Challenges of Slurry Distribution System Simulation for Fumed Silica Based Slurry

Pete Bridger
JSR Micro NV
Contents

- Background
- Test Configuration
- SDS Design
- Results of Levitronix & Diaphragm Pumps
- Impact of Filtration on LPC
- Impact of Slurry Mixing / Agitation
- Effect of Nitrogen Purging
- Conclusions
Background

- Slurry suppliers are often asked how their slurry should be handled in a slurry distribution system (SDS).

- Slurry suppliers often do not have experience of circulating slurry in distributions systems for long periods of time without cleaning.

- This study demonstrates how JSR simulated a distribution system to understand how key parameters affect the slurry quality and how Levitronix pumps provide an advantage over traditional pumps.
Test Configuration

- Tank: 400L Natural Polypropylene
- Piping: 1 inch Polypropylene
- Pump: Levitronix BPS-3 with cooling manifold
- Mixing / Agitator Speed: 100rpm continuously ON / OFF
- Filtration: None
- Nitrogen Blanket: 99.99% (No humidification)
- Slurry: Commercial Fumed Silica Oxide Slurry (Single Lot)
- Slurry Volume: 100Kg
- Sample Volume: 1L

- Metrology
  - Particle Size: Horiba LA-950 Laser Diffraction (Median D50)
  - Particle Counting: AccuSizer 780APS (>0.56um & >1.02um)
SDS Simulation with Levitronix Pump

Tank = 400L
Slurry Volume = 100L

Mixer ON 100rpm or OFF

Levitronix BPS-3 Pump or Diaphragm Pump

Filter Housing With or w/out filter
Levitronix BPS-3 with Air Cooling Line

* The slurry did not change between pump cooling and without pump cooling.
• The bulk of the fumed silica slurry distribution is <500nm (0.5µm)
• Using Single Particle Optical Sensing Larger Particles are present >0.56um
LPC : AccuSizer 780APS

• Very low large particle count >1.02um

Mean: 0.60 um
Std Dev.: 0.07 um (12.4%)
Mode: 0.58 um
Median: 0.58 um
Concentration: 1221079 #/ml

Sensor File: 0803907S.sns
Sensor Model: LE400-0.5 SUM
Sensor S/N: 0803907
Sample Time: 60 Sec
Fluid Volume: 60.00 ml
Threshold: 0.56 um
Total # Sized: 268386

D.F./2nd D.F.: 13.56 / 23.00
Comparison Levitronix and Diaphragm Pump

- No change in median particle size
Comparison Levitronix and Diaphragm Pumps

- Diaphragm pump increases the LPC >0.56um while Levitronix pump remains stable
Comparison Levitronix and Diaphragm Pumps

- A large increase in LPC >1.02um is seen with the diaphragm pump
Filtration Impact

- A test was set up to simulate the impact of different filters pore size on Large Particle Count (LPC) reduction.

- A high LPC slurry was created then filters of different pore sizes were used to see the impact on the LPC.

- For example, a 10um filter was used then the LPC was measured. This filter was replaced with a 5um filter and the LPC measured.
Effect of Filtration on High LPC >1.02um

- 10um, 5um and 1um filters all reduce the LPC >1.02um (Median PSD and LPC>0.56um were not effected by this filtration)
- The 1um filter (same media as POU filter) brings the LPC back close to baseline.
• Median Particle Size also increased when the slurry tank is mixed.
• The increase is believed to be due to excessive shearing during mixing.
• Test was repeated with a larger volume of slurry (Confirmation Run).
Impact of Mixing / Agitation

- Slurry Mixing has a big impact on LPC.

Levitronix Pump
Mixing 100rpm
No Filtration
N\textsubscript{2} Purging

**Impact of Mixing on LPC >0.56um**

**Impact of Mixing on LPC >1.02um**
Impact of Nitrogen Purging

- pH drops without Nitrogen purging
• The results of creating too much shear from mixing are confirmed
Conclusion

- Slurry distribution systems can be simulated on a small scale to determine the best conditions to handle the slurry.

- The Levitronix pump gave much lower levels of Large Particle Counts compared to Diaphragm pump.

- High mixing speeds result in high sheer and splashing / drying of the slurry which gives increased particle count.

- Mixing slurry without nitrogen purging can result in an absorption of CO$_2$ and change in pH.