LIQUID–SOLIDS SEPARATION
Liquid-Solids Separation is the process where we remove the solid material from the slurry to render clarified water.
Why Liquid-Solids Separation

- In coal preparation a significant amount of water is used to aide in the separation of coal from the refuse. This results in a need for liquid/solids separation by thickening and/or clarification.
- This water is used to rinse magnetite from the clean coal & refuse.
What is Thickening & Clarification?

- **Thickening** is the removal of solids in suspension from a slurry where the principal aim is to recover a high solids content pulp.

- **Clarification** is the removal of solids from a slurry where the principal aim is the recovery of clear supernatant.
## Thickener Troubleshooting Guide

<table>
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<tr>
<th>If This is Happening</th>
<th>Do This Cationic Feeder</th>
<th>Results/Comments</th>
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<tbody>
<tr>
<td>Settling Rate</td>
<td>Clarity</td>
<td>Sludge Bed</td>
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<tr>
<td>If not black water will rise</td>
<td>If not torque will</td>
<td>raise/shutdown rakes</td>
</tr>
<tr>
<td>If not poor clarity, magnetite loss, plugged sprays, flotation trouble</td>
<td>If not cationic cost will rise</td>
<td>If not, donut may result. See if mud moves with rakes.</td>
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<tr>
<td>Raise/lower rakes</td>
<td>Shut down/clear thickener or slow plant feed until controllable</td>
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Floc is negatively charged + Coal is positively charged  
Cationic is positively charged + Clays are negatively charged
• **Coagulation** is the destabilization (by surface charge neutralization) of stable negatively charged particles (clays) in suspension by using inorganic salts or polyelectrolytes.

• **Flocculation** is the aggregation of finely divided particles through the use of a flocculant that brings the particles together with a density high enough to settle in water.
• Anionic polymers are negatively charged, have a high molecular weight and are used as a bridging mechanism.
• Nonionic polymers as the name implies have no charge, with a low to medium molecular weight and are used to settle solids in low pH conditions.
• Sodium hydroxide is used to increase pH when processing oxidized or high sulfur coal.
Chemicals Used for Water Clarification

- Cationic polymers are positive in charge and usually lower in molecular weight. Cationic polymers are used for particle charge neutralization.
- Alum, aluminum sulfate, is sometimes used to aid in the removal of clays & to lower cationic use.
- Sulfuric acid is used in systems where the pH >8 and high clays. The acid will lower the pH making the clays more soluble and easier to remove; this also lowers the cationic demand.
MAJOR INFLUENCES ON LIQUID-SOLIDS SEPARATION

- Quality of chemical mix water (Fe content & Water Hardness)
- Particle size and shape (28Mx0)
- Weight & volume % of solids (2%-5% Normal)
- Specific gravity of the slurry (1.015-1.03 Normal)
- pH 6.5-9.0
- Variation & range in feed quality (clays, recovery)
- Quality requirements of the discharge water (<1% of solids by weight in the recycled water for heavy media processing)
Scatter Plot Anionic Charge vs. Molecular Weight

- A26-30
- A22-30
- A14-32
- N7-10
If the total water hardness in the process or mix water is >300 ppm, activity of an anionic flocculant will decrease. Little can be done cost effectively to reduce water hardness, alternatively a lower-charged anionic flocculant should be investigated.
Iron is positively charged & will adversely affect the performance of an anionic flocculant. If the soluble iron content of the process or mix water is > 2ppm performance will be reduced. We will need to elevate the pH to 8.5 to completely remove all of the iron.
Flocculation is dependent upon the surface charge of the solids to be treated. If the amount of solids are increased or finer material (higher surface area) is to be treated, more polymer will be required to obtain equal settling rates. A rule of thumb is if the % solids doubles in the slurry the treatment chemical will triple.
If the total water hardness of the water within the slurry is around 200 ppm as CaCO₃ there is typically no cationic demand. The Ca & Mn ++ ions present to produce hardness is normally sufficient to neutralize the surface charges present.
Effect of pH on Cationic Demand

At pH 7.0 water is neutral no positive or negative charges. In pH >7.0 the circuit is negatively charged & lowering the pH would reduce the cationic demand.

Figure 2. Effect of pH on Cationic Demand
**Formula & Calculations**

**Thickener or Pond Feed Lb/Hr**

\[
\text{Gal/Min} \times 60 \text{Min/Hour} \times 8.33 \text{ Lb/Gal} / 1,000,000 = \text{Million Lb/Hr Slurry}
\]

3500 \text{ Gal/Min} \times 60 \text{ Min/Hour} \times 8.33 \text{ Lb/Gal} / 1,000,000 = 1.75 \text{ Million Lb/Hr Slurry}

**Treatment Lb/ Hr**

Parts/Million(From Cylinder Testing) \times \text{Million Lb/Hr Slurry} = \text{Pounds Per Hour Product Required.}

8 PPM \times 1.75 \text{ Million Lb/Hr} = 14 \text{ Lb/Hr Product}
Cylinder Testing: Thickener Stock Product Solutions

- Mix stock solution of powder anionic to 0.25%, this will yield 2.5 ppm for every milliliter of solution added to a 1000 milliliter cylinder.
- Mix liquid cationic to 1% solution this will give 10 ppm for every milliliter added to the 1000 milliliter cylinder.

In most cases powder cationic will out perform the liquid by at least 5 or 10 to one.
Procedure for Cylinder Testing

• Dose cationic first:
  – Do 8-12 inversions then
• Dose with anionic
  – Do 4 inversions
  – Watch and record settling rate every 15 seconds for 1-minute
  – Note clarity.
• If clarity is poor do over & increase cationic leaving anionic constant.
• If clarity good but poor settling increase anionic leaving cationic constant.

A good starting point is 2-4 ppm powder cationic & 4-6 ppm powder anionic. If testing liquid cationic start with 16-20 ppm with 4-6 ppm powder anionic.
Test Equipment: Belt Press Free Drainage Test

Equipment required:

- 2-500 ml graduated cylinders
- 4” length of 4” ID PVC pipe
- 15 cm funnel
- 6” square piece of press belting
- stop watch
- syringes
**Procedure: Belt Press Free Drainage Test**

- Obtain 5-gallon sample of thickener underflow
- Thoroughly mix the sample, transfer 250 ml of the slurry into a 500 ml cylinder
- Starting point for treatment is 0.2-0.5 lb/ton dry floc or 1-1.5 lb/ton liquid floc and 0.5-0.75 lb/ton cationic.
- Measure desired amount of cationic as a 1% solution. Measure & add the desired amount of flocculant to a 50 ml beaker; dilute to a volume of 20 ml with process water mix.
- Invert the cylinder with the sample, immediately add the flocculant & invert 8 times, immediately add the pre-measured cationic & invert 4 additional times.
- Pour the conditioned slurry into the plastic collar (4” pipe) & start the stopwatch, record drainage volumes collected every 10 seconds for a time period ≥ actual plant process time for gravity drainage. Remove the collar, note cake stability & thickness. If cake unstable, sloughing or flowing, redo test increasing polymer.
- Plot the free drainage vs. time
Pond Water Clarification

- Problem Clays
  - Products Used
    - PC-1000
    - PC-1005
    - Floc Logs®
Cylinder Testing: Ponds

• Mix 1% solution of product to be tested PC-1000 or PC-1005
Pond Testing Procedure

- 1-milliliter of 1% solution in 1000 milliliter sample is 10ppm
- Start by dosing with AKJ product at 80 ppm, 100 ppm, 120 ppm in separate cylinders
- Mix samples equivalent to time water travels to pond, more mixing-contact time the better the results.
- Allow samples to set noting water clarity & floc size in 15 minute increments for about 1-hour. Note if samples appear to not have any floc formation, start again with higher dosage (about 180-200 ppm)
AKJ PC-1005 vs. Competition

Competitor
120 PPM

AKJ PC-1005
80 PPM

Competitor
80 PPM

Retention Time
1-Hour
Floc Logs®

- Floc Logs® are used to aid the above products and to polish the water
- Flog Logs® can be used alone when turbidity is low
- There are over 80 different types of logs for evaluation
Pond Clarification Problems: pH, Iron, Manganese

- **Products Used**
  - Caustic soda (Sodium Hydroxide)
  - AMD:
    - Blend of Sodium Hydroxide & Sodium Permanganate
  - Soda Ash Briquettes
  - Hydrated or Slaked Lime
Pond Testing & Treating

- pH $\geq 6.0$
  - very little if any treatment required
  - test for iron & manganese.
  - If pH near 6.0 & Fe-Mn in spec product of choice
    - soda ash briquettes.

- pH $< 6.0$
  - test for iron & manganese
  - products of choice
    - NaOH
    - AMD.
Iron & Manganese

• Permit parameters for Fe
  – 3 mg/l daily average
  – 6 mg/l daily max.

• Iron >3.0 mg/l
  – Increase pH >8.5 for removal
  – Product of choice is sodium hydroxide.

• Permit parameters Mn
  – 2 mg/l daily average
  – 4 mg/l daily max.

• Manganese >2.0 mg/l
  – Increase pH ≥8.5 for removal
  – Product of choice is AMD.