

Flour Powder Analysis



CLEMEX
Image Analysis Report #368

We make your microscope smarter



Flour Powder Analysis

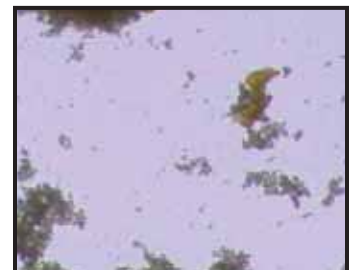
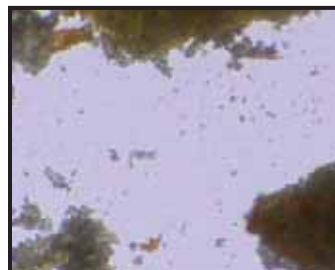
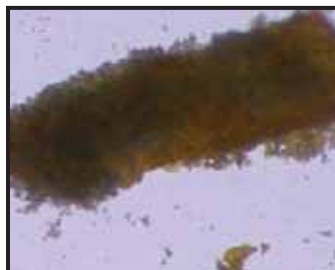
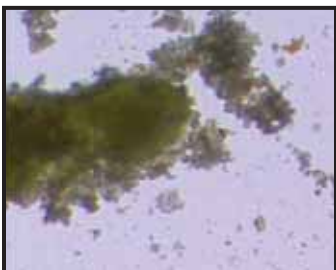
Quality control in the milling industry, specifically in establishing the purity of white flour, requires solutions that are precise, non-destructive and repeatable. Clemex Vision's image analysis system provides greater efficiency in rapid on-line monitoring of the product's refinement by measuring grain size, shape and color.

An ingredient used in many foods, flour is a finely ground powder prepared from wheat or other starchy plant food.

White flour, or bleached flour, is subjected to four bleaching agents in order to whiten it and give it more gluten-producing potential. Since freshly milled flour is yellowish and that specks of colored contaminants are unattractive to consumers, methods have been adopted to quantify the amount of endospermic color and non-endospermic contamination.



Two samples were made available for use with Clemex Vision PE's image analysis system to perform size and shape measurements of the particles and to demonstrate it's ease of use in color discrimination.



Sample Description

Two samples of flour powder were submitted for analysis.

Purpose of Analysis

To demonstrate that the Clemex Vision image analysis system can distinguish the particles and perform size and shape measurements. Also to demonstrate color discrimination.

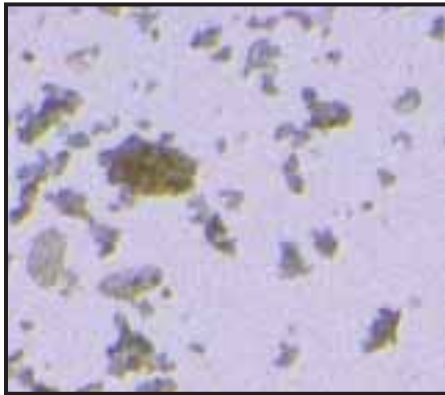


Figure 1: Part of the original image (3.65 microns/pixel).

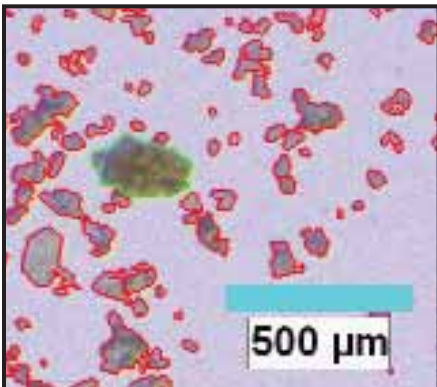


Figure 2: Outline view of particles as measured in red and green bitplanes.

Procedure¹

An automatic gray threshold was used to binarize all the particles into the red bitplane. Connected particles were separated and remaining features that were found to have holes were considered as remaining groups and were eliminated. Particles thinner than twice the optical resolution (<10 microns) were also eliminated.

Yellowish particles were isolated into the green bitplane using color thresholding to obtain separate results for both types of features.

Results²

Diameter, Length, Width, Volume, Area, Sphericity, Compactness, Roughness, Roundness, Aspect Ratio and Count measurements

¹ Images taken during the procedure are available in appendix A
² Complete results are available in appendix B.

were performed on each feature of each type. Automated statistics and graph were generated and were cumulated for the whole sample. Final results could be printed directly from Clemex Vision and saved for further use. A customized report was produced here using the Report Generator module. Raw data is linked to their respective objects for validation purposes. Raw data could also be exported in Excel format.

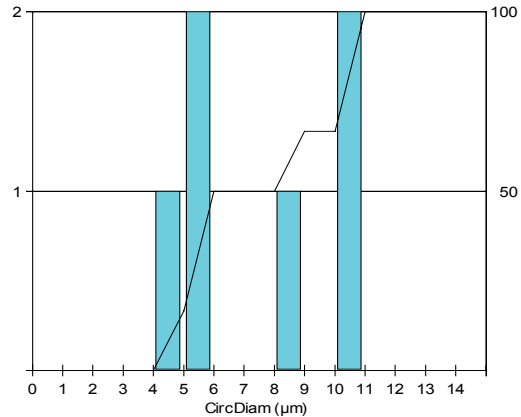


Figure 3: Length distribution of gray particles and corresponding statistics.

Equipment

Image Analysis System:	Clemex Vision PE
Microscope:	Leica MZ 16 A
Objective/Magnification:	25x
Illumination:	Transmitted Light
Calibration:	3.6496350765 microns/pixel
Camera:	Clemex L 1.4 C (1392 x 1040)
Motorized Stage:	Marzhauser EK32IM 75x50mm
Stage Controller:	Clemex ST-2000

Discussion

The main difficulty of this analysis was to clearly distinguish the color of the particles. The problem was overcome using a stereoscope instead of regular microscope.

It is possible that some connected features were measured as a single larger one. Some additional elimination criterion could be added to minimize remaining groups. A validating step was added at the end of the run to confirm that maximums found really correspond to the largest particles and not to a few connected particles.

Results are reproducible.

Appendix A: Image Analysis Steps



Sample # 1 - Coarse Flour

Image Analysis Steps

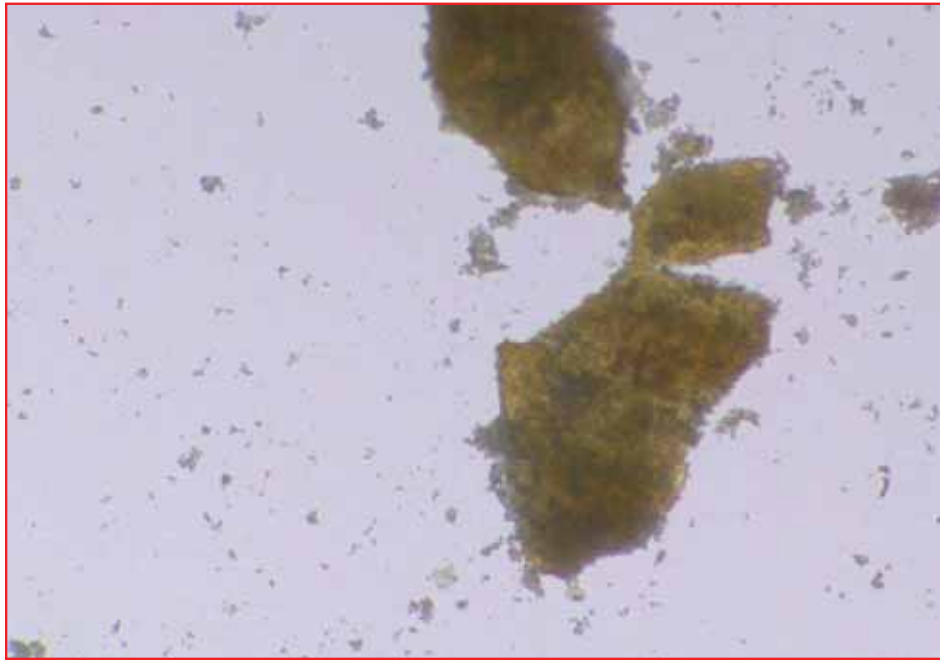


Figure 1: Original image from stereoscope at 25x (3.65 microns / pixel).

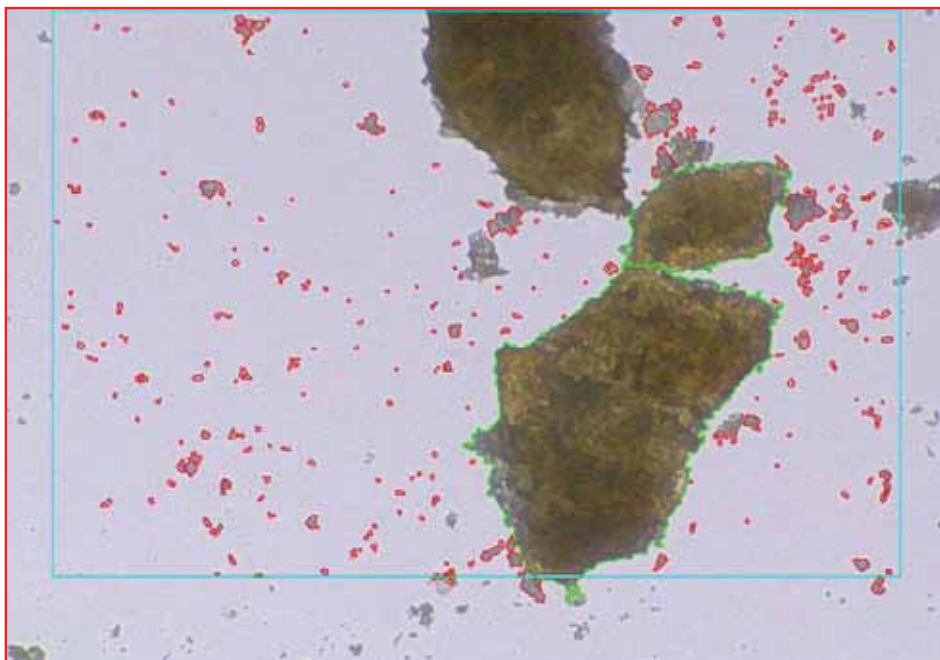


Figure 2: Particles as detected into the red bitplane using automatic gray thresholding.

Image Analysis Steps



Figure 3: Features thinner than 10 microns and those with holes inside were eliminated. Yellowish particles were isolated into the green bitplane for separate measurements.



Figures 4: Outline view of the particles as measured. A guard frame (represented in cyan) was used to avoid measuring too many features sectioned by the field of view.

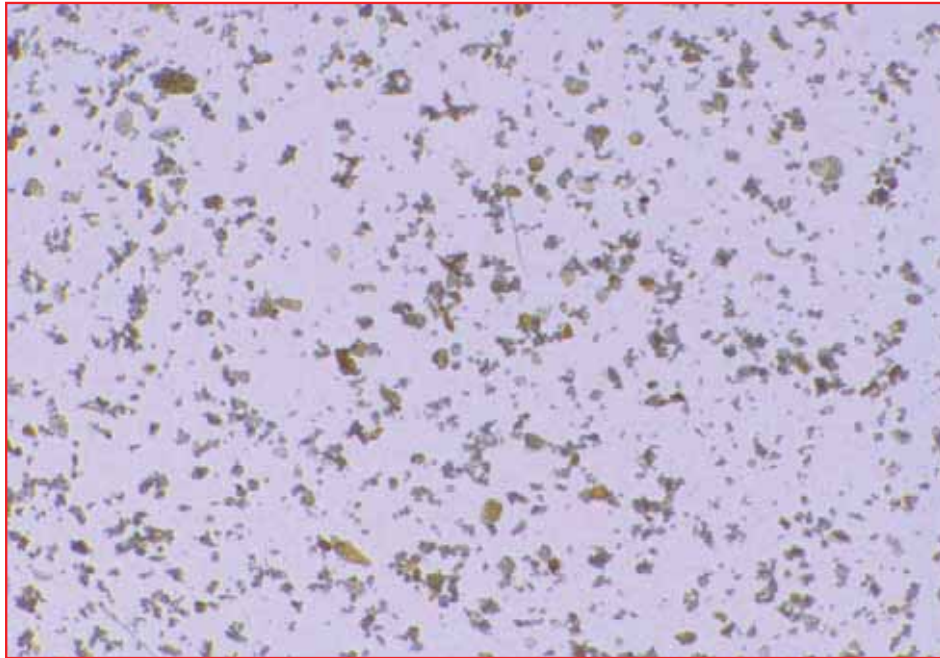
Sample # 2 - Fine Flour**Image Analysis Steps**

Figure 1: Original image from stereoscope at 25x (3.65 microns / pixel).

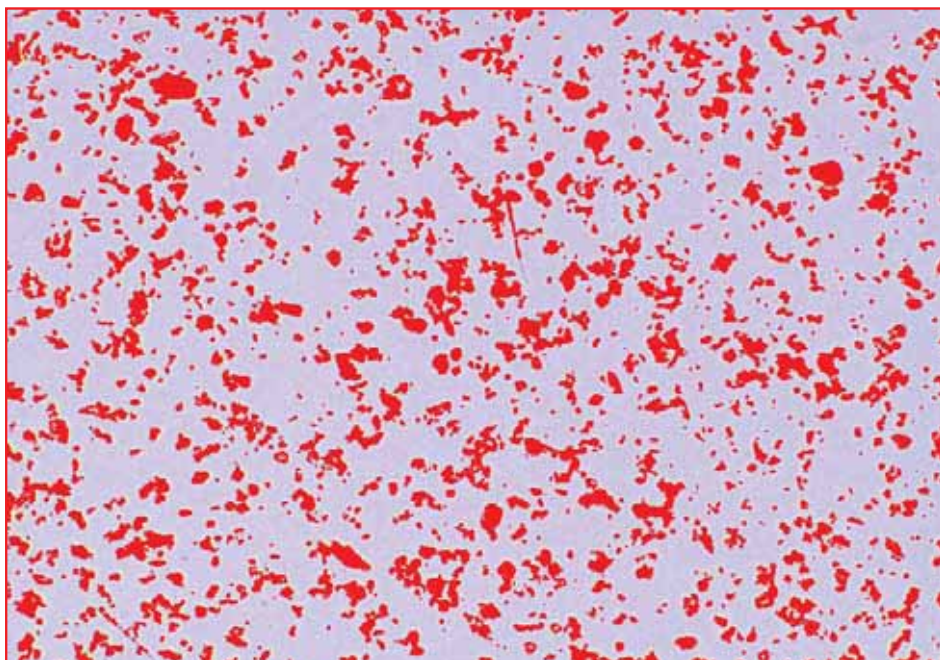


Figure 2: Particles as detected into the red bitplane using automatic gray thresholding.

Image Analysis Steps

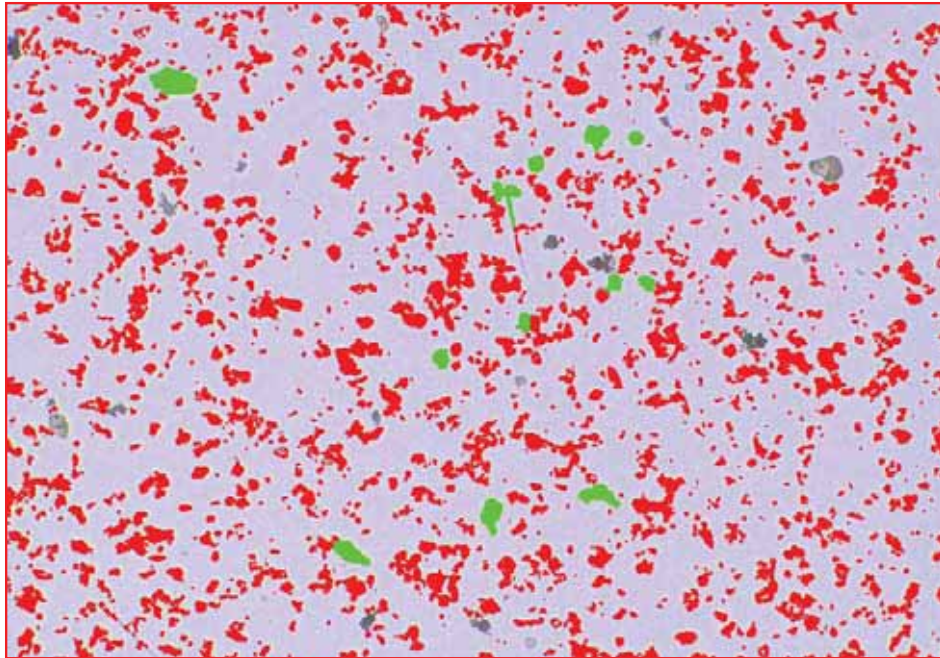
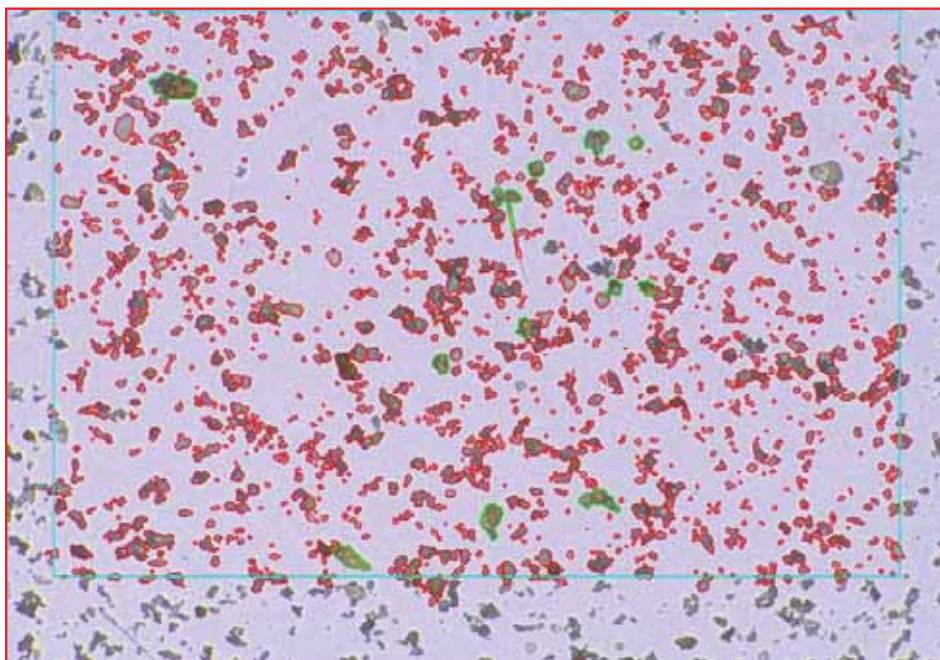


Figure 3: Features thinner than 10 microns and those with holes inside were eliminated. Yellowish particles were isolated into the green bitplane for separate measurements.



Figures 4: Outline view of the particles as measured. A guard frame (represented in cyan) was used to avoid measuring features sectioned by the field of view.

Appendix B: Results



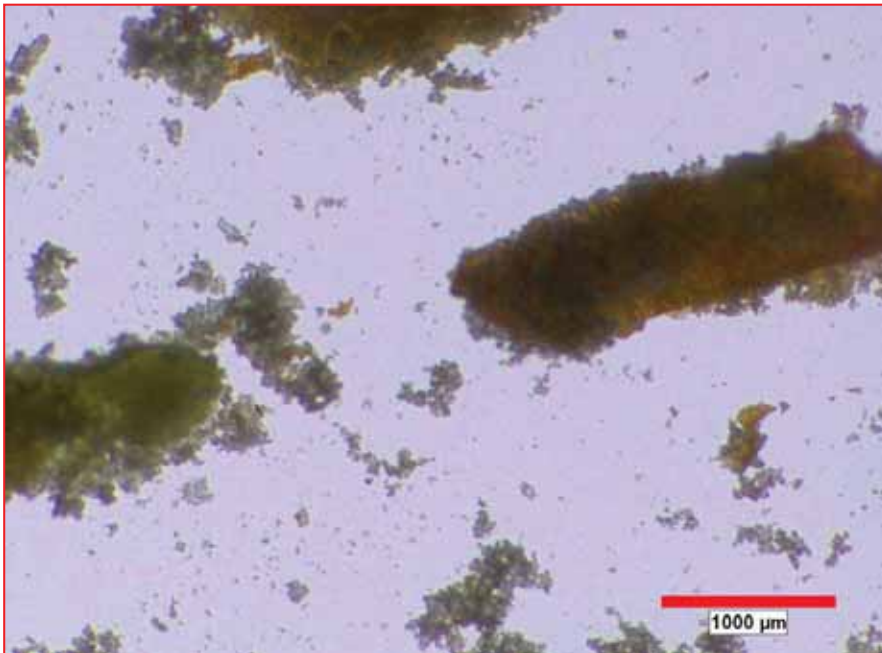
Sample # 1 - Coarse Flour

Particle Sizing Analysis

Compagny: Clemex Technologies
Date: 2006-Aug-22, 3:25:45 PM -04'00'
User: Myriam Savard
Sample ID: Coarse flour powder

Magnification: 25x
Calibration: 3.6496 $\mu\text{m}/\text{pixel}$
Units: microns
Fields: 56
Count: 18822 (Gray particles - Red bitplane)
109 (Yellowish particles - Green bitplane)

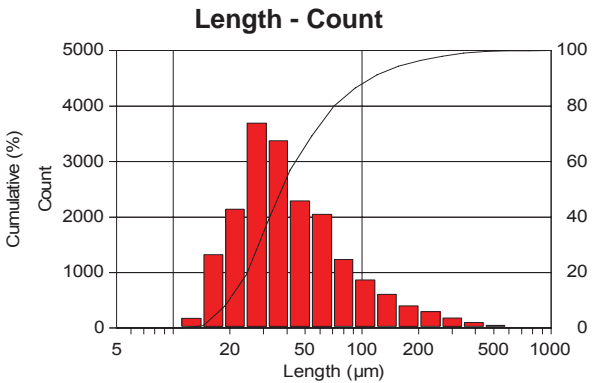
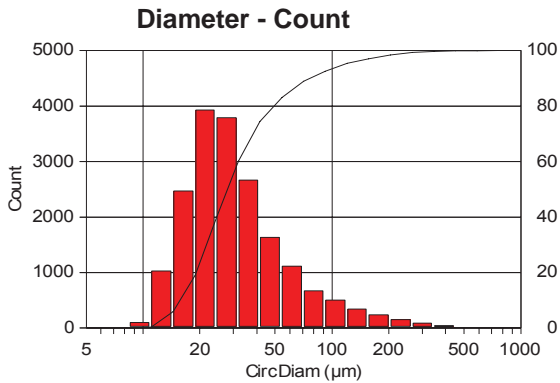
Figure 1: Typical field of view.



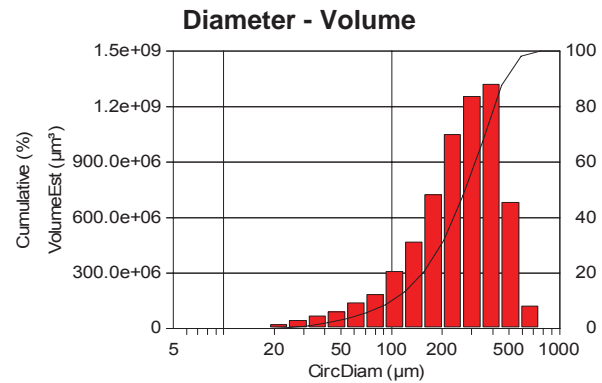
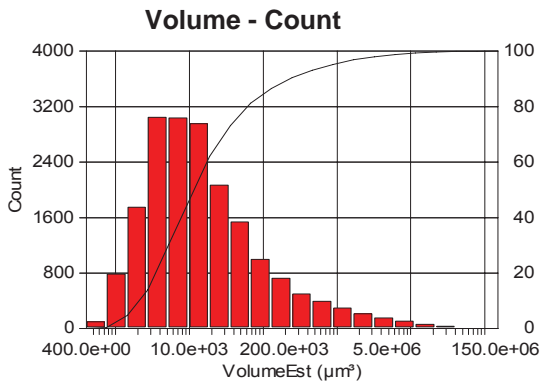
Comments:

Analysis was performed at 25x using a stereoscope and a color camera. The sample was spread on the slide to minimize agglomerates as much as possible. Small particles (less than 10 microns in width) were eliminated from the analysis. Connected features were separated when possible. Particles with yellowish color were isolated and measured separately. Many measurements were performed and their chart and statistics appear at the following pages. Many other measurements are available and we can always create custom ones if needed.

Particle Sizing Analysis

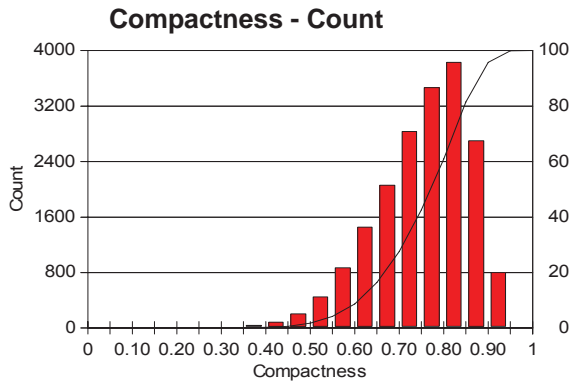
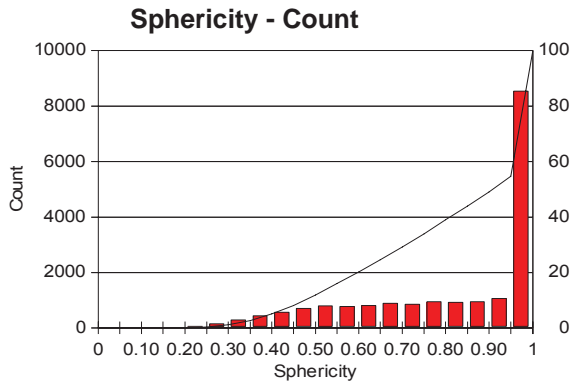


Minimum:	9.21	microns	11.41	microns
Maximum:	615.26	microns	828.47	microns
Mean:	41.01	microns	57.26	microns
Std Dev.:	43.34	microns	61.66	microns
D10:	15.72	microns	29.65	microns
D50:	27.59	microns	57.18	microns
D90:	75.18	microns	111.31	microns



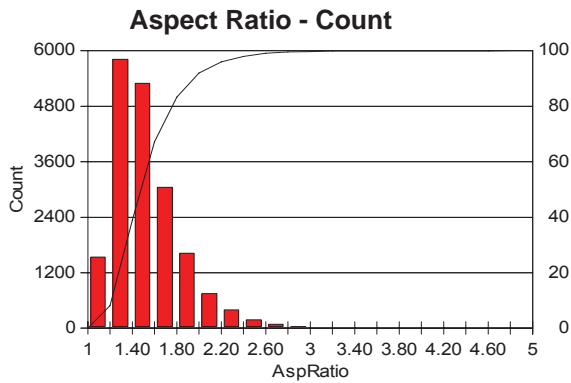
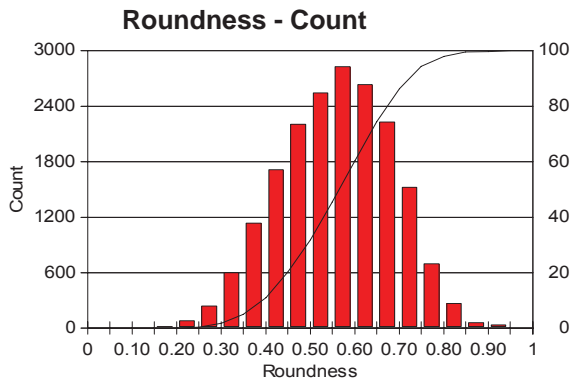
Minimum:	408.85	microns	3	9.21	microns
Maximum:	121950216.00	microns	3	615.26	microns
Mean:	344713.38	microns	3	285.25	microns
Std Dev.:	2723689.94	microns	3	-	microns
D10:	2035.69	microns	3	100.93	microns
D50:	10997.27	microns	3	273.28	microns
D90:	222471.59	microns	3	496.52	microns

Particle Sizing Analysis



Minimum: 0.08
Maximum: 1.00
Mean: 0.81
Std Dev.: 0.21
D10: 0.47
D50: 0.91
D90: 1.00

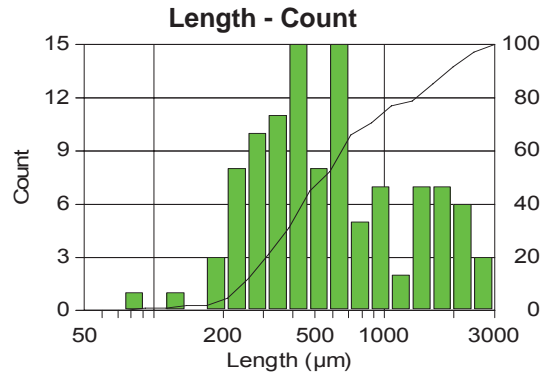
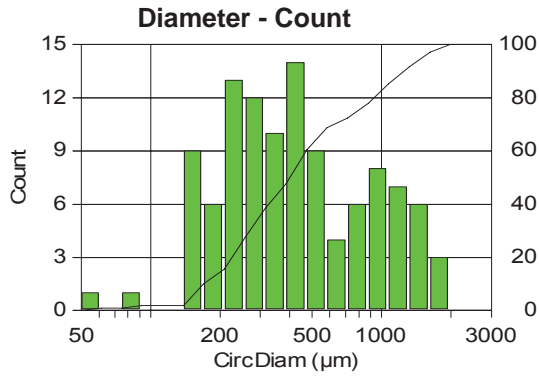
Minimum: 0.26
Maximum: 0.96
Mean: 0.75
Std Dev.: 0.10
D10: 0.61
D50: 0.77
D90: 0.87



Minimum: 0.13
Maximum: 0.93
Mean: 0.56
Std Dev.: 0.13
D10: 0.39
D50: 0.56
D90: 0.72

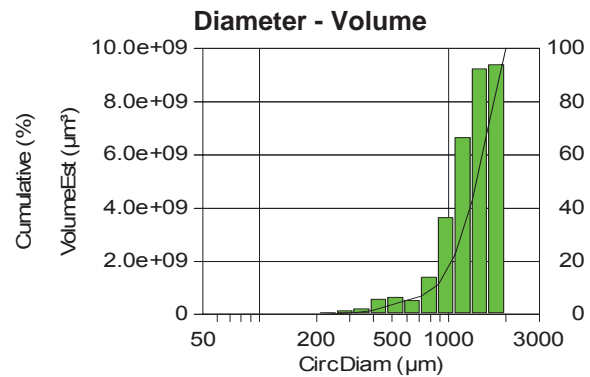
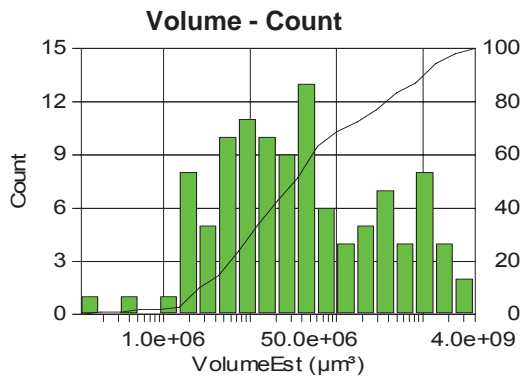
Minimum: 1.02
Maximum: 4.69
Mean: 1.54
Std Dev.: 0.31
D10: 1.22
D50: 1.48
D90: 1.96

Particle Sizing Analysis



Minimum:	59.54	microns
Maximum:	1960.99	microns
Mean:	554.40	microns
Std Dev.:	426.73	microns
D10:	164.85	microns
D50:	403.59	microns
D90:	1238.28	microns

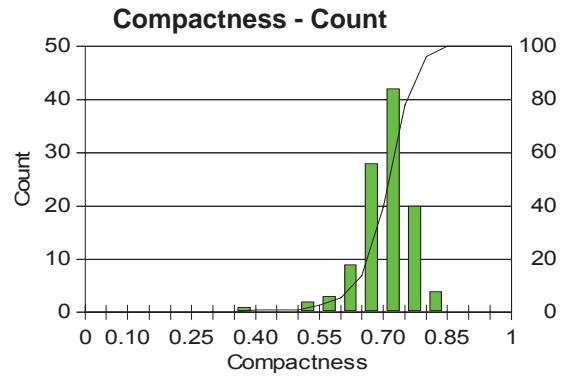
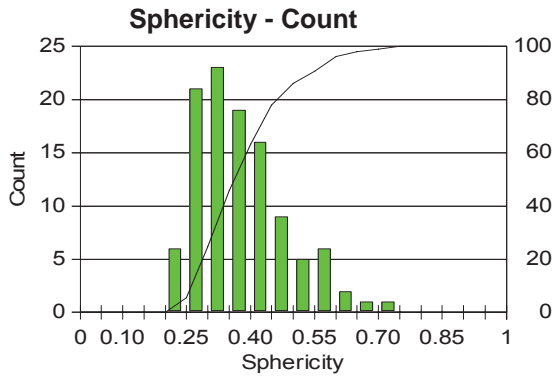
	77.10	microns
	2647.35	microns
	791.98	microns
	641.72	microns
	234.35	microns
	546.30	microns
	1889.69	microns



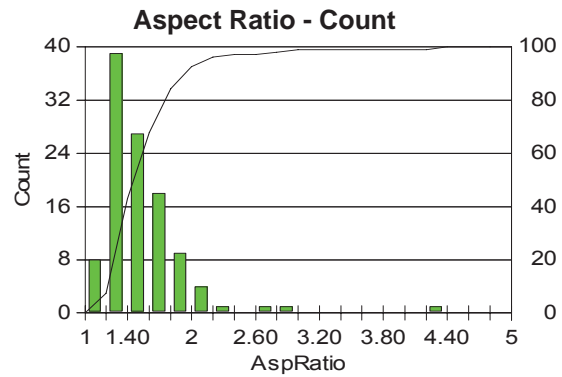
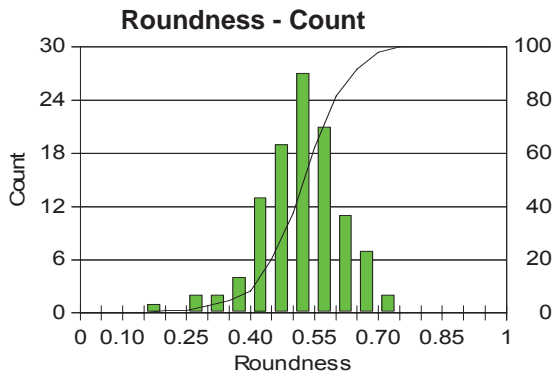
Minimum:	110492.18	microns	³
Maximum:	3948403968.00	microns	³
Mean:	298920313.33	microns	³
Std Dev.:	639034436.74	microns	³
D10:	2346073.00	microns	³
D50:	34422136.00	microns	³
D90:	995200256.00	microns	³

	59.54	microns
	1960.99	microns
	1359.90	microns
	-	microns
	775.64	microns
	1371.51	microns
	1831.10	microns

Particle Sizing Analysis



Minimum:	0.21	0.39
Maximum:	0.71	0.81
Mean:	0.38	0.71
Std Dev.:	0.10	0.06
D10:	0.26	0.63
D50:	0.37	0.71
D90:	0.54	0.78



Minimum:	0.19	1.14
Maximum:	0.73	4.24
Mean:	0.52	1.55
Std Dev.:	0.09	0.40
D10:	0.41	1.23
D50:	0.52	1.42
D90:	0.64	1.95

Particle Sizing Analysis

Description of each measurement performed:

Length:	Longest feret
Width:	Shortest feret
Volume:	$(\text{Diameter}^3) \times \text{PI} / 6$
Diameter:	$2 \times (\text{Area} / \text{PI})^{1/2}$
Area:	Calibrated detected pixels (see calibration in page 1)
Sphericity:	$4 \times \text{PI} \times \text{Area} / (\text{Perimeter}^2)$
Compactness:	$4 \times \text{PI} \times \text{Area} / (\text{Convex Perimeter}^2)$
Roughness:	Convex Perimeter / Perimeter
Roundness:	$4 \times \text{Area} / (\text{PI} \times \text{Length}^2)$
Aspect Ratio:	Length / Width
Feret:	Distance between two parallel tangents on each side of an object (analogous to using a caliper).

* Perimeter accuracy decreases when measuring very small particles because of pixel shape

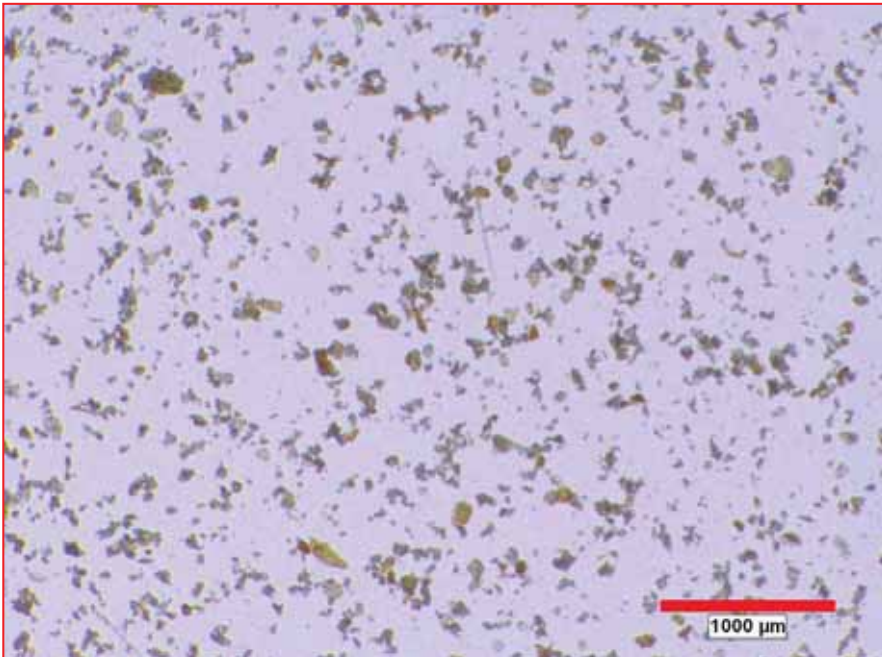
Sample # 2 - Fine Flour

Particle Sizing Analysis

Compagny: Clemex Technologies
Date: 2006-Aug-22, 3:42:13 PM -04'00'
User: Myriam Savard
Sample ID: Fine flour powder

Magnification: 25x
Calibration: 3.6496 $\mu\text{m}/\text{pixel}$
Units: microns
Fields: 56
Count: 59789 (Gray particles - Red bitplane)
129 (Yellowish particles - Green bitplane)

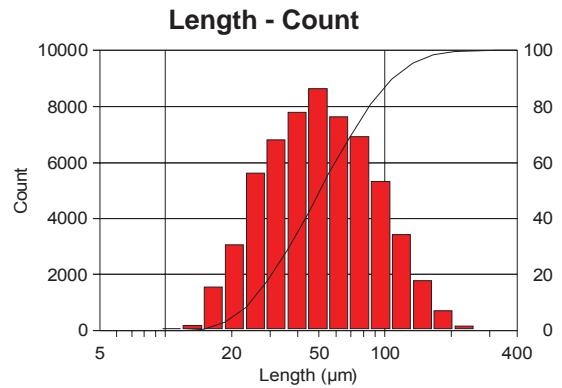
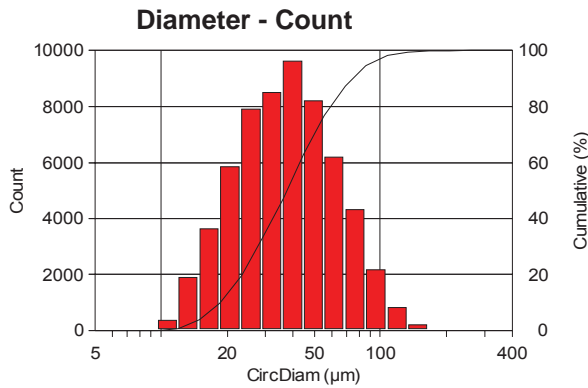
Figure 1: Typical field of view.



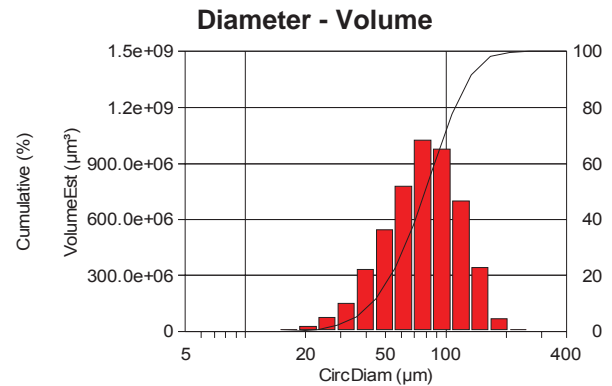
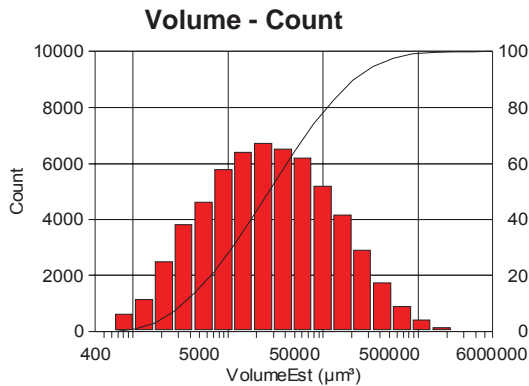
Comments:

Analysis was performed at 25x using a stereoscope and a color camera. The sample was spread on the slide to minimize agglomerates as much as possible. Small particles (less than 10 microns in width) were eliminated from the analysis. Connected features were separated when possible. Particles with yellowish color were isolated and measured separately. Many measurements were performed and their chart and statistics appear at the following pages. Many other measurements are available and we can always create custom ones if needed.

Particle Sizing Analysis

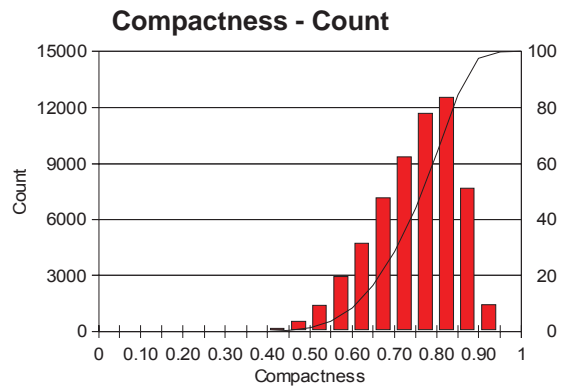
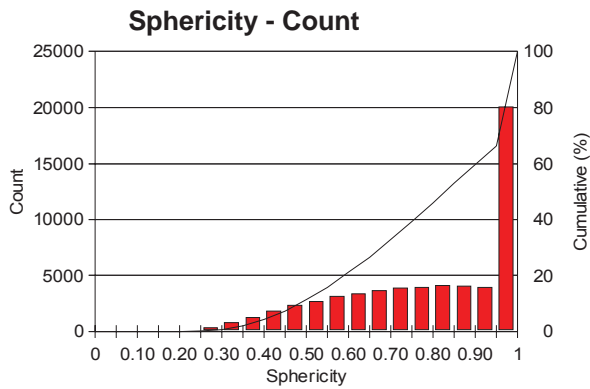


Minimum:	9.21	microns	11.41	microns
Maximum:	220.93	microns	312.04	microns
Mean:	42.58	microns	59.55	microns
Std Dev.:	23.01	microns	35.68	microns
D10:	18.47	microns	23.64	microns
D50:	37.13	microns	50.61	microns
D90:	73.79	microns	107.71	microns

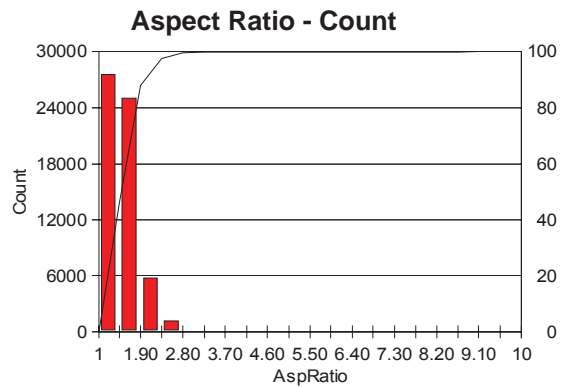
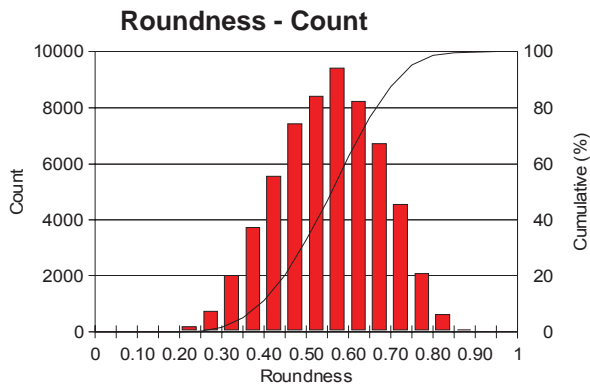


Minimum:	408.85	microns	³ 9.21	microns
Maximum:	5646097.00	microns	³ 220.93	microns
Mean:	84396.18	microns	³ 82.82	microns
Std Dev.:	177530.91	microns	-	microns
D10:	3299.04	microns	³ 42.70	microns
D50:	26801.80	microns	³ 78.73	microns
D90:	210398.45	microns	³ 129.31	microns

Particle Sizing Analysis

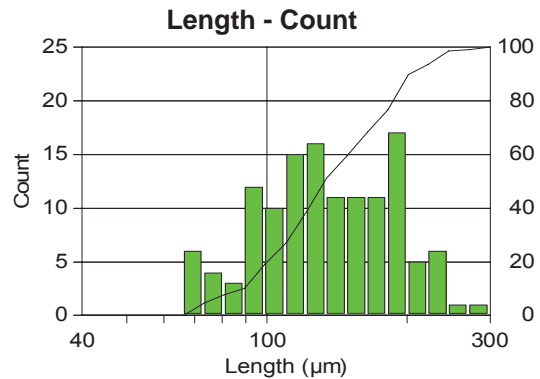
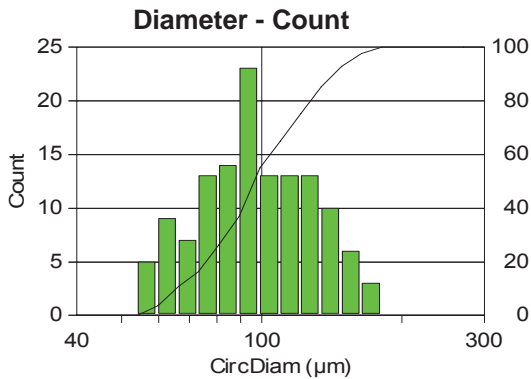


Minimum:	0.15	0.22
Maximum:	1.00	0.96
Mean:	0.79	0.75
Std Dev.:	0.20	0.10
D10:	0.48	0.61
D50:	0.83	0.77
D90:	1.00	0.87

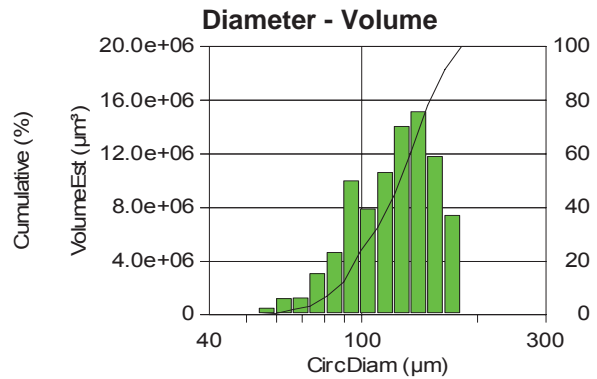
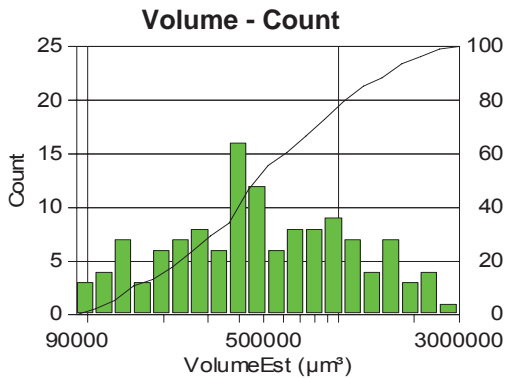


Minimum:	0.10	1.02
Maximum:	0.93	8.97
Mean:	0.56	1.54
Std Dev.:	0.12	0.31
D10:	0.39	1.23
D50:	0.56	1.48
D90:	0.71	1.95

Particle Sizing Analysis

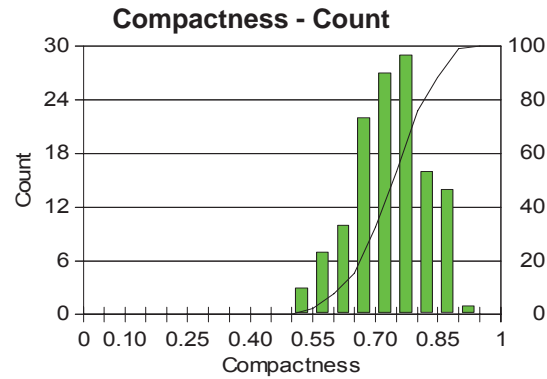
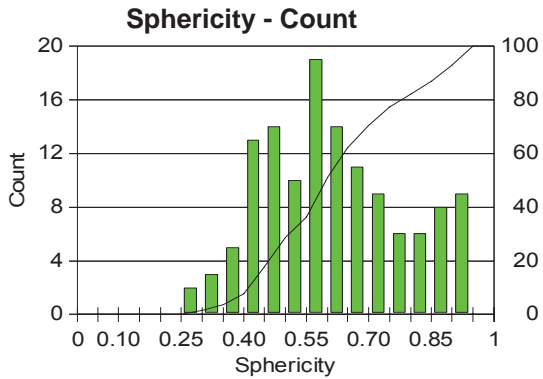


Minimum:	56.47	microns	66.61	microns
Maximum:	172.37	microns	271.44	microns
Mean:	101.51	microns	140.83	microns
Std Dev.:	28.25	microns	45.12	microns
D10:	64.31	microns	89.01	microns
D50:	95.43	microns	130.47	microns
D90:	142.91	microns	200.00	microns

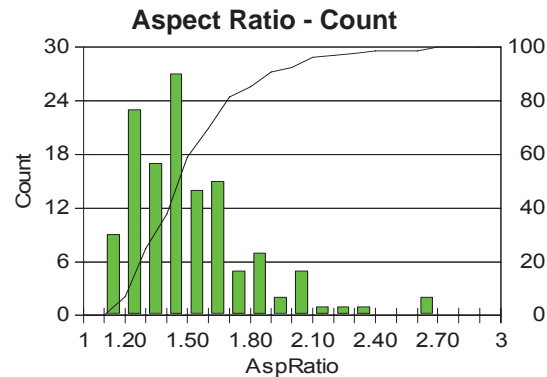
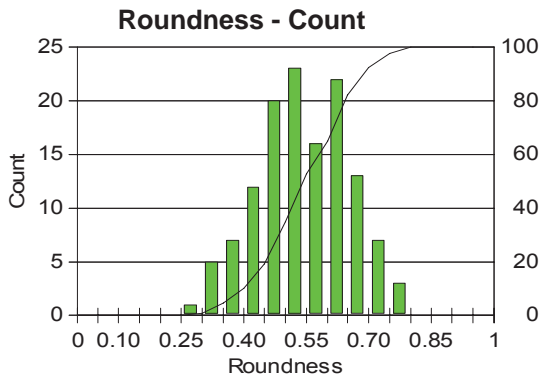


Minimum:	94264.65	microns	56.47	microns
Maximum:	2681719.00	microns	172.37	microns
Mean:	679648.81	microns	124.11	microns
Std Dev.:	568545.06	microns	-	microns
D10:	139293.23	microns	87.12	microns
D50:	455067.41	microns	124.93	microns
D90:	1528128.88	microns	160.65	microns

Particle Sizing Analysis



Minimum:	0.26	0.51
Maximum:	0.95	0.90
Mean:	0.62	0.74
Std Dev.:	0.17	0.09
D10:	0.40	0.62
D50:	0.60	0.74
D90:	0.87	0.85



Minimum:	0.28	1.12
Maximum:	0.79	2.67
Mean:	0.54	1.51
Std Dev.:	0.11	0.28
D10:	0.40	1.22
D50:	0.53	1.47
D90:	0.69	1.86

Particle Sizing Analysis

Description of each measurement performed:

Length:	Longest feret
Width:	Shortest feret
Volume:	$(\text{Diameter}^3) \times \text{PI} / 6$
Diameter:	$2 \times (\text{Area} / \text{PI})^{1/2}$
Area:	Calibrated detected pixels (see calibration in page 1)
Sphericity:	$4 \times \text{PI} \times \text{Area} / (\text{Perimeter}^2)$
Compactness:	$4 \times \text{PI} \times \text{Area} / (\text{Convex Perimeter}^2)$
Roughness:	Convex Perimeter / Perimeter
Roundness:	$4 \times \text{Area} / (\text{PI} \times \text{Length}^2)$
Aspect Ratio:	Length / Width
Feret:	Distance between two parallel tangents on each side of an object (analogous to using a caliper).

* Perimeter accuracy decreases when measuring very small particles because of pixel shape



CLEMEX
www.clemex.com