Planetary Ball Mills
PM 100, PM 200 and PM 400

Powerful and fast –
Grinding down to the nano range

RETSCH planetary ball mills are used wherever the highest degree of fineness is required. Apart from the classical mixing and size reduction processes, the mills also meet all the technical requirements for colloidal grinding and have the energy input necessary for mechanical alloying processes.

The extremely high centrifugal forces of the planetary ball mills result in very high pulverization energy and therefore **short grinding times**.

Together with the "comfort" grinding jars these planetary ball mills offer the highest possible degree of performance, safety and reliability.

RETSCH planetary ball mills pulverize and mix soft, medium-hard to extremely hard, brittle and fibrous materials. Dry and wet grinding can be carried out. **Minerals, ores, alloys, chemicals, glass, ceramics, plant parts, soils, sewage sludge, household and industrial waste and many other materials** can be pulverized easily, quickly and without loss. Planetary ball mills are used successfully **in virtually all industry and research sectors**, in particular wherever the highest demands are placed on purity, quickness, fineness and reproducibility.

The main fields of application for planetary ball mills are:

- **Agriculture**
- **Biology and Biotechnology**
- **Ceramics and Glass**
- **Chemicals**
- **Construction Materials**
- **Environmental Research**
- **Medicine**
- **Mineralogy and Metallurgy**

to name just a few.

Planetary ball mills are available in versions with 1, 2 and 4 grinding stations. The freely selectable machine 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 **individual adaptation of the grinding parameters to the particular size reduction task.**

Planetary ball mills
PM 100, PM 200 and PM 400

Benefits at a glance

- Extreme speeds for particularly high final fineness down to the submicron range
- Different speed ratios available
- Grinding jar volumes from 12 ml to 500 ml, in 6 different materials
- Suitable for long-term trials and continuous use
- Automatic direction reversal helps to avoid agglomerations
- FFCS technology compensates vibrations (PM 100)
- Reproducible results due to energy and speed control
- Measurement of input energy helps to optimize grinding parameters
- 10 combinations of grinding parameters can be stored
- Graphics display and ergonomic 1-button operation
- Automatic grinding chamber ventilation
- 2-year warranty, CE-conforming

Innovative technology for increased safety

A **well thought-out operating concept** and, above all, the **optimized safety aspects** set new standards in this product segment and offer the user the possibility of carrying out size reduction tasks optimally and safely. The powerful and maintenance-free mill drive guarantees a constant controlled speed even **for continuous use** in long-term trials and under maximum load.

The planetary ball mills offer a high degree of operating convenience, safety and versatility. Thanks to the **programmable starting time** grinding jobs can be started at night. If a power cut should occur during operation, the mills save all parameters including the remaining grinding time at that point of time. When the power supply is restored the grinding process can be resumed.

A **built-in fan with standstill monitoring** cools the grinding jars during operation. The extraction volume per hour is greater than the 20-fold grinding chamber volume.

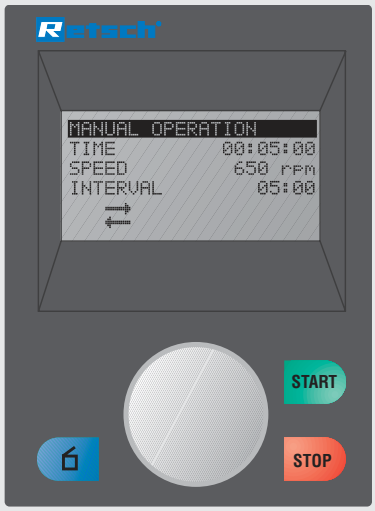
All mills are equipped with an automatic cover closure which prevents the machine from starting without being properly closed. After the grinding process is finished, the cover unlocks automatically. It can only be opened when the mill is at a complete standstill.

New technology with maximum operating comfort

The Planetary Ball Mills feature a very convenient operator guidance. All the relevant data can be entered or called up via a graphics display with 1-button operation:

- speed
- grinding time
- energy input
- grinding direction reversal with selection of running and pause times
- starting time
- remaining running time
- display of drive load factor
- operating hours
- clear text error messages
- service intervals.

10 combinations of speed, grinding time and interval settings can be stored for repetitive grinding tasks. **With multi-language graphical menu guidance.**



Benchtop instruments
PM 100, PM 100 CM and PM 200

RETSCH planetary ball mills are available in different versions. Please refer to page 13 for a complete overview of the different performance features.

PM 100

PM 100 CM

PM 200

Type PM 100

The convenient bench-top model with 1 grinding station for grinding jars with a nominal volume of 12 to 500 ml. The PM 100 features Free-Force-Compensation-Sockets (FFCS) which ensure a safe low-vibration run and minimal oscillation transfers to the laboratory bench.

Type PM 100 CM

The PM 100 CM operates in centrifugal mode, i.e. the speed ratio of sun wheel to grinding jar is 1:-1 (PM 100: 1:-2). This results in a different ball movement which leads to a more gentle size reduction process with less abrasion.

Type PM 200

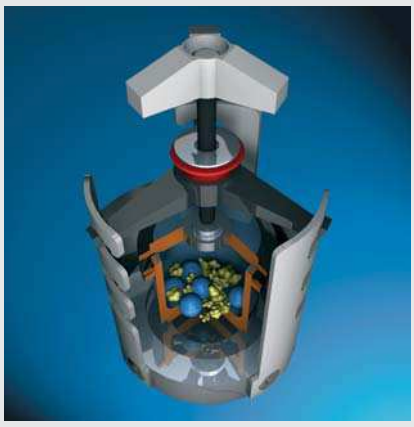
The bench-top model PM 200 with 2 grinding stations for grinding jars with a nominal volume of 12 to 125 ml. The larger sun wheel diameter results in a higher energy input when compared to the PM 100.

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 (or 1:-2.5 or 1:-3).
The grinding balls in the grinding jars are subjected to superimposed rotational movements, the so-called **Coriolis forces**. The difference in speeds 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.

The PM 100 CM operates with a speed ratio of 1:-1 (centrifugal mode). The centrifugal forces produced by the rotation force the sample and the grinding balls against the inner wall of the grinding jar, where size reduction takes place primarily by pressure and friction.



Floor models
PM 400 and PM 400 MA

Type PM 400

The robust floor model PM 400 with 4 grinding stations for grinding jars with a nominal volume of 12 to 500 ml. It can grind up to 8 samples simultaneously down to the submicron range thus generating a high sample throughput. The PM 400 is also available with 2 grinding stations. The freely selectable speed from 30 to 400 min^{-1} in combination with an effective sun wheel diameter of 300 mm allow for a particularly high energy input. Thus, the PM 400 produces samples with **analytical fineness in no time**.

Type 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.

PM 400

Mechanical alloying with RETSCH planetary ball mills

The mechanical alloying of materials in a grinding process to form new materials with new properties is no problem for RETSCH planetary ball mills. For ductile metals the speed ratio of the jar to the sun wheel of 1:-2 is fully adequate in most cases, as the impact energy produced by the ball charge is large enough to form an alloy.

However, greater energy is required for hard-brittle materials such as covalently bound semiconductors. The PM 400 MA with an increased speed ratio of 1:-2.5 or 1:-3.0 is available for such applications. The best speed ratio and all other grinding parameters must be determined experimentally for the specific product.

The ideal planetary ball mill for your requirements

RETSCH planetary ball mills are available in different versions

Performance data	PM 100 / PM 100 CM	PM 200	PM 400 / PM 400 MA
Field of application	pulverizing, mixing, homogenizing, colloidal milling, mechanical alloying		
Feed material	soft, hard, brittle, fibrous – dry or wet		
Feed size*	<10 mm	<4 mm	<10 mm
Final fineness*	<1 µm	<1 µm	<1 µm
For colloidal grinding	<0.1 µm	<0.1 µm	<0.1 µm
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	4 or 2
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}
Max. speed of the jars	1300 min^{-1} / 650 min^{-1}	1300 min^{-1}	800 min^{-1} / 1000 min^{-1} or 1200 min^{-1}
Effective sun wheel diameter	141 mm	157 mm	300 mm
Digital grinding time setting (hours:minutes:seconds)	00:00:01 to 99:59:59	00:00:01 to 99:59:59	00:00:01 to 99:59:59
Direction reversal	yes	yes	yes
Interval time (minutes:seconds)	00:00:01 to 99:59:59	00:00:01 to 99:59:59	00:00:01 to 99:59:59
Pause time (minutes:seconds)	00:00:01 to 99:59:59	00:00:01 to 99:59:59	00:00:01 to 99:59:59
Measurement of input energy possible	yes	yes	yes
Serial interface	yes	yes	yes
*depending on feed material and instrument configuration/settings			
Technical data			
Power consumption	approx. 1250 W (VA)	approx. 1250 W (VA)	approx. 2100 W (VA)
Nominal Power	750 W	750 W	1500 W
W x H x D	630 x 468 x 415 mm	630 x 468 x 415 mm	836 x 1220 x 780 mm
Net weight	approx. 80 kg / approx. 86 kg	approx. 72 kg	approx. 290 kg
Noise values (Noise measurement according to DIN 45635-31-01-KL3)			
Emission value with regard to workplace	L_{pAeq} up to 85 dB(A)	L_{pAeq} up to 80 dB(A)	L_{pAeq} up to 85 dB(A)
*depending on feed material, grinding jar volume, ball charge and selected speed			

Speed ratios

The working principle of the planetary ball mills is based on the relative rotational movement between the grinding jar and the sun wheel. In addition to the sun wheel diameter and speed of rotation this speed ratio is decisive for the energy input and therefore for the results of the size reduction process. **The higher the speed ratio, the more energy is generated.**

There are planetary ball mills with different speed ratio settings. For example, a ratio of 1:-1 means that each time that the sun wheel rotates the grinding jar also rotates exactly once in the opposite direction (indicated by the minus sign). With a speed ratio of 1:-2 the grinding jar rotates twice for each sun wheel rotation. In order to follow the rotational movement of the grinding jar you have to imagine that you are standing at the center of the sun wheel. During the sun wheel rotation you will see the red reference point exactly twice, i.e. the grinding jar has rotated twice (see illustration).

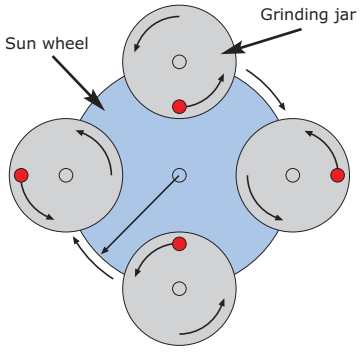


Diagram: speed ratio 1:-2

“comfort” grinding jars for PM 100, PM 200 and PM 400

Grinding jars for excellent grinding results

The performance and the result of sample preparation are also determined by the choice of the grinding jar and its ball charge. The choice depends on the amount of sample and the final fineness and purity of the ground sample that are necessary for the subsequent analysis.

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.

In the PM 100 and PM 400 each grinding station can accommodate 2 stacked 12 - 50 ml “comfort” grinding jars. The 50 ml grinding jars require an additional adapter, the smaller grinding jars can be stacked directly.

The unique advantages of “comfort” grinding jars

- **Unusually simple and safe handling**
- Safe, non-slip seating with built-in anti-rotation device and conical base centering
- **O-ring for gas-tight and dust-proof seal**
- User-friendly gripping flanges on jar and lid
- Gap between jar and edge of lid for easy opening
- Stainless steel protective jacket (for agate, sintered aluminum oxide, zirconium oxide and tungsten carbide grinding jars)
- Grinding jar identification (item number, material and volume)
- Labeling field (e.g. for sample information)

Grinding jar filling levels – guidelines for sample volume and ball charge

Grinding jar nominal volume	Sample amount	Max. feed size	PM 100	PM 200	PM 400	Recommended ball charge Ø 10 mm	Ø 20 mm	Ø 30 mm	Ø 40 mm
12 ml	up to 5 ml	<1 mm	■	■	■	5 pcs.	–	–	–
25 ml	up to 10 ml	<1 mm	■	■	■	8 pcs.	–	–	–
50 ml	5 - 20 ml	<3 mm	■	■	■	10 pcs.	3 pcs.	–	–
80 ml	10 - 35 ml	<4 mm	■	■	■	25 pcs.	5 pcs.	–	–
125 ml	15 - 50 ml	<4 mm	■	■	■	30 pcs.	7 pcs.	–	–
250 ml	25 - 120 ml	<6 mm	■	–	■	50 pcs.	15 pcs.	6 pcs.	–
500 ml	75 - 220 ml	<10 mm	■	–	■	100 pcs.	25 pcs.	8 pcs.	4 pcs.

Material composition guidelines

Grinding jar	Material no.	approx. hardness	Material analysis (in %)
Hardened steel	1.2080	62-63 HRC	Fe (84.89), Cr (12), C (2.2), Mn (0.45), Si (0.4), P (0.03), S (0.03)
Stainless steel	1.4034	48-52 HRC	Fe (82.925), Cr (14.5), Mn (1), Si (1), C (0.5), P (0.045), S (0.03)
Tungsten carbide		1180-1280 HV 30	WC (94), Co (6)
Agate		6.5-7 Mohs	SiO_2 (99.91), Al_2O_3 (0.02), Na_2O (0.02), Fe_2O_3 (0.01), K_2O (0.01), MnO (0.01), MgO (0.01), CaO (0.01)
Sintered aluminum oxide		1750 HV	Al_2O_3 (99.7), MgO (0.075), SiO_2 (0.075), CaO (0.07), Fe_2O_3 (0.01), Na_2O (0.01)
Zirconium oxide*		1200 HV	$Zr0_2$ (94.5), Y_2O_3 (5.2), SiO_2/ MgO/ CaO/ Fe_2O_3/ Na_2O/ K_2O (< 0.3)

The above percentages are mean values. We reserve the right to make alterations.

*Yttrium-part-stabilized

Accessories for grinding jars „comfort“

Optimum safety during wet grinding and under inert atmosphere

The planetary ball mills are not only suitable for dry grinding but also for wet grinding, e.g. for the production of colloidal systems. The **“comfort” grinding jars** offer maximum safety. They are gas-tight and dust-proof and can be equipped with special **safety closure devices**. Thus over pressure which may build up during and after the wet grinding process cannot escape.

The **aeration cover** is used to create an inert atmosphere in the grinding jar. **The safety closure device** permits the gas-tight handling inside and outside of a glovebox and ensures the safe transport of the grinding jar.

Grinding jar „comfort“ with safety closure device

Aeration cover

Pressure and temperature measuring system PM GrindControl

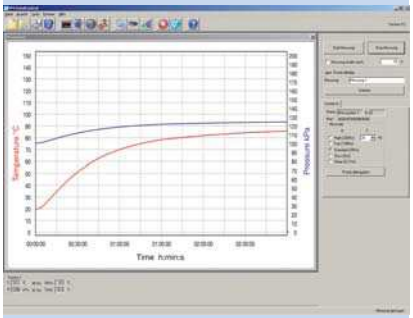
In order to understand the processes which occur during grinding with ball mills (e.g. chemical reactions, phase changes), it is helpful to record the most important thermodynamic parameters: pressure and temperature. Planetary ball mills are frequently used for the development of new materials by mechanical alloying due to their high energy input. The processes and reactions which take place in the grinding jar during grinding can be monitored and controlled.

The PM GrindControl is available for stainless steel grinding jars of 250 ml and 500 ml. A transmitter which is integrated in the jar lid sends digital signals to a stationary receiver which is connected to a PC. **Up to 200 values are measured per second** (single transmission mode). The transmission protocol is a very safe industry standard. Once the data is transmitted to the PC, it can easily be processed with established office programs.

The complete system including accessories is delivered in an aluminum case.

Benefits at a glance

- Measurement ranges
  gas pressure: 0 - 500 kPa
  temperature: 0 - 200 °C
- No modification of the mill required
- Indoor range up to 20 m
- Operating time with fully charged accumulator 80 h
- Evaluation of data with Windows XP/Vista
- Multilingual software



Planetary ball mills order data

Planetary Ball Mills PM 100, PM 200, PM 400					Item No.
PM 100 (please order grinding jars and grinding balls separately)			speed ratio		
PM 100	for 230 V, 50/60 Hz	with 1 grinding station	1 : -2		20.540.0001
PM 100 CM	for 230 V, 50/60 Hz	with 1 grinding station	1 : -1	centrifugal mode for gentle size reduction	20.520.0001
PM 200 (please order grinding jars and grinding balls separately)			speed ratio		
PM 200	for 230 V, 50/60 Hz	with 2 grinding stations	1 : -2		20.640.0001
PM 400 mounted on casters (2 x lockable) (please order grinding jars and grinding balls separately)					
PM 400	for 1 x 220-230 V, 50-60 Hz	with 4 grinding stations	1 : -2		20.535.0001
PM 400/2	for 1 x 220-230 V, 50-60 Hz	with 2 grinding stations	1 : -2		20.535.0005
PM 400 MA	for 220-230 V, 50/60 Hz	with 4 grinding stations	1 : -2.5	special version for mechanical alloying	20.535.0007
PM 400 MA	for 220-230 V, 50/60 Hz	with 4 grinding stations	1 : -3	special version for mechanical alloying	20.535.0008
Accessories					
Add-on weight for PM 100 (if total weight of grinding jar, grinding balls, sample material and accessories is >7.3 kg)					22.221.0002
Other electrical versions available for the same price					

Measuring system PM GrindControl for PM 100 and PM 400	Item No.
Pressure and temperature measuring system PM GrindControl, incl. measuring transceiver, stationary transceiver, software, case and grinding jar	
PM GrindControl with grinding jar „comfort" 250 ml, stainless steel, for PM 100 and PM 400	22.782.0004
PM GrindControl with grinding jar „comfort" 500 ml, stainless steel, for PM 100 and PM 400	22.782.0005

"comfort" grinding jars for PM 100, PM 200 and PM 400							Item No.
"comfort" grinding jars	12 ml	25 ml	50 ml	80 ml	125 ml	250 ml*	500 ml*
Hardened steel	–	–	01.462.0145	–	01.462.0144	01.462.0224	01.462.0229
Stainless steel	01.462.0239	01.462.0240	01.462.0149	–	01.462.0148	01.462.0223	01.462.0228
Tungsten carbide	–	–	01.462.0156	01.462.0267	01.462.0155	01.462.0222	–
Agate	–	–	01.462.0139	01.462.0197	01.462.0136	01.462.0220	01.462.0225
Sintered aluminum oxide	–	–	01.462.0153	–	01.462.0152	01.462.0221	01.462.0226
Zirconium oxide	–	–	01.462.0188	–	01.462.0187	01.462.0219	01.462.0227
*not for PM 200							

Accessories for "comfort" grinding jars	Item No.
Adapter for stacking 50 ml "comfort" grinding jars in the PM 100 or PM 400	
for 50 ml "comfort" grinding jars made from hardened steel or stainless steel	03.025.0002
for 50 ml "comfort" grinding jars made from tungsten carbide, agate, sintered aluminum oxide, zirconium oxide	03.025.0003
Aeration cover	
for 250 ml "comfort" grinding jars made from stainless steel	22.107.0005
for 250 ml "comfort" grinding jars made from tungsten carbide	22.107.0006
for 500 ml "comfort" grinding jars made from stainless steel	22.107.0007
Safety closure devices	
for 50 ml "comfort" grinding jars	22.867.0002
for 125 ml "comfort" grinding jars	22.867.0003
for 250 ml "comfort" grinding jars	22.867.0004
for 500 ml "comfort" grinding jars	22.867.0005

Grinding balls						Item No.
Grinding balls	2 mm Ø*	3 mm Ø*	10 mm Ø	20 mm Ø	30 mm Ø	40 mm Ø
Hardened steel	–	–	05.368.0059	05.368.0033	05.368.0057	05.368.0056
Stainless steel	22.455.0010	22.455.0011	05.368.0063	05.368.0062	05.368.0061	05.368.0060
Tungsten carbide	–	–	05.368.0071	05.368.0070	05.368.0069	05.368.0068
Agate, polished	–	–	05.368.0067	05.368.0028	05.368.0065	05.368.0064
Sintered aluminum oxide	–	–	05.368.0021	05.368.0054	05.368.0053	05.368.0052
Zirconium oxide	05.368.0089	05.368.0090	05.368.0094	05.368.0093	05.368.0092	05.368.0091
*Grinding balls for colloidal milling (container = 500 g)						

Retsch®

Retsch GmbH
Rheinische Straße 36
42781 Haan, Germany

Telephone +49 21 29 / 55 61 - 0
Telefax +49 21 29 / 87 02

E-mail info@retsch.com
Internet www.retsch.com

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