NETZSCH

Proven Excellence.

Fine Grinding and Classifying of Rare Earth Alloys

Business Unit
GRINDING & DISPERSING

Solutions for Processing Rare Earth Alloys

Fine Grinding and Classifying with a narrow

Magnetic materials are used in numerous applications as functional materials, e.g. in the field of communication technology, in regulation and control processes, in drives, in measuring technology, etc.

Neodymium-iron-boron-magnets (NdFeB) are so-called rare earth magnets, which are characterized by their high energy density. This makes them particularly interesting for application areas in which strong magnetic fields, small volumes and low weights are required. For instance, in sensor technology the high energy density of NdFeB magnets allow for miniaturization or a reduction of the component size in motor construction which therefore reduces volume and weight. Another example is their use in wind power plants in which rare earth magnets are used for permanent excitation of the generators.

Samarium-Cobalt magnets

Compared to neodymium magnets, samarium-cobalt magnets (SmCo) are characterized by a lower reversible temperature coefficient. They are very insensitive to temperature and can be used up to 350°C. Their high coercitivities make them very resistant to demagnetizing fields and they do not need to be protected against corrosion.

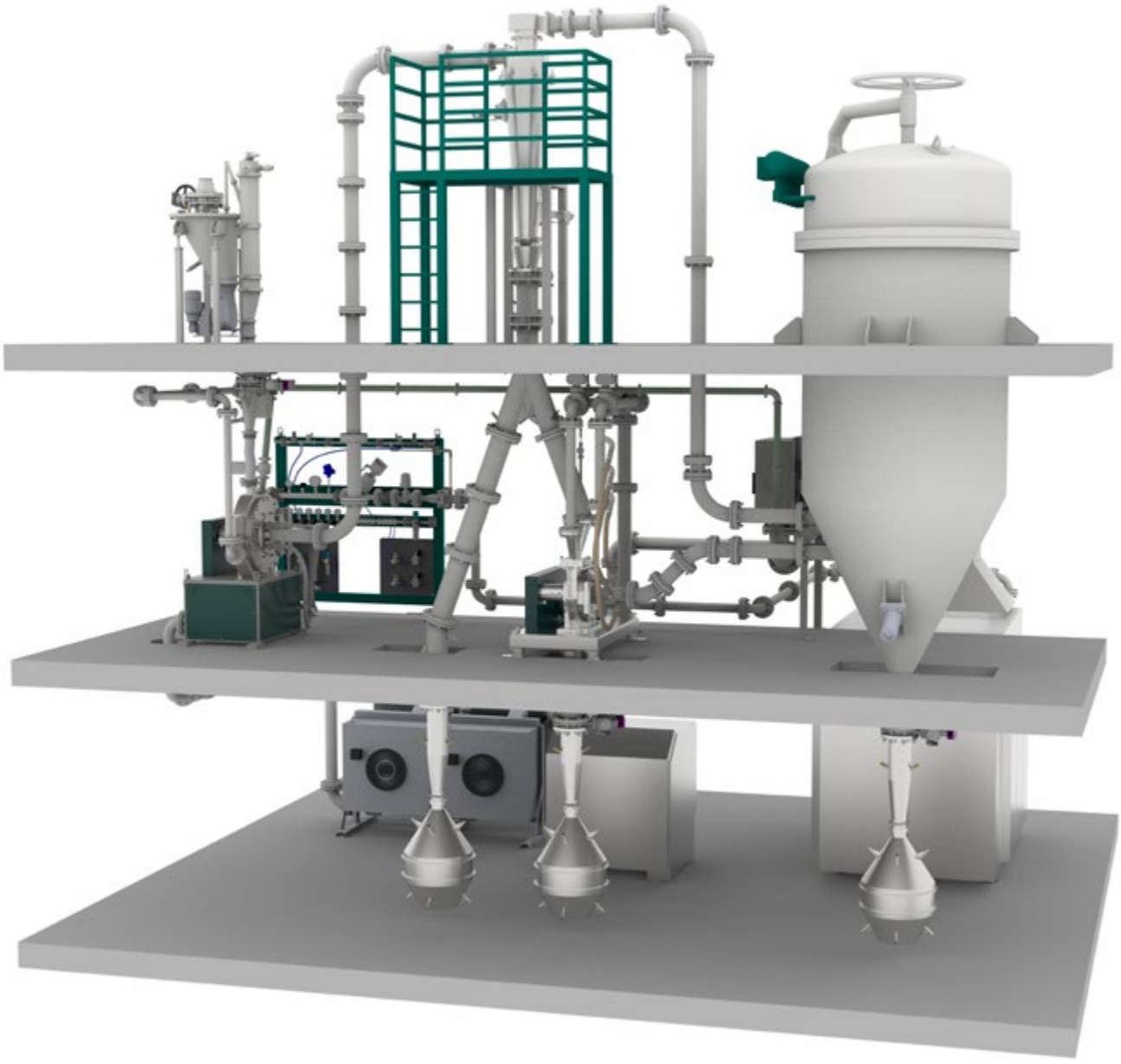
Application Examples

- Neodymium-iron-boron (NdFeB)
- Samarium-cobalt (SmCo)
- Niobium-tin (NbSn)
- Other types of magnetic materials

particle size distribution

In the manufacturing process the material powder is ground before being pressed and sintered. Its grinding is an essential step as the particle size is of significant importance for the quality and properties of the magnets which are subsequently manufactured from the powder. Ideally the particle size distribution should be narrow and contain an extremely low, ultra-fine fraction (< 2 µm) and only a small amount of coarse particles (> 8 µm).

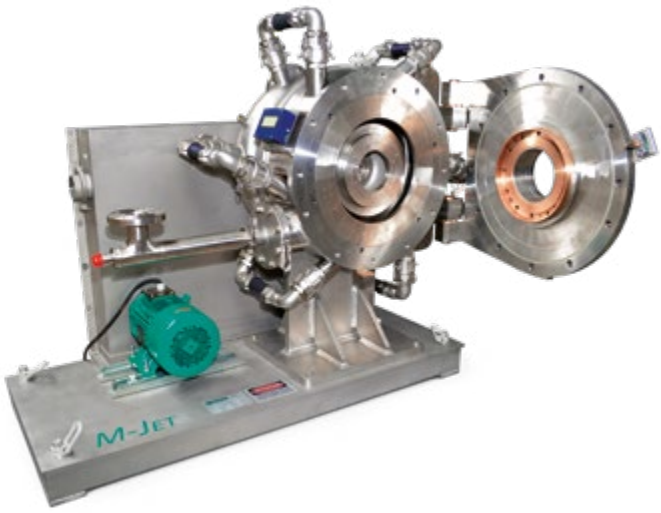
Using jet mills and classifiers made by NETZSCH you can reliably process sensitive NdFeB compounds or other alloys under inert gas conditions and obtain a product with a narrow particle size distribution and a defined upper particle size limit.



Dry Fine Grinding

M-JET High-density Bed Jet Mill

- The combination of a spiral jet mill with a dynamic gas classifier enables you to achieve a final product with a steep particle size distribution free of under- and oversized particles and also guarantees reproducible product quality.
- The setting of the fineness depends only on the rotational speed of the gas classifier and is independent of the product load. This allows the feeding of larger amounts of product to markedly increase the efficiency and economy of the mill.
- Residue-free grinding and minimal build-up of material inside the machine make the *M-JET* the ideal mill for high-quality products. Each batch is completely ground under equal conditions.
- The compact design of the NETZSCH *M-JET* provides very good access for easy and fast cleaning to remove components that cannot be ground.



NETZSCH *M-JET* High-density Bed Jet Mill

NETZSCH CGS 50 Fluidized Bed Jet Mill

CGS Fluidized Bed Jet Mill

- Innovative gas jet mill suitable for grinding even the hardest products down to a size of d_{97} 2 µm to 120 µm (depending on density) with a steep particle size distribution.
- The product is accelerated in a free gas jet and size reduction is carried out by the impact of particle against particle. Grinding is entirely autogenous and no contamination of your product occurs.
- The integrated dynamic air classifier can be infinitely adjusted to your desired fineness, which guarantees reproducible product quality.
- A flap at the bottom of the grinding chamber makes the discharge of the product bed (components that cannot be ground) quick and easy.
- Contamination of the fine product with coarse particles is excluded.

Classifying – Dedusting of fine Powder

M-Class High-efficiency Fine Classifier

- The *M-Class* High-efficiency Fine Classifier, equipped with the patented *ConVor*® classifier wheel, is suitable for an extremely fine classification (d_{97} 1 µm to 120 µm) with a closely defined sharpness of cut providing you with a high and consistent product quality.
- Reliably removing of fine dust (< 1 µm) to further optimize product properties.
- Effective separation results can easily be achieved with just one classifier wheel.
- The specially designed housing means a significant improvement in throughput.
- Accessibility and cleaning of the machine are made easy by the hinged housing door and the removable guide vane basket.

NETZSCH *M-Class* High-efficiency Fine Classifier

Compact Laboratory Plants

Smaller sizes of the NETZSCH Jet Mills and Fine Classifiers are available as a complete, compact skid-mounted plant in gas-tight execution for operation under inert gas.

- PU lining prevents product build-up
- Rinsing connections for Argon / N_2
- Aspiration of product components which are difficult to grind such as ductile neodymium or α-iron can easily be carried out
- Central connection points for aspiration
- Automatic passivation of the plant

NETZSCH *LabPilot* with *M-Jet* High-density Bed Jet Mill and *M-Class* High-efficiency Fine Classifier

Extraction of Difficult to Grind Components

When grinding rare earth alloys residue deposits of difficult-to-grind components are frequently formed. In the case of NdFeB alloys these consist mainly of neodymium, other rare earth fractions or iron. The residues are ductile and are difficult to grind in jet mills. Instead they tend to accumulate in the grinding chamber. Consequently, throughput capacities decrease during the grinding process and the productivity of the complete plant diminishes. In addition to this, if these components contaminate the final product, this has a negative effect on its magnetic characteristics. Furthermore, the accumulation of difficult-to-grind components can also modify the particle size distribution which also influences product quality. Another problem is the shift in the composition of the alloy of the rare earth powder due to selective grinding in the fluidized bed.
Therefore, depending on the quality of the rare earth alloys it is necessary to remove the components which are difficult to grind from the grinding chamber at regular intervals.

The extraction process in conventional jet mills is frequently a very time-consuming and complicated one which is usually carried out dependent on the speed of the mill and can take several hours. This means that production must be interrupted for a longer period.

The Solution from NETZSCH

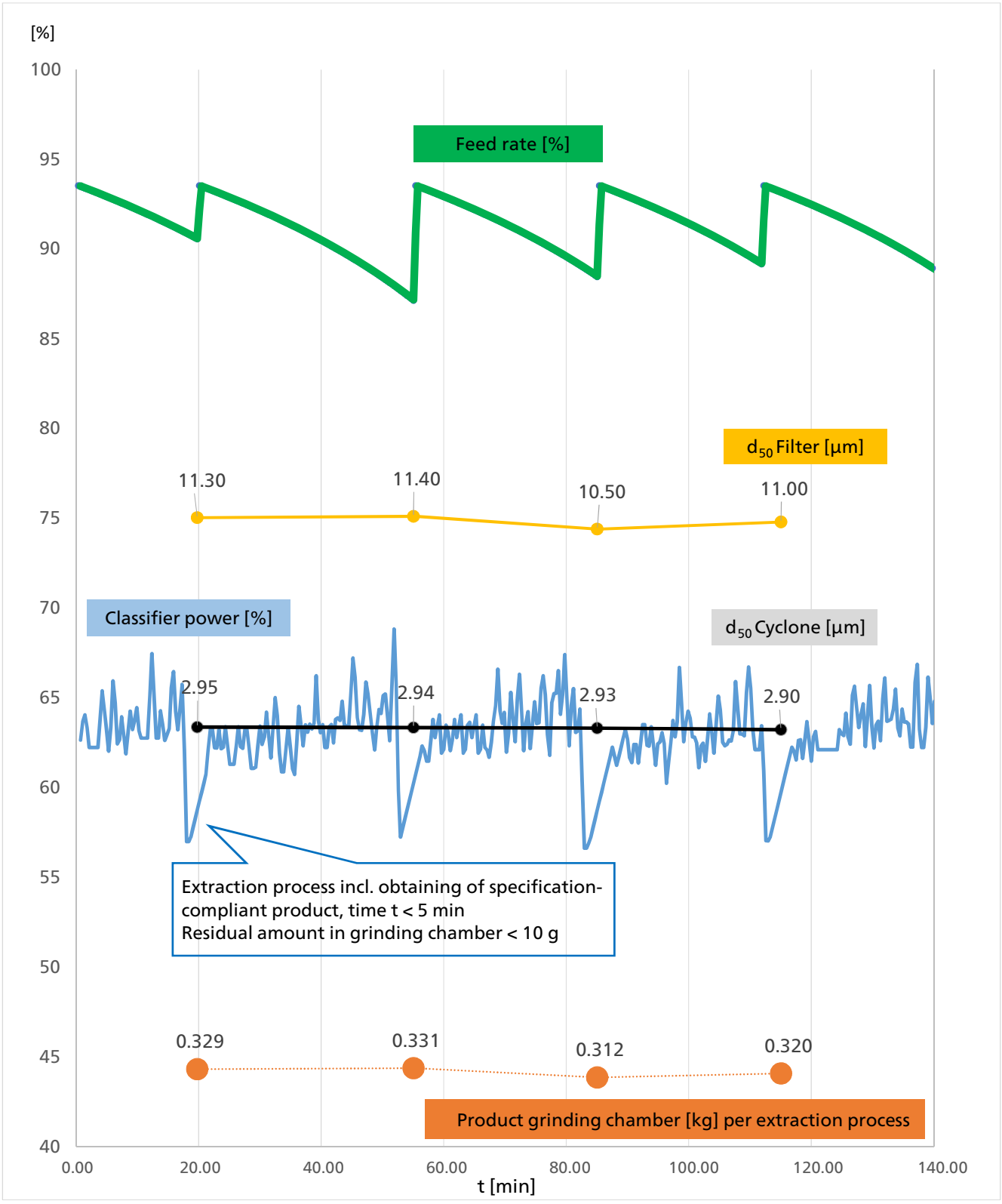
The extraction of difficult-to-grind components has been elegantly solved by our experts and is carried out directly from the grinding chamber during operation of the *M-Jet*.

This process can easily be automated. By decreasing the duty cycle, reductions in the throughput capacity can be detected. When a specified value is reached, a flap installed in the piping to the filter opens, and the product is pressed out of the mill by the overpressure in the grinding chamber. During this process, the classifier wheel operates via the bypass. The contents of the mill are then discharged directly into the downstream dust filter via a separate piping, which is only used for emptying the mill. The extracted product does not leave the inert closed loop process.

After the contents of the grinding chamber have been extracted, the mill delivers specification-compliant product again within 10 min. This represents a significant saving of time in comparison to conventional fluidized bed jet mills.

Laboratory plant *M-Jet* 10 with extraction pipe in the dust filter

Extraction of difficult-to-grind components from the Spiral Jet Mill *M-Jet* 10 in detail

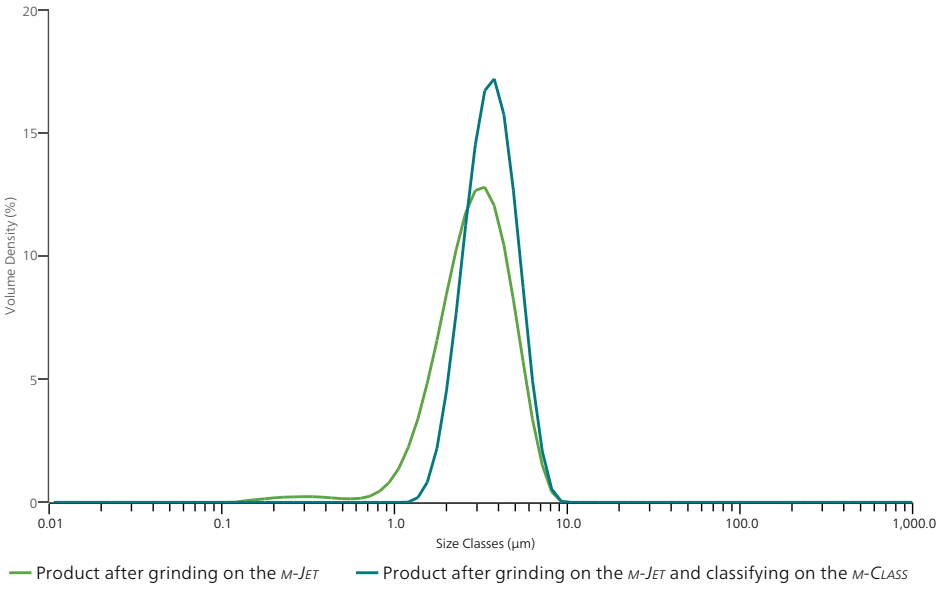


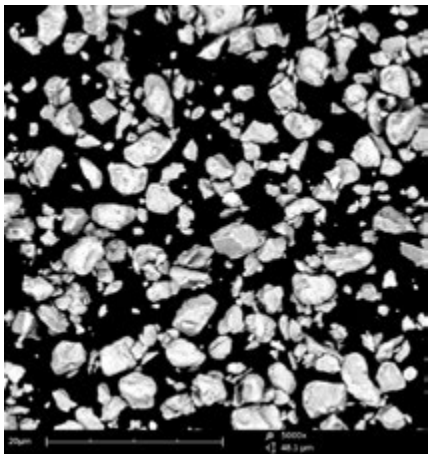
Results

The ideal particle size before pressing and sintering of rare earth magnets ranges between 2 µm and 8 µm. Particles of these sizes can be well oriented by conventional magnetic fields and contribute to obtaining a high residual magnetism of the magnets which are made from them.

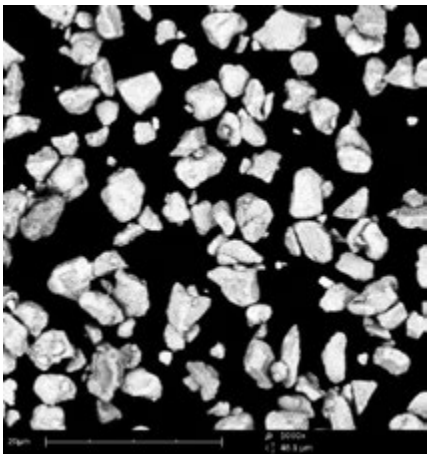
The measurements of the particle size distribution of the NdFeB powder made on NETZSCH mills and classifiers, and the magnetic properties of the sintered magnets subsequently manufactured from it, deliver convincing results. After classifying, the fines fraction < 1 µm was 0%. The d_{90}/d_{10} value at d_{50} = 3.5 µm was 2.7.

Comparison of particle size distribution of NdFeB powder after grinding and after additional classifying.



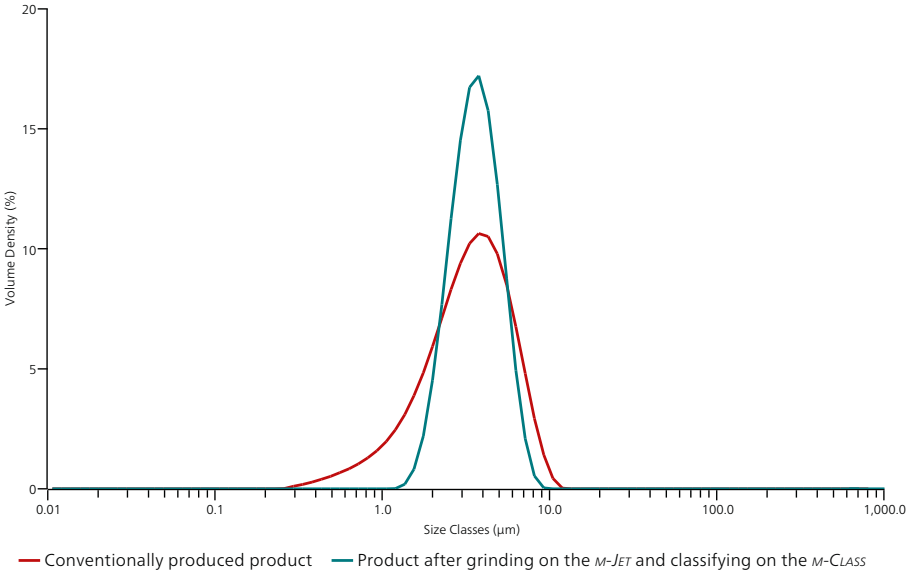


NdFeB powder after grinding on NETZSCH M-JET (magnification 5000x)

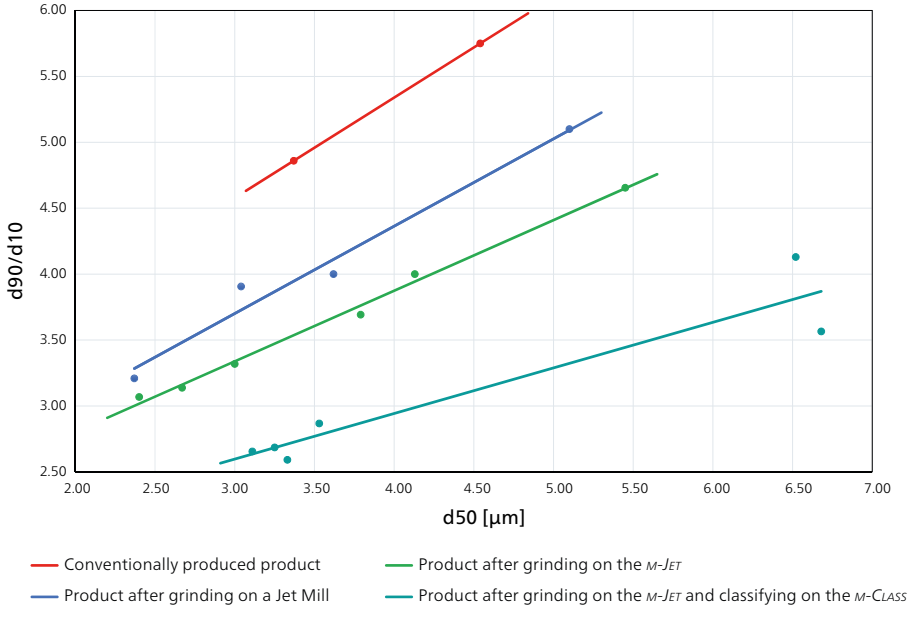


NdFeB powder after grinding on NETZSCH M-JET and classifying with NETZSCH M-CLASS (magnification 5000x)

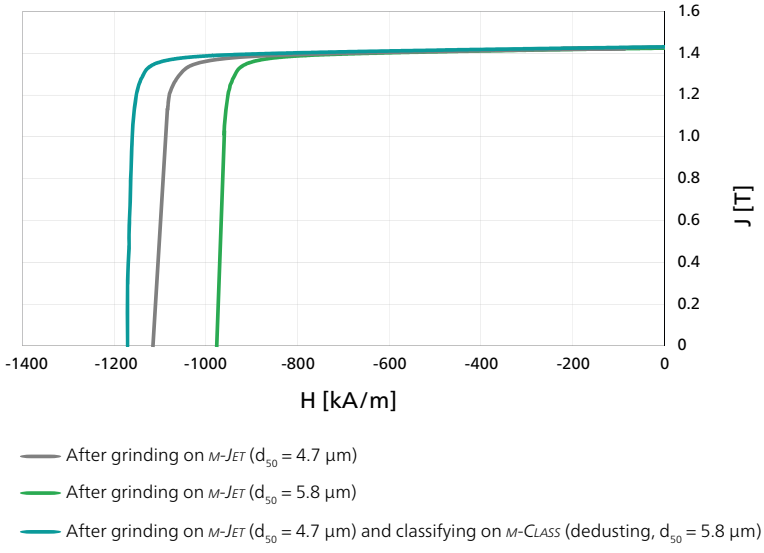
Particle size distribution of NdFeB powder after grinding and classifying in comparison to conventionally produced product.



Comparison of d_{90}/d_{10} values of NdFeB powders



Comparison of demagnetization curves of NdFeB magnets



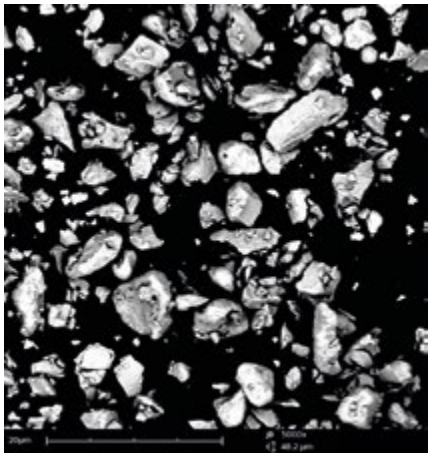
Particle design – Rounding of Rare Earth particles

Round rare earth particles without corners and edges provide decisive advantages for the magnets made from them:

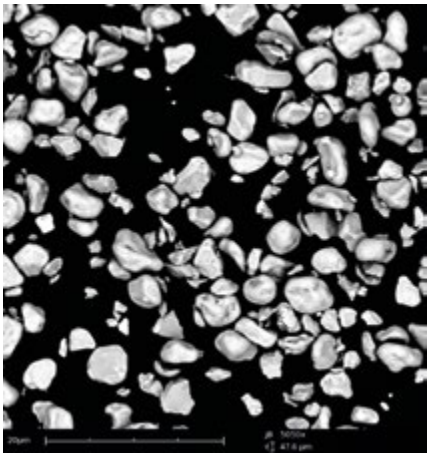
- Higher degrees of orientation
- Higher remanence
- Increase in knee-field strength
- Increase in coercivity

With NETZSCH technology, the reduction of the finest particles and the rounding of the particles is achieved in one step.

Particle Design	Before (left)	After (right)
fraction of finest particles < 1 µm	4.1%	0.0%
d_{90}/d_{10} value	3.54	2.46



ground powder



rounded powder

Processing of recyclates

Recycling is an important topic in the circular economy. Valuable raw materials are pro-cessed and reused, which helps to protect the environment and uses natural resources more efficiently.

However, magnetic recyclates from motors or generators contain a high proportion of impurities with oxygen, nitrogen or carbon, which accumulate mainly in the finest components. These have a negative effect on the magnetic properties and must therefore be removed before reuse.

In order to achieve an effective reduction of the oxygen content, the hydrogen embrittled powder must first be subjected to a grinding process. Subsequently, the finest particles and thus the impurities are reliably separated from the recycled magnetic powder by the *M-Class* High-efficiency Fine Classifier, resulting in a reusable magnetic powder.

NETZSCH offers you comprehensive service

- Grinding- and classifying tests under inert conditions with your original material are possible in our test lab.
- With a cooperation partner magnet samples can be prepared from the material samples obtained in grinding tests. This is done according to parameters defined by you.
- We are pleased to invite you to be present in our lab in order to ensure that tests are carried out according to your specification.

0% finest fraction < 1 µm after dedusting with the *m-Class* High-efficiency Fine Classifier

Halving of the d_{90}/d_{10}-value after classification (dedusting) with *m-Class* compared to conventionally produced powder

Consistent qualities thanks to small product volumes in the *m-Jet* High-density Bed Jet Mill – compared to the classic fluidized bed jet mill, the grinding chamber volume of the *m-Jet* is lower by a factor of **15 to 40**.

Steep particle size distribution with *m-Jet* and *m-Class* from laboratory to production scale

6 to 10 kg active filling during the grinding process in a *m-Jet* 50 (150 to 250 kg with comparable jet mills)

Advantages when classifying with *m-Class* (d_{50} = 5.8 µm):

Knee-field strength Hk	+ 21%
Rectangularity R = Hk/Hcj	+ 3%
Intrinsic coercivity Hcj	+ 21%

FOCUS ON YOUR ADVANTAGES

The NETZSCH Group is an owner-managed, international technology company with headquarters in Germany. The Business Units Analyzing & Testing, Grinding & Dispersing and Pumps & Systems represent customized solutions at the highest level. More than 4,000 employees in 36 countries and a worldwide sales and service network ensure customer proximity and competent service.

Our performance standards are high. We promise our customers Proven Excellence – exceptional performance in everything we do, proven time and again since 1873.

Proven Excellence.

Business Unit Grinding & Dispersing – The World's Leading Grinding Technology

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