THE LATEST SIZE REDUCTION TECHNOLOGY FOR COLOR & MONOCHROME TONERS

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  - Our company information
  - Trends in Particle Characteristics
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- Mechanical Mill
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  - Closed circuit grinding system
  - Comparison of performance of mechanical mill for monochrome toner with that of conventional jet mill
- New Jet Mill
  - Mechanism & Features
  - Comparison of performance of new jet mill for color toner with that of other mills
- Summary
Trends in toner

Recent demand for toner

• Smaller particle design
  10\(\mu\)m \(\rightarrow\) 5\(\mu\)m

• Particle size distribution
  Broad \(\rightarrow\) Narrow
  Less fine particle & coarse particle

• Particle shape control
  Non Spherical \(\rightarrow\) Spherical

Method of producing toner

• Pulverizing process
• Chemical process
The design of toner

• Pulverized toner (5~10\(\mu\)m)
  • Monochrome toner ・・ mechanical mill or jet mill
  • Color toner (especially ,polyester resin) ・・ jet mill

• Sharp particle size distribution
  • Development of grinding and classifying system

• Particle shape control
  • Circularity Index ≥ 0.97
Mechanical mill ~Super Rotor~

Super Rotor  SR-25
Mechanical mill

Cross sectional view of Super Rotor
Air classifier ~Turbo-Classifier~

Cross sectional view of Turbo-Classifier

- Powder feed
- Classification rotor
- Dispersion blades
- Dispersion disc
- Classification blades
- Coarse fraction outlet
- Auxiliary blades
- Scroll casing
- Balance rotor
- Air flow
Principle of Air Classification
(Centrifugal Force Classification)

Large Particles
Centrifugal Force > Drag Force

Small Particles
Centrifugal Force < Drag Force
Grinding & Classifying System

TC-25
For fine classification

Product

TC-25

SR-25
Flow sheet of toner grinding and classifying process
Relation between the median diameter of product and the volume percentage of fine particles less than 5μm.

- **Styrene-acrylic toner**
  - Mechanical mill
  - Jet mill

(Closed circuit system)
Relation between the median diameter and product yield in grinding and classifying
Relation between the median diameter of product and specific energy consumption of closed circuit grinding system.
Determination of particle shape of toner

Malvern ; FPIA-2000
( Flow Particle Image Analyzer )
Circularity index ( C.I. )
= \frac{\pi (4\pi \cdot \text{Area})}{\text{Perimeter}}
\overset{\text{Smooth & rounded surface shape}}{\underset{\text{(Spherical shape)}}{\overset{\text{\[\square\] 1}}{1}}

NIRECO ; LUZEX
Surface shape factor (S.S.F.)
= \frac{(\text{Perimeter}^2)}{4\pi \cdot \text{Area}}
\overset{\text{Smooth & rounded surface shape}}{\underset{\text{(Spherical shape)}}{\overset{\text{\[\square\] 1}}{1}}

Measuring particle shape
S. S. F. = 1.41

SEM photos of toners

(a) Target jet mill
C.I. = 0.927
S. S. F. = 1.41

(b) Pancake jet mill
C.I. = 0.927
S. S. F. = 1.35

(c) Mechanical mill
C.I. = 0.941
S. S. F. = 1.26
TEMPERATURE CONTROL FOR MECHANICAL MILL

Feed Material: Non-magnetic Toner with Polyester Resin, $D_{50}=500\mu m$ (Color Toner)

Grinding Mill: Mechanical Mill with Cooling Air

Product Diameter: 8 $\mu m$

Temp. of Mill Outlet: 50 degree C (122 degree F)

Temp. of Cooling Air: from +5 to -40 degree C (from 41 to -40 degree F)
Relation between the Temperature of Cooling Air and the Maximum Throughput of the Mechanical Grinding System
Relation between Temperature of Cooling Air and Specific Energy Consumption of Closed Mechanical Grinding System

### Specific Energy Consumption

- **[kW h/kg]**

### Temperature of Cooling Air

- **[degree C]**

- 10
- 8
- 6
- 4
- 2
- 0
- -5
- -4
- -3
- -2
- -1
- 0
- 1
- 2
- 3
- 4
- 5

- Closed Circuit System with Mechanical Mill

- Polyester Toner

- 0 F

- 4 F

- 32 F
Toner manufacturing plant
Toner Manufacturing Process Flow Sheet
Outline of toner plant

Equipment: Grinding and classifying systems

Feed material: mainly monochrome toner

Product capacity: 30-100 ton / month / line

Product diameter: 8 ~ 10 µm

Product yield: 85 ~ 93 %
New jet mill ~Super Jet Mill~

Contents

• Super Jet Mill’ features
• Performance of SJ for color toner
  ➢ Comparison with
  ➢ conventional jet mill,
  ➢ target jet mill
  ➢ mechanical mill
• Overall summary

SJ-500
Features

- Two stage classification

- Prevent coarse powder from mixing, achieves narrow particle size distribution.

- Simple inner structure without moving parts

- Less dead space for internal structure, less powder accumulation and adhesion.

- Easy maintenance and cleaning.
Outlet
Grinding nozzle
Inlet
Comp. air
Outlet
Inlet
Grinding zone (1st stage classifying)
Classifying zone (2nd stage classifying)
Comparison between Super Jet Mill and our conventional jet mill

Current Jet (Loop jet type)

(1) Screw feeder
(2) Jet Mill
(3) Bag house

Grinding system of Jet Mill
Conventional jet mill (Current Jet)

Relation between particle size distribution of product and mixture rate (Color toner with polyester resin)
Super Jet Mill

Super Jet Mill achieves precise particle size distribution!

Relation between particle size distribution of product and mixture rate (Color toner with polyester resin)
Current Jet

Super Jet Mill

SEM photos of color toners (Median diameter: 7µm)
Comparison between SJ and a target jet mill

<table>
<thead>
<tr>
<th>Type of Jet mill</th>
<th>Median diameter [µm]</th>
<th>Over 16µm [vol%]</th>
<th>Under 5µm [pop%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>SJ-500</td>
<td>9.8</td>
<td>1.57</td>
<td>48.5</td>
</tr>
<tr>
<td>Target jet mill</td>
<td>9.5</td>
<td>3.80</td>
<td>51.9</td>
</tr>
</tbody>
</table>
Comparison of Mechanical Mill and Super Jet Mill

Closed circuit grinding system of Mechanical Mill

Grinding system of Super Jet Mill

(1) Screw feeder (4) Bag house
(2) Mechanical Mill (5) Classifier
(3) Cyclone (6) Blower

(1) Screw feeder
(2) Super Jet Mill
(3) Cyclone
(4) Bag house
Test condition

**Mechanical grinding system**

Raw Material: Color & Monochrome toner

Mechanical mill: SR-15 (rotor diameter $\Phi 150$)
- Rotational speed: $13,000 \sim 14,000 \text{ min}^{-1}$
- Air flow rate: $1.5 \text{ m}^3/\text{min}$
- Throughput: $\sim 1 \text{ kg/h}$

Air classifier: TC-15 (rotor diameter $\Phi 150$)
- Rotational speed: $5,000 \sim 7,000 \text{ min}^{-1}$
- Air flow rate: $2.5 \text{ m}^3/\text{min}$

**Grinding system of Super Jet Mill**

SJ-500
- Air Pressure: $0.6 \text{ MPa}$ (0.55 m$^3$/min)
- Throughput: $\sim 1 \text{ kg/h}$
Relation between the median diameter and the population percentage of fine particles less than 3\(\mu m\) (Color toner with polyester resin)
SEM photo of color toner

C.I. = 0.944

Mechanical grinding system

C.I. = 0.943

Super Jet Mill
Relation between the median diameter of product and specific energy consumption
(Color toner with polyester resin)
Effect of fine classification on particle shape

Color toner with polyester resin

**TC-15**
Rotational Speed: 10,000 min$^{-1}$
Air Flow Rate: 2.1 m$^3$/min
Throughput: 1.8 kg/h

Before fine classification
C.I. = 0.943

After fine classification
C.I. = 0.959
Relation between the median diameter of product and specific energy consumption (Monochrome toner with Styrene-acrylic resin)
Comparison of our toner and chemical toner

**Chemical toner**
- $D_{50} = 6.4 \mu m$
- Coefficient of Variation = 21.5
- Circularity Index = 0.990

**Pulverized toner**
- $D_{50} = 6.3 \mu m$
- Yield = 72 %
- Coefficient of Variation = 17.9
- Circularity Index = 0.956
## Line-up

<table>
<thead>
<tr>
<th>Throughput</th>
<th>Pulverizer Type</th>
<th>Pulverizer Power consumption</th>
<th>Fine classifier Type</th>
<th>Fine classifier Power consumption (with blower)</th>
</tr>
</thead>
<tbody>
<tr>
<td>~2 kg/h</td>
<td>SJ-500</td>
<td>~7.5 kW (10HP)</td>
<td>TC-15</td>
<td>~3.7 kW (5HP)</td>
</tr>
<tr>
<td>~10 kg/h</td>
<td>SJ-2500</td>
<td>~22 kW (30HP)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>~40 kg/h</td>
<td>SJ-10K</td>
<td>~90 kW (120HP)</td>
<td>TC-25</td>
<td>~13 kW (18HP)</td>
</tr>
<tr>
<td>(~120 kg/h)</td>
<td>(SJ-30K)</td>
<td>(~190 kW) (250HP)</td>
<td>TC-40</td>
<td>18.5<del>37 kW (25</del>50HP)</td>
</tr>
</tbody>
</table>
Mechanical Mill
(for monochrome toner with diameter more than 5.5-7µm)
- It can easily prevent over-pulverization
  - narrow particle size distribution
  - less power consumption
- It produces spherical toner accepted in market without additional treatment for rounding
New Jet Mill - Super Jet Mill

(for color & monochrome toner with diameter less than 7 µm)

- It can prevent the mixture of coarse particles
  - narrow particle size distribution
  - easy to control particle size
- It has less dead space for internal structure
  - less the powder accumulation and adhesion
- It produces spherical color toner as same as toner ground by mechanical mill