Meet the New CAMSIZER P4 Dynamic Image Analyzer

- Why Image Analysis?
- Features of the CAMSIZER P4
- Benefits of the CAMSIZER P4

Jeff Bodycomb
HORIBA Scientific

Gert Beckmann
Retsch Technology GmbH
Why Image Analysis: Images of Particles

What information can we get from this image?

• Shape
• Size
• Transparency
• Surface Texture
• ...........
• in excellent resolution!
• on a single particle!
Why Image Analysis: Sample ↔ Single Particle

What do we want to characterize?

- Particle?
- Sample?
- Product?
What information of the sample or the product do we need?

- Particle size distribution
- Shape characteristics
- Differences between product samples (uncoated ↔ coated or new ↔ used, etc)
- Agreement with quality specifications (good ↔ bad)
- Amount of a part of the product (% component 1 ↔ % component 2) using size, shape or transparency parameters
Why Image Analysis: Sample ↔ Single Particle

Requirements:

• Measurement of many particles
• Complete measurement of the entire sample
• Quick measurement
• Objective and reproducible
• Limited manual effort

→ Automatic Image Capturing and computer aided processing of data!
Measuring Principle

Digital Image Analysis

**STATIC**
(ISO 13322-1)
- Particles do not move during measurement
- High resolution > 0.5 μm
- Low statistic (few 100 particles are analyzed)
- Limited measurement range
- Time consuming
- Particles detected in stable orientation (2 Dimensions)

**DYNAMIC**
(ISO 13322-2)
- Particles in motion relative to camera
- Resolution > 1 μm
- Few million particles are analyzed (representative measurement)
- Wide measurement range
- Fast
- Particles can be measured in all random orientations (3 Dimensions)
Static ↔ Dynamic Image Analysis

ISO 13322-1
Orientated 2D

ISO 13322-2
Random 3D
length measurement methods
without and with flexible guidance sheet (sample director)
Measurement Results
Particle Size

\( x_{c_{\text{min}}} \)  
"width"

\( x_{\text{area}} \)  
"diameter over projection surface"

\( x_{F_{\text{e max}}} \)  
"length"

CAMSIZER results are compatible with sieve analysis.
Results of Dynamic Image Analysis

Better Size Analysis due to Understanding of Particle Shape: Length, Width, Average Diameter
If sieve analysis is used for quality control within the context of DIN EN ISO 9000:2000 then both the **sieve shaker** and the **test sieves** must be subjected to test agent monitoring.

**Technical requirements & testing according to ISO 3310**

Tolerance for mean value ($Y$):
The mean value of the mesh width must not differ from the nominal value $w$ by more than the tolerance $\pm Y$.

$$w = \text{mesh width}$$
$$d = \text{wire diameter}$$
Results of Dynamic Image Analysis

\[ \varnothing = d = X_{c\text{ min}} \]

\[ X_{c\text{ min}} = \text{particle-width} \]
CAMSIZER P4
Wide Measurement Range because of 2 Camera-System

Large particles in high representation

Basic-Camera

Small particles in high resolution

Zoom-Camera
Measurement Principle (CAMSIZER XT)

Advanced, Patented Optics Design

Light Source 1

Light Source 2

Sample Flow

Basic Camera

Zoom Camera
## Whats New?

### CAMSIZER P4 Introduction

1. New Hardware
2. New Software
3. Application Examples
4. Options and Accessories
What's New?

CAMSIZER P4  Introduction

1. New Hardware
2. New Software
3. Application Examples
4. Options and Accessories
CAMSIZER P4 (What’s new)
Measurement principle

Resolution

Detection of particles

One pixel is element of a projection when at least half of the pixel is covered.
Sieving Aids and CAMSIZER Dispersion Aids

**Fluid sieving aids**
- Wet sieving
- Remove grease:
  - Benzines
  - Alcohols

**Powders**
- Aerosil®
- Aerioxide ® Aluminiumoxid
- Talcum (only sieving)

**Mechanical sieving aids**
- Chain rings
- Brushes
- Cubes
- Rubber balls
- Achat balls
- Steatite balls
CAMSIZER® P4
The New Generation
Two Camera-System

Large dynamic measuring range:

**Size-Range:**
Factor of 1500 within one measurement

Lower limit: 20 μm

Upper limit: 30 mm

Particle size
What's New?

CAMSIZER P4 market introduction

1. New Hardware
2. New Software
3. Application Examples
4. Options and accessories
New Tool for improved understanding and documentation

Typically ~100,000 single particle pictures per measurement
New Software: Scattergrams

3D-Cloud

3D-Display of Data points

Powerful tool for distinguishing particles with different size and / or different shapes
New Software: Particle Library

The Particle Library is a software package separate from the CAMSIZER software. It includes the data presentation: 3D-cloud, image database, and filtering.
Stability of Size and Shape Parameters

\( x_{c \text{min}} \)  

“width”

=> stable parameter for good sieve correlation even when particles overlap

For detection of twins and triplets

=> \( x_{Fe \text{max}} \)  length or w/l aspect ratio can be used
New Software: New Shape Descriptors

Krumbeins Roundness and Sphericity

For proppants, sands, and other non-round, angular particles
Compatible with ISO 13503-2 and API

Krumbein Roundness  **RDNS_C**
measures the "angularity", or "corner curvature radius"

\[
\text{Average diameter of all corners divided by diameter of maximum inscribed circle}
\]

Krumbein Sphericity  **SPHT_K**
measures the elongation of the particles (like \( w/l = b/l \)).
Calculation based on \( W/L_{\text{perp}} = B/L_{\text{rec}} \), with a different scaling
Clumps (are "Round") => Stability

RDNS_C => stable parameter
for good microscope correlation
even when particles overlap
Whats New?

CAMSIZER P4 market introduction

1. New Hardware
2. New Software
3. Application Examples
4. Options and accessories
Application Examples

Whats New?

• Higher Resolution of Zoom and Basic
• Higher Brightness of the LED

⇒ Better image quality
⇒ More depth of focus
⇒ Precise shape detection for small particles

more pixels and more optical resolution

Transparent plastic extrudates: Measurement of length and diameter with the motorized guidance sheet
What’s New?

New Specification: 20µm instead of 30µm lower limit

• Higher Resolution of Zoom and Basic
• Higher Brightness of the LED

⇒ More precise detection of small particles < 100µm

Tungsten Carbide powder in the size range from 20µm - 300µm. Laser diffraction results are shown for comparison.
Application Examples

Whats New?

• Higher Resolution of Zoom and Basic
• Higher Brightness of the LED

⇒ Better statistics
⇒ More particles per second

Wider size range

Refractory materials with extremely wide particle size distribution: Same results as the sieve analysis
Whats New?

CAMSIZER P4 market introduction

1. New Hardware
2. New Software
3. Application Examples
4. Options and Accessories
Options and Accessories

Whats New?

Same range of accessories as for the CAMSIZER:
- Calibration reticle
- Guidance sheet
- Chutes and funnels
- De-Ionizer
- Dust filter
- Air filter
- IQ/OQ/PQ

• 21CFR Part 11 software
AutoSampler

CAMSIZER P4 AutoSampler for 12 – 60 cups
CAMSIZER P4 can be configured as „Online“ or „Online light“
Whats New?

CAMSIZER P4

1. New Hardware
2. New Software
3. Application Examples
4. Options and accessories
CAMSIZER XT for Carbon Graphite Powders

Motor electrodes and sample containers
CAMSIZER XT for Carbon Powders

Correlation with Laser Analysis

Correlation with sieve analysis
CAMSIZER XT with X-Fall for Graphite Powder

Results graphic of measure:

CAMSIZER XT with X-Fall for Graphite Powder
Features of the CAMSIZER®

Calibration Reticule

- Traceable to an International Standard
- Covering the Whole Measurement Range
- Instrument to Instrument Agreement
3D printing with metal: The final frontier of additive manufacturing
### Particle Shape (CAMSizer and CAMSizer XT)

<table>
<thead>
<tr>
<th>Shape Property</th>
<th>Diagram</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breadth-/Length-Ratio</td>
<td></td>
</tr>
<tr>
<td>Roundness</td>
<td></td>
</tr>
<tr>
<td>Symmetry</td>
<td></td>
</tr>
<tr>
<td>Convexity</td>
<td></td>
</tr>
</tbody>
</table>

- **Breadth-/Length-Ratio**
  
- **Roundness**
  
- **Symmetry**
  
- **Convexity**

- **Convexity**
  
- **Real Area**
  
- **Convex Area**

**Formulas**

- $A_{\text{convex}}$:
  
- $A_{\text{real}}$:

**Parameters**

- $x_{\text{Fe max}}$
  - $x_{c \text{ min}}$

**Symbols**

- $r_1$
  - $r_2$

**Note:**

- CAMSizer and CAMSizer XT are particle size analysis equipment manufactured by Retsch Technology GmbH.
Reports and Warnings

Reg. 56266; 10.20mm

Company: Maxitec (Skantab)
User: T. Pfohlke
Result file: C:\M5RIZER\SkinLab\Technical\CAMDAT\Skamat Corp;2020;10.20mm B 1% w\% mm 001.rfd
Task file: C:\M5RIZER\SkinLab\Technical\CAMDAT\Skamat Corp;2020;10.20mm B 1% w\% mm 001.rfd
Time: 3.15.2020, 6:00, duration 90 min 2 s at 10% covered area, image rate 12 and 30 mm fed

Particle model: m(h) [\(\mu m\)] 100
No. of particles: 40280
CCD: Znot active
Fitting: none

Comment: Doubtful, 500 mm long, SMKU 1.2

Size class [\(\mu m\)] | p1 [%] | Q1 [%] | SPHT3 | bP | P00
--- | --- | --- | --- | --- | ---
0.00 - 0.05 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1
0.05 - 0.10 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1
0.10 - 0.15 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1
0.15 - 0.20 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1
0.20 - 0.25 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1
0.25 - 0.30 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1
0.30 - 0.35 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1
0.35 - 0.40 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1
0.40 - 0.45 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1

Characteristics:
Q1 [%] | s [\(\mu m\)] | SPATT3 |
--- | --- | ---
10.0 | 0.1 | 0.1
50.0 | 0.8 | 0.8
95.0 | 10.0 | 10.0

Mean value SPHT3 = 0.927
Mean value sP00 = 0.795

Use:

© Retsch Technology GmbH
Optical Process Control Analysis for Size and Shape
Fused Silica

Graph of measurement results:
- D: January
  - Mesh 30-50
  - Task file: RT1594_Misco_10mm-GS_concave.agf

Graph of measurement results:
- C: -3-16
  - Mesh 50-100
  - Task file: RT1549_Misco_400mm-400GSMConcave.agf

Graph of measurement results:
- 0.1 – 0.35mm
  - Misco 50-100 Sample 4 -5% xcm_min_001.rdf

0.2 – 0.7mm
  - Misco 50-100 Sample 3 -5% xcm_min_006.rdf
  - Misco 50-100 Sample 1 Half Repeat xcm_min_005.rdf

Graph of measurement results:
- 0.1 – 0.35mm
  - Misco 20-100 Sample 08% xcm_min_001.rdf
  - Misco 20-100 Sample 08% xcm_min_008.rdf

Graph of measurement results:
- 0.2 – 0.7mm
  - Misco 20-100 Sample 08% xcm_min_002.rdf

Graph of measurement results:
- 0.1 – 0.35mm
  - Misco 20-100 Sample 08% xcm_min_007.rdf
Silicon seeds and beads

Counting and Sieve Correlation of fine silicon seeds and beads
CAMSIZER Counting with Stepped feeder and CCD- Zoom

Size Distribution of Cadmium, Cadmium Sulfate, and Cadmium Tellurite with CAMSIZER XT + X-Dry + X-Jet
CAMSIZER P4 Benefits

1. Two Camera System
2. Unique Calibration
3. Better Hardware (light source, cameras, interfaces)  
   => faster measurements, higher reproducibility
4. New Software (specific tools to solve quality requirements  
   for example RDNS_C Roundness)
5. New Features (Automatic Feed Guide, Particle Library
CAMSIZER® P4

1998 => 2004 => 2006 => 2015 CAMSIZER P4
Fourth Generation of Dynamic Image Analyzer
<table>
<thead>
<tr>
<th>CAMSIZER 1998</th>
<th>CAMSIZER 2004</th>
<th>CAMSIZER 2006</th>
<th>CAMSIZER P4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lightsource</td>
<td>Ccfl 100µs</td>
<td>Ccfl/cont. LED 100µs with Dimming (50%)</td>
<td>90Hz LED-30µs (On ↔ Off)</td>
</tr>
<tr>
<td>exposure time</td>
<td>2 years</td>
<td>4 years</td>
<td>20 years</td>
</tr>
<tr>
<td>Source life time</td>
<td>factor 1</td>
<td>factor 1 / 2</td>
<td>factor 20</td>
</tr>
<tr>
<td>Light intensity</td>
<td>425,000</td>
<td>425,000</td>
<td>780,000</td>
</tr>
<tr>
<td>Cameras (pixels)</td>
<td>20µm</td>
<td>20µm</td>
<td>15µm (7.5µm)</td>
</tr>
<tr>
<td>Resolution (Zoom)</td>
<td>50/s</td>
<td>50/s</td>
<td>56/s</td>
</tr>
<tr>
<td>Image rate</td>
<td>vertical</td>
<td>vertical</td>
<td>horizontal</td>
</tr>
<tr>
<td>Orientation (Basic)</td>
<td>ISA-Bus</td>
<td>RS 232</td>
<td>RS 232</td>
</tr>
<tr>
<td>Feeder control</td>
<td>manual</td>
<td>AutoHeight 30mm</td>
<td>AutoHeight 50mm</td>
</tr>
<tr>
<td>Funnel adjustment</td>
<td>-</td>
<td>12 Volt</td>
<td>24 Volt</td>
</tr>
<tr>
<td>Vacuum</td>
<td>manual</td>
<td>manual</td>
<td>automatic</td>
</tr>
<tr>
<td>Motorized Feedguide</td>
<td>-</td>
<td>-</td>
<td>manual</td>
</tr>
</tbody>
</table>
## Comparison Chart

### Technical Specifications

<table>
<thead>
<tr>
<th>Feature</th>
<th>CAMSIZER 2006</th>
<th>CAMSIZER P4</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Camera resolution Basic [Pixel]</td>
<td>1024 x 768</td>
<td>1296 x 966</td>
<td>+60%</td>
</tr>
<tr>
<td>Image resolution Basic [µm / Pixel]</td>
<td>87</td>
<td>66</td>
<td>+25%</td>
</tr>
<tr>
<td>Field of view Basic [mm x mm]</td>
<td>82 x 62</td>
<td>82 x 62</td>
<td>-</td>
</tr>
<tr>
<td>Frames per second Basic [fps]</td>
<td>28</td>
<td>30</td>
<td>+6%</td>
</tr>
<tr>
<td>Camera resolution Zoom [Pixel]</td>
<td>1024 x 786</td>
<td>1296 x 966</td>
<td>+60%</td>
</tr>
<tr>
<td>Image resolution Zoom [µm / Pixel]</td>
<td>15</td>
<td>10</td>
<td>+33.3%</td>
</tr>
<tr>
<td>Field of view Zoom [mm x mm]</td>
<td>15 x 12</td>
<td>15 x 12</td>
<td>-</td>
</tr>
<tr>
<td>Frames per second Zoom [fps]</td>
<td>28</td>
<td>30</td>
<td>+6%</td>
</tr>
</tbody>
</table>

Better camera resolution and larger number of pixels improves statistics and reproducibility.
New Hardware in CAMSIZER P4

New Cameras
• Higher resolution 1296 x 966 pixel
• Faster interface: more pixel / second

New Lenses
• Higher resolution for Zoom camera
• Larger depth of focus (Sharpness)

New light source
• Brighter, better contrast

Lighted Switch at Front
• Better control
New Hardware in CAMSIZER P4

New camera interface: GigE
• Ethernet cables and Ethernet interface card

Different PC
• more performance for database and 3D CAMSIZER Cloud
• faster harddisk: SSD
• standard GigE Interface card replaces old framegrabber board

New power supply and control board
• more Amps for brighter LED
• more flexible (pulse length, frequency etc.)
• USB interface instead of RS232
CAMSIZER P4 Benefits

1. Two Camera System
2. Unique Calibration
3. Better Hardware (light source, cameras, interfaces)
   => faster measurements, higher reproducibility
4. New Software (specific tools to solve quality requirements for example RDNS_C Roundness)
5. New Features (Automatic Feed Guide, Particle Library)
## Alternative Methods

<table>
<thead>
<tr>
<th>Method</th>
<th>Particle Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sieve Analysis (dry)</td>
<td>1 nm</td>
</tr>
<tr>
<td><strong>Dynamic Image Analysis</strong></td>
<td>1 µm</td>
</tr>
<tr>
<td>Light Scattering</td>
<td>1 nm</td>
</tr>
<tr>
<td>Optical Microscope</td>
<td>600 nm</td>
</tr>
</tbody>
</table>
Particle Shape: Mixture of Activated Carbon and Ion Exchanger

Graph of measurement results:

- A
- B
- A + B

B

A

Q3 [%]
Particle Shape: Mixture of Activated Carbon and Ion Exchanger (Water Purifier)

Q₃ (round particles) = 32.8%
Traditional Measurement (Carbon Black)

- Particle size of pelletized carbon black
  - sieve analysis: 0.1 – 2.0 mm (approx. 2 min.)
  - abrasion analysis: (approx. 3 * 6 min.)

pelletized carbon black
Sensitive carbon black pellets are destroyed by sieving, conveyance and storing.
CAMSIZER measures size and shape without destroying sensitive carbon black granules.
Activated Carbon (Powder, Granules & Extrudates)
Sieve Correlation Activated Carbon (Granules)
Diameter and Length Results of Wood Fibers measured with CAMSIZER P4
CAMSZIER® width definitions for elongated particles (extrudates)

\[ x_{c \min} \quad x_{Fe \ min} \quad x_{Ma \ min} \]
CAMSIZER® length definitions for elongated particles (extrudates)

\[ X_{\text{Fe max}} \]

\[ X_{\text{length}} = \sqrt{X_{\text{Fe max}}^2 - X_{\text{Ma min}}^2} \]

\[ X_{\text{stretch}} = \frac{A}{X_{\text{Ma min}}} \]
CAMSIZER® length definitions for elongated particles (extrudates)
Length measurement
without guidance sheet (sample director)
CAMSIZER® length measurements for elongated particles (extrudates)

\[ X_{\text{length}} = \sqrt{(X_{Fe \ max})^2 - (X_{Ma \ min})^2} \]
length measurement
without guidance sheet (sample director)
Reference particles
Calibration validation with steel rods of the same dimensions as particles
Length + Diameter of Implants

Length measurement $x_{\text{length}} \sim 26\text{mm}$

Diameter measurement $\varnothing \sim 0.85\text{mm}$

validation and test 1. with plastic and 2. steel cylinders

measurements of produced implants (release time 1 month)
Reference particles

Calibration validation with steel rods of the same dimensions as particles

Applications
- Pharmaceuticals

reticles

reticles of „short extrudates to homogenise the product“
Thank you for your attention!