Maximizing Screening Efficiency

Tod Eberle
Craig Burke
Mike Garrison
Dave Turin
Basic Terms

• **Stratification**  
  When the particles in the product stream separate with large particles floating to the top.

• **Screen Stroke**  
  The shape and amplitude of the motion of a screen. Usually screen strokes are circular, oval or straight line strokes.

• **Open Area**  
  The area available on a screen for a aggregate particle to fall through a hole in a screen. Usually expressed as a percentage.

• **Screen Efficiency**  
  The percentage of material that falls through a screen compared to the total amount of material in the product stream of that size.

• **G-Force of a Screen**  
  The force at which a screen moves to the top and returns to bottom of its respective stroke.

• **Travel Rate**  
  The speed material travels down the screen.

• **Bed Depth**  
  The depth of the material on any given screen deck. The limit of which is usually four times the screen aperture of the deck.

Screen Types
**Horizontal vs. Inclined**

- **Pros of Horizontal Screens**
  - Triple shaft
    - Oval motion stroke
    - High G screening
    - Adjustable stroke length, timing angle, RPM
  - Double Shaft
    - Linear stroke

- **Cons**
  - Slower travel speed
  - Less access room (repairs)

- **Pros of Inclined Screens**
  - Higher travel speed (feed)
    - Higher feed capacity
    - Less “surging”/spillover
    - Fines stratify faster
  - “Tumbling” action
  - More clearance/access

- **Cons**
  - Travel rate higher

**Combo or Multi Slope Screen**

- **Increased material travel speed - similar to inclined screens**
  - Reduces bed depth in feed area
  - Enables fines to “stratify” quicker through the cloth
  - Introduces fines to bottom deck faster for increased utilization
  - Travel rate slows down at discharge end to make better cut
High Frequency Screens

- High Frequency screen normal operating range is 38 – 45 degrees.
- Excellent material processing in separations from ½” to 30mm. Can make a “finer” cut than most conventional screens.
- Many High Frequency decks are not crowned
- Material spread is critical for high frequency screen

Screen Setup

Screen application determines how a screen is set up

- **Coarse Separation**
  - Lower Speed And Large Stroke is necessary to properly stratify the material so it can be effectively screened
  - Scalp screens will typically run at 600 RPM with 1” of stroke to effectively shake the coarse particles to the top of the strata

- **Fine Separation**
  - High Speed And Small Stroke is necessary to properly stratify small particles while keeping the material in contact with the screen for maximum screening efficiency
  - Tertiary screens will often operate at 1200 RPM with 0.25 inch stroke
Properly Feeding a Screen

Proper feed introduction is critical to screen efficiency

The bottom decks can’t screen material if it can’t get through the top deck!
Good Feed Distribution

Screen Efficiency
What is Screen Efficiency?

- A measure of how much of the feed material should have gone through the hole versus how much really did go through the hole.

- VSMA Handbook

  Efficiency = \( \frac{\text{TPH of undersize in feed which actually passes}}{\text{TPH of undersize in feed (should pass)}} \)

Calculating Screen Efficiency Example

Calculate the efficiency of the 1” cut on the top deck.

How many TPH didn’t go through?
41.1% of the deck overs passes 1”, so:

\[ \text{TPH (1”)} \text{ Overs} = 0.411 \times 53 \text{ TPH} \]

TPH (1”) Overs = 22 TPH

How many TPH should go through?
93.8% passes 1”, so:

\[ \text{TPH (1”)} \text{ Unders} = 0.938 \times 500 \text{ TPH} \]

TPH (1”) Unders = 469 TPH

Efficiency = \( \frac{\text{TPH of Undersize in feed which actually passes}}{\text{TPH of Undersize in feed (should pass)}} \) = \( \frac{469 - 22}{469} \) = 95.3%
Factors That Effect Screen Efficiency?

- **Particle Size**
  - The closer the particle size to the aperture, the harder to pass it.
  - “Half Size” and smaller go fairly easily.
    - ¼” particle, ½” aperture, e.g.
  - “Near Size” takes a lot more time.

<table>
<thead>
<tr>
<th>Ratio of Particle Size to Aperture Size</th>
<th>Chance of Unrestricted Passage per 1000</th>
<th>Number of Apertures Required in Path</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.001</td>
<td>598</td>
<td>1</td>
</tr>
<tr>
<td>0.01</td>
<td>980</td>
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<td>2</td>
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<td>3</td>
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<td>0.6</td>
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<td>7</td>
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<td>0.7</td>
<td>82</td>
<td>12</td>
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<td>25</td>
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<td>0.9</td>
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<td>100</td>
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<td>1000000000000</td>
</tr>
<tr>
<td>0.999</td>
<td>0.001</td>
<td>10000000000</td>
</tr>
</tbody>
</table>


Factors That Effect Screen Efficiency?

- **Particle Shape**
  - Elongated, flat or otherwise irregular shapes don’t place easily.
  - Not only do these particles not pass easily themselves, they hinder other particles.
  - Understand your particle shape.
  - Are there opportunities to amend particle shape in your crusher?
    - Reduction ratio
    - Compression vs. Impact
Factors That Affect Screen Efficiency?

- **Moisture**
  - Inherent versus introduced moisture.
  - Clays and silts.
  - Damp or wet material tends to:
    - Clump or stick together
      - Hitchhikers
      - Artificial oversize
    - Accrete to the screen media – Blinding
      - Reduced aperture size
      - Closed apertures

Factors That Affect Screen Efficiency?

- **Feed Rate**
  - Feed rate affects bed depth.
    - Before a particle can be screened, it has to get to the deck.
  - Thin bed depth can be as bad as thick.
    - A bounding particle is not seeing much of the deck either.
  - Increasing feed rate is not always bad.
• Feed Rate, Cont.
  ▪ Bed Depth Ratio
    o Less than 4:1 ratio of bed depth to aperture size at the discharge of the deck is recommended for efficient screening.
      ❖ e.g. – For a ½” aperture, a bed depth at discharge of no more than 2” is recommended.
      ❖ Check wear pattern on clamp bars or side plate wear protectors.
      ❖ Establish reference points on each deck.

Factors That Affect Screen Efficiency?

• Open Area
  ▪ What percentage of the deck will allow material to be screened?
  ▪ Inspect decks for aperture blockage.
    – Homemade impact plates.
    – Plugging and blinding.
    – Crown bars.
Factors That Effect Screen Efficiency?

• Screen Angle
  ▪ Changes the shape of the aperture relative to what the particle sees.
    – The “Apparent Aperture”.
    – Remember our basketball shot? What goes through easier, a “rainbow” shot or a flat “brick”?
  ▪ Higher angles produces higher particle speeds.
    – Fewer opportunities to find a hole.
  ▪ Horizontal screen throw angle.
    – Also changes the particles presentation.
    – Pair the best throw angle with application.

Screen Motion/Orbits
Screen Motion/Orbits

There are three primary types of screen orbits:

**Circular** – Inclined screens have circular orbits

Inclined screens are very popular

**Elliptical** – Horizontal screens have elliptical orbits

Electronically recorded orbit
Screen Motion / ORBITS

There are three primary types of screen orbits:

**Linear** – Many mining screens have linear orbits

![Linear Orbit Diagram]

**Elliptical Orbits**
When the vibrators are moved away from the screen’s “CG” (Center of Gravity) elliptical orbits may be created as displayed below.

*FAST* travel rate

*Medium* travel rate

*SLOW* travel rate

Multi-slope screens commonly use this design.

![Elliptical Orbit Diagram]
Screen Performance Evaluations

- The orbits of the screen are recorded at each spring base (velocity) and at each vibrator (Displacement / stroke)
- The speed of the screen and motor is recorded
- The ‘Z’ axis deflections of the screen is recorded
- The total movement of the supporting structure is recorded
Screen Performance Evaluations are used to:

• Increase efficiency
• Prevent / correct screen body problems (broken cross members, sideplates, etc.)

A Polydeck Screen Performance Evaluation reports:

• Screen Acceleration / ‘G’ force
• Screen Displacement / Stroke
• Screen natural / critical frequencies
• Supporting structure integrity
• The recorded movement and deflections of the screen
Screen Performance Evaluations

Case Study #1 = **Excessive Acceleration / ‘G’ force**

10’x24’ screen

- This screen had .65mm slotted panels (slots with flow) and recorded **4.8 G’s Acceleration**
- The screen was adjusted to **3.1 G’s Acceleration** with a resulting 28% increase in ore through the media!
- This screen then had .5mm panels installed to allow a finer finished product
- The resulting improvements allows this screen to be operated reduced hours to achieve production demands
- The reduction in G force combined with increased efficiencies is a winning combination for this producer

<table>
<thead>
<tr>
<th>RPM</th>
<th>G force</th>
<th>Velocity</th>
<th>Displacement Travel Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>839</td>
<td>4.3</td>
<td>18.75 inch/sec</td>
<td>.43 inch 2.85 ft/sec</td>
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</tbody>
</table>

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</thead>
<tbody>
<tr>
<td>839</td>
<td>3.8</td>
<td>16.48 inch/sec</td>
<td>.38 inch 1.59 ft/sec</td>
</tr>
</tbody>
</table>

Example: reduction in Acceleration increase screening efficiency
Screen Performance Evaluations

Case Study #2 = **Acceleration / ‘G’ force too low**
**Displacement / Stroke too low**

- This screen suffered poor production at **650 tons/hour** serving as the ‘scalping screen’
- The recorded displacement (stroke) of this screen was **.37 inch**.
- Additional counterweights were installed – displacement was increased to **.51 inch**
- The result allows this screen to produce **1200 tons/hour**!
- Screen now operates at full capacity

<table>
<thead>
<tr>
<th></th>
<th>RPM</th>
<th>Displacement</th>
<th>Acceleration</th>
<th>Average Velocity</th>
<th>Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>October 2012</td>
<td>784</td>
<td>.37 Inch</td>
<td>3.4 'G's</td>
<td>15.58 Inch/sec</td>
<td>650 Tons/hour</td>
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<tr>
<td>August 2013</td>
<td>805</td>
<td>.51 Inch</td>
<td>4.7 'G's</td>
<td>20.90 Inch/sec</td>
<td>1200 Tons/hour</td>
</tr>
</tbody>
</table>

Screen Performance Evaluations

3.4 'G's
.37 Inch
Displacement
650 Tons/hour
Screen Performance Evaluations

Case Study #3 = **Excessive Supporting Structure Movement**
8x20 horizontal screen-gravel

- This customer replaced 3 screens in a 10-year period on this tower due to failures!
- Supporting structures should not exceed movement of more than .6 inch/sec (15.25mm/sec) in the ‘Y’, ‘X’ and ‘Z’ axis
- **Structure movement far in excess of allowable standards were the root cause of the screen body failures!**
Screen Performance Evaluations

Case Study #4  
Operations at Critical Frequencies

- This screen suffered multiple cross member failures over a 3-year period with very low loading conditions
- Multiple screens recorded operation at or near critical frequencies requiring changes to speed and counterweight settings to prevent failures

Critical frequency ‘peak’ @ 13Hz / 780 RPM

Operation at or near such peaks result in screen body damages

- Screens often require such adjustments for best long-term reliability

96 total cross member failures over 4 screens
Screen Performance Evaluations

8x20 triple deck horizontal operating at severe critical frequency

The same screen after corrections

GOLD-RUSH
Middle deck after 2 years and 500,000 tons

Questions???