consisting of several preparation machines into a single processing unit. One outstanding characteristic of the special EIRICH mixing principle is the flexibly adjustable energy input. This enables the mixer to be used for the dispersion of raw materials. In the past this required additional grinding systems. Using ultrafine raw materials, EVACMIX® vacuum mixers can achieve an additional notable increase in homogeneity.

Numerous process steps in connection with the production of raw materials for anodes, cathodes and even separators can be successfully implemented with the unique EIRICH mixing principle, for example:

- moistening/coating of particle surfaces with aqueous liquids, liquids containing solvents and/or binder systems
- EVACMIX® vacuum dry dispersion of ultra-fine raw materials and nanoparticles for the production of mixes with the highest homogeneity
- coating with solids on dry or moist particle surfaces
- melt coating of particle systems in the temperature range 35 – 260°C
- fibrillating (dry and wet) of polymers such as PTFE and PVDF
- dry mixing/homogenizing of cathode raw materials for subsequent calcination
- agglomeration and granulation of cathode raw material mixers for active material synthesis (e.g. solid-state systems, carbothermal reduction)
- graphite production through intensive kneading of carbons with solid or liquid pitch at mix temperatures of up to 260°C using the patented EIRICH induction heating system

1 Weighed basic materials

2 Fibrillating of PTFE

3 Volume expansion through excellent dry dispersion

4 Homogeneous mixing of the basic materials

5 Coating with solids

6 Agglomerated or granulated mixes



Electrode masses for battery systems

EIRICH offers innovative, efficient preparation processes for the production of not only raw materials but also cathodes, anodes and separation layers. Depending on the particular case, the mixes are further processed by pressing/compacting, extrusion or coating. The basic materials for the further processing are either homogeneous bulk powders, granules, plastic extrusion mixes or suspensions/slurries.

Particularly where plastic bodies and suspensions are concerned, there are advantages in using the EVACMIX® process. Preparation with absolutely no bubbles is possible.

Intelligent use of the highly efficient mixing system can reduce preparation times dramatically to total times in the range of 5 to approx. 15 minutes. Thanks to these short preparation times it is generally possible to do without product cooling. If necessary, the optional EVACTHERM® vacuum reflux cooling system can be used to remove any amount of heat. Powdery polymer or cellulose-based binder systems no longer need to be dissolved in advance but are added to the mix

as solid material and activated after feeding in the liquid. The uniquely short preparation times thus enable a particularly energy-efficient and low-cost preparation of raw materials.

Applications for the mixing system, which is also available in explosion-protected design, are for example

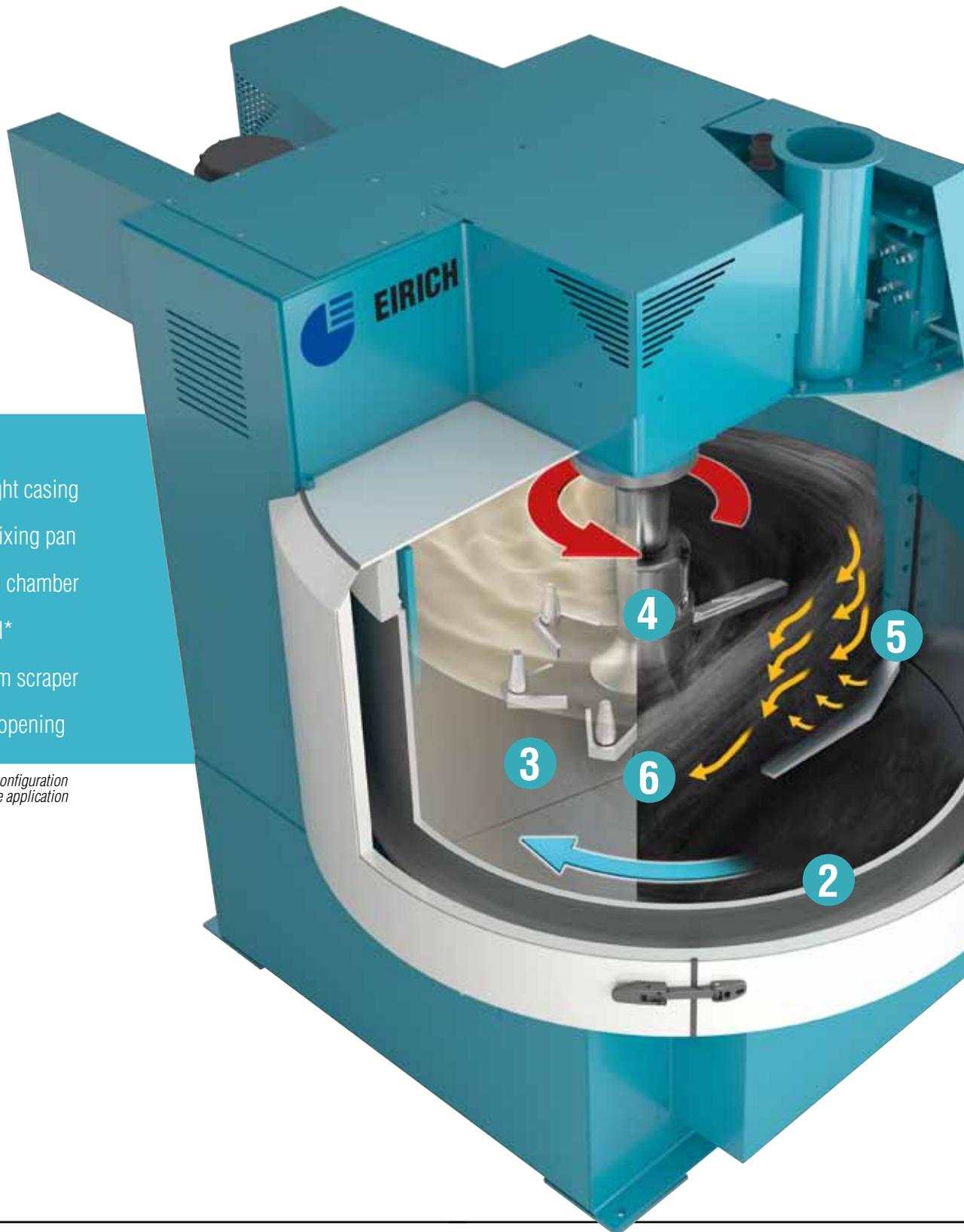
- dry mixing and dispersion of anode and cathode pastes
- granulation for the production of pressed granules < 1 mm or other grain distributions with aqueous or solvent-based liquids
- melt granulation with electrolytes or polymers
- production of aqueous or solvent-based plastic bodies
- suspension of aqueous or solvent-based anode and cathode pastes – also with absolutely no bubbles when using the EVACMIX® process



The advantages of the unique EIRICH mixing system

- 1 Stationary, vacuum-tight casing
- 2 Rotating mixing pan
- 3 Processing chamber
- 4 Mixing tool*
- 5 Wall-bottom scraper
- 6 Discharge opening

**Geometry and configuration depending on the application*





The special characteristics of the EIRICH intensive mixers are

- the rotating mixing pan
- the stationary wall-bottom scraper
- the high-speed mixing tool in eccentric position to the mixing pan center

The unique working principle of the EIRICH intensive mixer

The EIRICH mixer differs from other mixing systems available on the market by its rotating mixing pan with built-in eccentric mixing tool. Material is transported through the rotating mixing pan to the mixing tool and is not trapped in any dead spaces. A stationary wall-bottom scraper directs material accumulations on the pan walls back into the material flow. This means that, unlike with other mixing systems, the mixing tool is not required to perform any transport tasks. It can be optimally coordinated in its geometry and speeds with the material processing task. Tool speeds in the range from 1 to 30 m/s can be set by frequency inverter – and even varied in the different preparation phases – to enable an unprecedented diversity of process variations.

EVACMIX® vacuum technology

For vacuum processing with the EVACMIX® process the rotating mixing pan is surrounded by a pressure vessel which closely envelops the processing chamber. Thanks to the overhung bearing of the mixing tool and the positioning of the mixing pan drive outside the processing chamber, the seals do not come into contact with the product. The entire drive system, actuators and sensors are arranged outside the pressure chamber.

The advantages of the EIRICH intensive mixer

Thanks to their special machine design and the variability of the energy input, EIRICH mixers are able to process not only hard-to-mix powder mixes but also highly plastic bodies and even suspensions in just a single machine with only one mixing tool. The complete mixer is available in an explosion-protected version for preparation jobs involving solvents and explosive dry materials.

EIRICH intensive mixers are service-friendly, low-wearing and operationally reliable.

Their special characteristics are:

- high flexibility
- no dead zones and temperature gradients in the mixer
- easy access and cleaning of the mixer, can be automated on request
- excellent scale-up capability

EIRICH preparation technology for batteries with more power

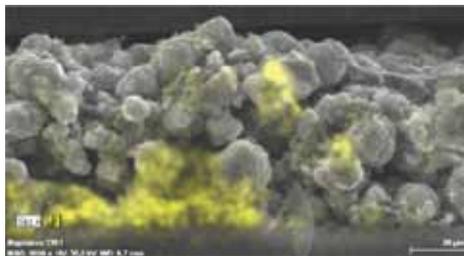
Renowned research institutes and top-name companies that work with the EIRICH mixer and carry out comparative tests on existing and alternative production methods have the following to report: Not only is handling far easier in the

single-pot process and preparation times far shorter, there are also significant improvements in quality parameters and battery characteristic values to report.

Coating properties

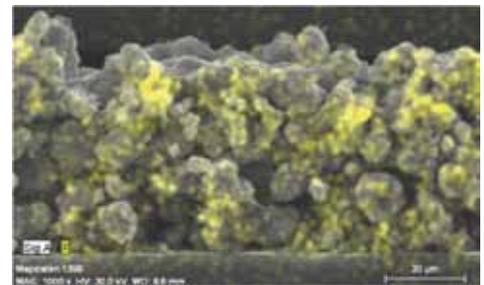
Combined gravity mixer –
high-speed vacuum dissolver

Yellow =
PVDF

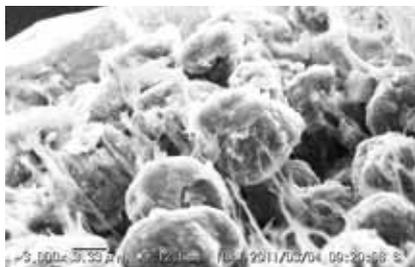


Picture source: IPAT, TU Braunschweig

EVACMIX® mixer

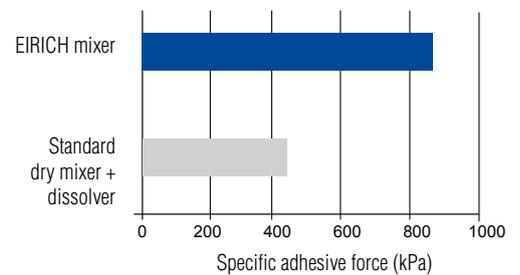


Homogeneous PVDF distribution across the entire coating height



SEM section of anode

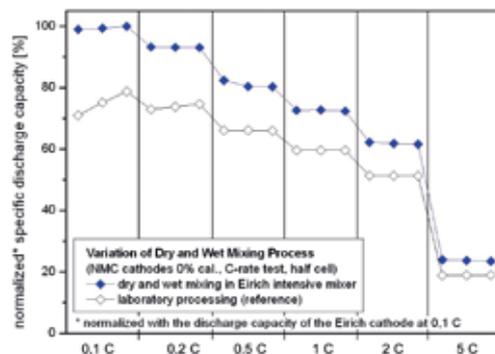
Uniform distribution of binder



Excellent adhesive properties of the electrode layers on the conductor foils

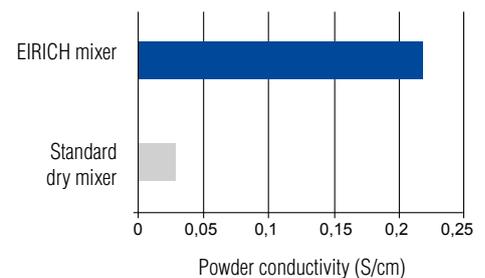
Test results IPAT, TU Braunschweig

Better electrochemical properties



Picture source IPAT, TU Braunschweig

Excellent powder conductivity



Test results IPAT, TU Braunschweig

¹Bockholt, H., Advanced Battery Power Symposium, 2012

The EIRICH preparation system is easy, saves space and cuts costs

System comparison: Production system with a capacity of 20,000 l/day

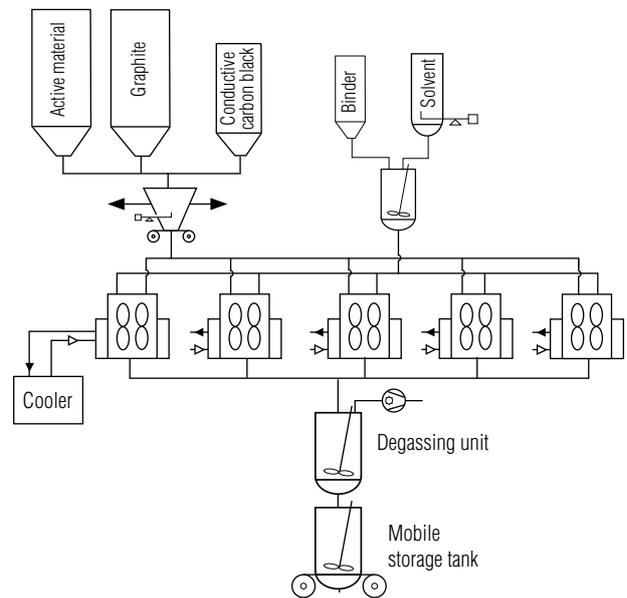
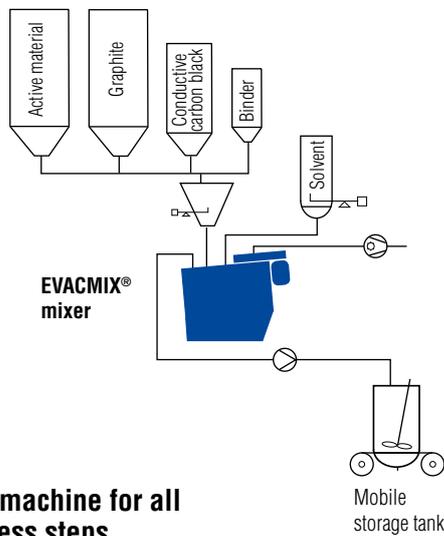
EIRICH mixer

Planetary mixer

Process workflow

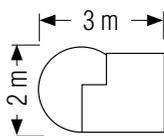
Mixer size: 250 l
 Processing time: 15 min
 Daily output/machine: 20,000 l (80 batches)
 Number of mixers: 1

Mixer size: 1,000 l
 Processing time: 6 h
 Daily output/machine: 4,000 l (4 batches)
 Number of mixers: 5

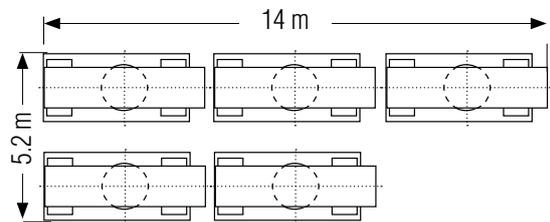


- One machine for all process steps
- No cooler
- Direct addition of binder
- Direct degassing in the mixer

Space required by the system



6 m²



60 m²

Current consumption per 1,000 liters

45 KWh

460 KWh

Systems engineering, transport solutions, control, quality assurance – Complete solutions from one source

Tailored systems engineering

Whatever your specific requirements might be – in EIRICH you have a partner with comprehensive project experience. We will join you in developing an optimally adapted process and system concept. The results are preparation systems which produce defined qualities in a reproducible, verifiable and highly efficient manner.

Test centers

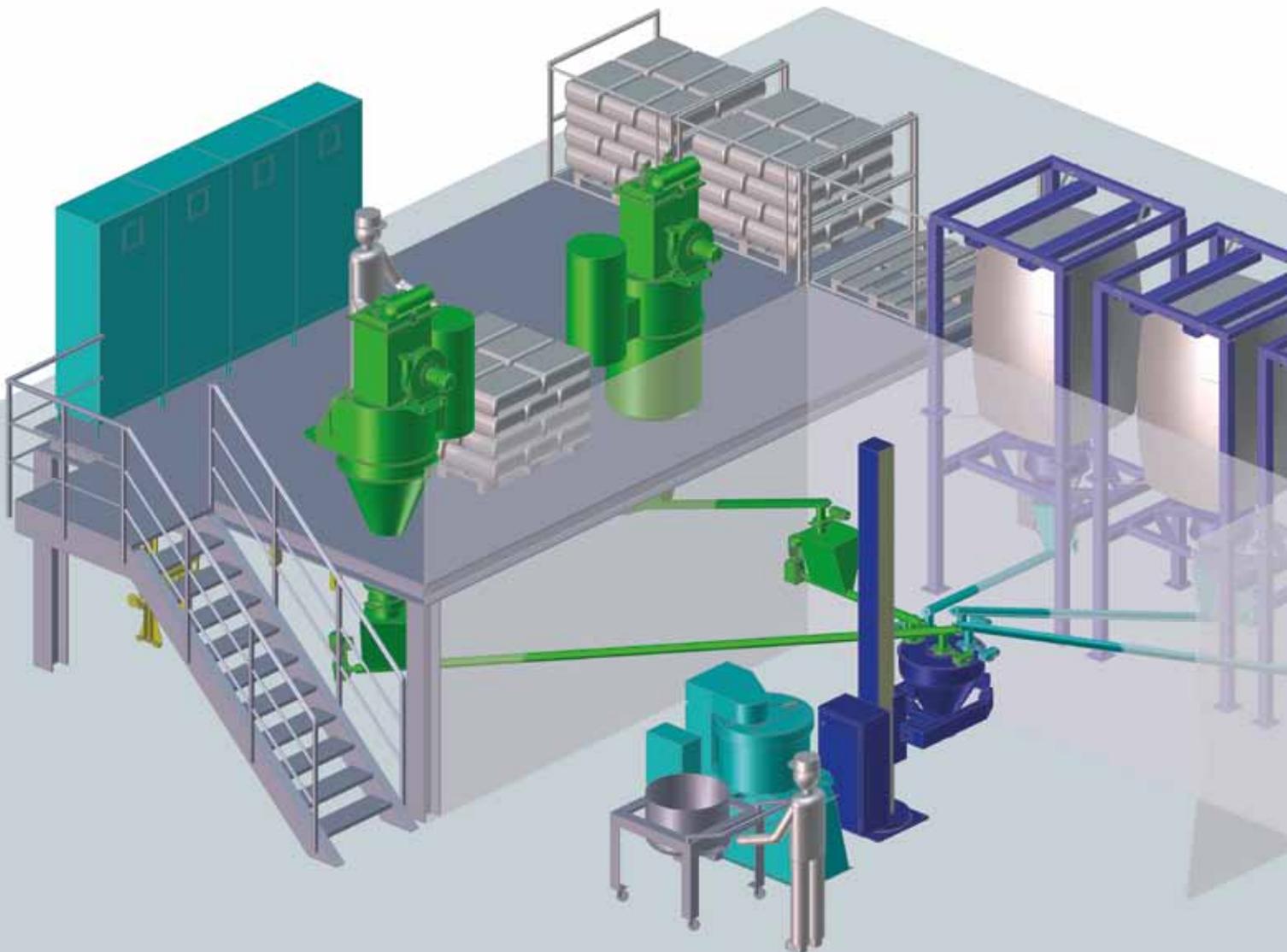
On various continents EIRICH runs test centers in which experienced engineers and process technicians join you in optimizing individual process steps. This paves the way to process engineering solutions for future products.

Engineering

The necessary machines, units and equipment are selected on the basis of the data collected in the EIRICH test center.

Systems engineering

The engineering results are implemented with machines and units from our own development and production activities. Components from efficient and experienced partners are used where required.



Process control and instrumentation technology

EIRICH develops and manufactures its own machine and process control solutions for preparation systems. This offering includes both new installations and the modernization or expansion of existing machines and lines. All components are configured for the user's requirements. The results are tailored solutions which extend from the simple machine controller to batch controllers with formula management. Special software packages round off the control hardware. They include e.g. online documentation with proactive planning of maintenance measures, condition monitoring and the teleservicing of your equipment.

Use the advantages of cooperating with EIRICH!



*Fine batching
from mbd-tec GmbH*



*Control systems
from our own
production department*



1



2



3

*Preparation system with:
Bag emptying station (1)
Intensive mixer type
RV12W (2)
Mobile storage tank as
Conti-Feeder (3)*



Machine range

The right mixer for all performance classes

The EIRICH range of mixers includes sizes from 1 to 12,000 liters, which meet user-specific requirements with great efficiency. Thanks to the high efficiency and filling variability, relatively

small mixer volumes are sufficient for even the high production outputs in the battery industry. Depending on the solvents or solid materials used, the mixers are available in an explosion-protected version with optional nitrogen inertization.

Excerpt from the range of mixer types

Type	EVACMIX® vacuum technology	Explosion-protected version possible	Max. capacity	Production output	Drive power in kW (max.)	
			Liters		Rotor	Mixing pan
EL1	No*	No	1	Laboratory / Development	0.38	0.17
R02VRVAC	Yes	Yes	1	Laboratory / Development	4	0.88
R02VAC	Yes	Yes	5	15 l/h	4	0.88
EL5/10 Profi	No*	Yes	5/10	15 l/h / 40 l/h	4	0.88
EL5/10 Profi Plus	No*	No	5/10	15 l/h / 40 l/h	3.8/5.2	0.88
R05T	No*	Yes	40	3600 l/day	15	1.5
R08VAC	Yes	Yes	75	6000 l/day	22	3
RV11VAC	Yes	Yes	375	24000 l/day	45	9.2

*EVACMIX® vacuum technology cannot be retrofitted! **in 3-shift operation with 4 batches/h



EL1



EL5 Profi Plus



RV12W



R08VAC



R02VAC

Industrial Mixing and Fine Grinding Technology

Tradition and innovation since 1863

EIRICH stands worldwide for a comprehensive range of products and services in the field of preparation technology. Its particular focus is on mixing and fine grinding technology, with know-how developed over 150 years of close cooperation with industrial users, universities and research institutions.

Pursuing a corporate philosophy of operating internationally and thereby ensuring close proximity to every customer, the EIRICH Group has secured its place in all the key economic regions of the world.

The focus is on innovative technology for machinery and systems engineering designed to offer solutions for high-standard preparation tasks from a single source.

Applications and process technology with own test centers, a high vertical range of production and comprehensive after-sales service provide the ideal basis for the development of modern and economical processes for a multitude of industries.

**Building materials – Ceramics – Glass – Carbon paste – Battery paste
Friction linings – Metallurgy – Foundries – Environmental protection**

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Dnepropetrovsk, Ukraine



Eirich East Europe GmbH
Representative Kazakhstan
Almaty, Kazakhstan



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Gurnee, IL, USA



Eirich Industrial Ltda.
Jandira S.P., Brazil



Nippon Eirich Co. Ltd.
Nagoya, Japan



Nippon Eirich Co. Ltd.
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