Bleach Stage Washers, Pumps and Mixers; Putting the Components Together

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Bleach Stage Components

Retention time

Washer  Pump  Mixer  Tower
Bleach Stage Feed System:
Three Essential Components to Work as One

- Uniform consistency
- Even flow
- Accurate process control

- Consistency
- Steam usage
- Water usage
- Chemical usage
- Brightness

- Consistency
- System pressure
- Brightness

- Consistency
- Chemical usage
- Brightness

Washer  Pump  Mixer  Tower

Retention time
Washers

- Operation
- Design
- Performance
Bleach Plant Washer

- **Purpose**
  - Reduce carryover levels to bleach stage (organic and inorganic)
  - Adjust pH and temperature of pulp
  - Thicken pulp

- **Method (with filtrate recycle)**
  - Use cleaner filtrates or warm fresh water on lower showers (wash)
  - Use filtrates from following bleach stage on upper showers (pH and temperature)
Bleach Plant Washers in North America

- Operate above design specific loading
- Older, original part of pulp mill operation
- Primarily drum washers (vacuum and pressure)
Displacement Ratio and Mat Mechanics

**Principles of Washing Theory**

Displacement ratio = \( DR = \frac{S_V - S_D}{S_V - S_S} \)

Wash ratio = \( RW = \frac{L_S}{L_D} \)

- \( S = \) Concentration of dissolved solids
- \( L = \) Weight unit of filtrate

Subscripts:
- \( V \) – Inlet (vat)
- \( S \) – Shower
- \( D \) – Discharge (mat)

References: 2 & 3

\( L_S = \text{kg shower/kg pulp} \)

\( L_D = \text{kg in pulp/kg pulp} \)

Pulp mat

Drum

Reference 2 & 3
Drum Washing Steps

1. Dilution
2. Extraction
3. Displacement
4. Extraction

reference 2
Drum Washing Steps

1. Dilution
2. Extraction
3. Displacement
4. Extraction
## Bleach Plant Washing

<table>
<thead>
<tr>
<th>Washer Location</th>
<th>Washing Goal</th>
<th>Wash Filtrates Utilized</th>
</tr>
</thead>
<tbody>
<tr>
<td>$D_0$ Stage</td>
<td>Acids, organics, inorganics (Ca, Mn, etc.), pH, temperature</td>
<td>D stage, fresh water condensate, $E_{op}$ stage</td>
</tr>
<tr>
<td>$E_{op}$ Stage</td>
<td>Alkali, organics, pH, temperature</td>
<td>D stage, fresh water, condensate,</td>
</tr>
<tr>
<td>D Stage</td>
<td>Conductivity, chlorides, “anionic trash”</td>
<td>Fresh water, condensate</td>
</tr>
</tbody>
</table>
Vacuum Drum Designs

Center Drainage - Flat Valve - Drive Shaft

End Drainage - Radial Valve - Drive Trunnion
End Drainage Vacuum Filter (GL&V) Radial Valve, Trunnion Drive

- Displacement Shower
- Corrugated Deck
- Drainage Bucket Valve
- Inlet Box
- Dropleg
- Worm Gear Drive
- Drum Rotation
- Face Wire
- Take-Off Assembly
- Repulper
Face Wire Support

Traditional Wire Wound

Anti-Rewet Corrugated Deck
Bleach Washer Seal Tank/Dropleg Design

- Dropleg Design:
  - Sized for 12 to 16 fps superficial velocity
  - Straight, vertical, drop, no jogs

Recommended ht. > 30 ft.
Increase Feed Consistency

From 1% to 4% reduces

1. Dilution flow/pumping requirement
2. Extraction requirement
3. Filtrate volume
4. Seal tank size

Requires Inlet Box Design

reference 2
Comparison of Specific Loading Rates

For various drum washer designs,
units in ODTPD/ ft²

<table>
<thead>
<tr>
<th>Washer Type</th>
<th>SWD</th>
<th>HWD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vacuum washer</td>
<td>0.75-0.80</td>
<td>0.65-0.70</td>
</tr>
<tr>
<td>Pressure washer</td>
<td>2.5-2.7</td>
<td>2.3-2.5</td>
</tr>
<tr>
<td>Wash Press</td>
<td>2.4-2.6</td>
<td>2.2-2.4</td>
</tr>
</tbody>
</table>

Specific loading = ODTPD/(drum dia. x π)(drum length)
Compaction Baffle (GL&V)

End drainage, corrugated deck, deck plate

- PRESSURIZED AIR
- DRUM ROTATION
- DISPLACEMENT SHOWER
- EXTRACTION
- TAKE-OFF ASSEMBLY
- REPULPER
- INLET BOX
Displacement Press DP (Metso)
Bleach Stage Components with Wash Press

- Wash press/conveyor
- Filtrate
- Pump
- Mixer
- Tower
- Pulp

32% cs
12% cs
Drum Utilization for Various Washer Designs

Vacuum

Pressure

Nip Pressure

4% feed

4% and 10% feed

Formation Extraction

Displacement

Final Extraction
Low Level ECF Fiberline

$OD_0 E_{op} D$ Sequence
Effect of $E_O$ Washing on D Stage Brightness Development

- 100%
- 83% $\rightarrow$ (EO) washer efficiency
- (CD)(EO) bleached, 2.7 kappa number
- softwood kraft pulp

Reference 4
Bleach Washing Measurements

**D₀ washer**
- **Displacement Ratio:** Cl⁻, Ca⁺⁺, TDS, cond.,
- **Eₒp stage:** pH, chemical demand
- Discharge consistency

**Eₒp washer**
- **Displacement Ratio:** COD, TOC, cond., Na⁺
- **D stage:** pH and pH control, chemical demand
- Discharge consistency

**D washer**
- **Displacement Ratio:** Cl⁻, cond.,
- Stock prep. chemicals
- Discharge consistency
Solids for Washing Measurement

- Soluble
- Easy to measure
- Relevant to process
Penalty for Poor Bleach Plant Washer Performance

- Higher extracted kappa number and lower final brightness
- Increased chemical usage
  - ClO₂
  - Hydrogen peroxide (Eop)
  - NaOH
  - H₂SO₄
- Scale and/or pitch deposition
Medium Consistency Pumps
Medium Consistency Pumps Purpose

Bleach Stage

- Deliver non-pulsing, stable pulp flow
- Remove air
- Reduce mixer load
- Improve bleach chemical control
Positive Displacement Pumps

- No pulp fluidization
- No air removal
- Uneven pulp flow due to lack of feed control
- No speed control, belt drive
- Vibration
- Low head requirements at higher stock consistency due to air content, no CV

What goes in is what comes out
Positive Displacement Pumps

- Screw feeders
- Closed pocket rotors
- Belt drive
Fluidization

- When medium consistency (8-18%) stock is exposed to sufficient shear forces, it can be brought into a turbulent state.

- In a turbulent state of flow, the stock becomes fluidized and behaves rheologically as water.

- Stock can be pumped by the centrifugal pumping method.
Air Content in Stock

- Stocks often contain large amounts of air.
- The use of conventional centrifugal pumps results in air separation and accumulation of air on the inlet side of the impeller.
- This disturbs pumping.

Source: TAPP/1986 Engineering Conference
Five Functional Zones of Medium Consistency Pumping

A. Fluidization Zone, fiber network disrupted by high shear forces.

B. Gas Separation Zone, air is separated from the stock.

C. Pumping Zone, impeller vanes pump stock towards discharge

D. Fiber Return Zone, fibers entrained with air from zone B are returned to the pump discharge.

E. Degassing Zone, air is removed to the degassing unit.
Medium Consistency Pump
Medium Consistency Pump Control System
Medium Consistency Pumping - Variables

• Raising consistency from 10% to 12% increases friction loss by 53%.

• Increasing production from 1000 to 1500 ADST/D increases friction loss by only 6%.

• Raising pH from 7 to 10 decreases friction loss by 43%.

• Dropping temperature from 200°F to 100°F doubles the friction loss.
The patented MC® Pump design has five functional zones:

A. **Fluidization Zone**, where the fiber network is disrupted by high shear forces.

B. **Gas Separation Zone**, where air is separated from the stock.

C. **Pumping Zone**, where impeller vanes pump the stock towards the discharge.

D. **Fiber Return Zone**, where fibers coming with air from zone B are returned to the pump discharge.

E. **Degassing Zone**, where air is removed to the degassing unit.
Mixers

- Design
- Operation
- Performance
Mixer Purpose

- Reduce degree of non uniformity in chemical/pulp distribution. Assure each fiber sees equal chemical concentration.
- Reduce non uniformity by:
  - larger mixer retention time
  - chemical pre-distribution
  - proper metering of flows
  - eliminate stock flow pulsation
  - maintain uniform consistency and pressure
Three Basic Steps for Mixer Load Optimization

1. Pre-distribution
   - bulk flow
   - macro-mixing, >10 mm scale

2. Fiber mixing
   - turbulent shear, diffusion
   - 0.5-10 mm scale

3. Micro-mixing
   - Diffusion, small scale fluid motion
   - <0.05 mm scale
Chemical Addition Configuration

Chemical Addition

MIXER A

CHEMICAL ADDITION

PULP

MIXER B

CHEMICAL ADDITION

PULP
High-Shear/High-Intensity Mixers
Mixer and Liquid Chemical Addition

Viewed from Motor

CHEMICAL INJECTION

STOCK FLOW

L R
ClO$_2$ Mixer Variance Testing
Chemical Mixer - Average Flow Field
Mixing Index (M) Measurements

Liquid mixing only

- **M = s/x**
  - S is standard deviation of measured quantity
  - X is mean value of measured quantity
  - pipe surface temperature measurements
  - also determines equivalent chemical charges

- **Mixing index** has same definition as inhomogeneity or variance
Mixing Inhomogeneity Testing

- Portable recorder
- Eight (8) surface thermocouples
  - Insulated
  - Calibrated
- Eight (8) temperature data sets after ClO₂
  - Thirty (30) minute intervals
- One (1) stock temperature reading before ClO₂
- One (1) ClO₂ temperature
ClO$_2$ Mixer Variance Testing

ClO$_2$ Mixer

T1  T2  T3  T4  T5  T6  T7  T8

Pulp and ClO$_2$

Mixer

TSTC

ClO$_2$

TC  TS

Pulp
Balance Calculations

**Balance Calculations**

<table>
<thead>
<tr>
<th>Pulp</th>
<th>( P )</th>
<th>Flow (GPM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>( T )</td>
<td>Temperature °F</td>
</tr>
<tr>
<td>( C_{LM} )</td>
<td>( C_{LM} )</td>
<td>ClO₂ Concentration ppm</td>
</tr>
<tr>
<td>( BDT )</td>
<td>( BDT )</td>
<td>BDT Charge Rate/BTD</td>
</tr>
<tr>
<td>( C )</td>
<td>( S )</td>
<td>Consistency % BD</td>
</tr>
</tbody>
</table>

**Mass Balance**

\[ P_x + P_m + P_c = P_m \]

**Heat Balance**

\[ C_x T_x P_x + C_m T_m P_m + C_{LM} T_{LM} P_{LM} = T_{LM} S_{LM} P_{LM} \]

- \( S_x = 0.35 \), \( T_x = 0.1665 \)
- \( S_m = S_{LM} = 1.0 \), \( T_m = 0.1665 \) (\((100-C)/C\))
- \( T_{LM} = T_x \), \( S_{LM} = 0.1665 \) (\((100-C)/C\))

\[ C_{HG} = 2 \times C_{o} (0.35 + ((100-C)/C) \times ((T_x - T_m)/(T_m - T_c))) \]
Inhomogeneity Calculations

<table>
<thead>
<tr>
<th>Date</th>
<th>August 1990</th>
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</thead>
<tbody>
<tr>
<td>Mill</td>
<td>Mitsui Japan</td>
</tr>
<tr>
<td>Calc. by</td>
<td>S. Dunn</td>
</tr>
</tbody>
</table>

- Conclid: 11.10 (% R.D.) Delta T°F 1.30
- ClO₂ Comp 9.80 (ppm)

<table>
<thead>
<tr>
<th>Temp (°F)</th>
<th>Chg (#/BDT)</th>
<th>Temp (°F)</th>
<th>Chg (#/BDT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>157.8</td>
<td>15</td>
<td>158.0</td>
</tr>
<tr>
<td>12</td>
<td>159.4</td>
<td>16</td>
<td>157.6</td>
</tr>
<tr>
<td>13</td>
<td>159.2</td>
<td>17</td>
<td>0.0</td>
</tr>
<tr>
<td>14</td>
<td>157.6</td>
<td>18</td>
<td>0.0</td>
</tr>
<tr>
<td>110</td>
<td>65.3</td>
<td>(ClO₂ temp)</td>
<td></td>
</tr>
<tr>
<td>112</td>
<td>169.7</td>
<td>(Stock 1)</td>
<td></td>
</tr>
</tbody>
</table>

- ClO₂ mean 9.01 (#/BDT)
- Std. dev: 0.80 0.64
- % Error: 6.83 (%/Vol.)
Importance of ClO₂ Line Configuration
Optimized for Pre-Distribution Addition

![Graph showing inhomog,% and #ClO2/T(act) before and after pre-distribution addition.](image_url)
Conclusion

Bleach Stage Feed System Components

**Will impact**

- Pulp consistency
- Process flow stability
- Process control accuracy
- Bleach chemical usage
- Brightness ceiling