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RETSCH instruments for ceramic production

From homogenization of raw materials to recycling of green bodies or sintered products

Crushers and grinders are essential tools in the ceramic production process, not only in the first steps where raw materials are homogenized and mixed but also for subsequent steps like forming green bodies or sintering. The intermediate products need to be analyzed with regards to their mineralogical and chemical composition to optimize the manufacturing steps. At each stage of the production, samples must be taken, homogenized and analyzed to ensure gapless quality control.

RETSCH offers a range of instruments suitable for sample preparation. The typical sample preparation process involves preliminary size reduction and fine size reduction before the sample can be submitted to further analyses. RETSCH sample dividers are used to take a representative part of a large sample taken out of the production process or to reduce the sample volume after pre-crushing.

Primary size reduction

Depending on the initial sample size, the raw materials or intermediate products must be pre-ground prior to full homogenization by fine-grinding. RETSCH offers a broad range of jaw crushers for this important step. The **jaw crushers are used for rapid, powerful crushing and pre-crushing of medium-hard, hard, brittle and tough materials** which are typical for the ceramic industry. The throughput and final fineness depend on the crusher type, selected gap width and breaking properties of the sample material.



Fig. 1: Jaw Crusher BB 250

The feed sizes of the eight different jaw crusher models range from 40 mm to 350 mm. The final size also differs, BB 50 and BB 500 are suitable to crush samples down to 500 μm (depending on the sample breaking properties), whereas the largest crusher BB 600 produces sample particles sized approx. 6 mm. Sometimes it is advisable to crush large lumps in a first step with large gap width followed by a second step with reduced gap width. The overall time required is usually shorter with two grinding steps than forcing the sample directly through the narrower gap width in one step. Some raw materials like calcium magnesium oxide tend to be sticky when being crushed. For this application the use of a jaw crusher equipped with a front door is recommended (e. g. BB 250, Fig. 1, BB 400) which allows easy access for cleaning.



Fig. 2: Ceramic cones before and after size reduction in a jaw crusher

Table 1: Pre-crushing of raw materials and intermediate products in jaw crushers

Overview Applications						
Sample	Sample amount	Feed size	Model	Parameters Accessories	Final size D_{90}	Time
Ceramic with SiC	1 kg	40 mm	BB 50	<ul style="list-style-type: none"> Gap setting 1 mm jaws and wearing plates: tungsten carbide 	<5 mm	4 min
Mixed ceramic: BN and TiB ₂	3 kg	250 x 80 mm plates	BB 500	<ul style="list-style-type: none"> Gap setting 0 mm jaws and wearing plates: tungsten carbide 	<2 mm	2 min
WC	3.5 kg	100 mm	BB 300	<ul style="list-style-type: none"> Gap setting 2 mm jaws and wearing plates: stainless steel 	<10 mm	1 min
Al ₂ O ₃	20 kg	50 mm	BB 500	<ul style="list-style-type: none"> Gap setting 2 mm jaws and wearing plates: manganese steel and hardened steel 	<0.7 mm	5 min
Tiles	10 kg	240 x 115 mm plate	BB 300	<ul style="list-style-type: none"> Gap setting 1 mm jaws and wearing plates: manganese steel and hardened steel 	<15 mm	7 min
Refractory material	20 kg	300 x 155 mm	BB 600	<ul style="list-style-type: none"> Gap setting 6 mm jaws and wearing plates: manganese steel 	<6 mm	2 min
CaMgO ₂	15 kg	120 mm	BB 250	<ul style="list-style-type: none"> Gap setting 20 & 2 mm jaws and wearing plates: manganese steel & hardened steel 	<4 mm	2 min + 7 min
Fireproof rock of MgO, Al ₂ O ₃ , C	2 kg	110 mm	BB 250	<ul style="list-style-type: none"> Gap setting 0 mm jaws and wearing plates: manganese steel & hardened steel 	<3 mm	1 min

Pulverization

For fine grinding of hard and brittle sample materials after pre-crushing, ball mills are usually a suitable option. **With 12 different ball mill types, RETSCH boasts the largest offering worldwide.** Depending on the sample amount, sample throughput, initial particle size, required fineness and subsequent analysis, RETSCH is able to provide a suitable solution for the specific requirements in the ceramic industry.

When it comes to long-term grindings of several hours with high energy input to obtain particles sizes $<1 \mu\text{m}$ in wet grinding mode, **planetary ball mills** have been the instruments of choice so far. Depending on the model, sample volumes up to 4 x 220 ml can be processed in one step; eight different grinding tool materials are available to ensure neutral-to-analysis sample preparation. Despite their benefits, planetary ball mills often have the drawback of requiring cooling breaks and not being as easy to handle as **mixer mills**. These compact versatile bench-top units for dry, wet and cryogenic grinding of small sample amounts mix and homogenize powders in only a few seconds and are easy to handle. RETSCH has now introduced the new Mixer Mill MM 500 nano which features a maximum frequency of 35 Hz and is the first mixer mill in the market with sufficient crushing power to produce particles in the nanometer range. It accommodates 2 grinding jars sized 50 ml, 80 ml or 125 ml and with its suitability for long-term grinding processes up to 99 hours, it is a real alternative to planetary ball mills – with all the benefits a mixer mills offers, like high impact grinding, comfortable handling and less warming effects.

Table 2: Pulverization of ceramic samples in Ball Mills

Overview Applications						
Sample	Sample amount	Feed size	Model	Parameters Accessories	Final size D_{90}	Time
Vitroceraic	4 x 250 g	2 mm	PM 400	<ul style="list-style-type: none"> • Revolution speed 280 rpm • 4 x 500 ml grinding jars & 4 x 25 balls 20 mm, zirconium oxide 	$<20 \mu\text{m}$	20 min
Zeolite	1 x 30 g	1 mm	PM 100	<ul style="list-style-type: none"> • Revolution speed 600 rpm • 1 x 500 ml grinding jar & 300 ml balls 0.5 mm, zirconium oxide • 200 ml isopropanol 	$<0.35 \mu\text{m}$	90 min
SiC	2x 10 g	5 mm	MM 400	<ul style="list-style-type: none"> • Frequency 30 Hz • 2 x 25 ml grinding jars & 2 x 4 balls 12 mm, tungsten carbide 	$<12 \mu\text{m}$	2 min
30% SiO_2 40% CaO 30% Al_2O_3	8 g in total	0.2 mm	PM 100 CM	<ul style="list-style-type: none"> • Revolution speed 400 rpm • 1 x 125 ml grinding jar & 30 x balls 10 mm, agate 	$<10 \mu\text{m}$	150 min
Dental ceramic	30 g	50 μm	PM 100	<ul style="list-style-type: none"> • Revolution speed 420 rpm • 1 x 125 ml grinding jar & 275 g balls 2 mm, zirconium oxide • 25 ml isopropanol 	$<2 \mu\text{m}$	90 min
Bricks	2x 11 g	4 mm	MM 400	<ul style="list-style-type: none"> • Frequency 30 Hz • 2 x 50 ml grinding jars & 2 x balls 25 mm, stainless steel 	$<100 \mu\text{m}$	40 sec
Al_2O_3	2x 62 ml suspension (1 g sample per 1 g phosphate buffer)	5 μm	MM 500 nano	<ul style="list-style-type: none"> • Frequency 35 Hz • 2 x 125 ml grinding jars & 2 x 275 g balls 0.1 mm, zirconium oxide 	$<0.14 \mu\text{m}$	2 h



Fig. 3: Planetary Ball Mill
PM 400



Fig. 4: Composite ceramics before and after pulverization in a planetary ball mill

Conclusion

Quality control is an important aspect of ceramic production. Sample preparation is an essential part of it, because only a representative and reproducible processing of the sample material ensures reliable and meaningful analysis results. RETSCH offers a range of instruments for dividing, crushing and pulverizing all materials which are involved in the production process of ceramics. To ensure the right choice of instrument for the right sample material, RETSCH offers free-of-charge sample testing in application laboratories all over the world.

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