Milling

Reproducible Sample Preparation for Reliable Analysis Results

A reliable and accurate analysis can only be guaranteed by reproducible sample preparation. The "art of milling and homogenization" is turning a laboratory sample into a representative part sample with homogeneous analytical fineness. For these tasks RETSCH offers a comprehensive range of the most modern mills and crushers for coarse, fine and ultra-fine size reduction of almost any material. The choice of grinding tools and accessories not only ensures contamination-free preparation of a wide range of materials but also the adaptation to the individual requirements of such different areas of application as construction materials, metallurgy, foodstuffs, pharmaceuticals or environment.

To find the best suited mill for a specific application, the following should be considered in advance:

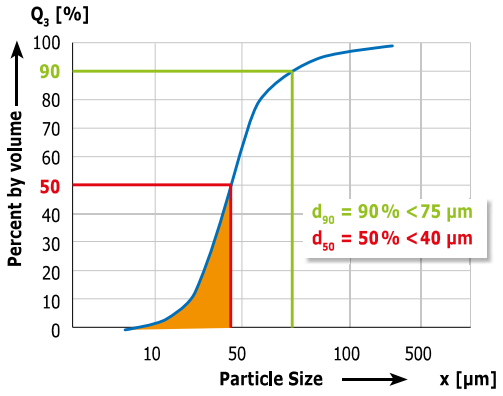
- Quality/characteristics of sample (e.g. dry, tough, abrasive, fibrous, brittle, hard, soft, temperature-sensitive etc.)
- Feed size
- Required final fineness
- Sample volume
- Sample throughput
- Subsequent analysis (which type of contamination by abrasion of grinding tools is acceptable?)
- May the sample be dried or embrittled before grinding?

Depending on the quality of the material different size reduction principles are applied to obtain the required fineness. Hard-brittle materials, for example, are best comminuted with impact and friction, for example in a planetary ball mill. For soft and elastic materials, however, size reduction with knife or cutting mills is the most suitable method.

Large particles cannot always be ground to analytical fineness in one step. In some cases it is possible to carry out coarse and fine grinding in the same mill with different settings; in other cases two mills or crushers are required.

An essential rule of thumb for size reduction is to only grind the sample as fine as necessary and not as fine as possible.

Cumulative distribution of a bulk material



The grind sizes indicated in this catalog relate to the d_{90} value which means that 90 % of the sample has a particle size smaller or equal to that value. The exemplary graphic shows that the sample also contains considerably smaller particles. Generally, the achievable grind sizes depend on the sample characteristics and instrument configurations which means that different results may be obtained with apparently similar samples.

Selection Guide for Size Reduction Tools

The following selection guide gives an initial overview of the application areas of RETSCH mills and crushers. The selection of a suitable mill depends on the individual application.

Contact us to find the optimum solution for your application!

● suitable
◒ suitable to a limited extent
\- not suitable

Jaw Crushers	Model	Feed size* approx.		Final fineness* approx		Page	Applications													
							Construction materials	Soil, sewage sludge	Chemical products	Electronic waste	Feed stuff	Glass, ceramics	Wood, bones, paper	Coal, coke	Plastics, cable, rubber	Food	Leather, textiles	Minerals, ores, rocks	Pharmaceutical products	Plants, hay, straw	Secondary fuels
Jaw Crusher	**BB 50**	40	mm	500	µm	12	●	◒	◒	-	-	●	◒	●	-	-	-	●	-	-	-
Jaw Crusher	**BB 100**	50	mm	4	mm	12	●	◒	◒	-	-	●	-	●	-	-	-	●	-	-	-
Jaw Crusher	**BB 200**	90	mm	2	mm	12	●	◒	◒	-	-	●	-	●	-	-	-	●	-	-	-
Jaw Crusher	**BB 300**	130	mm	5	mm	12	●	◒	◒	-	-	●	-	●	-	-	-	●	-	-	-
Rotor Mills																				
Ultra Centrifugal Mill	**ZM 200**	10	mm	40	µm	16	◒	◒	●	●	●	-	●	●	●	●	●	◒	●	●	●
Rotor Beater Mill	**SR 300**	25	mm	50	µm	20	◒	◒	●	-	●	-	◒	◒	◒	●	◒	◒	●	◒	-
Cross Beater Mill	**SK 300**	25	mm	100	µm	22	◒	◒	◒	◒	◒	◒	-	●	-	-	◒	●	◒	-	◒
Cyclone Mill	**TWISTER**	10	mm	250	µm	24	-	-	-	-	●	-	-	-	-	●	-	-	◒	●	-
Knife Mills																				
Knife Mill	**GRINDOMIX GM 200**	40	mm	300	µm	26	-	-	◒	-	●	-	-	-	-	●	-	-	●	◒	-
Knife Mill	**GRINDOMIX GM 300**	130	mm	300	µm	26	-	-	◒	-	●	-	-	-	-	●	-	-	●	◒	-
Cutting Mills																				
Cutting Mill	**SM 100**	80x60	mm	250	µm	28	-	-	◒	◒	●	-	◒	◒	◒	●	●	-	◒	●	◒
Cutting Mill	**SM 200**	80x60	mm	250	µm	28	-	-	◒	●	●	-	●	◒	●	●	●	-	◒	●	●
Cutting Mill	**SM 300**	80x60	mm	250	µm	28	-	-	◒	●	●	-	●	◒	●	●	●	-	◒	●	●
Mortar Grinders/Disc Mills																				
Mortar Grinder	**RM 200**	8	mm	10	µm	32	●	●	●	-	-	●	◒	●	-	●	-	●	●	◒	-
Disc Mill	**DM 200**	20	mm	100	µm	34	●	●	◒	◒	◒	●	-	●	-	-	-	●	-	-	-
Disc Mill	**DM 400**	20	mm	50	µm	34	●	●	◒	◒	◒	●	-	●	-	-	-	●	-	-	-
Vibratory Disc Mill	**RS 200**	15	mm	20	µm	36	●	●	◒	◒	-	●	◒	●	-	-	-	●	◒	●	◒
Ball Mills																				
XRD-Mill	**McCrone**	500	µm	1	µm	38	●	◒	●	-	-	●	-	◒	-	-	-	●	◒	◒	-
Mixer Mill	**CryoMill**	8	mm	5	µm	40	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Mixer Mill	**MM 200**	6	mm	10	µm	42	●	●	●	◒	●	●	●	●	◒	◒	●	●	◒	●	◒
Mixer Mill	**MM 400**	8	mm	5	µm	42	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
High Energy Ball Mill	**E_{max}**	5	mm	80	nm	44	●	●	●	●	◒	●	●	●	-	◒	◒	●	●	●	◒
Planetary Ball Mill	**PM 100**	10	mm	100	nm	46	●	●	●	●	◒	●	●	●	-	◒	◒	●	●	●	◒
Planetary Ball Mill	**PM 100 CM**	10	mm	100	nm	46	●	●	●	●	◒	●	●	●	-	◒	◒	●	●	●	◒
Planetary Ball Mill	**PM 200**	4	mm	100	nm	46	●	●	●	●	◒	●	●	●	-	◒	◒	●	●	●	◒
Planetary Ball Mill	**PM 400**	10	mm	100	nm	46	●	●	●	●	◒	●	●	●	-	◒	◒	●	●	●	◒

Please note:
The achieved final fineness depends on the sample material and instrument configurations which means that different results may be obtained with apparently similar samples.

12 Jaw Crushers

BB 100, BB 200, BB 300 – Robust and Versatile Floor Models

Floor model BB 300

The powerful RETSCH jaw crushers are designed for the rapid, coarse and primary crushing of hard, brittle and tough materials. The breaking jaws are available in a variety of materials which include heavy-metal-free steel. Their efficiency and safety makes these crushers ideal for sample preparation in laboratories and industrial plants.

The floor models BB 100, BB 200 and BB 300 are characterized by robust design, easy operation and rapid cleaning. The crushers process samples both batchwise and continuously.

Safety is a top priority with RETSCH jaw crushers. The feed hopper with splash-back protection cannot be accessed by hand. A safety switch and the brake motor ensure an immediate stop if the unit is opened or switched on incorrectly. For easy cleaning of the crushing chamber, the hinged hopper can be removed in a few simple steps. The jaw crushers run very smoothly and quietly and are virtually maintenance-free.

Benefits

- High throughput, high degree of size reduction
- Feed size up to 130 mm (BB 300)
- High final fineness (d_{90} < 2 mm)*
- Zero point adjustment for wear compensation
- Batchwise or continuous grinding
- Breaking jaws made of 4 different materials
- Feed hopper with splash-back protection
- Safe and simple operation and cleaning

Video on www.retsch.com/bb

*depending on feed material and instrument configuration

40 mm
500 µm*

Laboratory Scale Pre-Crushing

BB 50 – Powerful and Compact Benchtop Model

The BB 50 is the smallest model of the RETSCH jaw crusher series and has been specially designed for crushing smaller sample volumes with a maximum feed size of 40 mm. In many cases a final fineness of 500 microns – which is determined by digital gap width setting – is obtained in one go. The BB 50 features zero-point adjustment for wear compensation and maximum reproducibility. With its compact size and dust-tight housing this unique jaw crusher fits on any laboratory bench.

The BB 50 is designed for a very efficient and convenient size reduction process. The variable speed can be set between 550 min^{-1} and 950 min^{-1} to adapt the crushing process to sample requirements. The possibility to reverse the rotating direction is helpful if too much sample material has been fed to the crusher causing it to block. Due to a frequency converter the motor starts with enough power to achieve the maximum speed in a very short time. A Belleville spring washer and intelligent monitoring electronics protect the jaw crusher against overloading. Due to permanently lubricated bearings and its solid design, the BB 50 is virtually maintenance-free.

Benchtop model BB 50

Benefits

- High final fineness (d_{90} < 500 µm)*
- Compact benchtop instrument
- Digital setting of speed from 550 to 950 min^{-1}
- Digital display and storage of gap width
- Breaking jaws in 5 different materials
- Removable crusher arm for easy cleaning
- Dust-tight, maintenance-free
- Permanent lubrication and wearout notification
- Reversal of rotating direction possible

www.retsch.com/bb50

Superiority in Detail

Easy removal of the crusher arm without tools

Digital speed setting and display of gap width

Large collecting receptacle (3 liters) with optional lid

*depending on feed material and instrument configuration

Accessories and Options

Breaking jaws made from five different materials allow for adaptation to different sample properties (e.g. hardness) or heavy-metal-free crushing.

- **Manganese steel**
  is a material whose structure becomes compressed under pressure and hardens with time (cold hardening).
- **Stainless steel**
  is recommended if the expected feed material is not too hard and could cause corrosion.
- **Tungsten carbide**
  is the most abrasion-resistant and pure material. It ensures a longer working life of the jaws even if materials with a hardness of up to 7-8 on Mohs' scale are regularly processed.
- **Steel 1.1750**
  is ideally suited for heavy-metal-free grinding of samples which are not extremely abrasive (such as construction waste, soil, road pavings).
- **Zirconium oxide (BB 50)**
  is used as a ceramic material for metal-free preparation, e.g. for dental or clinical ceramics, optical glasses. Another advantage is that no color changes as a result of abrasion are observed.

The models BB 100, BB 200 and BB 300 can be connected to an industrial vacuum cleaner to minimize dust development.

Versatile Use

Apart from the four standard models, RETSCH jaw crushers are also available as special versions adapted to particular application requirements.

- **Combination with Disc Mill**
  For the rapid, continuous grinding of large quantities of coarse material to analytical fineness, the combination of the RETSCH jaw crusher BB 200 and the RETSCH Disc Mill DM 200 is the perfect solution.
- **Process-line versions**
  The BB 200 and BB 300 jaw crushers are also available in versions which are suitable for continuous size reduction in online operation, e.g. for quality control during the production process. These are supplied without feed hopper and motor protection switch.
- **Special version for size reduction of semiconductor materials**
  This version of the BB 200 resp. BB 300 features feed hopper and collector with plastic lining as well as breaking jaws and wear plates of tungsten carbide.

Jaw Crusher Technology:
RETSCH jaw crushers are robust and powerful forced-feed crushers. The feed material passes through the hopper with splash-back protection and enters the crushing chamber. Size reduction takes place in the wedge-shaped area between the fixed crushing arm and a second crushing arm moved by an eccentric drive shaft. The elliptical motion crushes the sample which falls under gravity into a removable collector as soon as the particles are smaller than the set gap width.

Jaw Crushers at a Glance

	Jaw Crushers			
				
Model	BB 50	BB 100	BB 200	BB 300
Applications	coarse and pre-crushing			
Fields of application	chemistry / plastics, construction materials, engineering / electronics, environment / recycling, geology / metallurgy, glass / ceramics			
Feed material	medium-hard, hard, brittle, tough			

Performance data

Material feed size*	< 40 mm	< 50 mm	< 90 mm	< 130 mm
Final fineness*	d_{90} < 500 µm	d_{90} < 4 mm	d_{90} < 2 mm	d_{90} < 5 mm
Collector capacity	3 liter	2 liter	5 liter	27.5 Liter / 35.4 liter
Max. throughput*	3 liter/batch	200 kg/h	300 kg/h	600 kg/h
Gap width setting	0 – 11 mm	0 – 20 mm	0 – 30 mm	1 – 40 mm
Speed (at 50 Hz)	550 – 950 min^{-1}	275 min^{-1}	275 min^{-1}	253 min^{-1}
Gap width display	digital	analog	analog	analog
Zero point adjustment	✓	✓	✓	✓
Hinged hopper	✓	✓	✓	✓
Connection for dust extraction	dust-tight housing	✓	✓	✓
Central lubrication	greased for life	–	–	✓
Maintenance- and lubricant-free sliding bearings	–	–	✓	–
Process line version available	–	–	optional	optional
Wearout warning notice	✓	–	–	–

Technical data

Drive power	1,100 W	750 W	1,500 W	3,000 W
W x H x D	420 x 460 x 560 mm	320 x 960 x 800 mm	450 x 1,160 x 900 mm	670 x 1450 x 1,600 mm
Net weight	approx. 79 kg	approx. 137 kg	approx. 300 kg	approx. 700 kg
More information on	**www.retsch.com/bb50**	**www.retsch.com/bb100**	**www.retsch.com/bb200**	**www.retsch.com/bb300**

*depending on feed material and instrument configuration

Please note: For Retsch's offering of bigger jaw crushers please visit www.retsch.com/bb

Typical Sample Materials

RETSCH's powerful jaw crushers are ideally suited for preliminary crushing of construction materials, ores, granite, oxide ceramics, quartz, slag, silicon, coal, tungsten alloys, cement clinker etc.


before


after

Application example: Silicon

16 Ultra Centrifugal Mill

ZM 200 – Ultrafast, Ultrafine

The powerful and versatile ZM 200 offers the ultimate in performance and operating comfort. This mill pulverizes a great variety of substances extremely fast, thus allowing for a high sample throughput.

The highly effective rotor-ring sieve system ensures that the sample remains in the grinding chamber only for a short amount of time. Thus the sample properties – which could otherwise be altered due to overheating – are preserved. Cleaning of the grinding tools is quick and easy which helps to avoid cross-contaminations due to frequently changing sample materials.

The heart of the ZM 200 is the innovative Powerdrive. The perfectly matched frequency converter and 3-phase motor provide a considerably higher throughput when compared with other rotor mills, resulting in a particularly effective grinding process.

Thanks to the efficient size reduction technique and comprehensive range of accessories the ZM 200 provides gentle and rapid preparation of analytical samples.

Ultra Centrifugal Mill
ZM 200

Benefits

- Powerdrive with a speed range from 6,000 to 18,000 min^{-1} and a rotor peripheral speed of up to 93 m/s
- Rapid and gentle grinding in two steps (rotor/ring sieve system)
- Automatic feeding (option) of up to 3.5 l sample material
- Suitable for grinding cryogenic samples (LN_2)
- Patented cassette system for maximum sample recovery and easy cleaning
- Defined final fineness
- Comfortable safety housing with automatic cover closure
- Comfortable parameter setting via display and ergonomic 1-button operation
- Optional cyclone for improved material discharge and additional cooling

Video on www.retsch.com/zm200

*depending on feed material and instrument configuration

Accessories and Options

Its wide range of accessories and the possibility to individually select the rotor speed make the ZM 200 easily adaptable to any size reduction task. All parts which come into contact with the feed material can be removed without using tools and are easily cleaned and reinserted.

The feed material is introduced either manually or via the optional load-controlled Vibratory Feeder DR 100 which is connected to the mill through an interface. **The automatic, steady sample feed maximizes the throughput without any risk of overload and ensures uniform grinding results**. The ground sample is collected in the cassette. The innovative cassette design ensures easy and loss-free sample recovery and avoids cross-contaminations.

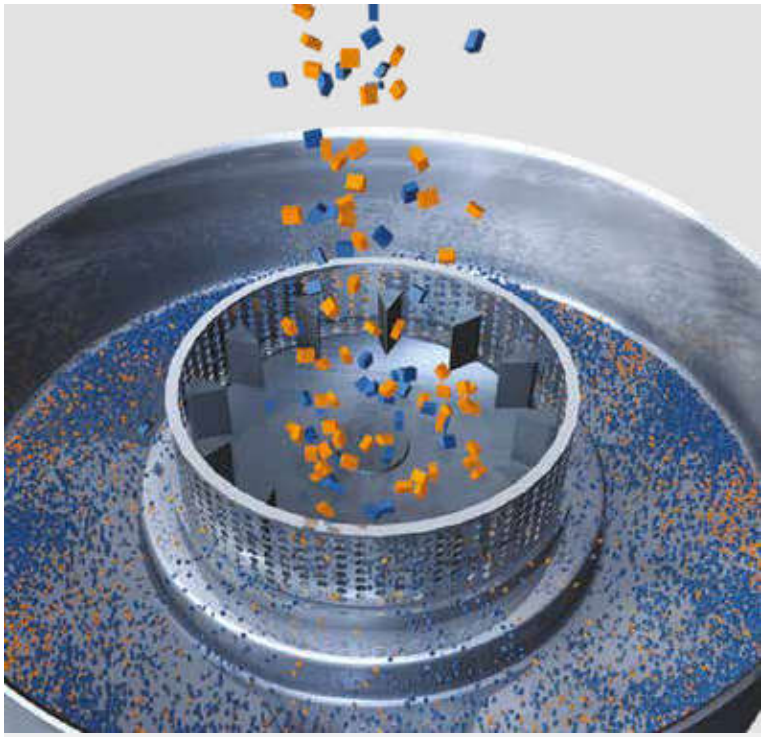
When using a **cyclone** the sample material is additionally cooled by the air stream and more rapidly discharged from the grinding chamber via the cassette pan with outlet. When additionally **connecting a vacuum cleaner, the system is virtually self-cleaning**. The cyclone accommodates 250 ml or 500 ml sample bottles; for **grinding larger volumes**, 3 liter and 5 liter collecting receptacles are available.

Controlled and uniform material feed: ZM 200 with Vibratory Feeder DR 100

Automatic size reduction of large amounts: ZM 200 with Vibratory Feeder DR 100 and cyclone

ZM 200 with Vibratory Feeder DR 100 and cyclone with connection for industrial vacuum cleaner

ZM 200 Technology:
In the ultra centrifugal mill size reduction is achieved by **impact and shearing effects** between the rotor and the fixed ring sieve. The feed material passes through the hopper (with splash-back protection) onto the rotor. It is thrown outward by centrifugal acceleration with great energy and is pre-crushed on impact with the wedge-shaped rotor teeth moving at high speed. The particles are then finely ground between the rotor and the ring sieve. This 2-step process ensures particularly gentle yet fast pulverization. As the feed material only remains in the grinding chamber for a very short time, there is no risk of overheating and the characteristics of the sample to be analyzed remain unaltered. The ground sample is collected in the cassette surrounding the grinding chamber or in the attached cyclone or paper filter bag.



Rotors and Ring Sieves

The selection of the push-fit rotor and ring sieve depends on the properties of the sample, the required final fineness and the subsequent analysis.

The ring sieve aperture size is primarily chosen according to the required final fineness and the feed material. With most materials approx. **80% of the total sample achieves a fineness of less than half the aperture size of the ring sieve used.**

Rotor Selection Guide	
Rotor	Field of Application
6-tooth-rotor	coarse, bulky, fibrous goods such as feed pellets, hay and straw
12-tooth-rotor	medium-coarse goods such as wheat, oats, corn, tablets, powder coatings and plastics
24-tooth-rotor	fine goods such as chemicals, coal and sugar
8-tooth mini-rotor	special rotor for size reduction of small sample amounts up to 20 ml

Rotors and ring sieves are available in various materials and types. The **reinforced rims** of some ring sieves provide greater stability so that these are typically used for heavy-duty applications.

Temperature-sensitive, brittle materials, such as powder coatings or resins, are particularly easy to grind with **distance sieves** which have been specially developed for this purpose.

Rotors and ring sieves with an **abrasion-resistant coating** are used for reducing the size of abrasive substances such as fertilizers.

For **heavy-metal-free size reduction** of non-abrasive materials we recommend the use of rotors and ring sieves made from titanium in combination with a titanium-niobium coated cassette and cover.

Thanks to the wide range of accessories with rotors, ring sieves and different types of collection systems, the ZM 200 can be easily adapted to suit a wide variety of applications.

Maximum Operating Comfort

The ZM 200 is very easy and safe to use. The parameters are readily set with one single button and a graphics display. Thus all relevant data (e.g. speed, drive load, operating hours or clear text error messages) are comfortably entered and clearly displayed.

With manual feeding of the sample, the performance display allows to monitor the load of the drive and to adjust the feed rate for optimum results. The electronic safety and diagnosis system virtually rules out operating errors.

ZM 200 at a Glance

Model	Ultra Centrifugal Mill
	
	ZM 200

Application	fine grinding
Fields of application	agriculture, biology, chemistry/ plastics, construction materials, engineering/electronics, environment, food, geology/ metallurgy, medicine/ pharmaceuticals
Feed material	soft, medium-hard, brittle, fibrous

Performance data

Feed size*	< 10 mm
Final fineness*	d_{90} < 40 µm
Sample volume (nominal)	
with standard cassette	up to 300 ml (900 ml)
with mini cassette	up to 20 ml (50 ml)
with paper filter bag	up to 1,000 ml (3,000 ml)
with cyclone	230 / 450 / 2,500 / 4,500 ml (250 / 500 / 3,000 / 5,000 ml)
Speed range	6,000 – 18,000 min^{-1}, freely selectable
Peripheral speed (rotor)	31 – 93 m/s
Aperture sizes	0.08 – 10 mm

Technical data

Drive power	750 W
W x H x D	410 x 515 x 365 mm
Net weight	approx. 38 kg
More information on	**www.retsch.com/zm200**

*depending on feed material and instrument configuration

Typical Sample Materials

RETSCH's versatile ultra centrifugal mill processes, for example, chemical products, fertilizers, drugs, food and feed stuff, cereals, spices, bones, coal, plastics, plants, pharmaceutical products, powder coatings, refuse derived fuels etc.

before

after

Application example: Corn

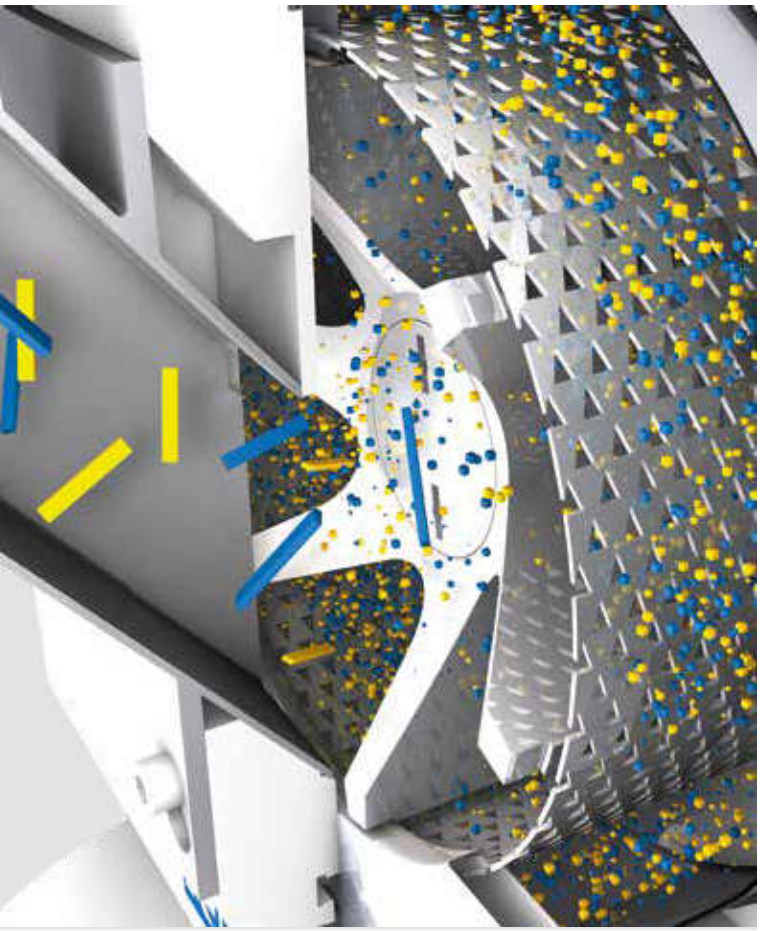
20 Rotor Beater Mill

SR 300 – Rapid Grinding of Large Volumes

Thanks to the robust design and the possibility to process large sample volumes the rotor beater mill SR 300 can be used for sample preparation in the lab as well as for small scale production. Another field of application is continuous grinding and desagglomeration in the process line. Grinding chamber, feed hopper as well as material inlet and outlet are completely made of high-quality stainless steel. Thanks to the extensive free surface of the 360 °C ring sieves the SR 300 processes samples very rapidly. The wide range of accessories for this mill matches the wide range of applications.

The adjustable speed from 3,000 to 10,000 min^{-1} allows for adaptation to different application requirements. The powerful drive capacity ensures high throughput with grind sizes down to < 50 microns. The mill provides results which are comparable to those achieved with the ultra centrifugal mill ZM 200 but accepts larger batches. The feed hopper can be easily removed for cleaning

Rotor Beater Mill SR 300
with base frame (option)



Benefits

- Suitable for batchwise operation of larger quantities
- Increased rotor speed of 3,000 – 10,000 min^{-1}
- Accepts feed sizes up to 25 mm
- Final fineness d_{90} < 50 µm*
- Optional grinding inserts 180° for grinding of hard-brittle materials
- Defined final fineness due to bottom sieves with aperture sizes from 0.08 – 10 mm
- Quick cleaning thanks to removable sieve cassette, push-fit rotor and removable hopper
- Distance rotor for grinding temperature-sensitive samples
- Ring filter and collecting receptacle with convenient, dust-tight bayonet locking mechanism
- Quick-action door lock and safety lock
- Optional cyclone for improved material discharge and additional cooling

Video on www.retsch.com/sr300

SR 300 Technology:
Size reduction and desagglomeration in rotor mills are achieved by **impact and shearing effects.** The feed material passes from the hopper into the center of the grinding chamber where it is crushed between the rotor, sieve and grinding insert. As soon as the material is smaller than the aperture size of the sieve, it passes into the collecting receptacle.

*depending on feed material and instrument configuration

Accessories and Options

The SR 300 is supplied with a 5 liter stainless steel collecting receptacle and a textile filter hose.
A wide selection of accessories is available for optimum sample preparation:

- **Sieve frame with ring sieve 360°**
  Recommended for grinding soft to medium-hard, fibrous samples. Available aperture sizes: 0.08 mm – 10.00 mm.
- **Grinding insert 180° with ring sieve 180°**
  Recommended for grinding hard and brittle materials. Available aperture sizes: 0.08 mm – 10.00 mm.
- **Distance rotor**
  Recommended for grinding slightly oily and fatty or very soft substances.
- **Ring-type filter**
  Instead of the textile tube a ring-type filter made of stainless steel (aperture size 36 µm) can be installed to avoid cross contamination.
- **Cyclone-suction-combination**
  Provides additional cooling of the feed material and the grinding tools and improves discharge of the sample from the grinding chamber. For collecting vessels 5/30 liters.
- **Vibratory feeder DR 100 and 30 l collecting vessel**
  Ideally suited for uniform material feed and for processing large volumes.

The SR 300 can be bench-mounted or installed on the optional base frame.

SR 300 at a Glance

Model	Rotor Beater Mill
	
	SR 300

Application	size reduction, desagglomeration
Fields of application	agriculture, chemistry/plastics, construction materials, environment, food, medicine/ pharmaceuticals
Feed material	soft to medium-hard

Performance data

Feed size*	< 25 mm
Final fineness*	d_{90} < 50 µm
Vessel capacity	5 or 30 l
Speed	3,000 – 10,000 min^{-1}
Rotor peripheral speed	22 – 72 m/s
Aperture sizes	0.08 – 10 mm

Technical data

Drive power	2,200 W
W x H x D	600 x 1200 x 700 mm (with base frame)
Net weight	approx. 60 kg (with base frame)
More information on	**www.retsch.com/sr300**

*depending on feed material and instrument configuration

Typical Sample Materials

RETSCH rotor beater mills are used for rapid size reduction of large volumes of materials such as construction materials, soil, chemicals, drugs, fertilizer, feed pellets, grain, spices, coal, pharmaceutical products, seeds etc.


before


after

Application example: Animal feed pellets

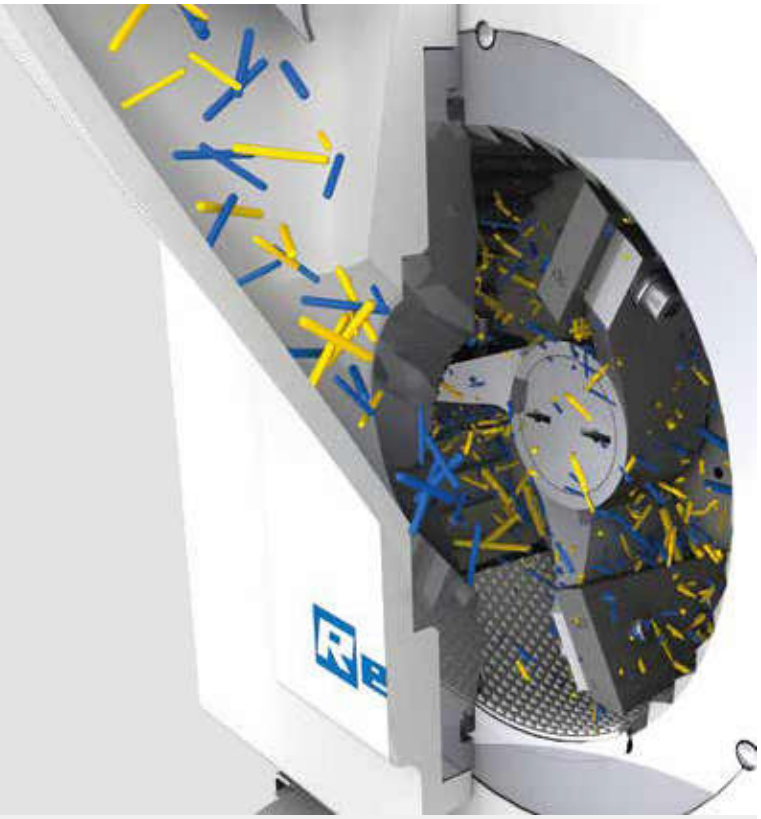
Cross Beater Mill

SK 300 – Hard-to-beat Size Reduction

The Cross Beater Mill SK 300 just like the Rotor Beater Mill SR 300 is used for batchwise or continuous primary and fine size reduction. This robust mill can be operated in laboratories but also in production environments under rougher conditions. The maximum material feed size is 25 mm. Thanks to the powerful drive of the SK 300 and a rotor speed of up to 4,000 min^{-1} it is often possible to achieve a grind size <100 microns in one working step.

The SK 300 offers the highest possible degree of operating safety. If, for example, the off-switch is pressed or the door is opened, the motor brake ensures that the rotor will come to a standstill in less than 0.5 seconds. The feed hopper and the optimized sample outlet are equipped with an access barrier that also prevents sample splashback. The SK 300 is robust, maintenance-free and thanks to the removable push-fit rotor and grinding insert it is quickly and easily cleaned. The high-quality finish of the mill guarantees a long working life.

Cross Beater Mill SK 300
with optional base frame



Benefits

- Suitable for batchwise operation of large quantities
- Material feed size up to 25 mm
- Adjustable speed from 2,000 to 4,000 min^{-1}
- Defined final fineness d_{90} < 100 µm* due to bottom sieves with aperture sizes from 0.12 – 10 mm
- Quick cleaning thanks to push-fit rotor and removable grinding insert
- Ring-type filter and collecting vessel with convenient, dust-tight bayonet locking mechanism
- Quick-action door lock and motor brake
- Optional cyclone for improved material discharge and additional cooling

Video on www.retsch.com/sk300

SK 300 Technology:
Size reduction in cross beater mills is effected by **impact and shearing.** The feed material passes from the hopper directly into the center of the grinding chamber, where it is caught by the cross beater and ground between the baffle plates of the cross beater and the toothed grinding insert. As soon as the material is smaller than the aperture size of the bottom sieve, it passes into the collecting receptacle.

*depending on feed material and instrument configuration

Accessories and Options

The standard equipment supplied with the SK 300 includes a 5 liter stainless steel collecting receptacle and a textile filter hose.
A wide selection of accessories is available for optimum sample preparation:

- **Bottom sieves**
  Stainless steel with trapezoid or round holes; 15 aperture sizes from 0.12 – 10 mm.
- **Bottom sieves, steel 1.0344**
  With trapezoid holes in 9 aperture sizes; for heavy-metal-free grinding.
- **Ring-type filter, stainless steel**
  Aperture size 36 µm, with or without dust filter; facilitates cleaning when very fine particles are involved.
- **30 liter collector**
  The 5 liter collecting receptacle can be replaced by a 30 liter collector which is connected to the mill with a corresponding filter hose.
- **Cyclone-suction-combination**
  Provides additional cooling of the feed material and the grinding tools and improves discharge of the sample from the grinding chamber. For collecting vessels 5/30 liters.
- **Vibratory feeder DR 100**
  Ideally suited for uniform material feed and for processing large volumes.

The SK 300 can be bench-mounted or installed on the optional base frame.

SK 300 at a Glance

Model	Cross Beater Mill
	
	SK 300

Application	size reduction
Fields of application	agriculture, chemistry/plastics, construction materials, environment, geology/metallurgy, glass/ceramics
Feed material	medium-hard, brittle

Performance data

Feed size*	< 25 mm
Final fineness*	d_{90} < 100 µm
Vessel capacity	5 or 30 l
Speed	2,000 – 4,000 min^{-1}
Rotor peripheral speed	15.5 – 31 m/s
Aperture sizes	0.12 – 10 mm

Technical data

Drive power	1,100 W
W x H x D	600 x 1200 x 700 mm (with base frame)
Net weight	approx. 55 kg (with base frame)
More information on	**www.retsch.com/sk300**

*depending on feed material and instrument configuration

Typical Sample Materials

RETSCH cross beater mills are typically used for processing, for example, soil, ores, glass, coke, minerals, oxide ceramics, slag, gravel, cement clinker, etc.

before

after

Application example: Mortar

TWISTER – Reproducible Sample Preparation to NIR Analysis

The Cyclone Mill TWISTER was specially designed for the processing of food and feeds for subsequent NIR (Near Infrared Spectroscopy) analysis. It quickly and gently pulverizes fibrous and soft materials by impact and friction to the required analytical fineness and is virtually self-cleaning.

The high speed and the optimized geometry of rotor and grinding chamber generate an air stream which carries the sample through the integrated cyclone into the sample bottle. The cyclone provides cooling of the sample and the grinding tools and due to its efficient extraction of the sample from the grinding chamber, avoids cross-contamination. This prevents loss of moisture and thermal degradation and ensures preservation of the sample properties to be determined. The ground material is separated in the cyclone and collected in a sample bottle for full recovery.

Cyclone Mill TWISTER

Benefits

- 3 controlled speeds
- Cyclone separator with 250 ml collecting bottle for quick extraction of sample
- No cross contamination thanks to easy cleaning
- Ideal for grinding feeds, grains, forage and similar products
- Convenient operating panel
- Professional industrial design ensures long lifetime

www.retsch.com/twister

Cyclone Mill Technology:
In the Cyclone Mill TWISTER size reduction is effected by **impact and friction** between the rotor and the abrasive surface of the fixed grinding ring. The feed material passes through the hopper (with splashback protection) onto the rotor, which rotates with high speed, and is thus submitted to preliminary size reduction. The sample is then projected outwards by centrifugal acceleration and is pulverized between rotor and grinding ring until the particles are smaller than the aperture size of the sieve insert.

*depending on feed material and instrument configuration

Accessories and Options

The Cyclone Mill TWISTER is supplied with the following components:

- **Aluminum rotor**
- **Stainless steel grinding ring with CrWFe coating**
- **Two stainless steel sieve inserts (1 mm and 2 mm)**
- **Adapter for connection of vacuum cleaner**
- **Cyclone with filter bag and ten 250 ml sample bottles**

Other accessories:

- **Sieve insert 0.5 mm and 0.8 mm**
- **Industrial vacuum cleaner**

TWISTER at a Glance

Model	Cyclone Mill
	
	TWISTER

Application	sample preparation to NIR analysis
Fields of application	agriculture food & feeds, medicine/ pharmaceuticals
Feed material	fibrous, soft

Performance data

Feed size*	< 10 mm
Final fineness*	d_{90} < 250 µm
Batch size/sample volume*	< 250 ml
Speed	10,000 / 12,000 / 14,000 min^{-1}
Rotor peripheral speed	52 / 62 / 93 m/s
Connection for vacuum cleaner	✓

Technical data

Drive power	900 W
W x H x D	449 x 427 x 283 mm
Net weight	approx. 14 kg
More information on	**www.retsch.com/twister**

*depending on feed material and instrument configuration

Typical Sample Materials

The cyclone mill TWISTER is perfectly suitable for grinding samples such as feed, grain, pharmaceutical products, tobacco, etc.


before


after

Application example: Hay

GRINDOMIX – Perfect Homogenization with High Reproducibility

The GRINDOMIX Knife Mills GM 200 and GM 300 set new standards in food sample preparation. The cutting effect produced by the steel blades results in the perfect homogenization of samples with high water or oil content. It is possible to take a random, yet representative sub-sample from any location in the grinding chamber and still obtain an accurate analysis result.

The GRINDOMIX mills produce representative samples with minimum standard deviation within seconds. They are characterized by robust design, a strong industrial motor, high safety standards, and digital parameter setting with storage of SOPs. All these features make these mills the only professional solution for the laboratory, highly superior to any household mixer or conventional knife mill! Whereas the GM 200 processes up to 700 ml of sample material, the GM 300 also accepts larger volumes up to 4,500 ml for quick and reproducible homogenization.

GRINDOMIX GM 300

GRINDOMIX GM 200

Benefits

- Thorough size reduction and homogenization of the complete sample material in seconds
- Pre- and fine grinding in one mill
- Variable speed up to 4,000 min^{-1} (GM 300) or 10,000 min^{-1} (GM 200)
- For sample volumes up to 700 ml (GM 200) or 4,500 ml (GM 300)
- Operation via touch display: easy, well-structured menu navigation, access to MyRETSCH web portal (GM 200)
- Quick Start and boost function with 14,000 min^{-1} (GM 200)
- Interval mode for better mixing of the sample
- Reverse mode for pre-grinding of hard materials
- GM 300 is suitable for cryogenic grinding
- Storage of Standard Operation Procedures (SOPs)
- Storage of program sequences (GM 200)
- Autoclavable grinding tools and grinding container
- Patented gravitation lid for automatic reduction of the grinding chamber volume
- Accessories for heavy-metal-free grinding
- Volume reduction lids (GM 200)
- Serrated blade knife improves homogenization of tough samples

Video on www.retsch.com/gm

Knife Mill Technology:
Two (GM 200) resp. four (GM 300) sharp, robust blades rotate in the center of the grinding container. Depending on the rotational direction, size reduction is effected with the blunt side (preliminary size reduction) or the sharp side (fine grinding).

*depending on feed material and instrument configuration

Accessories and Options

A range of different containers and lids is available for the GRINDOMIX GM 200 and GM 300 for optimum adaptation to a particular application. These include:

- **Patented gravity lid**
  Automatically adjusts the grinding chamber volume to the changing sample volume.
- **Gravity lid with overflow channels**
  Ideally suited to homogenize samples with a high water content.
- **Stainless steel container**
  Minimum wear when hard sample materials are processed.
- **Reduction lid**
  Reduces the chamber volume of the GM 200.
- **Serrated blade knife**
  Used for particularly tough samples such as fatty, streaky meat.
- **Accessories for cryogenic grinding**
  Applications with dry ice are carried out in the GM 300 with a full metal knife and a special lid.

Knife Mills at a Glance

	Knife Mills	
		
Model	GRINDOMIX GM 200	GRINDOMIX GM 300
Application	size reduction, homogenization and mixing	
Fields of application	agriculture, biology, food, medicine / pharmaceuticals	
Feed material	soft, medium-hard, elastic, fibrous, containing water / fat / oil, dry	

Performance data

Feed size*	< 40 mm	< 130 mm
Final fineness*	d_{90} < 300 µm	d_{90} < 300 µm
Batch size / sample volume*	< 700 ml	< 4,500 ml
Speed setting	Digital, 2,000–10,000 min^{-1}	Digital, 500–4,000 min^{-1}
Knife diameter	118 mm	180 mm
Knife peripheral speed	12.4–62 m/s	4.8–38 m/s
Number of blades	2	4
Grinding time setting	digital, 1 s–3 min	digital, 5 s–3 min
Interval and reverse mode possible	✓	✓
Boost function	✓	–
Program sequences	✓	–
Standard Operating Procedures (SOPs)	memory for 8 plus Quick Start	memory for 10

Technical data

Drive power	1000 W	1,100 W (short-term peak 3,000 W)
W x H x D	approx. 350 x 275 x 392 mm	approx. 440 x 340 x 440 mm
Net weight	approx. 10 kg	approx. 30 kg
More information on	**www.retsch.com/gm200**	**www.retsch.com/gm300**

*depending on feed material and instrument configuration

Typical Sample Materials

The GRINDOMIX Knife Mills GM 200 and GM 300 provide perfect homogenization of samples such as bread, fish, meat, feed pellets, cookies, vegetables, spices, cocoa nibs, seafood, cereal bars, fruit, seeds, deep-frozen food, sausages, etc.


before


after

Application example: Frozen pizza

SM 100, SM 200, SM 300 – The Perfect Cutting Mill for Every Requirement

The RETSCH cutting mills provide highly efficient primary size reduction of heterogeneous material mixes but are also suitable for grinding soft, medium-hard, elastic or fibrous samples. With the SM 100, SM 200 and SM 300 RETSCH offers three models for different requirements.

SM 100 – The Budget-Priced Basic Model

The SM 100 model is suitable for the size reduction of soft, medium-hard, elastic or fibrous products which can be comminuted without requiring extremely high forces. The mill is particularly suitable for routine applications. It is easy to operate and can be mounted on a solid table or on the optional base frame.

Cutting Mill SM 100
with optional base frame

Benefits

- Powerful size reduction – also of heterogeneous material mixes
- Selection of models to suit different requirements
- Optimum cutting effects thanks to double acting cutting bars (SM 200 & SM 300)
- SM 300 with variable speed from 700 to 3,000 min^{-1}, 3 kW drive with high torque
- Rotational Energy Storage Technology (RES) provides exceptional cutting power reserves (SM 300)
- Defined final fineness due to bottom sieves with aperture sizes from 0.25 – 20 mm
- Low heat build-up
- Quick and easy cleaning thanks to push-fit rotors, smooth surfaces and foldback hoppers (SM 200 and SM 300)
- Highest safety standard due to motor brake, central locking device and electronic safety check
- Wide range of accessories including various hoppers, collecting systems, rotors and sieves

Video on www.retsch.com/sm

*depending on feed material and instrument configuration

SM 200 – The Universal Standard Model

Within the RETSCH cutting mill family, the SM 200 is the universal standard model which covers a vast range of applications with its strong 2.2 kW drive and 1,500 rpm rotor speed. It can be operated with the optional cyclone-suction-combination to improve, for example, discharge of low-density materials. The hopper can be folded back and the push-fit rotor and sieve are easily removed for cleaning without tools.

SM 300 – The High Performance Model with RES Technology

The SM 300 model is characterized by a high torque, maximum cutting effect as well as safe and convenient operation. To allow for optimum adaptation to the sample properties with regards to breaking behavior and temperature sensitivity, the SM 300 features a variable speed from 700 min^{-1} to 3,000 min^{-1}. Thus it is possible to grind a great variety of products with one mill, including tough and thermally sensitive materials. An additional flywheel mass provides exceptional cutting power reserves, thus enabling the SM 300 to grind many materials to analytical fineness in only one working run (RES technology). The grinding chamber features an optimum geometry. The wide opening of the hopper and excellent feeding properties allow for large sample volumes, resp. pieces, thus increasing the throughput. Just like the SM 200, the SM 300 can be equipped with the cyclone-suction-combination which is especially recommended for fibrous, light sample stock.

The RETSCH Cutting Mills SM 200 and SM 300 excel especially in the tough jobs where other cutting mills fail. They offer a high degree of safety and longevity of the grinding tools.

Cutting Mill SM 200

Cutting Mill SM 300

Superiority in Detail

Push fit rotors facilitate quick and easy cleaning

3 double acting cutting bars provide optimum cutting effects (SM 200 & SM 300)

Cyclone-suction-combination ensures adequate cooling of sample and cutting tools (SM 200 & SM 300)

Accessories and Options

A comprehensive range of accessories allows for quick adaptation to individual application requirements. All three models are available in a special version for heavy-metal-free grinding (mill, rotor, sieves).

Rotors

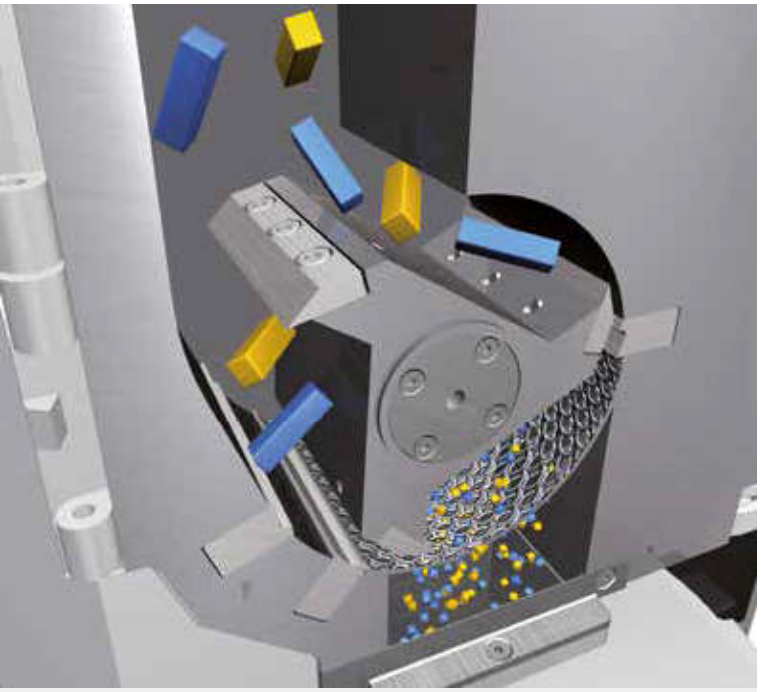
- **The parallel section rotor is equipped with 3 cutting plates and suitable for universal use.**
- **The 6-disc rotor with its 18 replaceable and reversible hard metal cutting tips is mostly used for medium-hard and brittle materials and for preliminary cutting of coarse goods.**
- **The V rotor (only SM 300) very effectively cuts through fibrous and tough materials and promotes rapid sample discharge.**

Cyclone-suction-combination (SM 200 & SM 300)

- **Efficient cooling of sample and cutting tools**
- **Improved material discharge from the grinding chamber**
- **Beneficial for low-density materials and small sample amounts**
- **The cyclone accommodates sample bottles of 0.5, 1 or 2 liters**

Other accessories

- **Universal or long stock hopper**
- **Sieves from 0.25 to 20 mm, also for heavy-metal-free grinding**
- **Collecting vessels from 0.25 l sample bottle to 30 liter plastic receptacle**
- **Stainless steel ring-type filter or textile filter hose help to remove dust**



Cutting Mill Technology:
Size reduction in cutting mills is effected by **cutting and shearing forces**. The sample passes through the hopper into the grinding chamber where it is seized by the rotor and is comminuted between the rotor blades and the stationary cutting bars inserted in the housing. The dwelling time of the sample in the chamber is short; as soon as it is small enough to pass through the openings of the bottom sieve it is discharged and collected in the receptacle.

Cutting Mills at a Glance

	Cutting Mills		
			
Model	SM 100	SM 200	SM 300
Application	size reduction by cutting		
Fields of application	agriculture, biology, chemicals / plastics, food, engineering / electronics, medicine / pharmaceuticals, environment / recycling		
Feed material	soft, medium-hard, elastic, fibrous	soft, medium-hard, tough, elastic, fibrous	

Performance data

Feed size*	max. 60 x 80 mm	max. 60 x 80 mm	max. 60 x 80 mm
Final fineness*	d_{90} < 250 µm	d_{90} < 250 µm	d_{90} < 250 µm
Rotor speed at 50 Hz	1,500 min^{-1}	1,500 min^{-1}	700 – 3,000 min^{-1}
Cutting bars	standard	double acting	double acting
Rotors	6-disc rotor and parallel section rotor	6-disc rotor and parallel section rotor	6-disc rotor, parallel section rotor and V rotor
Hoppers	fixed	foldback	foldback
Collecting receptacle			
Standard	5 l	5 l	5 l
Options	0.25 / 0.5 / 30 l	0.25 / 0.5 / 30 l	0.25 / 0.5 / 30 l
Cyclone (Option)	–	0.5 / 1 / 2 / 5 l	0.5 / 1 / 2 / 5 l

Technical data

Drive	3-phase-motor	3-phase-motor	frequency-controlled 3-phase-motor
Drive power	1,500 W	2,200 W	3,000 W with flywheel mass (approx. 28.5 kg)
Motor brake	✓	✓	✓
W x H x D (with base frame and universal hopper)	582 x 1,675 x 700 mm	576 x 1,675 x 760 mm	576 x 1,677 x 750 mm
Net weight	approx. 73 kg without base frame, hopper and rotor	approx. 90 kg without hopper and rotor	approx. 160 kg without hopper and rotor
More information on	**www.retsch.com/sm100**	**www.retsch.com/sm200**	**www.retsch.com/sm300**

*depending on feed material and instrument configuration

Typical Sample Materials

RETSCH cutting mills are suitable for a vast range of applications. Typical samples include lignite, non-ferrous metals, electronic scrap, drugs, foils, feedstuff, spices, rubber, wood, cables, bones, plastics, leather, organic and inorganic waste, paper, cardboard, plants, refuse derived fuels, straw, etc.

Application example: wood

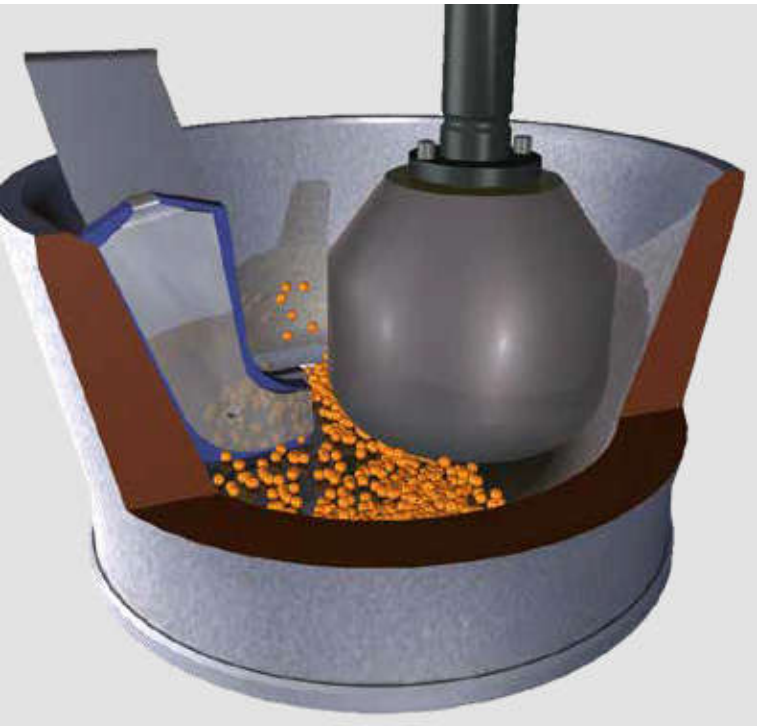
Mortar Grinder

RM 200 – The Classic Mill for Grinding, Mixing, Trituration

The RM 200 is the latest generation of the classic "RETSCH Mill" which replaced manual mortars and pestles more than 90 years ago. Mortar grinders are widely used for reproducible sample preparation in R&D, materials testing and especially in pharmaceutics and homeopathy. The versatile RM 200 efficiently homogenizes a variety of materials in dry and wet condition and is the perfect choice for cryogenic disruption of large quantities of yeast cells.

The grinding sets of the RM 200 can be selected out of 7 different materials which ensures neutral-to-analysis sample preparation. The mill is efficient, safe and easy to operate. It achieves a final fineness < 10 µm and provides a useable volume of 10 ml to 190 ml. The maximum feed size depends on the properties of the material and is approx. 8 mm. The sample, or any additives like liquids, can be fed to the mill during operation. The contact pressure of the pestle is conveniently set via a scale; the positions of the pestle and the scraper are adjustable. The RM 200 features a performance display which indicates the current workload of the mill for maximum efficiency.

Mortar Grinder RM 200



Benefits

- Suitable for dry, wet and cryogenic grinding
- Reproducible results by adjustment of the pestle pressure (via a scale) and digital time setting
- Final fineness d_{90} < 10 µm*
- Easy exchange of pestle and mortar without tools
- Closed grinding chamber with windows
- Digital time setting from 0 to 99 min or continuous operation
- 7 different grinding set materials ensure neutral-to-analysis sample preparation
- High-performance drive with electronic control

Video on www.retsch.com/rm200

RM 200 Technology:
Mortar grinders comminute, mix and triturate by **pressure and friction.** The material is fed by the scraper into the area between the mortar and pestle. This forced feed ensures that the entire sample is continuously subjected to the grinding and trituration process and is also thoroughly mixed.

*depending on feed material and instrument configuration

Accessories and Options

The choice of the suitable grinding set material depends primarily on the hardness of the sample and the possible effects of abrasion on the subsequent analysis or further processing.

- **Hard porcelain**
  suitable for pharmaceutical and homeopathic products.
- **Hard procelain or sintered aluminum oxide Al_2O_3**
  suitable for soft to medium-hard or pasty substances
- **Agate, zirconium oxide or tungsten carbide**
  suitable for processing hard, abrasive materials, for long-term trials and heavy-metal-free grinding.
- **Hardened or stainless steel**
  suitable for non-abrasive samples and rough conditions. Stainless steel is also the material of choice for grinding frozen yeast cells.

The **standard scraper** is made from abrasion-resistant polyurethane (PU). For applications in the pharmaceutical industry a special beech wood version is available. A PTFE scraper is particularly suitable for cryogenic grinding. The mortar of the RM 200 has a maximum useable volume of 190 ml.

RM 200 at a Glance

Model	Mortar Grinder
	
	RM 200

Application	grinding, mixing and triturating
Fields of application	agriculture, biology, chemistry / plastics, construction materials, food, geology / metallurgy, glass / ceramics, medicine / pharmaceuticals
Feed material	soft, hard, brittle, pasty, dry and wet

Performance data

Feed size*	< 8 mm
Final fineness*	d_{90} < 10 µm
Batch size / sample volume*	10 – 190 ml
Setting grinding time	1 – 99 min / continuous
Setting pestle pressure/ position	via scale
Setting scraper position	via knob
Setting scraper pressure	via knob

Technical data

Drive power	130 W
Speed	100 min^{-1}
Protection code	IP 53
W x H x D	approx. 400 x 480 x 370 mm
Net weight	approx. 24 kg
More information on	**www.retsch.com/rm200**

*depending on feed material and instrument configuration

Typical Sample Materials

RETSCH's Mortar Grinder RM 200 is used for dry, wet and cryogenic grinding of materials such as ash, soil, chemicals, drugs, spices, frozen yeast cells, food, oil seed, pharmaceutical and homeopathic raw materials and finished products, salt, slag, silicates, cement clinker, etc.


before


after

Application example: Cocoa nibs

DM 200, DM 400 – Grinding Even the Hardest Products

The Disc Mills DM 200 and DM 400 process large batches of hard and abrasive materials and are also suitable for continuous operation. Their rugged design permits use under rough conditions in laboratories and pilot plants as well as in-line for quality control of raw materials. The disc mills achieve an average final fineness of approximately 50 microns, often in a single grinding process. The comfort model DM 400 is particularly convenient and safe to handle. A major advantage of the mill is the large sample feed size, with an edge length of up to 20 mm.

The gap between the grinding discs can be adjusted via a scale with an accuracy of 0.05 mm (DM 400) resp. 0.1 mm (DM 200) which ensures reproducible grinding results. Operation of the RETSCH Disc Mills is very easy. When the grinding process is finished, the hinged grinding chamber can be opened completely, providing easy access for cleaning and changing the grinding discs. The DM 200 and DM 400 may be equipped with an optional connecting piece for a dust extraction.

20 mm
50 µm*

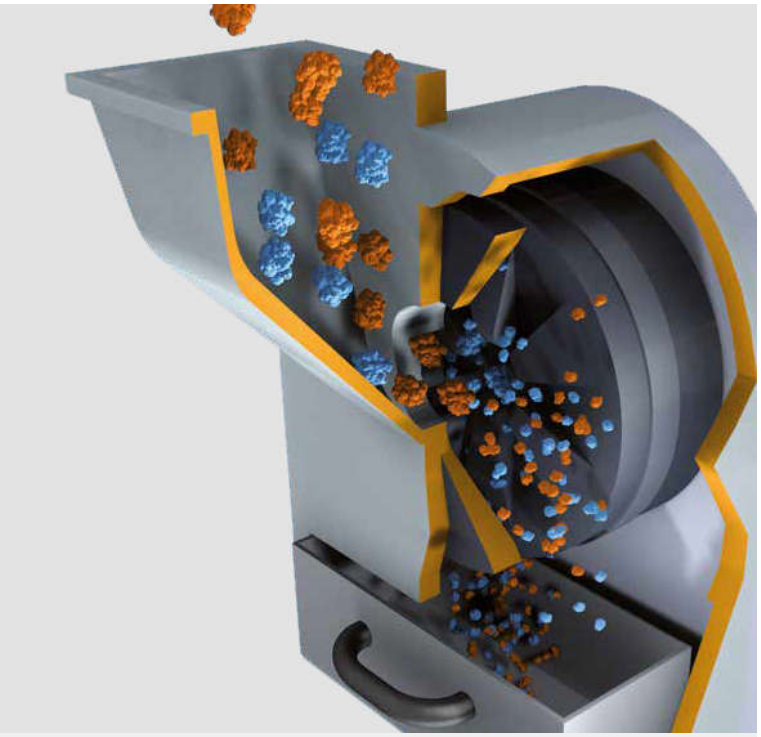
Suitable for Hardness up to 8 Mohs

Disc Mill DM 400

Benefits

- Short grinding times, high final fineness d_{90} < 50 µm*
- Material feed size up to 20 mm
- Accurate gap setting for reproducible grinding results
- Grinding discs made from 4 different materials, with long working life
- Easy access to grinding chamber facilitates cleaning
- Connector for dust extraction
- Maintenance-free 3-phase geared motor
- Combination of DM 200 with Jaw Crusher BB 200 permits pre- and fine grinding in one step

www.retsch.com/dm



Disc Mill Technology:
The feed material falls through the feed hopper into the dustproof chamber and is fed centrally between two vertical grinding discs. A moving grinding disc rotates against a fixed one and draws in the feed material. The necessary size reduction effects are generated by **pressure and frictional forces**. The progressively arranged teeth of the grinding disc first subject the sample to preliminary crushing; centrifugal force then moves it to the outer regions of the grinding discs where fine grinding takes place. The ground sample exits through the grinding gap and is collected in a receptacle. The gap width between the grinding discs is continuously adjustable.

*depending on feed material and instrument configuration

Accessories and Options

A set of grinding discs consists of a fixed and a rotating disc. The material should be selected so that contamination of the sample is avoided and abrasion minimized. 4 different materials are available.

- **Hardened steel**
  suitable for standard applications, e.g. minerals with Mohs hardness 3 – 6.
- **Manganese steel**
  suitable for standard applications. The structure of manganese steel is compacted by pressure, thus getting harder with usage (strain hardening).
- **Tungsten carbide (WC)**
  suitable for extremely hard products with Mohs hardness > 6.
- **Zirconium oxide**
  suitable for heavy-metal-free grinding, e.g. of dental ceramics

After a long period of use the grinding discs will show signs of wear. However, before they need to be replaced, the opposite side of the teeth can also be used by changing the direction of rotation of the motor. This considerably extends the working life of the grinding discs.

Disc Mills at a Glance

	Disc Mills	
		
Model	DM 200	DM 400

Application	preliminary and fine comminution	
Fields of application	chemistry / plastics, construction materials, engineering / electronics, geology / metallurgy, glass / ceramics	
Feed material	medium-hard, hard, brittle	

Performance data

Feed size*	< 20 mm	< 20 mm
Final fineness*	d_{90} < 100 µm	d_{90} < 50 µm
Hopper volume/Throughput	2.5 l / up to 150 kg/h	2.5 l / up to 150 kg/h
Gap width setting	continuous, 0.1 – 5 mm	gradually, 0.05 – 12 mm
Grinding disc speed at 50 Hz	440 min^{-1}	440 min^{-1}

Technical data

Drive power	1,500 W	1,500 W
W x H x D	approx. 440 x 400 x 870 mm	approx. 520 x 630 x 1050 mm
Net weight	approx. 140 kg	approx. 240 kg
More information on	**www.retsch.com/dm200**	**www.retsch.com/dm400**

*depending on feed material and instrument configuration

Typical Sample Materials

Disc mills are suitable for grinding very hard materials like bauxite, dental ceramics, ores, gypsum, glass, dried soil, sewage sludge, coal, coke, quartz, slag, sintered ceramics, steatite, etc.


before


after

Application example: Clinker

36

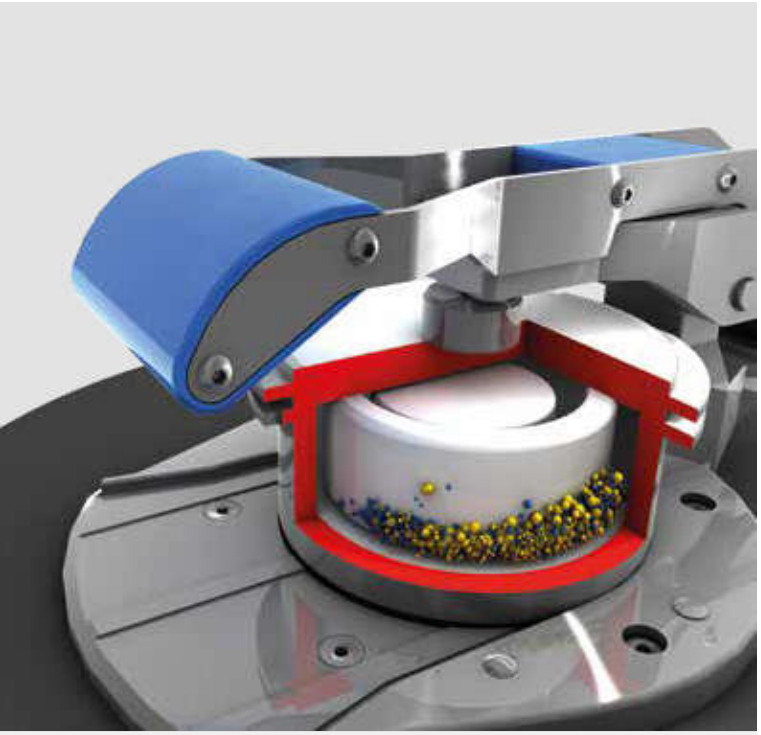
Vibratory Disc Mill

RS 200 – Analytical Fineness in Seconds

No Mill can beat the speed of a Vibratory Disc Mill when it comes to preparing samples for spectral analyses. RETSCH's RS 200 with its powerful stabilized plane drive achieves grind sizes <20 microns within seconds and with excellent reproducibility. The powerful instrument runs steadily and smoothly, even with heavy grinding sets and at maximum speed.

Thanks to grinding sets in various materials and sizes, this mill can be used for a wide range of sample materials. Sensors detect grinding sets made of agate or tungsten carbide and automatically reduce the speed to the ideal setting for optimum results while protecting the grinding tools. Handling and operation of the RS 200 are user-friendly and ergonomic. A carry handle facilitates transport of the heavy grinding set which slides along a rail into the optimum position inside the mill. The new quick-action clamping device permits rapid and safe fixing of the grinding set with minimum force. The correct locking and position of the grinding jar is monitored by sensors.

RS 200 Technology:
The vibratory disc mill comminutes by **pressure and friction**. The grinding set is firmly attached to the vibration plate with a quick-action clamping device. The plate with the grinding set is subjected to circular horizontal vibrations. The centrifugal force acting on the grinding rings in the dish results in extreme pressure, impact and frictional forces acting on the sample. The Stabilized-Plane-Drive prevents the jar from gyrating so that the entire energy is available for the grinding process.



Vibratory Disc Mill
RS 200

New carry handle

Benefits

- Excellent reproducibility
- Speed range 700 min^{-1} to 1,500 min^{-1}, freely selectable
- New ergonomic design allows for back-friendly placing of the heavy grinding set which slides on a rail into the correct position inside the mill
- Quick-action clamping system for grinding set
- Powerful Stabilized-Plane-Drive
- Convenient 1-button operation with color display
- Memory for 10 Standard Operating Procedures (SOP)
- Sealed, noise-insulated grinding chamber
- Grinding sets in different sizes and materials
- New carry handle allows for comfortable and safe transport of grinding set
- Automatic detection of agate and tungsten carbide (speed reduction to 700 min^{-1} resp. 1,200 min^{-1})
- Maintenance-free

Video on www.retsch.com/rs200

*depending on feed material and instrument configuration

Accessories and Options:

The grinding sets of the RS 200 are available in five different materials and three sizes (50 ml – 100 ml – 250 ml) which makes the mill easily adaptable to a wide range of applications and ensures uncontaminated analyses.

A grinding set for the vibratory disc mill consists of a grinding dish with cover and a grinding disc. The 100 ml and 250 ml grinding sets contain an additional grinding ring. The grinding sets are characterized by the following features:

- Safe, non-slip attachment with anti-twist lock on cover and base
- User-friendly gripping on cover and base
- Gap between dish and cover edge for easy opening
- Optimum sealing with O-ring (ideal for wet grinding)
- Protective jacket made from stainless steel (for agate, zirconium oxide and tungsten carbide dishes)
- Clear grinding set identification (article number, material and volume)

RS 200 at a Glance

Model	Vibratory Disc Mill
	
	RS 200

Application	size reduction, mixing, triturating
Fields of application	construction materials, environment / recycling, geology / metallurgy, glass / ceramics
Feed material	medium-hard, hard, brittle, fibrous

Performance data

Feed size*	< 15 mm
Final fineness*	d_{90} < 20 µm
Batch size / sample volume*	15 – 250 ml
Speed settings	700 min^{-1} – 1,500 min^{-1}
Digital grinding time setting	00:01 – 99:59 min

Technical data

Drive power	1,500 W
W x H x D (closed)	836 x 1,220 x 780 mm
W x H x D (with opened cover)	836 x 1,900 x 780 mm
Net weight	approx. 210 kg
More information on	**www.retsch.com/rs200**

*depending on feed material and instrument configuration

Please note:

For Retsch's offering of Vibratory Disc Mills for larger sample volumes, please visit www.retsch.com/rs

Typical Sample Materials

RETSCH's Vibratory Disc Mill RS 200 rapidly pulverizes materials such as concrete, soil, ores, glass, ceramics, coal, coke, corundum, metal oxides, minerals, slag, silicate, cement, cement clinker etc

before

after

Application example: Slag

XRD-Mill McCrone – Rapid Particle Size Reduction for X-Ray Diffraction

The XRD-Mill McCrone was specifically developed for sample preparation to X-Ray diffraction analysis. Typical areas of application include geology, chemistry, mineralogy and materials science.

What makes this mill so effective is the unique grinding action of the cylinders producing both linear contact blows and planar shearing. This results in short grinding times with virtually no sample loss as well as exceptionally narrow particle size distributions. **The crystal lattice structure of the sample is largely preserved.**

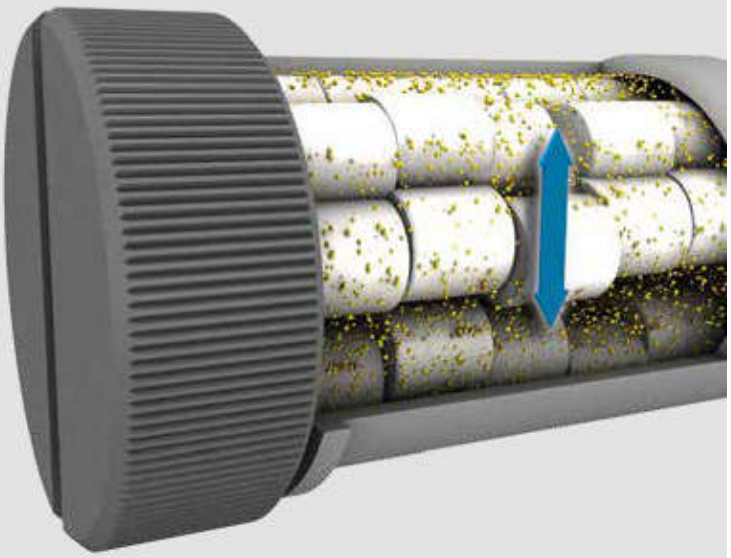
The grinding vessel consists of a 125 ml polypropylene jar fitted with a screw-capped gasketless polyethylene closure. The jar is packed with an ordered array of forty-eight identical cylindrical grinding elements which are available in either agate, zirconium oxide or sintered corundum. For optimum micronization the mill is operated for periods of 3 to 30 minutes; the recommended sample volume is 2 to 4 ml

XRD-Mill McCrone

Benefits

- Crystal lattice structure is preserved
- Minimum sample contamination
- Narrow, reproducible particle size distribution
- Compact bench-top model
- Pouring lid for easy sample recovery
- Easy cleaning
- Timer up to 99h:59min:50s
- Grinding performance adjustable in 4 steps
- Materials: agate, zirconium oxide, sintered corundum
- Suitable for dry and wet grinding
- Quiet operation
- Virtually maintenance-free

Video on www.retsch.com/xrd-mill



XRD-Mill Technology:
In the XRD-Mill McCrone size reduction is primarily achieved through friction. 48 cylindrical grinding elements are placed into the grinding jar in 8 rows of 6 elements each. The grinding jar is gyrated around a horizontal axis. Each element within the jar moves with respect to its neighbor so as to produce linear contact blows and planar shearing. Thus the particles are pulverized to sizes in the lower micron range (typically < 10 µm).

*depending on feed material and instrument configuration

Advantages of Wet Grinding

Both dry and wet grinding are basically suitable methods for sample preparation. Wet grinding causes minimum modifications to the sample's crystal lattice structure. When grinding has finished the lid is removed from the jar and replaced with the pouring lid for sample recovery. The ground slurry is then poured out. Repeated washing with liquid helps to remove sample residues from the grinding jar.

Accessories and Options

- **Grinding jar with lid and pouring lid**
- **Agate, zirconium oxide or sintered corundum grinding elements**
- **Loading device for grinding cylinder**
- **Sample preparation kit (Stainless steel percussion mortar, 10 sintered corundum cylinders, 1 sieve 500 µm and 1 cleaning brush)**

XRD-Mill McCrone at a Glance

Model	XRD-Mill
	
	XRD-Mill McCrone

Application	size reduction, mixing, triturating
Fields of application	biology, construction materials, geology / metallurgy, glass / ceramics
Feed material	medium-hard, hard, brittle, fibrous

Performance data

Feed size*	< 500 µm
Final fineness*	d_{90} < 1 µm
Batch size/sample volume*	2–4 ml
Speed setting	1,000–1,500 min^{-1} in 4 steps
Timer	00:00:10–99:59:50

Technical data

Drive power	50 W
W x H x D	205 x 155 x 520 mm
Net weight	approx. 19 kg
More information on	**www.retsch.com/xrd-mill**

*depending on feed material and instrument configuration

Typical Sample Materials

The XRD-Mill McCrone provides excellent grinding results for materials such as asbestos, borides, carbides, glass, glimmer, graphite, liver and muscular tissue, nitrides, paper, pigments, saw dust, slate, silicides, straw, talcum, clay, cement etc.


before


after

Application example: Glimmer

CryoMill – Efficient Grinding at -196 °C

Thermally sensitive and elastic substances are successfully processed by cooling with liquid nitrogen. The CryoMill was specifically designed for cryogenic grinding. It features an integrated cooling system which continually cools the grinding jar with liquid nitrogen before and during the grinding process. Thus the sample is embrittled and volatile components are preserved.

The liquid nitrogen is continually supplied from an autofill system in the exact amount required to keep the temperature at –196 °C. Thus the user never comes into direct contact with LN_2 which ensures a high degree of operational safety. The automatic cooling system guarantees that the grinding process is not started before the sample is thoroughly cooled. This helps to reduce consumption and guarantees optimum grinding results.

Parameters such as oscillation frequency, pre-cooling time or grinding time can be digitally set via a clearly structured keypad. If longer grinding times are required, it is also possible to pre-select periods of intermediate cooling and the number of cryogenic cycles. The mill can also be operated without cooling which makes it suitable for a vast range of applications.

CryoMill

Benefits

- Fast, efficient cryogenic grinding at -196 °C
- Ideal for plastics, temperature-sensitive materials and samples with volatile components
- Particularly safe due to autofill system for liquid nitrogen
- Automatic pre-cooling of sample and grinding jar for optimum results
- Programmable cooling and grinding cycles
- Highly reproducible grinding results
- Low consumption of liquid nitrogen
- Grinding jar materials include PTFE, stainless steel, hardened steel or zirconium oxide
- Memory for 9 Standard Operating Procedures (SOP)
- Suitable for dry and wet grinding

Video on www.retsch.com/cryomill

CryoMill Technology:
With a frequency of 30 Hz the CryoMill pulverizes most materials very effectively within a few minutes. The grinding jar performs horizontal oscillations; the inertia of the grinding balls causes them to impact with high energy on the sample material at the rounded ends of the grinding jar and pulverize it. The combination of **impact and friction** leads to substantially finer grind sizes compared to other cryogenic mills.

*depending on feed material and instrument configuration

Accessories and Options

The CryoMill is equipped with one grinding station for screw-top grinding jars with volumes of 10 ml, 25 ml, 35 ml or 50 ml. It is also possible to use adapters for 4 grinding jars of 5 ml each as well as for 6 reaction vials of 2 ml each. For applications where steel jars cannot be used due to possible sample contamination, RETSCH offers a 25 ml grinding jar of zirconium oxide and matching grinding balls. Alternatively, grinding jars of PTFE are available.

LN_2 Feed

For safe and comfortable operation of the CryoMill, RETSCH provides an autofill system for liquid nitrogen which is available with a 50 liter container and provides cooling for approximately 5 hours. It is also possible to connect existing cryo tanks to the mill, using a connection tube with safety valve.

Typical Sample Materials

Due to the automatic embrittlement of the samples the CryoMill is suitable for pulverizing, for example, waste, soil, chemical products, tissue, hair, wood, sewage sludge, bones, plastics, oil seed, paper, plants, pills, textiles, animal feed, wool etc.

CryoMill at a Glance

Model	Mixer Mill
	
	CryoMill

Application	size reduction, mixing, homogenization, cell disruption
Fields of application	agriculture, biology, chemistry / plastics, construction materials, engineering / electronics, environment / recycling, food, geology / metallurgy, glass / ceramics, medicine / pharmaceuticals
Feed material	hard, medium-hard, soft, brittle, elastic, fibrous

Performance data

Feed size*	< 8 mm
Final fineness*	d_{90} < 5 µm
Batch/Sample volume*	< 20 ml
Typical grinding time	Pre-cooling: 10 min, Grinding: 4 min
Possible applications	
Cryogenic grinding	✓
Grinding at room temperature	✓
Wet grinding	✓
Dry grinding	✓
Cell disruption	max. 6 x 2 ml
No. of grinding stations	1
Digital pre-selection of vibrational frequency	5 – 30 Hz (300 – 1,800 min^{-1})
Digital pre-selection of grinding time	30 s – 99 min
Memory for Standard Operating Procedures (SOP)	9

Technical data

Drive power	200 W
W x H x D	395 x 373 x 577 mm
Net weight	approx. 45 kg
More information on	**www.retsch.com/cryomill**

*depending on feed material and instrument configuration


before


after

Application example: rubber duck

MM 400 – Grinding, Mixing, Disrupting Small Sample Amounts

The Mixer Mill MM 400 is a true multipurpose talent in the lab. It has been developed specifically for dry, wet and cryogenic grinding of small sample amounts. The powerful ball mill grinds, mixes and homogenizes powders and suspensions with up to 30 Hz within a few seconds, providing grind sizes in the submicron range.

The mixer mill simultaneously pulverizes two samples from 0.2 to 20 ml. Thanks to the self-centering mechanism of the grinding jars and the self-locking clamping device handling of the grinding jars is extraordinarily safe and convenient. The MM 400 is perfectly suitable for the disruption of up to 20 samples of biological cells in one working run as well as for DNA/RNA and protein extraction. The MM 400 can also be used for wet grinding due to the screw-top grinding jars; these may also be embrittled in liquid nitrogen for cryogenic applications.

The mill operates so effectively that the sample is hardly warmed due to the very short grinding time. Thus most materials can be pulverized and mixed at ambient temperature, without any cooling. Thanks to the effective homogenization process, the MM 400 is also perfectly suited to mix powdered sample and binder in plastic vessels prior to pelletizing, for example for XRF analysis.

Mixer Mill MM 400

For dry processing of small sample volumes RETSCH also offers the basic model MM 200 as a budget-priced alternative with push-fit lids.

Benefits

- Quick, efficient pulverization and homogenization
- Suitable for wet and cryogenic grinding (MM 400)
- High sample throughput due to two grinding stations and short grinding times
- Digital parameter setting ensures reproducible results
- Choice of different sizes and materials for grinding jars
- Memory for 9 Standard Operating Procedures (SOP)
- Adapter for single-use vials, simultaneous preparation of up to 20 biological samples
- Suitable for cell disruption of up to 240 ml (8 x 30 ml) cell suspension (MM 400)
- Suitable for mixing up to 8 samples in 50 ml centrifuge tubes (MM 400)

Video on www.retsch.com/mm

Mixer Mill Technology:
The grinding jars perform horizontal oscillations. The inertia of the grinding balls causes them to impact with high energy on the sample material at the rounded ends of the grinding jars and pulverize it. Moreover, the movement of the grinding jars combined with the movement of the balls result in the intensive mixing of the sample. The degree of mixing can be increased by using several smaller balls.

*depending on feed material and instrument configuration

Accessories and Options

The MM 400 can be equipped with screw-top grinding jars from 1.5 ml to 50 ml. Available materials include hardened steel, stainless steel, tungsten carbide, agate, zirconium oxide, PTFE. Adapters for 0.2 ml to 50 ml single-use vials are used for cell disruption and DNA/RNA extraction.

Avantages of the screw-top grinding jars

- Suitable for wet and cryogenic grinding
- Ultimate reproducibility by automatic centering and uniform jar design
- Ergonomic gripping flanges on jar and lid
- Stainless steel protective jacket (for agate, zirconium oxide and tungsten carbide jars)

Mixer Mills at a Glance

	Mixer Mills	
		
Model	MM 200	MM 400
Application	size reduction, mixing, homogenization, cell disruption	
Fields of application	agriculture, biology, chemistry / plastics, construction materials, engineering / electronics, environment / recycling, food, geology / metallurgy, glass / ceramics, medicine / pharmaceuticals	
Feed material	hard, medium-hard, soft, brittle, elastic, fibrous	
Performance data		
Feed size*	< 6 mm	< 8 mm
Final fineness*	d_{90} < 10 µm	d_{90} < 5 µm
Batch size/sample volume*	2 x 10 ml	2 x 20 ml
Typical grinding time	30 s – 2 min	30 s – 2 min
Possible applications		
Dry grinding	✓	✓
Wet grinding	–	✓
Cryogenic grinding	–	✓
Cell disruption in single-use vials	max. 10 x 2.0 ml	max. 20 x 2.0 ml or 10 x 5.0 ml or 8 x 50 ml
Mixing with conical centrifuge tubes	–	✓
Suitable grinding jars		
Grinding jar with push-fit lids	1.5 – 25 ml	–
Grinding jars with screw-top lids	–	1.5 – 50 ml
Self-centering clamping device	–	✓
No. of grinding stations	2	2
Digital pre-selection of vibrational frequency	3 – 25 Hz (180 – 1,500 min^{-1})	3 – 30 Hz (180 – 1,800 min^{-1})
Digital pre-selection of grinding time	10 s – 99 min	10 s – 99 min
Memory for Standard Operating Procedures (SOP)	9	9
Technical data		
Drive power	85 W	120 W
W x H x D	371 x 266 x 461 mm	371 x 266 x 461 mm
Net weight	approx. 25 kg	approx. 26 kg
More information on	**www.retsch.com/mm200**	**www.retsch.com/mm400**

*depending on feed material and instrument configuration

Typical Sample Materials

RETSCH mixer mills are true allrounders. They homogenize, for example, waste, soil, chemical products, coated tablets, drugs, ores, grain, tissue, glass, hair, ceramics, bones, plastics, alloys, minerals, oil seeds, plants, sewage sludge, pills, textiles, wool etc.

Application example: Hair

High Energy Ball Mill

E_{max} – The Revolution in Ultrafine Grinding

The E_{max} is an entirely new type of ball mill for high energy milling. The unique combination of high friction and impact results in extremely fine particles within a very short time. The high energy input is a result of the unrivaled speed of 2,000 min^{-1} and the novel jar design.

An innovative cooling system with water ensures that the high energy input is effectively used for the grinding process without overheating the sample. Due to the special grinding jar geometry, the sample is thoroughly mixed which results in a narrow particle size distribution. Unlike other high energy ball mills, the E_{max} is capable of continuous grinding operation without interruptions for cooling down. This dramatically reduces the grinding time. The high energy ball mill provides perfect conditions for effective mechanical alloying or grinding down to the nanometer range.

Features such as the integrated safety closure of the grinding jar, control of the set temperature with automatic speed reduction, and integrated imbalance controls make operation of the bench-top mill E_{max} very user-friendly.

High Energy Ball Mill E_{max}

Benefits

- Faster and finer grinding than with any other ball mill
- Unmatched speed of 2,000 min^{-1}
- Innovative integrated liquid cooling allows for continuous operation without cool down breaks
- Temperature control mode
- Special jar design for narrow particle size distributions
- Patented drive concept
- Easy operation via touch screen, memory for 10 SOP
- Two grinding stations, grinding jars with integrated safety closure
- Selection of materials ensures neutral-to-analysis size reduction

Video on www.retsch.com/emax

E_{max} Technology:
The interplay of jar geometry and movement causes **strong friction** between grinding balls, sample material and jar walls as well as a rapid acceleration which lets the balls impact with great force on the sample at the rounded ends of the jars. This significantly improves the mixing of the particles resulting in smaller grind sizes and a narrower particle size distribution than in conventional ball mills.

*depending on feed material and instrument configuration

Cooling and Temperature Control

The grinding jars of the E_{max} are cooled in their bracket by an integrated water cooling system. To further reduce the temperature, the mill can be connected to a heat exchanger or the tap. The E_{max} software allows the user to carry out the grinding process within a defined temperature range, i. e. he can set a minimum and a maximum temperature. When the maximum temperature is exceeded, the mill automatically stops and starts again upon reaching the minimum temperature.

Measuring System GrindControl

By continuously measuring pressure and temperature the processes and reactions which take place inside the grinding jar during grinding can be monitored and recorded.

Accessories and Options

- **Grinding jars**
  – stainless steel 50 ml, 125 ml
  – zirconium oxide 50 ml, 125 ml
  – tungsten carbide 50 ml.
- **Grinding balls**
  stainless steel, zirconium oxide, tungsten carbide
  – up to 12 mm for 50 ml grinding jar or
  – up to 15 mm for 125 ml grinding jar.
- **Aeration lid**
  for grinding under inert atmosphere; for stainless steel and zirconium oxide jars.

Aeration cover

E_{max} at a Glance

Model	High Energy Ball Mill
	
	E_{max}

Application	nano grinding, size reduction, homogenizing, mechanical alloying, colloidal milling, high energy comminution
Fields of application	agriculture, biology, chemistry, construction materials, engineering / electronics, environment / recycling, geology / metallurgy, glass / ceramics, medicine / pharmaceuticals
Feed material	medium-hard, hard, brittle, fibrous – dry or wet

Performance data

Feed size*	< 5 mm
Final fineness*	d_{90} < 80 nm
Batch size/sample volume*	2 x 45 ml
Speed at 50 Hz	300 – 2,000 min^{-1}
G-force**	76 g
Cooling	controlled integrated water cooling
Temperature control	min and max temperature may be defined
No. of grinding stations	2
Type of grinding jars	with integrated safety closure devices
Setting of grinding time	00:01:00 – 99:59:59
Interval operation	with optional direction reversal
Interval time	00:01:00 – 99:59:59
Pause time	00:01:00 – 99:59:59
Memory for Standard Operating Procedures (SOPs)	10

Technical data

Drive power	2,600 W
W x H x D	625 x 525 x 645 mm
Net weight	approx. 120 kg
More information on	**www.retsch.com/emax**

*depending on feed material and instrument configuration **(1 g = 9.81 m/s^2)

Typical Sample Materials

The High Energy Ball Mill E_{max} efficiently pulverizes materials such as soil, concrete, carbon fibers, chemical products, ores, gypsum, glass, semi-precious stones, wood, lime, catalysts, ceramics, bones, coal, alloys, metal oxides, minerals, pigments, quartz, slag, tobacco, tea, clay minerals, cement clinker etc.

before

after

Application example: Ores

...more details on www.retsch.com

PM Series – Grind Sizes Down to the Nanometer Range

The powerful and versatile planetary ball mills meet and exceed all requirements for fast and reproducible grinding down to the submicron range. They are used for the most demanding tasks, from routine sample processing to colloidal grinding and mechanical alloying. The extremely high centrifugal forces of the planetary ball mills result in exceptional pulverization energy and therefore short grinding times.

The planetary ball mills are available in versions with 1, 2 and 4 grinding stations. The freely selectable parameter settings, comprehensive range of grinding jars made from top-quality materials as well as the numerous possible ball charge combinations (number and ball size) allow for individual adaptation to a particular size reduction task and are the basis of unmatched versatility in the PM range.

All RETSCH planetary ball mills feature programmable starting time, power failure back-up with storage of the remaining grinding time and automatic grinding chamber ventilation which also cools the grinding jars during operation. Grinding parameters are easily selected and stored via a single button and a graphic display. The mills – which are available in 7 different versions – are characterized by maximum performance, safety and reliability.

Planetary Ball Mill
PM 400 | PM 400 MA

Benefits

- Efficient grinding process for excellent results down to the submicron range
- Reproducible results due to energy and speed control
- 1-button operation and graphics display
- Memory for 10 Standard Operating Procedures (SOP)
- Smooth and safe operation
- Suitable for long-term trials and continuous use
- Different speed ratios available (1:-1; 1:-2; 1:-2,5; 1:-3)
- Grinding jar volumes from 12 ml to 500 ml, in 8 different materials
- Automatic direction reversal helps to avoid caking
- Free-Force-Compensation-Sockets for perfect stability on the bench
- Programmable starting time
- Automatic grinding chamber ventilation

Video on www.retsch.com/pm

*depending on feed material and instrument configuration

Range of Models

Planetary Ball Mill PM 100
This ball mill is equipped with one grinding station and pulverizes and mixes a large number of materials. It can be operated with grinding jar volumes from 12 ml to 500 ml. Thanks to the Free Force Compensation Socket (FFCS) technology the vibrations of the mill are compensated. If the PM 100 is placed on a suitable laboratory bench, it can be left unattended during operation.

Planetary Ball Mill PM 100 CM
This version features the same performance data as the classical PM 100; however, the speed ratio of sun wheel to grinding jar is 1:-1 instead of 1:-2. This results in a different ball movement which leads to the sample being pulverized rather by pressure and friction than by impact. This not only reduces abrasion but also heat built-up inside the grinding jar. Hence it is possible to process agglomerating materials in a more gentle way.

Planetary Ball Mill PM 200
The PM 200 possesses 2 grinding stations for grinding jars with a nominal volume of 12 ml to 125 ml. The larger sun wheel diameter results in a higher energy input compared to the PM 100.

Planetary Ball Mill PM 400
The PM 400 is a robust floor model with 4 grinding stations for grinding jars with a nominal volume of 12 ml to 500 ml. It can process up to 8 samples simultaneously which results in a high sample throughput.

Model PM 400 MA
To generate the high energy input which is required for mechanical alloying of hard-brittle materials, the PM 400 is available as "MA" type with a speed ratio of 1:-2.5 or 1:-3.

Planetary Ball Mill
PM 100 | PM 100 CM

Planetary Ball Mill PM 200

Pressure and Temperature Measuring System GrindControl

Due to their high energy input Planetary Ball Mills are frequently used for the development of new materials by mechanical alloying. The processes and reactions which take place in the grinding jar during grinding can be measured and monitored with the software controlled GrindControl system. It is available with a stainless steel grinding jar of 250 ml or 500 ml. Jar and PC communicate via a robust and secure wireless connection. The measurement data can be recorded with different sampling rates; the longest interval is 5 seconds, the shortest 5 milliseconds. The complete system – including accessories such as the grinding jar and a conversion kit for gassing – is delivered in an aluminum case.

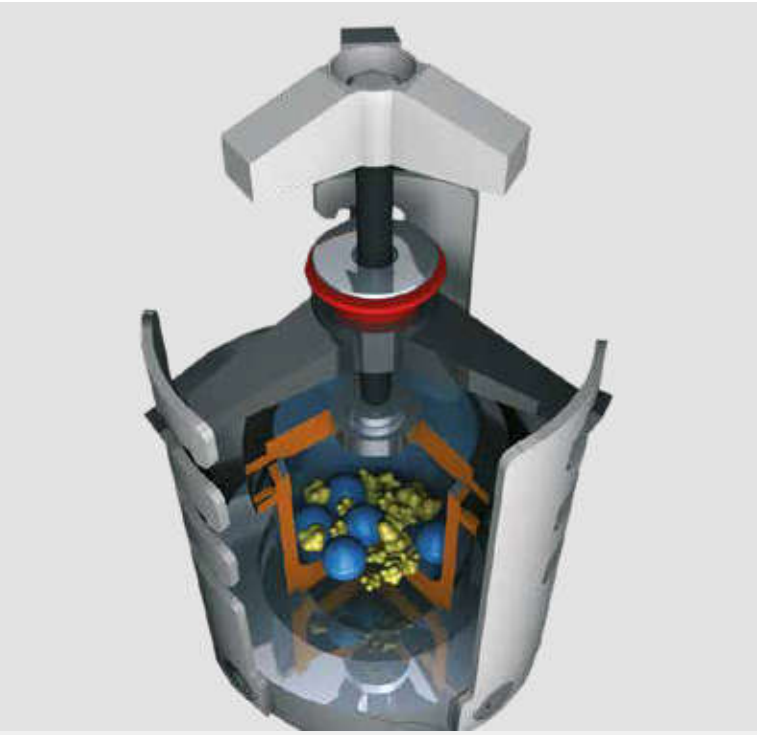
Measurement ranges

- Gas pressure: up to 500 kPa
- Temperature: 0 – 200 °C

Grinding Jars „comfort“

The “comfort” range of grinding jars has been specially designed for extreme working conditions such as long-term trials, wet grinding, high mechanical loads and maximum speeds as well as for mechanical alloying.

- Grinding jar sizes from 12 ml to 500 ml
- Hardened steel, stainless steel, tungsten carbide, agate, sintered aluminum oxide, zirconium oxide, silicon nitride, PTFE
- O-ring for gas-tight and dust-proof seal
- User-friendly gripping flanges on jar and lid
- Safe, non-slip seating with built-in anti-twist lock and conical base centering
- Gap between jar and edge of lid for easy opening
- Optional safety closure device for gas-tight handling inside and outside of glove boxes
- Optional aeration lid for creation of inert atmosphere inside the grinding jar
- PM 100, PM 100 CM and PM 400 also accommodate stacked grinding jars in various sizes



Safety

The planetary ball mills feature a Safety Slider which ensures that the mill can only be started after all grinding jars have been securely fixed with a clamping device. The self-acting lock ensures that the grinding jars are seated correctly and securely.

Thanks to the automatic cover closure, the machine does not start unless the cover is properly closed. It can only be opened when the mill is at a complete standstill.
The Free-Force-Compensation-Sockets (FFCS) compensate vibrations and secure the stability of the mills on the bench.

Planetary Ball Mill Technology:
The grinding jars are arranged eccentrically on the sun wheel of the planetary ball mill. The direction of movement of the sun wheel is opposite to that of the grinding jars in the ratio 1:-2 (resp. 1:-1, 1:-2.5 or 1:-3). The grinding balls in the grinding jars are subjected to superimposed rotational movements, which cause the so-called Coriolis forces. The speed difference between the balls and grinding jars produces an interaction between frictional and impact forces, which releases high dynamic energies. The interplay between these forces produces the high and very effective degree of size reduction of the Planetary Ball Mill.

Planetary Ball Mills at a Glance

	Planetary Ball Mills		
			
Model	PM 100 & PM 100 CM	PM 200	PM 400 & PM 400 MA
Applications	nano grinding, pulverizing, mixing, homogenizing, colloidal milling, mechanical alloying		
Fields of application	agriculture, biology, chemistry / plastics, construction materials, engineering / electronics, environment / recycling, geology / metallurgy, glass / ceramics, medicine / pharmaceuticals		
Feed material	soft, hard, brittle, fibrous – dry or wet		
Performance data			
Feed size*	< 10 mm	< 4 mm	< 10 mm
Final fineness*	d_{90} < 1 µm	d_{90} < 1 µm	d_{90} < 1 µm
For colloidal grinding*	d_{90} < 100 nm	d_{90} < 100 nm	d_{90} < 100 nm
Batch/sample volume*	max. 1 x 220 ml	max. 2 x 50 ml	max. 4 x 220 ml
with stacked grinding jars	max. 2 x 20 ml	–	max. 8 x 20 ml
No. of grinding stations	1	2	2 or 4
Suitable grinding jars „comfort"			
12 ml / 25 ml / 50 ml / 80 ml	1 or 2	2	2, 4 or 8
125 ml	1	2	2 or 4
250 ml / 500 ml	1	–	2 or 4
Speed ratio	1:-2 / 1:-1	1:-2	1:-2 / 1:-2.5 or 1:-3
Sun wheel speed	100 – 650 min^{-1}	100 – 650 min^{-1}	30 – 400 min^{-1}
Effective sun wheel diameter	141 mm	157 mm	300 mm
G-force**	33 g	37 g	27 g
Digital grinding time setting (hours:minutes:seconds)	00:00:01 – 99:59:59	00:00:01 – 99:59:59	00:00:01 – 99:59:59
Interval operation	with optional direction reversal	with optional direction reversal	with optional direction reversal
Interval time	00:00:01 – 99:59:59	00:00:01 – 99:59:59	00:00:01 – 99:59:59
Pause time	00:00:01 – 99:59:59	00:00:01 – 99:59:59	00:00:01 – 99:59:59
Memory for Standard Operating Procedures (SOPs)	10	10	10
Measurement of energy input	✓	✓	✓
Serial interface	✓	✓	✓
Technical data			
Drive power	750 W	750 W	1,500 W
W x H x D	630 x 468 x 415 mm	630 x 468 x 415 mm	836 x 1,220 x 780 mm
Net weight	approx. 80 kg / approx. 86 kg	approx. 72 kg	approx. 290 kg
More information on	**www.retsch.com/pm100**	**www.retsch.com/pm200**	**www.retsch.com/pm400**

*depending on feed material and instrument configuration **(1 g = 9.81 m/s^2)

Typical Sample Materials

RETSCH planetary ball mills are perfectly suitable for size reduction of, for example, soil, chemical products, ores, glass, household and industrial waste, ceramics, sewage sludge, alloys, minerals, plants etc.

Application example: Composite ceramics

The Perfect Solution for Any Product and Analysis Method

The following examples represent the core applications of a selection of industries. RETSCH's online database www.retsch.com/applicationdatabase contains many more test reports.

In addition, the RETSCH application laboratory offers free test grindings of customer samples. You will receive your pulverized sample together with a test report with information about recommended instrument configurations. Of course, you are welcome to visit our application laboratory to assist the trials and get to know the full range of RETSCH's equipment for milling and sieving.

For the majority of analysis methods only a few milligrams or grams of sample are required which should represent the original material. If the sample is not representative, the results will vary with regards to the composition of the material, depending on the part of the original material from which the sample was taken. Therefore, complete homogenization is an important prerequisite for representative sample properties and for correct qualitative and quantitative evaluation of the material. Basically, when selecting grinding parameters and accessories care should be taken not to influence the sample properties and to fulfill the requirements of the subsequent analysis method.

Application Examples:

before

after

Soil, Sewage Sludge

Samples of soil or sewage sludge are usually heterogeneous and may contain, for example, straw or stones. They are frequently moist and, when containing clay, even greasy. Which type of mill is suitable for pulverization and homogenization depends on the sample characteristics. As samples are often analyzed for their heavy metal content, it is paramount to use grinding tools made of materials which guarantee neutral-to-analysis sample preparation.

Sample		Mill	Accessories	Feed quantity	Grinding time	Speed	Final fineness (d_{90})
Soil	●	RM 200	mortar and pestle hard porcelain	50 g	4 min	100 min^{-1}	< 90 µm
Sediment	●	RS 200	100 ml grinding set agate	50 g	8 min	700 min^{-1}	< 100 µm
Sewage sludge	■	PM 100	125 ml grinding jar zirconium oxide, 7 grinding balls zirconium oxide 20 mm	25 g	10 min	450 min^{-1}	< 500 µm
	●	PM 100	125 ml grinding jar zirconium oxide, 50 grinding balls zirconium oxide 10 mm	25 g	30 min	500 min^{-1}	< 20 µm
Loamy soil	●	GM 200	grinding jar polycarbonate, pure titanium knife for heavy-metal-free grinding	290 g	30 s	4,000 min^{-1} reverse mode	< 4 mm
Soil	●	MM 400	35 ml grinding jar zirconium oxide, 10 grinding balls zirconium oxide 10 mm	10 g	7 min	30 Hz	< 20 µm

■ Pre-grinding ● Fine grinding * Embrittlement with liquid nitrogen or dry ice ** Wet grinding

Please note: The achieved grind size depends on the sample material and instrument configurations/settings. Even apparently similar samples may produce different results to those listed above.


Soil


Sediment


Sewage sludge


Loamy soil

Plants, Wood, Straw

Materials such as straw or wood are tough and elastic and frequently contain moisture. For size reduction of such samples RETSCH cutting or rotor mills are the best choice. These can be equipped with different rotor types in accordance with the sample characteristics. As fibrous particles may pass vertically through the sieve apertures, a subsequent fine grinding step is recommended.

Sample		Mill	Accessories	Feed quantity	Grinding time	Speed	Final fineness (d_{90})
Straw	■	SM 200	parallel section rotor, bottom sieve 2 mm, cyclone with 500 ml sample bottle	50 g	30 s	1,500 min^{-1}	< 10 mm
	●	PM 100	500 ml grinding jar zirconium oxide, 25 grinding balls zirconium oxide 20 mm	50 g	1:15 h	400 min^{-1}	< 50 µm
Waste wood	■	SM 300	6-disc rotor, bottom sieve 2 mm, cyclone with 5 l collecting receptacle	500 g	2 min	3,000 min^{-1}	< 2 mm
	●	MM 400	50 ml grinding jar stainless steel, 4 grinding balls stainless steel 15 mm	4 g	4 min	30 Hz	< 200 µm
Dried grass	●	Twister	sieve insert 0.5 mm	20 g	1 min	14,000 min^{-1}	< 500 µm

■ Pre-grinding ● Fine grinding * Embrittlement with liquid nitrogen or dry ice ** Wet grinding

Please note: The achieved grind size depends on the sample material and instrument configurations/settings. Even apparently similar samples may produce different results to those listed above.


Soil


Straw


Waste wood


Dried grass


Compound fertilizer


Mineral fertilizer


Dried, fermented manure


Dried compost


Hay


Animal feed pellets


Grain mix for poultry


Chewing bone

Fertilizers

The term „fertilizer" comprises a large variety of materials with different characteristics. A general distinction is made between organic fertilizers which are heterogeneous, for example manure or compost with soft-greasy or hard-brittle properties, and mineral fertilizers such as nitrate or phosphate compounds which are usually abrasive, hard and brittle. The choice of a suitable mill depends on the characteristics of the sample to be homogenized.

Sample		Mill	Accessories	Feed quantity	Grinding time	Speed	Final fineness (d_{90})
Compound fertilizer	●	SR 300	distance rotor, ring sieve 360° 4 mm	300 g	30 s	3,000 min^{-1}	< 1 mm
Mineral fertilizer	●	ZM 200	12-tooth push-fit rotor titanium, cassette titanium-niob-coated, ring sieve pure titanium 0.75 mm	500 g	1 min	18,000 min^{-1}	< 400 µm
Potassium nitrate	●	PM 400	grinding jar zirconium oxide 500 ml, 150 grinding balls zirconium oxide 10 mm	175 g	10 min	380 min^{-1}	< 9 µm
Dried, fermented manure	●	SM 200	6-disc rotor, bottom sieve 1.5 mm, 5 l collecting receptacle	2 liters	2 min	1,500 min^{-1}	< 1 mm
$NH_4H_2PO_4$	●	SR 300	standard rotor, ring sieve 360°, 0.25 mm, 30 l collecting receptacle	1 kg	2 min	8,000 min^{-1}	< 100 µm
Dried compost	■	SM 300	6-disc rotor, bottom sieve 8 mm, 5 l collecting receptacle	1 kg	20 min	2,000 min^{-1}	< 8 mm
	●	ZM 200	12-tooth push-fit rotor, distance sieve 0.75 mm	200 g	2 min	18,000 min^{-1}	< 750 µm

■ Pre-grinding ● Fine grinding * Embrittlement with liquid nitrogen or dry ice ** Wet grinding

Please note: The achieved grind size depends on the sample material and instrument configurations/settings. Even apparently similar samples may produce different results to those listed above.

Feed

The properties of feedstuff vary from fibrous to tough or oily. Quick and effective homogenization with RETSCH mills ensures that all sample components are uniformly represented in the analysis sample. The size reduction process should not have any impact on the residual moisture content, particularly if the sample is to be analyzed for nutritional values which are generally related to the dried substance.

Sample		Mill	Accessories	Feed quantity	Grinding time	Speed	Final fineness (d_{90})
Hay	●	Twister	sieve insert 1 mm	10 g	1 min	14,000 min^{-1}	< 1 mm
Animal feed pellets	●	SR 300	distance rotor, ring sieve 360° 0.5 mm	500 g	3 min	8,000 min^{-1}	< 500 µm
Beet pellets	●	SM 200	parallel-section-rotor, bottom sieve 6 mm, 5 l collecting receptacle	300 g	1 min	1,500 min^{-1}	< 4 mm
Grain mix for poultry	●	ZM 200	Cassette for small quantities, 8-tooth rotor, ring sieve for small quantities 0.25 mm	10 g	30 s	18,000 min^{-1}	< 200 µm
Cat food	●	GM 300	5 l grinding container stainless steel, standard lid, standard knife	180 g	3 min	4,000 min^{-1}	< 2 mm
Chewing bone	■	SM 200	parallel-section-rotor stainless steel, bottom sieve 6 mm stainless steel, 5 l collecting receptacle	50 g	1 min	1,500 min^{-1}	< 8 mm
	●	ZM 200	12-tooth push-fit rotor, distance rotor 0.5 mm, cyclone	50 g	2 min	18,000 min^{-1}	< 500 µm

■ Pre-grinding ● Fine grinding * Embrittlement with liquid nitrogen or dry ice ** Wet grinding

Please note: The achieved grind size depends on the sample material and instrument configurations/settings. Even apparently similar samples may produce different results to those listed above.

Food

Food occurs in a great variety of forms and consistencies and is often inhomogeneous. Food testing labs require representative samples to obtain meaningful and reproducible analysis results. Therefore, food samples need to be homogenized and pulverized to the required analytical fineness. For samples with high water, sugar or fat content, RETSCH's GRINDOMIX knife mills are the perfect choice. For medium-hard and granular food samples like grain one of the RETSCH rotor mills should be used. Cutting mills like RETSCH's powerful SM 300 are suitable for grinding large quantities of tough, fibrous or hard materials. Finally, sticky or pasty samples are best homogenized in a mortar grinder like the RM 200.

Sample		Mill	Accessories	Feed quantity	Grinding time	Speed	Final fineness (d_{90})
Streaky bacon	■	GM 200	standard lid, serrated blade knife, polycarbonate grinding container	150 g	40 s	3,000 min^{-1}	
	●	GM 200	gravity lid, serrated blade knife, polycarbonate grinding container	150 g	50 s	10,000 min^{-1}	homogeneous
Grapefruits	●	GM 300	gravity lid with overflow channels, serrated blade knife, polycarbonate grinding container	4 whole fruits	20 s	3,000 min^{-1}	homogeneous
Hard candy	■	GM 200	standard lid, standard knife, stainless steel grinding container	100 g	10 s	2,000 min^{-1}	
	■	GM 200	standard lid, standard knife, stainless steel grinding container	100 g	15 s	4,000 min^{-1}	
	●	GM 200	standard lid, standard knife, stainless steel grinding container	100 g	5 s	6,000 min^{-1}	< 400 µm
Fruit gum*	■	GM 300	lid for dry ice applications, full metal knife, stainless steel grinding container, dry ice	500 g	40 s	1,000 min^{-1}	
	●	GM 300	lid for dry ice applications, full metal knife, stainless steel grinding container, dry ice	500 g	20 s	4,000 min^{-1}	< 1 mm
Herbal tea	●	ZM 200	12-tooth push-fit rotor, ring sieve 0.5 mm	25 g	2 min	18,000 min^{-1}	< 100 µm
Corn	●	ZM 200	12-tooth push-fit rotor, distance sieve 0.5 mm, cyclone with 5 l collecting receptacle	200 g	2:30 min	18,000 min^{-1}	< 250 µm
Muesli	●	Twister	sieve insert 1 mm	50 g	1 min	14,000 min^{-1}	< 1 mm
Nuts with shell	●	SM 300	6-disc rotor, bottom sieve 4 mm, 5 l collecting receptacle	1 kg	2 min	2,000 min^{-1}	< 2 mm
Freeze-dried carp	●	SM 300	V rotor, bottom sieve 1 mm, 2 l collecting receptacle with cyclone	120 g	2 min	3,000 min^{-1}	< 1 mm
Stone salt	■	SM 300	6-disc rotor, bottom sieve 8 mm, 5 l collecting receptacle , cyclone	500 g	10 s	1,500 min^{-1}	< 4 mm
	●	SM 300	6-disc rotor, bottom sieve 0,5 mm, 5 l collecting receptacle , cyclone	500 g	1 min	1,500 min^{-1}	< 500 µm
Cocoa nibs	●	RM 200	mortar and pestle hard porcelain	75 g	10 min	100 min^{-1}	< 100 µm

■ Pre-grinding ● Fine grinding * Embrittlement with liquid nitrogen or dry ice ** Wet grinding

Please note: The achieved grind size depends on the sample material and instrument configurations/settings. Even apparently similar samples may produce different results to those listed above.


Streaky bacon


Grapefruits


Fruit gum


Corn


Nuts with shell


Muesli


Freeze-dried carp


Cocoa nibs

Painkillers

Pills with sticky coating

Capsules with liquid filling

Pharmaceutical Products

Pharmaceutical products such as pills or capsules are often composed of inhomogeneous components. Some have a sugary coating which makes the sample clump together during homogenization. Capsules with liquid fillings show the same behavior. If volatile or temperature-sensitive ingredients are involved, the homogenization process should not lead to heat build-up beyond a certain temperature in order to preserve these components for subsequent analysis. This can be ensured by improving the breaking properties of the sample by embrittlement during the grinding process. A range of RETSCH mills is suitable for this application.

Sample		Mill	Accessories	Feed quantity	Grinding time	Speed	Final fineness (d_{90})
Painkillers	●	RM 200	mortar and pestle hard porcelain, beech wood scraper	30 pieces	7 min	100 min^{-1}	< 500 µm
Pills with sticky coating*	●	ZM 200	cassette for small volumes with 8-tooth rotor, ring sieve for small volumes 0.12 mm	10 pieces	1 min	18,000 min^{-1}	< 60 µm
Capsules with liquid filling*	●	MM 400	50 ml grinding jar stainless steel, 25 mm grinding ball stainless steel, KryoKit	5 pieces	1 min	30 Hz	< 300 µm

■ Pre-grinding ● Fine grinding * Embrittlement with liquid nitrogen or dry ice ** Wet grinding

Please note: The achieved grind size depends on the sample material and instrument configurations/settings. Even apparently similar samples may produce different results to those listed above.

Sulfur

Rutil

$LiNbO_3$

Chemical Products

Adequate sample preparation ensures that the analyzed sample volume – which often is not more than a few grams – represents the original sample. For neutral-to-analysis size reduction of chemical products, which can vary strongly in their consistency from abrasive to greasy or from brittle to soft, RETSCH offers a variety of mills.

Sample		Mill	Accessories	Feed quantity	Grinding time	Speed	Final fineness (d_{90})
Potassium sulfate	●	SR 300	standard rotor, ring sieve 360° 0.12 mm	1,500 g	5 min	8,000 min^{-1}	< 100 µm
Aluminum sulfate	●	ZM 200	12-tooth push-fit rotor, ring sieve 0.08 mm, cyclone	100 g	1 min	18,000 min^{-1}	< 90 µm
Sulfur	●	ZM 200	12-tooth push-fit rotor, ring sieve 0.25 mm, cyclone	150 g	30 s	18,000 min^{-1}	< 10 µm
Chromium oxide	■	BB 200	breaking jars tungsten carbide, wearing plates stainless steel	150 g	1 min	gap width: 2 mm	< 5 mm
	●	MM 400	25 ml grinding jar tungsten carbide, 1 grinding ball tungsten carbide 15 mm	15 g	4 min	30 Hz	< 80 µm
Anion exchanger	●	PM 100	250 ml grinding jar stainless steel, 100 grinding balls stainless steel 10 mm	90 g	20 min	450 min^{-1}	< 60 µm
Rutile	●	E_{max}	50 ml grinding jar tungsten carbide, 15 grinding balls tungsten carbide 10 mm	20 g	15 min	1,000 min^{-1}	< 2.8 µm
$LiNbO_3$	●	PM 200	50 ml grinding jar zirconium oxide, 110 g grinding balls zirconium oxide 1 mm, 12 ml sodium phosphate 1%**	5 g	4 h	530 min^{-1}	< 140 nm
Carbon black	●	E_{max}	grinding jar zirconium oxide 125 ml, 110 g grinding balls zirconium oxide 0.1 mm, 49 g binder solution**	1 g	1 h	1,800 min^{-1}	< 150 nm

■ Pre-grinding ● Fine grinding * Embrittlement with liquid nitrogen or dry ice ** Wet grinding

Please note: The achieved grind size depends on the sample material and instrument configurations/settings. Even apparently similar samples may produce different results to those listed above.

Construction Materials

Construction materials are usually made up of different components which can be challenging for the size reduction process due to their different characteristics (abrasive, soft, oily, brittle). RETSCH's product portfolio comprises sample preparation equipment suitable for the various production steps of construction materials – from the quarrying to the end product. Sample preparation is often carried out in two steps: preliminary grinding or crushing is followed by pulverization of the sample to analytical fineness.

Sample		Mill	Accessories	Feed quantity	Grinding time	Speed	Final fineness (d_{90})
Slag	●	RS 200	100 ml grinding set tungsten carbide	90 g	1 min	1,200 min^{-1}	< 80 µm
Limestone	■	BB 200	breaking jaws manganese steel, wearing plates stainless steel	1 kg	2 min	gap width: 2 mm	< 5 mm
	●	PM 100	500 ml grinding jar stainless steel, 25 grinding balls stainless steel 20 mm	125 g	5 min	400 min^{-1}	< 80 µm
Limestone	●	XRD-Mill McCrone	Grinding cylinders sintered corundum, 7 ml propanol**	7 g	15 min	1,500 min^{-1}	< 6 µm
Sand	●	E_{max}	125 ml grinding jar zirconium oxide, 18 grinding balls zirconium oxide 15 mm	40 ml	10 min	1,200 min^{-1}	< 10 µm
Cement	●	MM 400	35 ml grinding jar zirconium oxide, 1 grinding ball zirconium oxide 20 mm	15 g	30 s	30 Hz	< 500 µm
Clinker	■	BB 100	breaking jaws and wearing plates stainless steel	500 g	1 min	gap width: 2 mm	< 8 mm
	●	DM 400	grinding discs hardened steel	500 g	2 min	gap width: 0.2 mm	< 250 µm
Mortar block	■	BB 200	breaking jaws and wearing plates stainless steel	500 g	1 min	gap width: 5 mm	< 8 mm
	●	SK 100	grinding insert and cross beater cast iron, baffle plates hardened steel, bottom sieve 0.5 mm	500 g	3 min	3,000 min^{-1}	< 500 µm
Concrete	■	BB 50	breaking jaws and wearing plates stainless steel	40 g	1 min	gap width: 2.5 mm	< 4 mm
	●	BB 50	breaking jaws and wearing plates stainless steel	40 g	1 min	0.1 mm	< 400 µm
Asphalt*	■	BB 200	breaking jaws and wearing plates stainless steel	400 g	1 min	gap width: 10 mm	< 20 mm
	■	BB 200	breaking jaws and wearing plates stainless steel	400 g	1 min	1 mm	< 5 mm
	●	SR 300	Distance rotor, sieve frame grinding insert 180°, sieve insert 180° 1.5 mm	400 g	1 min	3,000 min^{-1}	< 1 mm

■ Pre-grinding ● Fine grinding * Embrittlement with liquid nitrogen or dry ice ** Wet grinding


Slag


Limestone


Sand


Clinker


Mortar


Concrete

Please note: The achieved grind size depends on the sample material and instrument configurations/settings. Even apparently similar samples may produce different results to those listed above.


Iron ore


Chromic iron


Lapis lazuli


Jade


Glimmer


Composite ceramics


Ceramic cones


Glass bottle

Minerals, Ores, Rocks

Minerals and ores need to be homogenized to the required fineness before analysis. Material properties vary from brittle and abrasive (e.g. slag) to ductile behavior (e.g. metals in ore). RETSCH offers a full range of crushers and mills for preliminary and fine size reduction of these materials.

Sample		Mill	Accessories	Feed quantity	Grinding time	Speed	Final fineness (d_{90})
Iron ore	■	SK 100	grinding insert and cross beater cast iron, baffle plates hardened steel, bottom sieve 1.5 mm	100 g	30 s	3,000 min^{-1}	< 1 mm
	■	E_{max}	125 ml grinding jar zirconium oxide, 40 grinding balls zirconium oxide 10 mm	50 g	10 min	1,200 min^{-1}	< 5 µm
	●	E_{max}	125 ml grinding jar zirconium oxide, 275 g grinding balls zirconium oxide 0.5 mm, 40 ml water**	50 g	30 min	2,000 min^{-1}	< 800 nm
Chromic iron	■	BB 300	breaking jaws manganese steel, wearing plates stainless steel	500 g	5 min	gap width: 1 mm	< 8 mm
	●	RS 200	100 ml grinding set tungsten carbide	140 g	5 min	1,200 min^{-1}	< 600 µm
Lapis lazuli	●	PM 200	50 ml grinding jar zirconium oxide, 3 grinding balls zirconium oxide 20 mm	20 g	2 min	420 min^{-1}	< 90 µm
Jade	■	BB 50	breaking jaws and wearing plates zirconium oxide	200 g	1 min	gap width: 0.1 mm	< 1 mm
	●	PM 100	500 ml grinding jar zirconium oxide, 25 grinding balls zirconium oxide 20 mm	200 g	1 min	380 min^{-1}	< 600 µm
Glimmer	●	XRD-Mill McCrone	grinding elements sintered corundum, 5 ml propanol**	2 g	10 min	1,500 min^{-1}	< 10 µm
Zeolithe	●	E_{max}	50 ml grinding jar zirconium oxide, 110 g grinding balls zirconium oxide 0.1 mm, 13 ml water**	5 g	10 min	2,000 min^{-1}	< 200 nm

■ Pre-grinding ● Fine grinding * Embrittlement with liquid nitrogen or dry ice ** Wet grinding

Please note: The achieved grind size depends on the sample material and instrument configurations/settings. Even apparently similar samples may produce different results to those listed above.

Glass, Ceramics

Glass and ceramics as well as the raw materials required for their production are usually hard and brittle. Jaw crushers, disc and ball mills are most suitable to reduce these materials in one or two steps to analytical fineness.

Sample		Mill	Accessories	Feed quantity	Grinding time	Speed	Final fineness (d_{90})
Composite ceramics	●	PM 400	500 ml grinding jar zirconium oxide, 25 grinding balls zirconium oxide 20 mm	160 g	30 min	320 min^{-1}	< 27 µm
Ceramic cones	■	BB 200	breaking jaws manganese steel, wearing plates stainless steel	1 kg	30 s	gap width: 2.5 mm	< 8 mm
	●	RS 200	50 ml grinding set tungsten carbide	30 g	5 min	1,200 min^{-1}	< 100 µm
Al-Zr-Y ceramic	●	PM 100	50 ml grinding jar zirconium oxide, 3 grinding balls zirconium oxide 20 mm	35 g	5 min	550 min^{-1}	< 100 µm
Silica sand	●	XRD-Mill McCrone	grinding elements sintered corundum, 10 ml water**	2 g	10 min	1,500 min^{-1}	< 14 µm
Glass bottle (small)	■	BB 50	breaking jaws and wearing plates zirconium oxide	1 piece	30 s	gap width: 2 mm	< 2 mm
	●	BB 50	breaking jaws and wearing plates zirconium oxide		30 s	0.5 mm	< 800 µm

Sample		Mill	Accessories	Feed quantity	Grinding time	Speed	Final fineness (d_{90})
Glass	●	MM 400	25 ml grinding jar tungsten carbide, 4 grinding balls tungsten carbide 12 mm	10 g	4 min	30 Hz	< 50 µm
Glass powder	●	PM 100	50 ml grinding jar zirconium oxide, 110 g grinding balls zirconium oxide 2 mm, 15 ml water**	15 g	3 h	550 min^{-1}	< 600 nm
Aluminum oxide	●	E_{max}	50 ml grinding jar zirconium oxide, 110 g grinding balls zirconium oxide 0.1 mm, 18 ml 0.5 % sodium phosphate**	5 g	30 min	2,000 min^{-1}	< 130 nm
Broken glass	●	DM 400	grinding discs hardened steel	15 ml	1:30 min	gap width: 0.1 mm	< 400 µm

■ Pre-grinding ● Fine grinding * Embrittlement with liquid nitrogen or dry ice ** Wet grinding

Glass

Broken glass

Please note: The achieved grind size depends on the sample material and instrument configurations/settings. Even apparently similar samples may produce different results to those listed above.

Coal, Coke

Coal and coke occur in a great variety of compositions. Lignite often contains more residual moisture and fibers of plant residues than stone coal or anthracite. Graphite is a greasy substance and therefore requires extreme energy input to be pulverized. Laboratories worldwide produce representative and homogeneous analysis samples with RETSCH crushers and grinders.

Sample		Mill	Accessories	Feed quantity	Grinding time	Speed	Final fineness (d_{90})
Lignite	■	BB 300	breaking jaws and wearing plates stainless steel, collector 27.5 l	4 kg	1 min	gap width: 10 mm	< 40 mm
	■	BB 300	breaking jaws and wearing plates stainless steel, collector 27.5 l	4 kg	2 min	2 mm	< 8 mm
	●	ZM 200	12-tooth push-fit rotor, ring sieve 0.2 mm	100 ml	30 s	18,000 min^{-1}	< 100 µm
Boiler coal	●	SR 300	ring sieve 360° 0.25 mm, collecting receptacle 5 l	100 g	2 min	8,000 min^{-1}	< 200 µm
Coal	●	E_{max}	125 ml grinding jar stainless steel, 40 grinding balls stainless steel 10 mm	30 g	10 min	1,500 min^{-1}	< 17 µm
Anthracite coal	■	BB 50	breaking jaws and wearing plates stainless steel	500 g	30 s	gap width: 5 mm	8 mm
	●	SR 300	ring sieve 360° 0.5 mm, collecting receptacle 5 l	500 g	30 s	8,000 min^{-1}	< 300 µm
Graphite	●	E_{max}	50 ml grinding jar zirconium oxide, 110 g grinding balls zirconium oxide 1 mm, 13 ml isopropanol**	5 g	8 h	2,000 min^{-1}	< 1.7 µm

■ Pre-grinding ● Fine grinding * Embrittlement with liquid nitrogen or dry ice ** Wet grinding

Lignite

Anthracite coal

Please note: The achieved grind size depends on the sample material and instrument configurations/settings. Even apparently similar samples may produce different results to those listed above.

Keyboard and mouse

Circuit board

Secondary fuels

Electronic Scrap, Secondary Fuels

Both materials usually occur in very inhomogeneous forms. Electronic scrap may contain components as different as hard plastics, soft-elastic foil and thin, ductile metal parts. Secondary fuels consist of a mixture of elastic plastics, organic materials such as wood, plants or soil, and hard materials like glass, small stones or metal pieces. Cutting mills are best suited to reduce the particle size of these materials without too much heat build-up. Large metal pieces such as screws or nails, however, should be removed from the sample before grinding as these would accelerate the wearout of the mill and grinding tools. If materials like soft plastics and foil are subjected to fine grinding in a second step, embrittlement with liquid nitrogen or dry ice is strongly recommended.

Sample		Mill	Accessories	Feed quantity	Grinding time	Speed	Final fineness (d_{90})
Keyboard and mouse	■	SM 300	6-disc rotor, bottom sieve 4 mm, cyclone with 5 l collecting receptacle	1 piece each	2 min	1,500 min^{-1}	< 5 mm
	●	ZM 200	12-tooth push-fit rotor, ring sieve 0.5 mm, cyclone *		15 min	18,000 min^{-1}	< 500 µm
Circuit board	■	SM 300	6-disc rotor, bottom sieve 4 mm, cyclone with 5 l collecting receptacle	1 piece	1 min	3,000 min^{-1}	< 4 mm
	●	RS 200	250 ml grinding set hardened steel		6 min	1,500 min^{-1}	< 600 µm
Secondary fuels	●	SM 300	parallel-section rotor, bottom sieve 1 mm, cyclone with 5 l collecting receptacle	500 g	3 min	3,000 min^{-1}	< 1 mm

■ Pre-grinding ● Fine grinding * Embrittlement with liquid nitrogen or dry ice ** Wet grinding

Please note: The achieved grind size depends on the sample material and instrument configurations/settings. Even apparently similar samples may produce different results to those listed above.

Plastic granulate PET

Rubber duck

Epoxy molding material

Plastics, Cables, Elastomeres, Caoutchouc

Pulverizing plastics and elastomeres can be a true challenge due to their elastic and tough properties. Liquid nitrogen or dry ice are suitable grinding aids which improve their breaking behavior. The CryoMill is the perfect mill to pulverize these samples under constant cooling with LN_2. Before the actual grinding process starts, the sample is cooled down automatically to a constant temperature of -196 °C. It can also be useful to process plastics with better breaking properties cryogenically if, for example, volatile components need to be preserved during grinding.

Sample		Mill	Accessories	Feed quantity	Grinding time	Speed	Final fineness (d_{90})
Plastic granulate PET*	●	ZM 200	12-tooth push-fit rotor, distance sieve 0.5 mm, cyclone	40 g	20 s	18,000 min^{-1}	< 500 µm
Rubber duck	■	SM 300	V rotor, bottom sieve 4 mm, cyclone with 1 l collecting receptacle	1 piece	5 min	3,000 min^{-1}	< 5 mm
	●	CryoMill	50 ml grinding jar stainless steel, 1 grinding ball stainless steel 25 mm	6 g	2 min	30 Hz	< 400 µm
Epoxy molding material	■	BB 50	breaking jaws and wearing plates stainless steel	30 g	1 min	gap width: 2 mm	< 5 mm
	●	MM 400	50 ml grinding jar stainless steel, 1 grinding ball stainless steel 25 mm	5 g	12 min	30 Hz	< 200 µm
Styrene polymer	●	PM 100	500 ml grinding jar stainless steel, 25 grinding balls stainless steel 20 mm	40 g	15 min	380 min^{-1}	< 150 µm

Sample		Mill	Accessories	Feed quantity	Grinding time	Speed	Final fineness (d_{90})
Caoutchouc	●	CryoMill	50 ml grinding jar stainless steel, 1 grinding ball stainless steel 25 mm	4 g	2 min	30 Hz	< 500 µm

■ Pre-grinding ● Fine grinding * Embrittlement with liquid nitrogen or dry ice ** Wet grinding

Please note: The achieved grind size depends on the sample material and instrument configurations/settings. Even apparently similar samples may produce different results to those listed above.


Caoutchouc

Leather, Textiles

Leather and textiles are usually tough, fibrous and soft and are therefore best reduced in size by cutting. For fine grinding it is often necessary to embrittle and cool the materials down to -196 °C with liquid nitrogen.

Sample		Mill	Accessories	Feed quantity	Grinding time	Speed	Final fineness (d_{90})
Leather glove	■	SM 300	parallel-section rotor, bottom sieve 4 mm, 5 l collecting receptacle	1 piece	1 min	1,500 min^{-1}	< 4 mm fibers
	●	SM 300	parallel-section rotor, bottom sieve 1 mm, 5 l collecting receptacle		3 min	1,500 min^{-1}	< 1 mm fibers
Outdoor jacket	●	SM 300	V rotor, bottom sieve 0.5 mm, cyclone with 5 l collecting receptacle	1 piece	20 min	3,000 min^{-1}	< 500 µm
Textile	●	CryoMill	50 ml grinding jar stainless steel, 1 grinding ball stainless steel 25 mm	2 g	4 min	30 Hz	< 500 µm

■ Pre-grinding ● Fine grinding * Embrittlement with liquid nitrogen or dry ice ** Wet grinding

Please note: The achieved grind size depends on the sample material and instrument configurations/settings. Even apparently similar samples may produce different results to those listed above.

Leather glove


Outdoor jacket


Textile

Forensics: Hair, Bones, Teeth

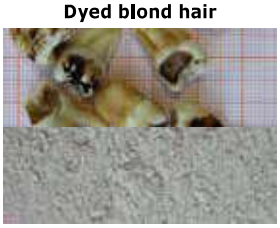
RETSCH offers a range of mills suitable for processing a variety of forensic samples such as fibrous and temperature-sensitive hair, brittle or ductile bones of different sizes and brittle, very hard teeth.

Sample		Mill	Accessories	Feed quantity	Grinding time	Speed	Final fineness (d_{90})
Dyed blond hair	●	MM 200	25 ml grinding jar stainless steel, 6 grinding balls stainless steel 10 mm	1 g	2 min	25 Hz	< 160 µm
Dark hair	●	CryoMill	25 ml grinding jar stainless steel, 6 grinding balls stainless steel 10 mm	1 g	4 min	30 Hz	< 200 µm
Molar tooth	●	MM 400	25 ml grinding jar zirconium oxide, 1 grinding ball zirconium oxide 15 mm	1 tooth	3 min	30 Hz	< 100 µm
Bones	■	BB 50	breaking jaws manganese steel, wearing plates stainless steel	50 g	1 min	gap width: 2 mm	< 8 mm
	●	MM 400	35 ml grinding jar zirconium oxide, 1 grinding ball zirconium oxide 20 mm	8 g	3 min	30 Hz	< 200 µm
Bones	●	SM 300	6-disc rotor, bottom sieve 6 mm	700 g	30 s	3,000 min^{-1}	< 6 mm

■ Pre-grinding ● Fine grinding * Embrittlement with liquid nitrogen or dry ice ** Wet grinding

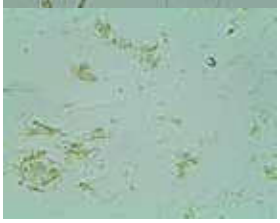
Please note: The achieved grind size depends on the sample material and instrument configurations/settings. Even apparently similar samples may produce different results to those listed above.


Dyed blond hair


Molar tooth

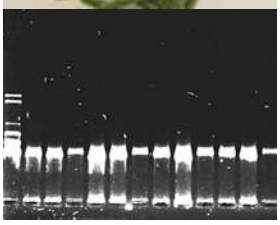

Bones


Bones



Micro algae in buffer

Homogenized liver



Fir needles

Cell Disruption, DNA or Protein Extraction, Tissue Homogenization

The RETSCH product range features various mills which are suitable for sample preparation of biological substances. A typical application is cell disruption of yeast, bacteria, filamentous fungi or algae in a Mixer Mill MM 400 with glass beads (Bead Beating). The mill can be equipped with adapters for single-use tubes and vials. In contrast to the manual procedure cell disruption in the mixer mill is fully automatic and therefore highly reproducible. Moreover, the sample is hardly warmed during the process. The MM 400 is also suitable for homogenization of cell tissue in buffer. In cases where the cell material must not be warmed, the CryoMill is used for disruption under liquid nitrogen.

Sample		Mill	Accessories	Feed quantity	Grinding time	Speed	Result
Yeast suspension	●	MM 400	2 adapters, each with 4 conical centrifuge tubes 50 ml, 16 g glass beads 0.5–0.75 mm in each tube	8 x 25 ml	7 min	20 Hz	High protein content
Micro algae in buffer	●	MM 400	2 adapters, each with 4 conical centrifuge tubes 50 ml, 40 ml glass beads 0.09–0.4 mm in each tube	8 x 20 ml	20 s–3 min	30 Hz	Almost complete cell disruption for DNA analysis
Liver	●	MM 400	2 adapters, each with 4 conical centrifuge tubes 50 ml, 4 x 20 mm grinding balls stainless steel, fill buffer up to 45 ml	8 x 8 g	2 min	30 Hz	Homogeneous suspension
Fir needles	●	MM 400	2 adapters for 10 reaction vials 2 ml, 2 grinding balls stainless steel 5 mm in each vial	20 x 2 needles	3 min	30 Hz	Reproducible RNA extraction
***E. coli* bacteria**	●	CryoMill	grinding jar stainless steel 50 ml, 1 grinding ball stainless steel 25 mm	10 ml frozen cell pellet	2 min	30 Hz	Complete cell disruption for metabolomic analysis

■ Pre-grinding ● Fine grinding * Embrittlement with liquid nitrogen or dry ice ** Wet grinding

Please note: The achieved grind size depends on the sample material and instrument configurations/settings. Even apparently similar samples may produce different results to those listed above.

Grinding in the Nanometer Range

Nano technology deals with particles in a range from 1 nm to 100 nm that possess special properties related to their size. Nano particles are produced either by the "bottom up" or "top down" method. The first involves synthesizing of single molecules whereas the latter is a mechanical procedure based on colloidal grinding. For the top down method the particles are dispersed in liquid, for example water, buffer solution or alcohol, to neutralize their surface charges. With the planetary ball mills and the high energy ball mill E_{max} RETSCH possesses suitable mills and the required know-how for grinding applications in the nanometer range.

Sample		Mill	Accessories	Feed quantity	Grinding time	Speed	Final fineness (d_{90})
Titanium dioxide	●	E_{max}	50 ml grinding jar zirconium oxide, 110 g grinding balls 0.1 mm, 15 ml 1% sodium phosphate**	10 g	30 min	2,000 min^{-1}	< 80 nm
Barium titanate	●	E_{max}	50 ml grinding jar zirconium oxide, 110 g grinding balls zirconium oxide 0.5 mm, 26 ml oleic acid-heptane mixture**	12 g	2 h	1,800 min^{-1}	< 95 nm
Barium titanate	●	PM 100	50 ml grinding jar zirconium oxide, 110 g grinding balls zirconium oxide 0.5 mm, 26 ml oleic acid-heptane mixture **	12 g	5 h	600 min^{-1}	< 100 nm

Sample		Mill	Accessories	Feed quantity	Grinding time	Speed	Final fineness (d_{90})
Aluminum oxide	●	PM 100	50 ml grinding jar zirconium oxide, 110 g grinding balls zirconium oxide 0.1 mm, 18 ml water**	5 g	4 h	650 min^{-1}	< 100 nm

■ Pre-grinding ● Fine grinding * Embrittlement with liquid nitrogen or dry ice ** Wet grinding

Please note: The achieved grind size depends on the sample material and instrument configurations/settings. Even apparently similar samples may produce different results to those listed above.

Metallurgy: Alloys and Mechanical Alloying

There are various methods to produce alloys. The classic way is to fuse the components at very high temperatures. If only small quantities are required or if the alloys cannot be fused by melting, mechanical alloying is an alternative. For this application ball mills are ideally suited because they provide high energy input. Mechanical alloying uses intensive kinetic processes to fuse powdery components. Alloys are mostly hard-brittle but may also have ductile metal components. RETSCH's planetary ball mills and high energy ball mill E_{max} are perfectly suited for mechanical alloying. Preparation of the alloys for further analysis can be carried out in a vibratory disc mill.

Sample		Mill	Accessories	Feed quantity	Grinding time	Speed	Result
Nickel and ceramic	○	PM 400 MA	500 ml grinding jar stainless steel, 400 grinding balls stainless steel 10 mm	270 g nickel 30 g ceramic	1:30 h	400 min^{-1}	alloy accomplished
Si + Ge + dopant	■	E_{max}	50 ml grinding jar tungsten carbide, 8 grinding balls tungsten carbide 10 mm sample:grinding ball ratio (w/w) 1:10	3.63 g Si 2.36 g Ge 0.02 g dopant	20 min	1,000 min^{-1}	good integration of Ge in Si, hardly any glass formation
	○	E_{max}			4 h	1,200 min^{-1}	

Sample		Mill	Accessories	Feed quantity	Grinding time	Speed	Final fineness (d_{90})
Iridium alloy	●	RS 200	50 ml grinding jar tungsten carbide	210 g	4 min	1,200 min^{-1}	< 150 µm
FeMo	●	RS 200	250 ml grinding set tungsten carbide	400 g	10 min	1,200 min^{-1}	< 200 µm

■ Pre-grinding ● Fine grinding ○ Mechanical alloying
* Embrittlement with liquid nitrogen or dry ice ** Wet grinding

Please note: The achieved grind size depends on the sample material and instrument configurations/settings. Even apparently similar samples may produce different results to those listed above.

Iridium alloy

FeMo

Your application is not listed?

Browse our online application data base at www.retsch.com/applicationdatabase for more examples.

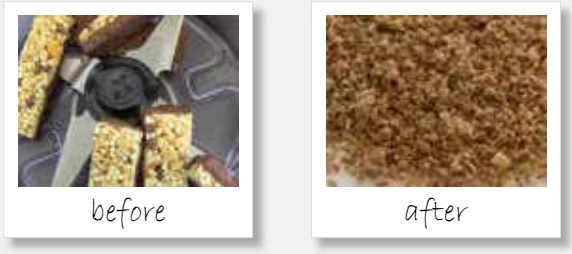
They Way to Correct Analysis Results

Analyses are part of the quality control process, for example during production or of incoming goods. Typical methods include spectroscopic or chromatographic analyses. If the particle size of the material is too large for processes such as analysis, division, mixing or further treatment it is necessary to reduce the size by grinding. As product properties (e.g. extraction, filtration, or absorption capacity) are often influenced by the particle size, size reduction on a laboratory scale is also essential for the development of new products or production processes.

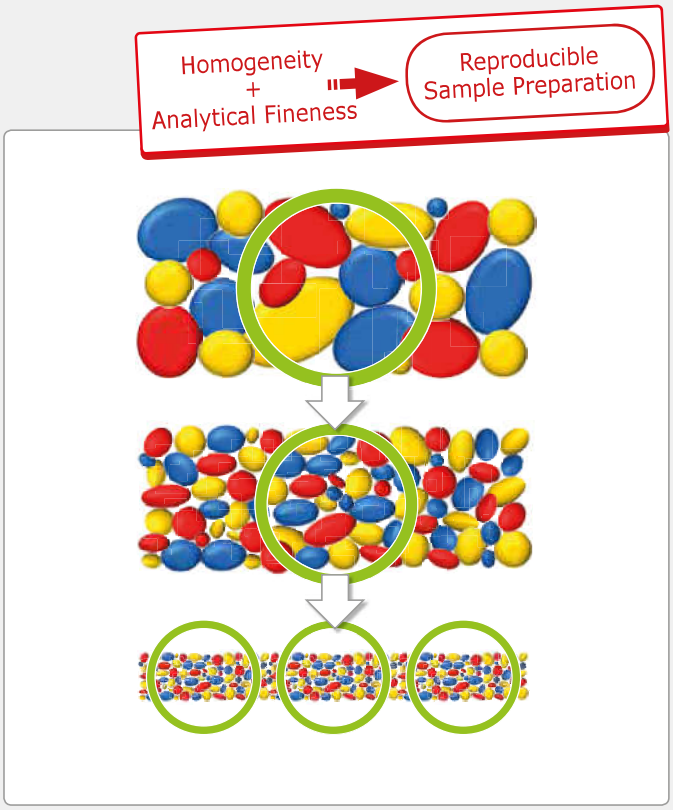
FTIR Sulfate AAS SEM NIR

Homogeneity

Usually only a few grams or milligrams of sample are required for analysis; these, however, need to represent the complete original sample. Depending on the part of the original material from which the sample has been taken, information on the composition of the material may vary greatly, as some components may be overrepresented in that part. To obtain a uniform distribution of components and properties in the laboratory sample it needs to be homogenized. If you take a 1 g analysis sample from a cereal bar, for example, this could consist of a raisin, a nut or a few grains. It is obvious that using such a sample for analysis will not provide representative results. Only through homogenization will parts of the raisin, the nut and the grains be included in the sample. Sometimes sample particles can be inhomogeneous in themselves, for example a grain of wheat.



Cereal bars before and after homogenization



Production of a representative part sample through milling

DTA Ash AES XRD

Required Fineness

A frequent requirement is to „grind the sample to fine powder". The term powder, however, is not precise. Washing powder, coffee powder and baking powder, for example, all have very different particle size distributions. Another typical request is to grind the sample "as fine as possible". This involves a high input of energy and time and hence an increase of costs. A more effective approach is to only grind as fine as necessary. It is sufficient if the sample has the required analytical fineness which for most techniques lies between 20 µm and 2 mm.

ICP HPLC Moisture UVS XRF Fat GC

Sample Preparation

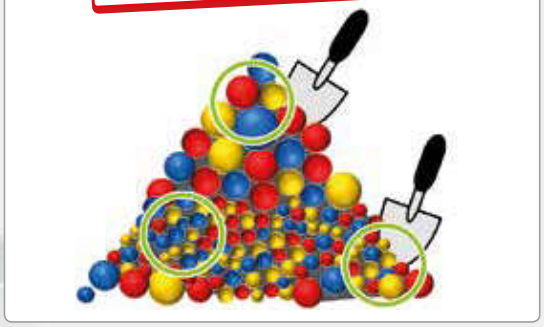
To generate a size reduction effect, the comminution principle of the mill should be matched to the breaking behavior of the particular sample material. Therefore, before selecting a suitable instrument and starting the preparation process, a thorough evaluation of the material is required. Properties such as density, hardness, consistency, residual moisture or fat contents have to be examined. The grinding process can also be influenced by temperature sensitivity, agglomeration behavior or surface reactions. In any case, the requirements of the following analysis should always be taken into account when homogenizing a particular sample.

Before starting the actual grinding process it must be examined if the sample can be processed without division or further treatment.

Sample Division:
The sample quantity is an important factor for correct sample preparation. How much sample is required for analysis? How big is the original quantity in relation to that and what is the particle size? These parameters determine the required amount which is needed for the part sample to be representative. Representative means that the composition of the part sample is identical to that of the original sample.

Sample Treatment:
Moisture, agglomeration, segregation or foreign substances in a sample affect the preparation process and falsify the grinding results. Therefore, the sample needs to be treated before being homogenized.

Even the best / most expensive analyzer cannot compensate sample preparation errors!



Bulk material behavior: small particles tend to accumulate at the bottom. If a sample is extracted from the upper part, representativeness is not guaranteed.

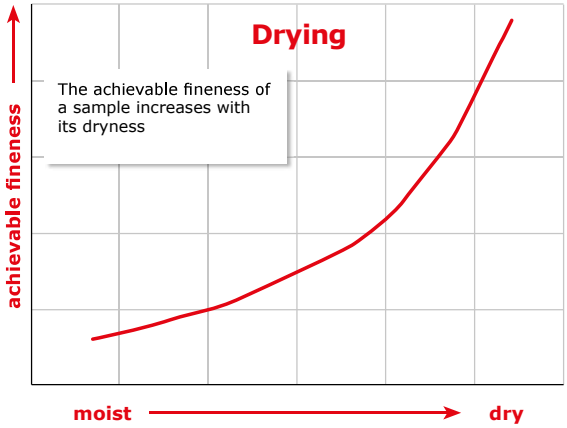
Sample Division

Most laboratory samples consist of an inhomogeneous mixture. Different particle sizes and material densities can lead to segregation during transportation. Extraction of a part sample by sample division is either carried out after preliminary grinding of the entire laboratory sample, or directly from the original material. The selection of the division method and instrument depends on the sample material and quantity. Dry, free flowing samples can be fed via vibratory feeders to rotary tube dividers and sample dividers with a rotating dividing head whereas sample splitters are used for materials with low flowability. Manual random sampling is only acceptable if the sample is absolutely homogeneous.

RETSCH sample dividers: PT 100, PT 200, RT 6.5 – RT 75

Sample Treatment

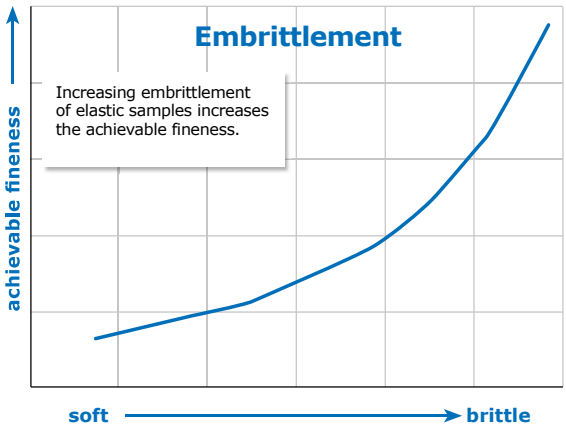
Drying
In most cases moist samples have to be dried before being subjected to size reduction. When choosing the drying method and temperature, care should be taken not to alter the properties of the sample to be determined. This is particularly important when dealing with volatile components such as furans, polychlorinated biphenyls or dioxins. Usually, these sample types can only be air-dried at room temperature.



RETSCH's TG 200 is suitable for gentle and quick drying using the fluidized bed drying method. For many products the drying time is as little as 5 to 20 minutes.
Other methods include vacuum and freeze drying as well as drying cabinets.

TG 200 for drying small amounts of 3 x 0.3 l or up to 1 x 6 l

Metal Separation
Samples such as industrial waste, recyclable waste or secondary fuels often contain metal components which cannot be pulverized with laboratory mills. On the contrary, metal objects such as steel nails or iron screws can damage the grinding tools which may lead to a considerable deterioration of the mill's performance. Therefore, metal components need to be removed before grinding, for example by using a magnetic separator, and evaluated separately if required.



CryoMill

Material embrittled with liquid nitrogen

Embrittlement (with liquid nitrogen or dry ice)
Cooling the sample material often improves its breaking behavior. Hence, temperature-sensitive materials such as some types of plastics need to be cooled directly before being subjected to primary or fine size reduction. One way is to embrittle the sample in liquid nitrogen (N_2, LN). At a temperature of -196 °C even soft rubber becomes so hard and brittle that it can be pulverized. Another way of embrittlement is to mix the sample with dry ice (CO_2 at -78 °C).

- Cryogenic grinding is used when volatile components of the sample need to be preserved.
- Materials which must not become moist should not be treated with cooling agents as the humidity condensates on the sample.
- Cooling agents such as LN or dry ice should not be used in closed grinding tools as evaporation causes overpressure inside the jar. Grinding jars of stainless steel, for example those used with the Mixer Mill MM 400, are filled with grinding balls and sample material, closed tightly and are then cooled in liquid nitrogen at -196 °C before being inserted into the mill. For grinding under continuous cooling RETSCH's CryoMill is the perfect choice.

Size Reduction Principles

Laboratory mills work with different size reduction principles. Which type of mill is used for a particular size reduction task always depends on the breaking properties of the sample material. Hard-brittle materials are best pulverized through impact, pressure and friction whereas soft and elastic substances require cutting and shearing effects to be successfully comminuted.

The following mechanisms are suitable for size reduction of solid material:

Size Reduction of Solid Materials				
hard, brittle materials			**soft, elastic, fibrous materials**	
				
Pressure	Impact	Friction	Shearing	Cutting
Force is applied between two solid surfaces. These can be the surfaces of the grinding tools or of adjacent particles. Pressure is exerted by the grinding tools.	Force is applied on/to a solid surface. It can either be generated by a grinding tool or by particles of the sample. Impact is mainly caused by one-sided and reciprocal particle acceleration.	Force is applied between two solid surfaces. Produced by the vertical pressure of one surface and the simultaneous movement of another surface.	Force is applied between two or more solid surfaces moving in opposite directions which causes a shearing effect. At least one fixed and one moving surface.	Force is applied by blades or by a combination of blades with fixed cutting bars.
Examples: • Jaw crusher • Toggle crusher	Examples: • Mixer mills • Planetary mills • Impact mills • Jet impact mills	Examples: • Mortar grinders • Disc mills • Hand mortars	Examples: • Rotor beater mills • Cross beater mills • Ultra centrifugal mills	Examples: • Shredder • Cutting mills • Knife mills
				

Typically, various size reduction principles are combined in a RETSCH mill, such as pressure and friction in mortar grinders or shearing and impact in rotor mills.

Grinding Tools

Each RETSCH mill is equipped with grinding tools that are optimized with regards to their functionality and handling. However, due to the wide range of applications, the requirements may differ greatly. Therefore, RETSCH offers a great variety of accessories to provide the optimum solution for each application. For ball mills, for example, the choice of jar volume, ball charge and material depends on the type and amount of sample. The pulverization energy is determined by the density and weight of the ball material. Jar and balls should always be made of the same material.
All grinding tools are available in different materials to ensure neutral-to-analysis sample preparation.

Materials
The materials used for RETSCH grinding tools can be grouped as follows:

- Metal (steel, tungsten carbide, cast iron, titanium)
- Ceramics (zirconium oxide, sintered aluminium oxide, hard porcelain, silicon nitride)
- Natural stone (agate)
- Plastics (PTFE)

The chemical and physical properties of a material determine whether it is available for a particular type of mill. Grinding tools made of steel are available for all mills.

The table below provides an overview of characteristics such as hardness, energy input, wear resistance and possible contamination through abrasion:

Materials					
	Hardness	**Density**	**Energy input***	**Wear resistance***	**Possible contamination through abrasion**
Stainless steel	48–52 HRC (approx. 550 HV)	7.8 g/cm³	very high	good (to a limited extent)	Fe, Cr
Hardened steel	58–63 HRC (approx. 750 HV)	7.85 g/cm³	very high	good	Fe, Cr, C (less than stainless steel)
Steel for heavy-metal-free grinding	up to 62 HRC (Rockwell)	7.85 g/cm³	very high	good	Fe, Mn, C, Si
Manganese steel („Manganese investment casting")	up to 55 HRC (Rockwell)	7.2 g/cm³	very high	good	Fe, Mn, C, Cr
Tungsten carbide	approx. 1250 HV	14.8 g/cm³	extremely high	very good	WC, Co (extremely low)
Agate	hard and brittle 6.5–7 Mohs (approx. 1000 HV)	2.65 g/cm³	very low	good (to a limited extent)	SiO_2
Sintered aluminum oxide	hard and brittle 8–8.5 Mohs (approx. 1750 HV)	3.9 g/cm³	low	good	Al_2O_3, SiO_2 (low), no contamination with Fe, Cr, Ni or Co
Zirconium oxide	hard and brittle, tougher than agate 7.5 Mohs (approx. 1200 HV)	5.9 g/cm³	high	very good	ZrO_2 und Y_2O_3 (marginal), insignificant for analyses
Silicon nitride	approx. 1500 HV	3.2 g/cm³	low	excellent	Si_3N_4, Y_2O_3, Al_2O_3
PTFE	Elastic Shore hardness D 56	2.1 g/cm³	very low	poor	contamination with F, C

* e.g. ball mills

Please visit the download area of our website www.retsch.com/downloads for a detailed overview of all materials used in RETSCH instruments including material analyses for all grinding tools.

When choosing a suitable grinding set, several aspects have to be considered:

- **Hardness and breaking behavior of the sample material:**
  The material of the grinding set should be harder than the sample to avoid wear. For example, silica sand should not be ground with agate tools but with the much harder zirconium oxide.

- **Abrasion resistance:**
  Abrasion resistance indicates how resistant a material is to signs of wear. Tungsten carbide and silicon nitride are highly resistant to abrasion. However, the amount of abrasion also depends on the properties of the sample and the size reduction principle of the mill.

- **Possible contamination through abrasion**
  Abrasion cannot be completely avoided in mechanical size reduction processes. Therefore, when choosing a material it should be taken into account if possible contamination will have a negative influence on the product or the subsequent analysis (e.g. abrasion of chrome or nickel influences heavy metal analysis).

- **Energy input**
  Another important feature of ball mills and vibratory disc mills is the energy input generated by the different materials. Grinding balls of tungsten carbide, for example, generate a much higher energy input, and thereby a better size reduction effect, due to the higher density of the material, than balls of the same size of other materials.

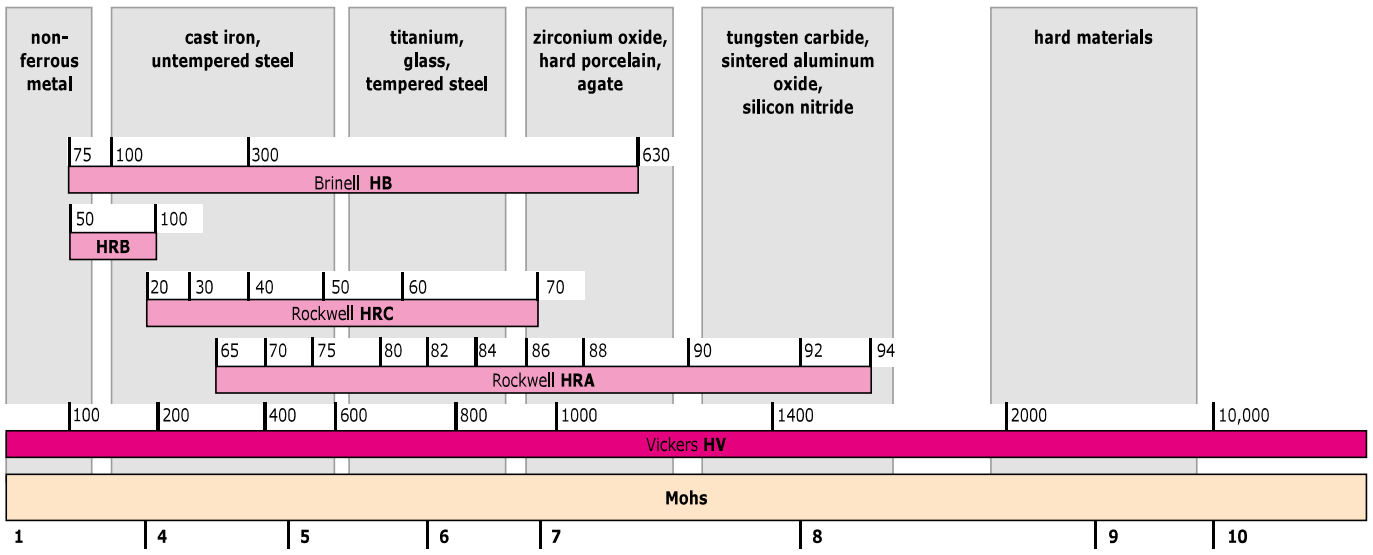
Application examples:

- If soil samples are to be analyzed for iron, chrome or cobalt, grinding tools of stainless or hardened steel are not suitable as they contain the elements which are to be determined.
- If, however, calcium or silicon dioxide are to be analyzed in cement clinker, grinding jars of steel are suitable.
- PTFE, zirconium oxide, silicon nitride and glass can be sterilized; therefore, they are often used for preparing food or microbiological samples.
- Homeopathic products and pharmaceuticals, for example, should only be ground in ceramic or agate grinding sets in order to avoid contamination of the sample.

Hardness

The term hardness describes the mechanical resistance of a material against the penetration of a foreign material. In materials testing the hardness of a material is ascertained by determining the penetration depth of a defined body under given parameters (pressure, angle).
The hardness of a particular material can be indicated with different values, depending on the hardness scale to which this value refers (like Mohs or Brinell). The different hardness scales have different origins. The Mohs' scale, for example, classifies the scratch hardness of minerals on the basis of a 10-step scale. The scales of Brinell (HB), Rockwell (HRA / HRB / HRC) and Vickers (HV) originate from the metallurgical sector.
It is not always possible to convert the hardness values from one scale to another. The table below shows a comparison of the scales of Mohs, Vickers, Rockwell (HRA / HRB / HRC).

Hardness table (approximate values)



Grinding Aids

Many grinding tasks which are known from the field of mechanical process engineering can be solved by using one of the various mill types with a suitable size reduction principle. However, some applications cannot be carried out successfully with common laboratory mills despite the wide range of accessories. Challenging grinding tasks include moist samples that cannot be dried as well as soft, elastic or fat, oily substances. To produce ultra-fine powders by mechanical energy input, it is often necessary to add a liquid.
In the above cases, the use of a grinding aid can be helpful. Grinding aids are additives which activate, accelerate and improve chemical or physical processes. Before using a grinding aid for the preparation of solids it must be ensured that the additive does not influence the subsequent analysis or further processing of the sample in any way.

Sample properties may be changed during preparation as long as analysis results are not influenced by it!

Grinding Aids / Additives	
Solid Additives	
Solid aggregation state (powder, granulate, pellets) for binding fat and/or moisture	When preparing samples for XRF analysis, neutral-to-analysis pellets such as Spectromelt (based on cellulose) are often added to the sample material during grinding in planetary ball mills or vibratory disc mills. Used in the correct mixing ratio, they promote the size reduction effect and help to avoid caking of the material inside the grinding jar. When pelletizing the sample material afterwards, this grinding aid also serves as a binding agent. The addition of sodium sulfate is a common method to bind fat or moisture that is to be determined afterwards (e.g. when grinding insects or moist soils). Trituration is carried out in mortar grinders which guarantees 100 % sample recovery.
Liquid Additives	
Liquid aggregation state (water, alcohol, benzine) to avoid agglomeration	To homogenize oil seeds such as rape seeds, soy beans or mustard seeds in ball mills or mortar grinders, it is helpful to add petroleum ether which is used as extraction liquid for the following determination of the oil contents. The production of ultra-fine powders, e.g. in the ceramics industry, powder metallurgy or mineralogy, can often only be realized by adding a few drops of alcohol or carrying out wet grinding. Usually, water or isopropanol are used as dispersants. Ball mills are especially suitable for wet grinding.
Gaseous Additives	
Gaseous aggregation state (inert gas, cooled air)	If a size reduction system is sufficiently ventilated, e.g. through a cyclone or a filter system, frictional heat is continuously discharged. This helps to reduce the warming of the sample material and to increase the throughput. Gassing with inert gas such as argon during grinding in a ball mill prevents the reaction of surface active particles with oxygen (= oxidation).

Expert Guides

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