Grinding ink-jet pigments for printing

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Ink jet describes a printing process where ink is brought onto the surface to be printed in the form of small drops. The color ejection takes place either by piezo electric or thermal modes. Because of digital ink mastering, ink jet printing technology distinguished by high flexibility with relatively cost-efficient prints is increasing and is capturing new fields of application. For example short runs of offset, art or textile prints or the print of large poster and advertisements can be accomplished quickly with low set up cost. However, for outdoor applications the color and light fastness quality of the inks had to be improved.[1]

The ink types used in ink jet printing ink technology can be divided into dye and pigment inks. In dye inks the dye molecules are completely dissolved in the solvent. For pigment inks where the organic and inorganic pigments are insoluble in the carrier material (water or organic solvent) a dispersion of the pigments is required. The advantages of the dye inks are the high color brilliance on normal and coated paper and the low blocking risk of the printing head nozzles, disadvantages are low UV and ozone-resistance, water solubility and the risk of running of the inks when printing or when exposed to moisture. Pigmented inks, based on water or solvent dispersions where pigments are the colorant, do not have these disadvantages.[2, 3] To guarantee optimal color brilliance and failure-free printing, pigmented ink jet inks should ideally have a size of 50 - 150 nm.[4, 5]

The requirements for pigmented inks are that the dispersion must be thermally stable, the inks must not contain contaminants and the finished ink should have a low viscosity. And furthermore, the pigment dispersion must also have a defined particle size in the nanometer range with a narrow particle size distribution.[3, 4]

Mechanical grinding in agitator bead mills produces particles in the nanometer range. To reach this particle size, the use of very small diameter grinding media is required. Additionally, when grinding pigments for ink jet inks the contamination of the grinding media must be low as possible. Therefore suitable materials, i.e. wear resistant ceramics or polymers, should be used as they have the lowest wearing values.

Agitator Bead Mills from Laboratory to Production Scale

Demands on a modern agitator bead mill for grinding to the nanometer range are as follows. The kinetic energy must effectively be transmitted to the grinding media so that the necessary stress intensities can be achieved. On the other side the grinding media must be separated in continuous operation from the product flow by a highly efficient separation system.

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Agitator bead mills achieve both points with the ZETA^{TM} grinding system of NETZSCH-Feinmahltechnik GmbH. The peg grinding system with agitator pegs on the rotor transmits the energy independently from the viscosity of the product. Picture 1 shows a horizontal agitator bead mill of the type ZETA^{TM} in production scale for grinding with high product throughput rates in circulation operation.

Pict. 1: High-speed mill system ZETA^{TM} – production scale

The development of new products, the processing of small batches of high-tech or high value products or the quality control or assurance and process optimisation are the fields of application for laboratory scale machines. For such machines easy handling and a high degree of flexibility are requested. Additionally, a low cleaning expenditure and thus a low product loss at an exact reproducibility and scale up must be guaranteed.

The laboratory agitator bead mills that are equipped with the ZETA^{TM} grinding system were designed with these features in consideration.

MINICER and *MINIPUR*

The laboratory machines *MINICER*, in ceramic design, and *MINIPUR*, in PU design, are designed for metal free grinding of smallest product batches from 0.25 – 0.5 l. The products are continuously processed in circulation operation between the integrated circulation tank, in case of the *MINIPUR* in cooled design, and the laboratory mill. Alternatively an enclosed batch operation with small product batches is also possible with the *MINICER* when the in- and outlet ports are closed. Both laboratory mills are equipped with a double acting mechanical seal and an adjustable hose pump. A swivelling grinding tank simplifies the filling and emptying and enables an easy cleaning. Both *MINICER* and *MINIPUR* are equipped with a peg agitator and the highly efficient rotor slotted pipe centrifugal separation system. This enables the use of smallest grinding media from 0.1 – 2 mm. With these features and ability to use fine grinding beads, the best reproducible grinding results and fineness to the nanometer range are achieved with easy handling.

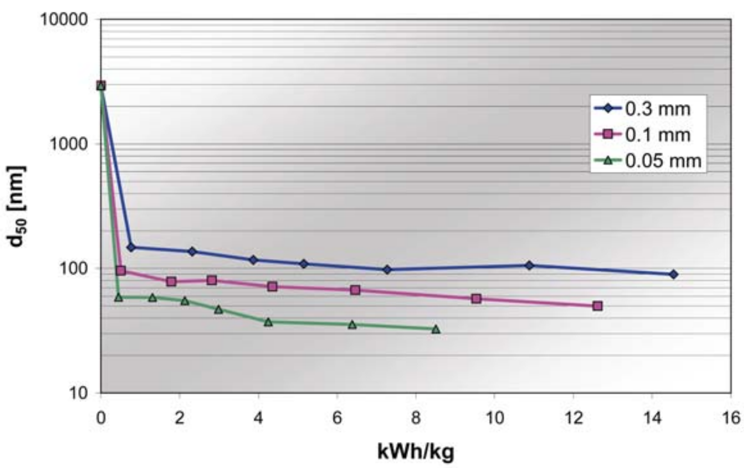
LABSTAR

The *LABSTAR* is the universally applicable laboratory mill for larger product batches from 1.5 – 5 l that enables precise grinding, particularly suited for difficult research and development tasks in industry and science. The machine designed in IP or Ex protection has an electrical drive of 3 kW, which is infinitely adjustable via frequency inverter. Depending on the application, the laboratory mill *LABSTAR* can be designed in steel, ceramic materials such as aluminum oxide, zirconium oxide, silicon nitride or silicon carbide, or polyurethane. Because of this versatility the *LABSTAR* can process virtually any material according to application and operation of the machine in e.g. circulation, passage or multi passage operation. When using grinding media as small as 0.1 mm, product fineness of d_{50} < 100 nm are achieved. These grinding results are exactly reproducible to production machines.

Pict. 2: Laboratory agitator bead mill *LABSTAR (left)*, *MINICER (right)*

Grinding Media

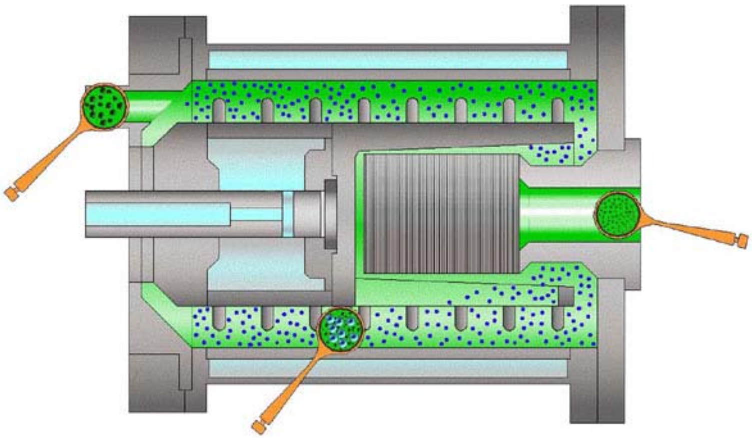
In order to get effective grinding, the ratio between grinding media and product particle size is 10 – 10^4 for dispersions or de-agglomeration and 10^2 – 10^3 for real comminution. From these values it is possible to predict the fineness that can be reached (pict. 3). While for real comminution median fineness of approx. 50 nm is possible, 20 nm can be achieved for dispersions. The necessary grinding media sizes are 0.05 – 0.5 mm.



Pict. 3: Fineness in dependence on grinding media size (∅ 0.05; 0.1 and 0.3 mm)

The Centrifugal Separation System

The use of small grinding media in continuous operation demands a highly efficient separation system. Common systems such as separation gap, screen plate or plug screen fail when flow forces accumulate and concentrate the grinding media on the separation system. Hydraulic pressing of grinding media is the consequence and the grinding chamber pressure and the outlet temperature of the product increase rapidly. The mill must be switched off when these limiting parameters are reached.



Pict. 4: Centrifugal separation system

Such problems are avoided with a centrifugal separation system (pict. 4) where the centrifugal force counteracts the flow force of the product suspension. The large open surface area of the slotted screen and the optimized design of the rotor achieve the high efficiency of the separation system.

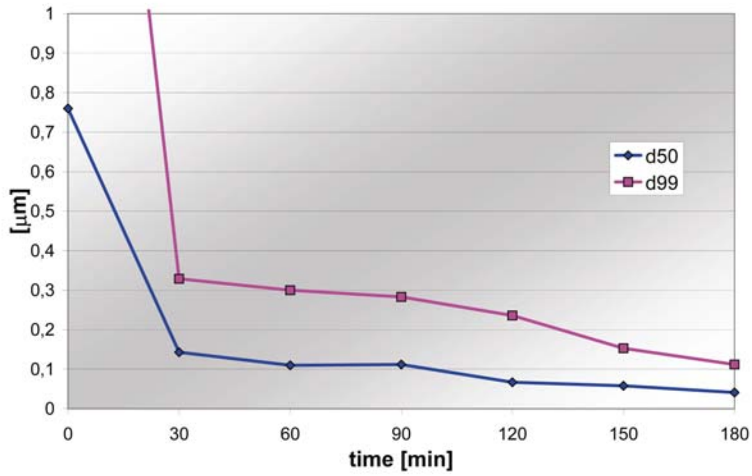
A large open surface area slotted screen is inserted within the slotted rotor. The product flow goes from the inlet on the bearing side axially along the rotor around its rear edge into the separation area between rotor and gap screen. The grinding media that follow the return of flow are subject to a high acceleration force and are returned through the slots of the rotor back into the grinding chamber. The product suspension flows out of the mill unimpeded by a screen blocked by the beads. Therefore, high throughput rates can be achieved even when using smallest grinding media with a diameter of 90 µm.

Application Example

The following example shows the possibilities of grinding pigments in agitator bead mills. A water based suspension of magenta pigment for ink jet ink was processed on the *LabStar* laboratory mill. The requested fineness with a d_{50} value below 50 nm was surpassed after a short grinding period (pict. 5). The appropriate process data are listed in the table below.

Table1:

Machine	LabStar – LMZ design
Grinding media	YTZ 0.3 mm
Formulation	water suspension + additive, solid content 25 %
Initial fineness	d_{50} = 0.76 µm, d_{99} = 2.82 µm
Duration of the test	180 min
Final fineness	d_{50} = 41 nm, d_{99} = 112 nm



Pict. 5: Grinding progress of a pigment for ink jet ink

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1 C. Halik „Putting the puzzle together – new developments in inkjet printing materials“ in: Supplement UV Inkjet Technology, Ink Maker, 2002, 9, 6-7.

2 H. P. Le, „Progress and Trends in Ink-jet Printing Technology“, Journal of Imaging Science and Technology, 1998, 42.

3 Ink Jet Inks Conference and Exhibit 2002: a) J. D. Hosmer, „Surface Modified Pigments for Inkjet Inks“, Cabot Corporation; b) S. L. Issler, „Photo Imaging with Ink Jet Inks“, DuPont Ink Jet; c) D. J. Matz, „Expanding Use of Pigment-Based Inks“, DuPont Ink Jet.

4 Ink Jet Inks Conference and Exhibit 2002: J. Stoffel, „Update on Ink Jet Inks“, Hewlett Packard.

5 J. Kunjappu, „Pigments in Ink“, Paint & Coatings Industry 2000.