

Characteristics of sand and criteria for its comminution

From construction material to semiconductor technology

On planet earth sand is a very common unconsolidated sedimentary rock. It is characterized by a particle size between 0.063 and 2.0 mm. The mineral composition can vary extremely. Many occurrences consist of quartz respectively silicon dioxide (SiO₂). Due to its physical and chemical characteristics sand is mainly used in the construction and glass industry. The analytical evaluation of the chemical composition and therefore the aptness for the intended uses make the comminution of quartz sand a prerequisite.

FRITSCH offers a wide spectrum of suitable mills for this. For the characterization of the particle size distribution, FRITSCH offers sieve shakers and instruments for particle sizing via static laser scattering as well as instruments for the dynamic image analysis. With these technologies, the tracking and optimization of the comminution processes can be excellently accomplished.

Composition of silicon dioxide

The main element of quartz sand is silicon dioxide (SiO₂). The oxygen atoms form with the silicon atom in the centre a tetrahedral structure. Each oxygen atom simultaneously belongs to two silicon atoms. In this manner the tetrahedral structures have a cross-linked high-molecular weight.

Due to this fact, silicon dioxide obtains its special hardness of 7 on the Mohs scale (compared to Diamonds = 10) and the extremely high melting point of 1713°C. These characteristics enable the utilization in the semiconductor or construction industry. ^{[1][2]}



Fig. 1: 20 g sand as base material for a test milling

Utilization of quartz sand

The everywhere, naturally occurring commodity has always been used as construction material and for the production of glass. First supporting documents about glass come from Ugarit and are dated approximately 1600 BC. Via many developmental stages it became possible to produce glass cost-efficient and therefore suitable for everyday use. Glass in many variations is used day in and day out in almost every area. Still further characteristics were discovered which could be achieved by a physical or chemical treatment of the quartz sand. As early as 1899 already, conducted the chemist Robert Küch the first melting tests with pure silicon dioxide and was able to produce pure quartz glass. Chemically pure crystalline SiO₂ shows a heavy piezoelectric effect, which is utilized in the semiconductor technology and computer chip production. Generally established is the utilization as vibratory quartz in quartz clocks. But probably most important and surrounding us daily application is the use of silica sand in the production of concrete.



Fig. 2: 20 g Sand ground with the P-2 after 30 min, agate grinding set

Several additional areas of utilization of quartz sand are:

- Filter sand in waste water treatment plants^[1]
- Abrasive products in metal processing^[2]
- Artificial bone substance (medical technology)^[3]

Comminution of quartz sand

Due to the brittle character of sand is the comminution unproblematic. But it must be kept in mind, that because of its composition it may vary in its abrasiveness. In order to minimize this influence, typically a mill with impact forces is chosen. The FRITSCH Planetary Mills are especially suitable for fast and effective processing. The application laboratory, as well as the application consultants performed a series of interlaboratory comparisons in order to optimize the grinding even further in regards to instrument choice, sample amount, addition of liquids and many additional parameters. These internal interlaboratory comparisons proof that the FRITSCH **Planetary Ball Mills** by far exceed the FRITSCH **Mortar Grinder** in the preparation of sand in regards to effectiveness and grinding duration. This is especially due to the transmission of power and energy. Planetary Ball Mills are optimized in regards to maximum energy impact. A distinct feature offers the FRITSCH **Planetary Ball Mill premium line**: through a clearly increased rotational speed, wet grinding is possible in the particle size range down to a few nanometres.



Fig. 3: 100 g quartz sand ground 5 min, P-6, 250 ml agate grinding bowl, 20 mm grinding balls

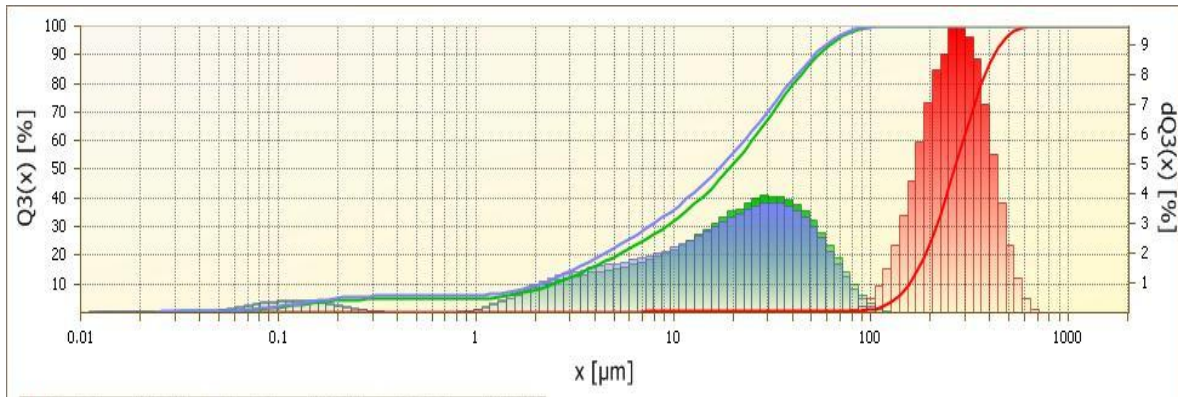
The task

In the concrete case, very pure quartz sand was to be ground down to a particle size below 100 µm. Prepared in this manner; it is possible to melt a water glass from the ground material. The goal, to determine the iron content is then photometrically possible without any problems. Slightest traces of iron in the glass extremely discolour it and it would be fatal if for example window glass or drinking glasses would show an uncontrolled brown discolouration. Therefore is the monitoring of the iron content of quartz sand in the glass industry of great significance.

Initially, a Mortar Grinder was used for this task: 20 g quartz sand is ground analytically fine with the Mortar Grinder PULVERISETTE 2 with agate bowl in 30 minutes. But in only 5 minutes, 100 g of quartz sand is ground to a comparable analytical fineness by using the **Planetary Mono Mill PULVERISETTE 6 classic line**, with a 250 ml agate grinding bowl and 15 agate balls with 20 mm diameter.

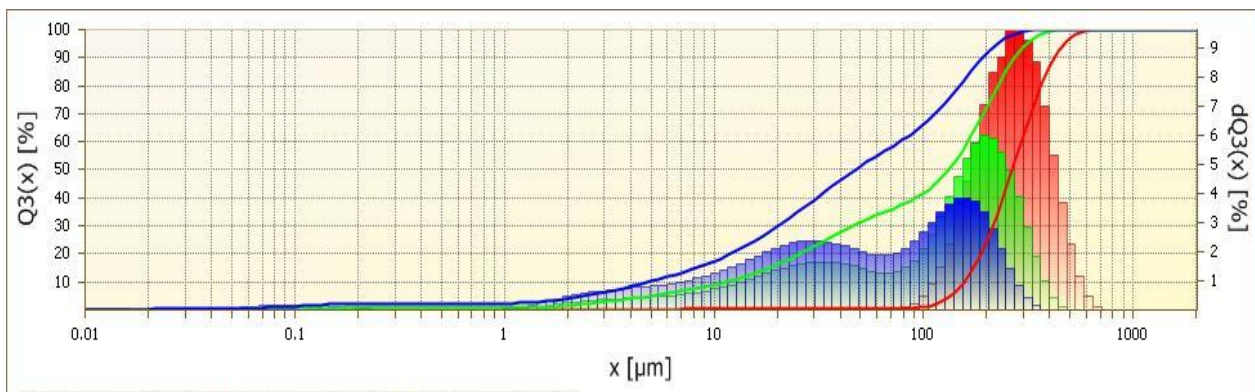
The measurements

The **Laser Particle Sizer ANALYSETTE 22** was used for the measurements of the particle size distributions. With static light scattering very fast and effective particle size distributions in the range between 10 nm and 2 mm can be determined.



- red curve quartz sand base material
- green curve 100 g quartz sand ground 5 minutes in the Planetary Ball Mill
- blue curve 20 g quartz sand ground 30 minutes in the Mortar Grinder

A sample of 100 g was chosen since the larger amount corresponds better to a representative sample. Even in an hour, this amount cannot be ground to a comparable final fineness with a Mortar Grinder.



- red curve quartz sand base material
- green curve 100 g quartz sand ground 30 minutes in the Mortar Grinder
- blue curve 100 g quartz sand ground 60 minutes in the Mortar Grinder

Generally the following can be derived from the test:

- For the fast comminution of hard and brittle materials Planetary Ball Mills are recommended
- Under the aspect of a representative sampling, the grinding bowl with 250 volume of the Planetary Ball Mill is recommended
- In order to avoid disturbing elements occurring during grinding, grinding sets made of various materials are available. Our recommendation in the concrete case was agate.

Sources and continuative Literature:

[1] Werkstoffkunde 17. Aufl., W. Weißbach, Vieweg Verlag
 [2] Praxiswissen der chemischen Verfahrenstechnik: Handbuch für Chemiker und Verfahreningenieure 2. Aufl., Springer Verlag
 [3] Chemie 10. Aufl., C. Mortimer und U Müller, Thieme Verlag

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