GRINDING AND DISPERSING IN THE NANOMETRE RANGE

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Abstract

The company Willy A. Bachofen AG, located in Muttenz Switzerland is specialized on wet fine grinding since more than 40 years. The accumulated know-how and a close relationship to our customers is the base for a continuous development of grinding processes and equipment supported by most modern research and design tools. A technology centre with full infrastructure is available for testing new developments, prototypes and the wide range of customer's products.

Over the past decade, the major R&D efforts were given to dispersing and grinding of nano-sized particles, leading to a full range of mills also suitable for this specific application. Also environmental thoughts were taken into account by consequent reduction of power consumption and grinding chamber volumes.

High quality Swiss manufacturing and quality controls according latest standards ensure highest reliability to our equipment. Together with a worldwide well trained sales and service net, we provide full support to our customers before and after sale. Our service offer reaches from process support to maintenance via validation and qualification of the equipment whenever needed.

Keywords: nano-grinding, pearl mill, Dyno-Mill ECM, Willy A. Bachofen

DYNO-MILLS FOR NANO-GRINDING

The company WILLY A. BACHOFEN AG MASCHNENFABRIK, Muttenz, Switzerland is one of the leading specialists in dispersion and grinding technology with its world famous DYNO-MILL products. With its extensive program of mills and the experience gained over decades, WAB delivers the right solutions for all applications to ensure that the clients can produce the finest quality products in a repeatable process.

Dispersion and grinding of nanoparticles are subject to many parameters of the formulation as well as of the process in a bead mill. The high specific surface area of nanoparticle and its corresponding surface tensions tends to agglomerate them and a high frequency stress -collisions between beads and particles- is required for de-agglomeration. The particles need to be wetted by the liquid phase of the slurry to neutralise their surface tension. There is a strong relation between the number of de-agglomerated particles and the wetting capability of the slurry within a residence time period in the mill. The process has to be conducted in a way to get as close as possible to the optimum conditions, meaning the mill must be able to run with smallest grinding beads and allow well controllable energy input and residence time (Fig. 1).

High stress intensity may break primary particles and increase their specific surface area. This will not only influence the intrinsic properties of the product but also lead to co-agglomerations by increasing the surface tension of the particles and to rheologic modifications. (commonly called „over-grinding“). The additives (dispersants) will not be adapted to the new particle size resp. the new surface area and surface tensions. Too intensive de-agglomeration doesn’t allow a „wetting“ of the particles and leads to re-agglomeration to even larger agglomerates as the original ones.
The smaller the grinding beads, the higher is their number in a given grinding chamber volume. The higher the number of beads, the higher is the stress frequency.

The diagram Fig 2 shows the increasing number of beads with their decreasing size in a 2 l laboratory Nano Performance Mill.
The regulation of energy input is provided by the well none ECM Technology using the patented Dyno-Accelerator. This unique technology allows to work with smallest beads at low energy input and high flow rates.

**Fig 3. ECM Accelerators and their working principle**

WAB has developed a range of mills, from the smallest laboratory unit Research Lab up to large scale production mills DYNO-MILL ECM-AP, able to full fill above mentioned conditions needed for grinding and dispersion in the Nano range. These mills can handle grinding beads starting by 50 microns diameter at a large range of flow rates to regulate the residence time. A precise adjustment of the energy input is provided by the speed regulation allowing mostly required low energy.

### 1.1 Dyno-Mill RESEARCH LAB

A small laboratory bead mill (Fig 4) used for basic research and development of product formulations for low and to high viscosity products. The unique, patented grinding principle, the DYNO-Accelerator, provides the best product quality with the most sharply defined ranges of fine grain particles in the range ≤ 100 nm. The RESEARCH LAB permits the grinding in a continuous passage- and circulation operation. The ceramic design made of zirconium oxide/silicon carbide ensure the metal-free processing. The RESEARCH LAB can be operated by easily owing to a well-designed control system acquisition and monitoring of operational data with a modern process control system.

*Batch sizes:* 80 - 500 ml

*Size of the beads:* 0.02 - 1.20 mm

Easy for handling, easy for cleaning.
1.2 Dyno-Mill MULTI LAB

A laboratory mill MULTI LAB (Fig 5) is ideal for the smallest possible application in research and development and as a pilot-mill for small scale production. Grinding containers with volumes of 0.3 and 0.6 can be used for processing highly fluid to viscous suspensions in amounts ≥ 500 ml. A pump next to the mill feeds the suspension into the MULTI LAB. The high-quality ceramic equipment offers metal-free grinding/dispersion. The MULTI LAB can be dismantled and changed to a different mill configuration within a few simple operations. The geometry of the grinding systems in MULTI LAB correspond to those of production mills DYNO-MILL ECM-AP. The MULTI LAB is easy to operate thanks to well designed control system – quantifying and monitoring operational data with the modern WAB VIEW process control system.

Batch size: 1 – 20 l
Size of beads: 0.1 - 2 mm

Easy to operate and scale up to production, easy to clean.
1.3 Dyno-Mill ECM-AP

A new generation of the high efficiency agitator bead mills ECM-AP with grinding chambers from 2 to 60 litres (Fig 6). A new separation system allows to use the small beads with a size of 0,1 mm and so to use even the production mills for dispersion and grinding in the Nanometre range.

Batch size:  10 – 10 000 l
Size of beads:  0,1 -  1,5 mm

Easy to operate, highly flexible, easy to clean.

WILLY A. BACHOFEN AG (WAB) has its own test facility with various mills in different sizes, ranging from laboratory up to full production scale. The partnership with the customer is the one of the main aspects for WAB. Therefore WAB offers the possibility to do experiments in this facility with the own products. With the results, one can check whether the machine fulfils the requirements before making any decision.

A global network of over 40 sales and service locations of WAB offers competent advice and efficient support concerning the mill and grinded product together with a full after sales service.

High efficient agitator bead mills DYNO-MILL RL, ML, ECM-AP grant new milling process at the highest level in the field of dispersion, ultra fine wet grinding and nano wet grinding.