Stock Preparation

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Presentation flow

❖ Introduction to Stock Preparation
❖ Retention Aids

❖ Refining
❖ Dyeing of Paper

❖ Chemical additives
❖ Optical whitening agents

❖ Loading of Paper
❖ Starch applications

❖ Internal Sizing
❖ Fiber Recovery

❖ Surface sizing
❖ Approach Flow System

❖ Alum , PAC
❖ Trouble shooting
Introduction

- Stock Preparation is the heart of Paper Making
- Pulp is treated mechanically and chemically
- The Quality of paper is significantly determined in stock preparation
- Lot of Energy is consumed
- Variety of Chemicals are used
- Different color combinations are involved
Properties of Cellulosic fibers

- High Tensile Strength
- Flexibility, conformability, suppleness
- Resistance to deformation
- Water insoluble
- Hydrophilic
- Wide range of dimensions
- Inherent bonding ability
- Ability to absorb modifying additives
- Chemically stable
- Relatively colourless (white), but not necessarily.
Stock Preparation Purpose

- Refining for mechanical treatment of fiber furnish - Development of paper properties
- Blending the various fiber and other components
- Screening for contaminant removal
- Provide consistent raw material inventory for the paper machine to use.
Refining
Refining

- Refining is the mechanical treatment of fibres between moving metal bars.
- The purpose of refining is to produce the desired sheet properties.
- Paper made from unrefined fibre is low in strength, porous, not well bonded, and wild in formation; whereas, paper made from refined stock is strong, dense, and of good formation.
What happens during refining

Primary effects

- Removal of primary wall
- Penetration of water into cell wall (swelling)
- Breaking of intra fiber bonds (hydration)
- Increased fiber flexibility
- Extra fibrillation and foliation
- Fiber shortening
What happens during refining

Secondary effects

- Fractures in the cell wall
- Fiber stretching and compression
- Partial solubilisation of surface hemicelluloses
- Straightening of fiber (at low consistency)
- Curling of fiber (at high consistency)
Morphological characterisation of fibers

Pine
*Pinus silvestris*

- Fiber length: 3.5 mm
- Coarseness: 0.16…0.23 mg/m
- Fibers: 2.5 million per gram

Eucalyptus

- Fiber length: 0.8 mm
- Coarseness: 0.08 mg/m
- Fibers: 15 million per gram
Effect of refining

A

B

C

Fiber floc gets the first hit

It is pressed between bars

It leaves tailing edge

Plates or fillings are grooved so that the bars treat fibers and grooves between the bars allow fiber flow through the refiner
Fiber properties of softwood

- The role is to ensure strength of the paper
- Excellent reinforcement fibers are flexible,
- Strong and long
- Thin-walled fibers are flexible and can get
  Close together ensuring good bonding ability
- Thick-walled fibers yield high tear strength
Fiber properties of softwood

- The role is to ensure the good printability of the paper
- Short fibers and narrow fiber length distribution gives good formation
- Sufficient tensile strength and tear strength are also required for good runnability
- The higher the number of fibers per gram, the better the optical properties
Other Paper Making Fibres

Non-wood plants such as straw, bagasse, bamboo, kenaf, flax, hemp and cotton are used for special paper grades and need refining sometimes.

Recycled fibres are increasingly used in papermaking. Refining is recommended for many paper grades. This is due to lost fiber properties in earlier papermaking processes.
The effect of refining

Strength properties generally, like tensile, burst and internal bonding strength are increased.
The effect of refining

Tear strength is initially increased, but is then reduced after prolonged refining.
The effect of refining

Drainage resistance and water removal resistance are increased
The effect of refining

Air permeability, bulk, absorbency, opacity, brightness and light scattering are reduced
The effect of refining

Fiber length are reduced
Refining system

Batch or Continuous the latter is more common. Batch operation is used typically for paper grades that require high refining degree.

Separate or Mixed both are used. Combination of these can offer benefits from both.

Number of stages depends on requirements refining degree and fiber properties
Refining system

Combined system

Broke

SW

HW

To Machine Chest

Blending Chest
Refining system

Energy input / split per stage

Max. specific surface load at achieved refining degree must be taken into account as shown earlier, e.g. for softwood:

15 SR

130 kWh/t

120 kWh/t

100 kWh/t

35 SR
Refiner fillings

Geometry

- Typically metallic stainless steel fillings / segments are used
- The basic design parameters are width of bars and grooves, height of bars and angle of bars.
- The optimal fillings are selected based on fibers, so that long and strong fibers require wider bars and grooves than shorter fibers.
# Refiner fillings

## Geometry

<table>
<thead>
<tr>
<th>Application</th>
<th>Bar width, mm</th>
<th>Groove width, mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardwood</td>
<td>2.0…3.0</td>
<td>3.0…4.0</td>
</tr>
<tr>
<td>Mixed pulp</td>
<td>3.5</td>
<td>4.5</td>
</tr>
<tr>
<td>Softwood</td>
<td>4.0…5.5</td>
<td>5.0…7.0</td>
</tr>
<tr>
<td>Fibrillating</td>
<td>4.0…8.0</td>
<td>3.0…5.0</td>
</tr>
<tr>
<td>Cutting</td>
<td>2.5…4.5</td>
<td>7.0…9.0</td>
</tr>
</tbody>
</table>

In general the bar width is about 2 ~ 3 times of fiber length
Refiner fillings

Intersecting Angle

- The bar to bar crossing angle varies from 10° to 40° depending on fibers, long fibers having greater angle
- Too small angle increases noise level
- Too big angle increases energy consumption and decreases hydraulic capacity
## Amount of refining

### Typical specific refining energy

<table>
<thead>
<tr>
<th>Material</th>
<th>Specific Energy (kWh/tºSR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NBKP</td>
<td>10 ... 15 kWh/tºSR</td>
</tr>
<tr>
<td>LBKP</td>
<td>7 ... 10 kWh/tºSR</td>
</tr>
<tr>
<td>Recycled fiber - DIP</td>
<td>5 ... 7 kWh/tºSR</td>
</tr>
<tr>
<td>Recycled fiber - OCC</td>
<td>7 ... 10 kWh/tºSR</td>
</tr>
<tr>
<td>NUKP</td>
<td>15 ... 17 kWh/tºSR</td>
</tr>
</tbody>
</table>
## Amount of refining

### Typical inputs in one pass

<table>
<thead>
<tr>
<th>Type</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>NBKP</td>
<td>60 ... 200 kWh/t</td>
</tr>
<tr>
<td>LBKP</td>
<td>40 ... 80 kWh/t</td>
</tr>
<tr>
<td>Recycled fiber</td>
<td>20 ... 100 kWh/t</td>
</tr>
<tr>
<td>Post refining of mechanical pulps</td>
<td>30 ... 80 kWh/t</td>
</tr>
<tr>
<td>Trim refining</td>
<td>20 ... 50 kWh/t</td>
</tr>
</tbody>
</table>
# Refining Process

<table>
<thead>
<tr>
<th>Description</th>
<th>Low consistency refining</th>
<th>Medium consistency refining</th>
<th>High consistency refining</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consistency</td>
<td>2 – 6 %</td>
<td>10 – 20 %</td>
<td>30 – 35 %</td>
</tr>
<tr>
<td>Rotor linear speed</td>
<td>15 – 25 m / sec</td>
<td>40 – 50 m / sec</td>
<td>90 – 110 m / sec</td>
</tr>
</tbody>
</table>
Refining result

HC Vs LC Refining
Refining result

HC Vs LC Refining

<table>
<thead>
<tr>
<th></th>
<th>Unrefined</th>
<th>After HC</th>
<th>After LC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freeness, mL/°SR</td>
<td>705/15.7</td>
<td>700/15.8</td>
<td>550/21.6</td>
</tr>
<tr>
<td>Bulk, cm³/g</td>
<td>2.23</td>
<td>1.93</td>
<td>1.68</td>
</tr>
<tr>
<td>Fiber length, mm</td>
<td>2.30</td>
<td>2.11</td>
<td>2.25</td>
</tr>
<tr>
<td>Tensile index, Nm/g</td>
<td>46.0</td>
<td>44.0</td>
<td>84.0</td>
</tr>
<tr>
<td>Tear index, mNm²/g</td>
<td>19.3</td>
<td>18.8</td>
<td>12.2</td>
</tr>
<tr>
<td>TEA, J/g</td>
<td>0.9</td>
<td>1.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Gurley, s</td>
<td>0.3</td>
<td>0.3</td>
<td>3.0</td>
</tr>
</tbody>
</table>

Unrefined

After HC-refining 220 kWh/bdmt

After LC-refining 110 kWh/bdmt
Refiners - batchwise operated

Hollander - Beater
Refiners

Geometry

Conical Refiners
- Low cone
- Short cone
  - Shallow angle
  - “Jordan”
  - “Conflo”
  - Wide angle
  - “Claflin”

Disc Refiners
- Single Disc
- Double Disc
- Multidisc
Conical refiner
Disc refiners

The disc refiner group comprises three types, namely single-disc, double-disc and Multi-disc type refiners.
Refining system

Control Strategy

Diagram showing control strategy with various components labeled as PIS, PI, FIC, NIC, EIC, Cs, white water, PIC, LIC, and SEC.
Control of refining

Manual control

Control with gap clearance

Power control

Gap clearance controlled according motor power

Specific refining energy control

Motor power controlled according production

Freeness control

Refining energy controlled according freeness temperature and couch vacuum i.e. can be used in a same way
Refining control

Power Control vs SEC Control

Specific Energy, kWh/t

Fiber Flow, t/h

Motor Power, kW
Chemical Additives
## Classification of wet-end chemicals and mineral additives

<table>
<thead>
<tr>
<th>Additives</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acids &amp; Bases</td>
<td>Control of pH</td>
</tr>
<tr>
<td>Alum</td>
<td>Control pH fix additives, improve retention</td>
</tr>
<tr>
<td>Sizing agents</td>
<td>Control penetration of liquids</td>
</tr>
<tr>
<td>Dry strength additives</td>
<td>Improve burst &amp; Tensile, add stiffness and pick resistance</td>
</tr>
<tr>
<td>Wet strength resins</td>
<td>Add wet strength (towelling &amp; wrapping paper)</td>
</tr>
<tr>
<td>Fillers</td>
<td>Improve optical and surface properties</td>
</tr>
<tr>
<td>Colouring materials</td>
<td>Impart desired colour</td>
</tr>
<tr>
<td>Retention aids</td>
<td>Improve retention of filler &amp; fines</td>
</tr>
</tbody>
</table>
## Non fibrous additives to Paper making stock

### Classification of wet-end chemicals and mineral additives

<table>
<thead>
<tr>
<th>Additives</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fiber flocculants</td>
<td>Improve sheet formation</td>
</tr>
<tr>
<td>Defoamers</td>
<td>Improve drainage and sheet formation</td>
</tr>
<tr>
<td>Drainage aids</td>
<td>Increase water removal on wire</td>
</tr>
<tr>
<td>Optical Brighteners</td>
<td>Improve apparent brightness</td>
</tr>
<tr>
<td>Pitch control chemicals</td>
<td>Prevent deposits / accumulation of pitch</td>
</tr>
<tr>
<td>Slimicides</td>
<td>Control slime growth and other microorganisms</td>
</tr>
<tr>
<td>Speciality chemicals</td>
<td>Corrosion inhibitors, flame proofing and anti tarnish chemicals</td>
</tr>
</tbody>
</table>
Loading of Paper
Fillers or Loading Materials

What are fillers

Fillers are basically inorganic pigments that are added to the stock for brightness, opacity improvements, decreasing its show through, and also improve the “feel” of the paper, i.e., they help in imparting better smoothness. Further most of the fillers are cheaper than the pulp and hence incorporation of these in the furnish helps in cost reduction also. All these will result in better printability of the printing papers.
Common fillers used in Paper manufacture

The following are the commonly used fillers

- China clay
- Talcum
- Calcium carbonate
- Calcined clay
- Titanium di oxide
Loading of Paper

▪ To Improve the Printability on Paper, uniform ink receptivity.

▪ To replace the fiber in paper up to the strength tolerance levels.

▪ To improve upon the drying efficiency of the machine.

▪ For Cost Reduction due to fiber saving.

▪ To increase the opacity and smoothness of paper.

▪ To Control the Pitch coming in the pulp.
Effect of filler on strength properties

- Despite their beneficial effects, fillers adversely affect the strength properties.
- The loss of strength properties occurs presumably because fibrous material having inter fiber bonding capacity is replaced by an amorphous material which disturb the fiber bonding.
### Relative sizes and shapes of common fillers

#### Fillers

<table>
<thead>
<tr>
<th>Filler</th>
<th>Formula</th>
<th>Shape</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCC</td>
<td>CaCO$_3$</td>
<td>Scalenohedral shape</td>
</tr>
<tr>
<td>GCC</td>
<td>CaCO$_3$ (dispersant)</td>
<td>Rhombohedral particle shape</td>
</tr>
<tr>
<td>Clay</td>
<td>Al$_4$Si$<em>4$O$</em>{10}$(OH)$_8$</td>
<td></td>
</tr>
<tr>
<td>TiO$_2$</td>
<td>Rutile, anatase</td>
<td></td>
</tr>
</tbody>
</table>

*Image credits: M. Hubbe*
Strategies for Use of Fillers

- The type of paper to be produced will have a huge bearing on the choice of filler, blends of fillers, and their level in the product.
- One thing to keep in mind is that fillers tend to interfere with inter-fiber bonding, reducing the strength of paper.
Strategies for Use of Fillers

The most general rules for use of fillers include

(a) Making sure that the material is fully dispersed into individual particles before it is added.

(b) Mixing it with the furnish at a location that doesn't adversely affect other additives, and

(c) Retaining filler by using Retention and drainage aid chemical.
Talcum

- Basically Talcum is Magnesium Silicate.
- Talcum is a soft mineral with a relatively water-hating surface and plate-like structure.
- It is basically a detactifier.
- Helps in overcoming pitch problems and it is a poor man’s pitch control chemical.
- Tendency to form a film at the surface of tacky or hydrophobic suspended matter.
Talcum

- Potential for dust on the paper. Retention aid is a must for better retention of the filler.
- Improves upon the smoothness of the paper.
- Improves upon the Printability when the paper used for printing.
- Improves upon the opacity when used.
Reduce the tackiness of pitch-like materials or stickies so that they have less tendency to form agglomerates or deposit onto papermaking equipment or create spots in the product. Also, the function of talc is to reduce tackiness of materials that already have deposited, so that further accumulation of tacky materials on those surfaces is slowed.
GCC - Ground Calcium Carbonate

- This filler is ground limestone (CaCo3)
- This chemical is used as filler in place of fiber to a tolerable limit of not disturbing the strength.
- It improves upon the brightness.
- It improves upon the printability and smoothness.
Precipitated Calcium carbonate (P.C.C)

- Most PCC added to the wet end of paper machines consists almost entirely of the calcite crystal form of CaCO$_3$.
- The calcite crystal can have several different macroscopic shapes. These depend on the conditions of production.
Precipitated Calcium carbonate (P.C.C)

Function

- Filling of paper, especially in cases requiring high brightness.
- Rosette-type PCC is used in applications requiring opacity improvements and maintenance of caliper at specified levels of weight and smoothness.
Titanium Dioxide – TiO₂

Pigmentary titanium dioxide, as used by the paper industry, usually consists of semi-spherical particles having diameters all very close to the range 0.25 to 0.4 micrometers.

**Function**

To increase the opacity of paper products, in addition with cost saving by replacement of fiber.
Titanium Dioxide - TiO2

Advantages of titanium dioxide

- Heavy gain in paper brightness.
- Opacity improvement due to low particle size.

Negative features of titanium dioxide

- Relatively high abrasiveness
- Costliest filler compared to other loading materials.
# Comparison between fillers

<table>
<thead>
<tr>
<th>Description</th>
<th>Talcum</th>
<th>GCC</th>
<th>PCC</th>
<th>Tio2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content</td>
<td>Magnesium Silicate</td>
<td>CaCO3</td>
<td>CaCO3</td>
<td>Titanium Dioxide</td>
</tr>
<tr>
<td>Brightness (% ISO)</td>
<td>85</td>
<td>93-94</td>
<td>93-94</td>
<td>97-98</td>
</tr>
<tr>
<td>Particle size</td>
<td>3 – 3.5 Microns</td>
<td>1.5 - 2.0 Microns</td>
<td>1.0-2.5</td>
<td>0.25 – 0.4 Microns</td>
</tr>
<tr>
<td>Shape</td>
<td>Monoclinic</td>
<td>Rhombohedral particle shape</td>
<td>Scalenohedral</td>
<td>Spheroidal</td>
</tr>
<tr>
<td>Abrasive Index</td>
<td></td>
<td></td>
<td></td>
<td>1.97 mg/cm²</td>
</tr>
<tr>
<td>Refractive Index</td>
<td>1.57</td>
<td>1.57</td>
<td>1.60</td>
<td>2.6</td>
</tr>
<tr>
<td>Charge</td>
<td>Anionic</td>
<td>Anionic</td>
<td>Anionic</td>
<td>Anionic</td>
</tr>
<tr>
<td>Density (kg/dm³)</td>
<td>2.8</td>
<td>2.7</td>
<td>2.7</td>
<td>4.0</td>
</tr>
<tr>
<td>Cost (Rs/Kg)</td>
<td>5</td>
<td>8</td>
<td>9</td>
<td>280</td>
</tr>
</tbody>
</table>
Limitations to increase GCC dosing

- Reduction in bulk and other strength properties.
- Increase in sizing chemical consumption.
- Increase in Dye consumption.
- Paper machine runnability.
- Paper machine wire wear out.
Sizing
Definition of Sizing

- Sizing is to control the penetration of water or watery Solution into paper sheet
- Treatment of paper in order to slow down the penetration of water and other liquids
What is Sizing?

- Paper (cellulose) is a hydrophilic (water loving, absorbing) material in that paper has a high affinity to absorb water and other water based liquids.
- Specifically, sizing is the application of a chemical to paper which reduces it’s free surface energy.
- Reduction of the paper’s free surface energy increases the hydrophobicity (water hating, repellency) of the paper.
Sizing Terms Defined

- Unsized or Waterleaf paper is absorbent and offers no water resistance
- Slack or Soft Sized paper exhibits only a limited degree of hold-out to aqueous materials
- Hard Sized paper has a high degree of Hydrophobicity
- Water Resistant paper is very hard sized. It can be immersed in water for several minutes with only very limited uptake.
- Fugitive Sizing is the total loss of sizing over time
- Size Reversion is the loss of Hydrophobicity over time
Residual Sizing occurs when natural wood resins or previously sized recycled fibers are present in the stock. These can impart a degree of water resistance to a sheet, even if no sizing agent has been added.

Internal Sizing is the wet end addition of size such that the internal fibers of the sheet are treated.

Surface Sizing is the size press application of size such that the surface of the sheet is treated.
Sizing Terms Defined (Contd)

- Acid Sizing refers to sizing conducted at pH 4-6
- Neutral Sizing refers to sizing conducted at pH 6-7
- Alkaline Sizing refers to sizing conducted at pH 7
Types of Sizing Process

There are two types of sizing processes

- Internal sizing
- Surface sizing

Penetration of liquids can be delayed by decrease of fiber wet ability using sizing agents

- Stock sizing - wet end addition
- Surface sizing - addition to paper surface
Types of Sizing Process

Internal sizing

Acquiring the property to resist the liquid penetration, wetting and absorption.

Where sizing additives are added to the paper making furnish and get incorporated into the web when it is formed.

Surface sizing

Where the paper web is formed and dried and sizing agent is applied to the paper surface by a size press.
Practical requirements for a sizing agent

- Must give good sizing
- Feasible method of application
- Well distributed
- Well anchored to fibre
- High degree of chemical inertness
- No adverse effects on process or properties
Internal Sizing

Controlling factors

- Order of addition
- Fiber furnish
- Process water quality (pH, hardness etc.,)
- Refining level
- Additives
- Stock temperature
- Total acidity/ alkalinity
- Interference from other chemicals (de-foamer)
Internal Sizing

Controlling factors

- Retention/Drainage
- Formation
- Press moisture
- Drying conditions
- Surface treatment
- Calendaring
Penetration of water into paper

Factors which influence

- Capillary attraction
- Wettability of the fiber surface
How they work

Rosin sizes

- Used together with aluminium salts
- Bonding to fibre by ionic bridges (alum!)
- Spreading of rosin is essential (drying section!)

Synthetic (reactive) sizing agents: (AKD/ASA)

- React with cellulose OH groups
- Covalent bonds formed (AKD, slow / ASA, fast)
Acid Sizing

Types of rosin used

Rosin acid

Saponification of rosin with alkali hydroxide (water soluble soap)

Fortified rosin

Fortification of abiatic acid rosin by fumaric acid or maleic anhydride
Acid Sizing Process

- Common chemicals being used in this process are rosin and alum.
- Carried out at stock pH of 4.5-5.0.
- Good old popular sizing process due to it’s simplicity.
Acid Sizing Process

Advantage

On machine cure

Draw backs

- Hi-brite paper difficult to manufacture
- Strength properties of papers are low
- Low permanency of paper
- Prone to slime growth
- Alum deposit can be a serious problem
Factors affecting sizing

- Type of fibre
- Type and amount of filler
- Incoming water
- Refining degree
- Stock additives
- Stock temperature
- Total acidity / alkalinity – pH
Factors affecting sizing

- Interference from other chemicals
- Sequence and timing
- Retention/Drainage
- Formation
- Press moisture
- Drying conditions
- Surface treatment
- Surface treatment
Basics For Sizing Product Selection

- Operating pH at head box
- Type of filler used
- Machine drying conditions
- Paper or board grade produced
- Furnish quality
- Sizing requirements
- End paper use
- Cost restrictions
# Basic product differences

<table>
<thead>
<tr>
<th>Description</th>
<th>AKD/AKD</th>
<th>ASA</th>
<th>Cationic Rosin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product shelf Life</td>
<td>1-3 months (Temperature dependent)</td>
<td>1 year + (30 mins in emulsion form)</td>
<td>3-6 months</td>
</tr>
<tr>
<td>Application</td>
<td>Simple</td>
<td>On site (Complex Equipment)</td>
<td>Simple</td>
</tr>
<tr>
<td>Dependency</td>
<td>Retention</td>
<td>Retention very important</td>
<td>Retention/Al³⁺</td>
</tr>
<tr>
<td>Sizing costs</td>
<td>Low</td>
<td>Low</td>
<td>Medium</td>
</tr>
</tbody>
</table>
## Product performance differences

<table>
<thead>
<tr>
<th>Description</th>
<th>AKD/AKD</th>
<th>ASA</th>
<th>Cationic Rosin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Graduate sizing</td>
<td>Very Less</td>
<td>Medium</td>
<td>Excellent</td>
</tr>
<tr>
<td>Pre size press sizing</td>
<td>Possible *</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Hot Liquid resistance</td>
<td>Poor</td>
<td>Good</td>
<td>Yes</td>
</tr>
<tr>
<td>Deposits</td>
<td>Few / None</td>
<td>Problem with sticky Ca(^{2+}) ASA salt</td>
<td>Possible if Al(^{3+}) Chemistry not correct</td>
</tr>
<tr>
<td>Foam</td>
<td>Not usual</td>
<td>Low but possible</td>
<td>Possible with high CaCO(_3)</td>
</tr>
<tr>
<td>Cure rate</td>
<td>Slow, but can develops 80% by reel</td>
<td>&gt; 80% developed on machine</td>
<td>Full</td>
</tr>
</tbody>
</table>
Alkyl Ketene Dimer AKD

- AKD melts at ~ 50 deg C.
- Protective colloid is either starch or polymer.
- Reacts with cellulose and water.
- Good sizing capacity under alkaline conditions, pH 6.5-9.0
- Can be stored for >60 days.
Benefits of alkaline papermaking

To the papermaker

- Corrosion reduction
- Use of CaCO3 as a filler
- Potential cheap fibre substitution
- Increased filler levels-Ash 15-30%
- Potentially stronger sheet
Benefits of alkaline papermaking

To the papermaker

- Potential production increase
- Improved retention
- Potential energy reductions
- Cleaner system
- Environmental benefits
Benefits of alkaline papermaking

To the end user

- Improved sheet brightness - Fine paper.
- Improved printability - Fine paper.
- Better holdout to acid/alkaline liquids.

  e.g. Lactic acid, water based flexographic inks.
Benefits of alkaline papermaking

To the end user

- Possible improvement to strength/rigidity - Board.
- Improved ply bond - Multi-ply board.
- Improved edge wick - Liquid packaging board.
- Improved ageing-longer lasting paper.

  e.g. Printing/writing, book.
Retention

- Most AKD/ASA and modern Rosin sizes are cationic and will be preferentially adsorbed on the highest surface area, highest charge density, materials - fines (and fillers).
- Good fines/filler retention is required.
- Change or modification of the retention system is important
- Use a good retention system.
- Use an ATC (Anionic Trash Controller) to neutralise
Properties of un-reacted AKD

- Not Resistant to hot Liquids.
- Slowly hydrolyses under mild conditions (pH 8.5, 35 - 40°C, 10% moisture)
- Possibly migrates
Properties of un-reacted AKD

- Hydrogen bonds broken by heat and moisture and AKD hydrolyses at alkaline pH.
- Movement of moisture in paper can break the cellulose hydrogen bonds and form hydrogen bonds with AKD, allowing it to move with the moisture.
How is AKD fixed to the cellulose fibre in the paper?

**Initially**

- It is attracted by electrostatic forces and adheres through Hydrogen bonding.

**Finally (After curing)**

- Reaction occurs, forming a covalent bond.
- The AKD is permanently linked to the fibre.
The stages of sizing - on machine

Wet end

- Size particle retained on fines/filler/fibre Agglomerates formed

- Water removed from agglomerates by drainage and pressing - 40-60% moisture
The stages of sizing - on machine

Dryers

- Further water removal from agglomerates in pre-dryers - 10% moisture
- Water removed from size particle in pre-dryers - below 10% moisture
- Below 10% moisture: Size spreads and reacts
The stages of sizing - Press section

High Press Moisture 55%+ means more water has to be removed by the dryers

**Result**

- Slower breaking of AKD particle
- Slower spreading of AKD
- More un-reacted AKD
- Less reacted AKD
The stages of sizing - Press section

Low Press Moisture 40-50% means less water has to be removed by the dryers

Result

- Faster breaking of AKD particle
- Faster spreading of AKD
- Less un reacted AKD
- More reacted AKD
- Use a good drainage and retention system
Effect of moisture content on final reacted AKD amount

Fine Paper

- Moisture pre film press: 2.500 %
- Final moisture: 5.000 %
- AKD retained: 0.118 %
- AKD reacted: 0.054 %
- % reacted of retained: 45.800 %
Effect of moisture content on final reacted AKD amount

Board

- Moisture pre size press 5.500 %
- Final moisture 8.000 %
- AKD retained 0.180 %
- AKD reacted 0.024 %
- % reacted of retained 13.300 %
Application information AKD sizing

Addition point / proximity to other chemicals

Filler

- Separate AKD from filler “Size the fibre, not the filler”

Retention chemicals

- Maximise AKD retention
- Use cationic starch positively for AKD
Recommended dosage points

- Constant level box
- Cationic starch
- Machine Chest
- AKD alternative
- Cleaners
- Cationic starch
- AKD
- Screens
- Flow box
- Fan Pump
Optimisation of AKD sizing

Cure rate on machine
- Improved formulations

Deposits
- Optimise AKD retention (Branched AKD?)
- Optimised retention systems

Slip and COF
- Optimise AKD retention

Printability and Toner Adhesion
- Optimise AKD retention
- Use Combined sizing!!
What is combined sizing?

- Combined sizing is the use of an optimised wet end size with a surface size to give the best performance of both sizes.

- How can this be achieved?

- Use a new generation AKD size which gives improved AKD retention and on-machine curing, to give sizing before the size-press.

- This controls the pickup of a surface sizing agent giving the final printing properties of the paper/board.
Benefits of alkaline papermaking

To the papermaker

- Corrosion reduction
- Use of CaCO3 as a filler
- Potential cheap fibre substitution
- Increased filler levels-Ash 15-30%
- Potentially stronger sheet
- Potential production increase
- Improved retention
- Potential energy reductions
- Cleaner system
- Environmental benefits
Benefits of alkaline papermaking

To the End user

- Improved sheet brightness - Fine paper
- Improved printability - Fine paper
- Less penetration of acid/alkaline liquids
e.g. Lactic acid, water based flexographic inks
- Possible improvement to strength/rigidity – Board
- Improved ply bond - Multi-ply board
- Improved edge wick - Liquid packaging board
- Improved ageing - longer lasting paper
e.g. Printing/writing, book.
Improvement of cure rate (AKD)

- Control wet end pH 7.5 - 8.5
- Maintain alkalinity at 50ppm+
- Rapid drying of the sheet
- Reel up at moisture content below 6%
- Reel up at higher temperature
- Use cure promoting resins at the wet end
What may change on the machine

Wet line
Neutral/alkaline fibres adsorb more water

Draws
Fibres behave differently under neutral/alkaline conditions

Drying
Water release is easier with neutral/alkaline fibre Lower additive levels, improving drying CaCO3 releases water easier than clay
Strength. Elimination of alum gives stronger bonds between fibres

Size press pickup
Sheet may not be fully cured before Sizepress
(Only with AKD)
# Factors which influence sizing

<table>
<thead>
<tr>
<th>Stock</th>
<th>Wet end</th>
<th>Machine</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Type of fibre</td>
<td>• pH / total acidity / alkalinity</td>
<td>• Dryness after press</td>
</tr>
<tr>
<td>• Type and amount of filler</td>
<td>• Influence of additives</td>
<td>• Drying profile</td>
</tr>
<tr>
<td>• Incoming water</td>
<td>• Surface active agents (surfactants, defoamers)</td>
<td>• Surface treatment</td>
</tr>
<tr>
<td>• SR⁰</td>
<td>• Dosage sequence, time</td>
<td>• Calendering</td>
</tr>
<tr>
<td>• Added chemicals</td>
<td>• Retention level</td>
<td>• Formation</td>
</tr>
<tr>
<td>• Temperature</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Factors influencing AKD sizing

pH
6.5 - 9

Alkalinity
150 - 250 ppm (typically)

Alum amount
Depends on AKD emulsion

Filler
Type, surface area and "pH of filler"

Pulp “Size ability”
Sulphate => Sulphite => Mechanical
Unbleached => bleached

Anionic trash
Level and composition

AKD is not influenced by

Strong acid or alkali / solvents / surfactant solutions
Dosage points for AKD

- Optimum dosage point is into thick stock, e.g.
  - Suction side of the machine chest pump
  - Into the level box
  - Suction side of the fan pump

- Above 55°C, addition into thin stock may be preferable

- If possible, add AKD before filler

- AKD should be added as is, or diluted with clean cold water

- Avoid refining after AKD addition

- Do not add AKD into white water
Neutral sizing process

Advantages

▪ Carried out at stock pH of 6.0 to 7.0

▪ Less amount of alum requires in process results less corrosion

▪ Use of CaCO$_3$ as a filler

▪ Improvement in permanency of paper.

▪ Improvement in strength properties of paper than acid sized paper
Alkaline sizing process

Advantages

- No alum resulting no corrosion
- Use of Calcium Carbonate as filler
- Improved retention, increased filler levels in paper results lower fiber consumption
- Increased production
- Energy reduction in refining process
- Cleaner system
Advantages (contd.)

- Improved sheet brightness
- Improved printability
- Possible improvement to strength.
- Improved permanency. (Bible, ledger, document)

Disadvantages

- Paper Slippery in nature
- Cannot be used to manufacture of MG varieties
Problems caused by over dosing

Acid size
- Deposits of Rosin or Alum
- Foam
- No significant effects on surface properties

Alkaline size (AKD)
- Slip
- High Ink Dry times
- Low toner adhesion
Surface Sizing
Surface Sizing

Objectives

- Higher demands from printing technology
- To increase the degree of surface bonding
- To increase the sheet’s resistance to water penetration by filling in voids capillaries and small holes in paper
Surface Sizing

- Starch applied to paper surface cements the fibers to the body of the paper
- Deposits a continuous film on paper surface
- Oil resistance increases (pores are sealed)
- Improves varnishability
Surface Sizing

Benefits

- Resistance to penetration of liquid by reducing pore radius.
- Better surface properties to the sheet
- Improves surface strength and internal bonding strength
- Improved base stock for coating

Drawbacks

- Higher energy consumption & maintenance cost
- Foaming problem
Factors Involved in Size Press Penetration

- Capillary Penetration
- Mechanical Pressure
- Hydraulic Pressure
- Surface Roughness
- Film Splitting
Variables Affecting Starch Pick-up

Sheet Characteristics

- Structure (weight, density, smoothness, pore size)
- Internal sizing levels
- Moisture content
Variables Affecting Starch Pick-up

Sizing Solution

- Solids
- Temperature
- Viscosity
- Composition (starch type, additives)

Process

- Speed
- Pond depth or film thickness
- Nip Load (PLI) and Intensity (PSI)
Puddle Size Press
Metering Size Press

- 50% fewer breaks than with a puddle size press
- Higher Speeds
  - Than puddle size presses
    - When after section limited
- Less post-size press drying required
- When not after section limited
Speed Sizer with 50° Roll Inclination
Versatility of the Speed Sizer

Differential Coating – Coating Color Supply System

Flow Monitoring

Solids Check

100 mm (150 mesh) Pressure Filters

Average Dwell Time 60 Sec.

Vibrating Screen mm (40 mesh)

Stand-By
## Applicator Rolls

<table>
<thead>
<tr>
<th>Type</th>
<th>Top</th>
<th>Bottom</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blade, Puddle</td>
<td>OP&amp;J</td>
<td>10-25 P&amp;J</td>
<td>Rubber</td>
</tr>
<tr>
<td>Rod</td>
<td>4-15 P&amp;J</td>
<td>1-25 P&amp;J</td>
<td>Rubber, Polyurethane</td>
</tr>
</tbody>
</table>
Troubleshooting

Uneven Pickup

- Improver Setup
- Plugged Heads
- Improper Profiling
- Damaged Blade or Rod
- Damaged Roll
- Foam in Starch
- Uneven Roll or Head Loading
Troubleshooting

Short Blade or Rod Life

▪ Improper Profiling
▪ Paper Wrapping the Applicator Roll
▪ Abrasive Applicator Roll
▪ Excess Loading

Contamination, Holes

▪ Debris
▪ Drips (condensate or leaks)
▪ Starch Quality
Puddle Size Press Focus Areas

- Applicator Rolls
- Showers
- Pond Depth
- Edge Wipes
- Return Pans
- Loading
- Cleanliness
- Entering Moisture (profile)
Metering Size Press Focus Areas

- Applicator Rolls
- Showers
- Film Thickness
- Edge Wipes
- Return Pans
- Loading
- Cleanliness
- Entering Moisture (profile)
- Head Pressure
- Starch Flow, Foam
Summary

Keep it Clean

▪ Housekeeping
▪ Biological Control

Keep it Controlled

▪ Temperature
▪ pH
▪ Solids
▪ Viscosity

Keep it Clothed

▪ Filters
▪ Covers

Keep it Maintained

▪ Roll Changes
▪ Boil outs
▪ Rod/Blade holders
Surface sizing and its importance

- Improves upon the surface strength
- Improves upon Printing characteristics of Paper
- Improves upon the opacity
- Improves upon the print gloss of the sheet
- Improves upon the brightness of the sheet
- Decreases the air permeability
Stock Preparation: Size Press
Process of Enzyme modification of raw starch

- Process water to 1/2 level of cooking tank
- Add Raw Maize Starch with agitation
- Add Enzyme 40 ml/500 kg of starch
- Start Steam to 70°C solution temperature
- Retain for 10 min
- Raise temperature to 90°C and maintain for 15 min

Parameters

<table>
<thead>
<tr>
<th>Starch Solids, %w/w</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viscosity, cps at 60°C</td>
</tr>
</tbody>
</table>

Dilute with process water to desired level
Add other inputs
To dilution tank
Alum & PAC
Various Aluminum compounds used in paper making

Following are the three different types of aluminum compounds used in paper making process:

- Alum
- Sodium aluminates
- Poly aluminum chloride
Advantages

pH control agent, Retention aid, anionic trash charge neutralizer, Pitch control agent, Water purifying coagulant. Acid catalyst for wet strength rosin cure and Alkaline papermaking scavenger.

Disadvantages

Being acidic in nature, it is corrosive. Excess usage can degrade paper strength, Low permanency of paper.
Sodium Aluminate

Advantage

- Easier and safer to handle
- Contains no sulphate ions, resulting less corrosion
- Eliminate barium sulphate and other metal deposits
- Nearly iron free

Disadvantage

- High cost
Poly Aluminum Chloride

Advantages

▪ It can be used for both acid and alkaline paper manufacturing process
▪ Pitch control
▪ Deposit reduction
▪ Fines and fillers retention

Disadvantages

▪ Storage and handling problem
Retention Drainage & Fixatives
Retention, Drainage & Formation

Why Use Retention and Drainage Aid

– What do we want to Retain
– Benefits of Using Retention Aids

Some Definitions

Factors that Affect Retention

Mechanisms

– Patch
– Bridging
Retention, Drainage & Formation

Products
– Differences between coagulants and flocculants

Laboratory Evaluations
– Britt Jar, Drainage with CSF

Retention Aids – Preparation

Retention Programs / Troubleshooting
What is Retention and Retention Aids

- Retention is defined as the act of retaining or the state of being retained.

- Retention aids retain the components mentioned below:
  - Fiber
  - Filler
  - Fines
  - Colloidal material (size, starch, dye, etc.)
Retention Aid Chemistry - Choices

Single polymer

Anionic or Cationic

Dual polymer

Promoter + Anionic or Promoter + Cationic

Oxicol / Oxirez system

Used in very dirty furnish (news, zero effluent mills – anionic trash level is very high)
## Retention Aid Chemistry - Choices

### Advanced retention systems

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrocol</td>
<td>P&amp;W, linerboard, coated board (can handle fairly dirty furnish)</td>
</tr>
<tr>
<td>Organopol</td>
<td>Mainly newsprint (mechanical furnish with high levels of anionic trash)</td>
</tr>
<tr>
<td>Telioform</td>
<td>Fine paper</td>
</tr>
</tbody>
</table>
Single Polymer

- Old technology
- Cost effective and easy to apply
- Mostly adopted under acidic pH where alum acts as a promoter
- Satisfactory performance
- Macro flocculation, high retentions usually sacrificed due to formation
- Free drainage improved, but macroflocs may hinder dewatering at the press section
- Susceptible variation due charge, furnish or filler changes
Single Polymer Application

Fan Pump → Screen → HMW Polymer (Cationic or Anionic) → HBX
Dual Polymer Systems

- Established technology
- Cationic promoter used to control charge
- Cationic or anionic polymer chosen to compliment wet end system charge
- Used under entire papermaking pH range
- Acceptable retention performance
- Formation concerns by late addition of very high molecular wt polymer
Dual Polymer Systems

- Performance limitations at high filler levels and machine speed
- Free drainage improved, but macroflocs may hinder dewatering at the press section
Dual Polymer Application

Cationic Promoter

Fan Pump

HMW Polymer Cationic or Anionic

Screen

HBX
High speed machines: Requirements

Independent control
- Drainage
- Retention

Formation
- Greater control of formation with higher retention levels

Ash Retention
- Ability to achieve high sheet ash content
- Greater stability of sheet ash content

More flexible to machine / chemistry variations
Problems of Having Poor Retentions

Poor additive retention / high chemical costs:

- Starch, Size etc

Poor runnability

- Machine downtime

Press picking / deposits

- Cleaning costs, paper quality issues

Increased downtime

Poor fiber yield
Bentonite - A Closer Look

Negative surface charge - Positive edge charge

Swells in water - increases surface area to 700-800 m$^2$/g
Bentonite Interactions

Polyamines, PAC, Poly DADMACs, Alum

Cationic Starch

Cationic Flocculants
Bentonite Interactions

Bentonite

Hydrolyzed Size, Pitch, Ink

Dissolved Solids

Contaminants, Stickies, Oils
Bentonite Interactions

Bentonite

- Hydrolyzed Size, Pitch, Ink
- Dissolved Solids
- Contaminants, Stickies, Oils
Hydrocol Mechanism

Fibers, fines & filler

Cationic Polymer

High Shear

Bentonite

Structured Floc
Hydrocol Benefits

- Improved fines and filler retention
- Improved additives retention (starch, size, dyes, etc..)
- Improved drainage and pressing efficiency
- Improved filler distribution
- Improves cleanliness of wet end
- Formation improvements
- Reduces steam usage
Program Components

Cationic PAM

Traditional addition point before an area of high shear.

A traditional micro particle (Bentonite, Colloidal Silica)

– Added after the last point of shear.

Advanced micro polymer

– Highly structured organic anionic polymer.

– Large surface area.
What is Micro-polymer?

**Chemically**

Organic, anionic structured poly acrylamide

**Molecular weight**

Very high molecular weight, structured, particulate material

**Charge**

Very anionic (7 milli eq/g), 10X greater than Bentonite

**Size**

Approximately 150nm (300nm swollen) porous particle with high surface area
What Is Micro-polymer?

Physical form
Stable emulsion

Function
Micro polymer
Micro Particle Mechanism

Fibers, fines & filler

Cationic Material
(CPAM, Alum, Starch, etc.)

High Shear

Microparticle
Micro Particle System

Application Technology

Fan Pump

Screen

Organic micro polymer

Flocculant

Inorganic micro particle
# Micro particle Control Strategy Principle

<table>
<thead>
<tr>
<th>Effect Needed</th>
<th>Micripolymer</th>
<th>Microparticle</th>
<th>Flocculent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Higher Filler Retention</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Higher Drainage</td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Better Formation</td>
<td>+</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Cleaner White water</td>
<td></td>
<td></td>
<td>+</td>
</tr>
<tr>
<td>Reducing Pitch *</td>
<td></td>
<td>+</td>
<td></td>
</tr>
</tbody>
</table>

* Not part of the retention program
Micro particle Benefits

- Small, Tighter Hard Flocs
  - Increased Retention
  - Increased Drainage
  - Increased Strength

- Increase Filler
- Decrease Hbx Cons.
- Adjust Foils
- Increase Refining
- Increase Recycle
- Increase HWD

- Improved Formation
Retention Program

- Enhanced Runnability
- Ability to increase filler
- Reduce variability
- Increase machine speed
- Manage pitch and stickies
- Formation improvements
- Additives optimization
<table>
<thead>
<tr>
<th>Paper Quality</th>
<th>Possible cause RDF chemistry</th>
<th>Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formation</td>
<td>• Too much flocculant&lt;br&gt;• Too fast dewatering too much HSW</td>
<td>• Check Percol dose amount, Conc, dilution.&lt;br&gt;• Check HSW dose, Conc, dilution</td>
</tr>
<tr>
<td>Sheet filler content, GSM Profile, Opacity.</td>
<td>• Too low in sheet or rapid increase of WW solids. Unstable distribution of products.</td>
<td>• First Check Teloioform dose, conc, dilution.</td>
</tr>
<tr>
<td>Sizing, Coloration</td>
<td>• Not stable or too low caused by unstable RDF dosage.</td>
<td>• Check FPR and FPAR, &amp; all three make-down and feed equipment.</td>
</tr>
<tr>
<td>Printability Ink-jet Copy ability</td>
<td>• Related to additives retention and sizing value (Internal &amp; Surface)</td>
<td>• As above</td>
</tr>
<tr>
<td>Holes or light spots in paper</td>
<td>• Too high Percol solids or lumps in flocculant mimics slime</td>
<td>• Check Percol make-down conc, dose amount and feed concentration.(filters to check)</td>
</tr>
</tbody>
</table>
Dyeing of Paper
Dyeing of Paper

Types of Dyes

- Acid dye
- Basic dye
- Direct dye
Acid Dyes

Positive Points

- No Tendency to mottling
- Good Solubility
- Can be mixed with direct dyes

Negative Points

- No Affinity to cellulose
- Must be fixed by size and alum
- Coloured back water
Basic dyes

Positive Points

▪ High tintorial strength
▪ Great brilliancy
▪ Good affinity towards lignin rich pulps
▪ Cheap to user

Negative Points:
▪ Low light fastness
▪ Low Acid, Alkali and Cl2 fastness
▪ Sensitive to heat and hard water
▪ Tendency for mottling with mixed furnish
▪ Can not be mixed with direct / acid dyes
Direct Dyes

**Positive Points**

- Direct affinity to cellulose
- Good back water
- Good light fastness

**Negative Points**

- Sensitive to excess alum
- Mottling with mixed furnish
Variables affecting Dyeing

Fillers
Absorb soluble dyes—decrease the strength of the dye

Refining
Improves strength of the dye (improved retention, decreased opacity)

Residual chemicals
Residual chlorine destroys the dyeing effect

pH
Most dyes are sensitive to pH
OBA
(Optical Brightening Agent)
OBA (optical brightening agent)

- OBA’s are in the liquid form which can be directly used
- Purpose of this OBA is to get the required brightness/maintain it in the paper

There are two types OBA

- Wet end OBA (used in wet end along with refined pulp)
- Size press OBA to improve optical properties of surface
OBA (optical brightening agent)

Whitening Agent

Also called optical whitener, optical bleaching agents.

The compound when added to paper and board, it absorbs light in the Ultraviolet range and reemits it in the visible range, thus making the paper appear whiter.
Shade Matching

- The shade of paper is being tested with $L$, $a$, $b$ Values
- The Values of $L$, $a$ and $b$ are measured and compared with standard. The Delta E is the norm to control the shade.
- $L$ - Whiteness
- $a$ - Red / Green
- $b$ - Blue / Yellow
- $Y$ - Depth of the shade
Cationic Starch

- Contains Cationic groups
- Provide positive charge to starch
- Attraction towards Negatively charged fiber
- Impart Wet Strength
- Impart water repellency
- Impart Dimensional stability
Why Use Starch?

- Strengthen & Improve Sheet Surface
- Improve Physical Properties
- Adhesive for Fiber Tubes, Cores, Sticks
- Pre-coating Treatments
Native Starches

- Corn
- Potato
- Waxy Maize
Modified Starches

Oxidized
  – treated with sodium hypochlorite

Ethylated
  – treated with ethylene oxide

Acid Modified
  – treated with hydrochloric acid

Cationic Waxy Maize
  – treated with cationic reagents
# Starch Comparison

<table>
<thead>
<tr>
<th>Products</th>
<th>Point of treatment</th>
<th>Paste Clarity</th>
<th>Color</th>
<th>Stability</th>
<th>Pigment Binding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydroxy-ethylated and cationic waxy</td>
<td>Manufacturer</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Excellent</td>
</tr>
<tr>
<td>Oxidized</td>
<td>Manufacturer</td>
<td>Good</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Good</td>
</tr>
<tr>
<td>Acid Thinned</td>
<td>Manufacturer</td>
<td>Fair</td>
<td>Excellent</td>
<td>Fair to poor</td>
<td>Fair to good</td>
</tr>
<tr>
<td>Enzyme thinned</td>
<td>User</td>
<td>Fair</td>
<td>Good</td>
<td>Good</td>
<td>Fair to poor</td>
</tr>
<tr>
<td>Thermal-chemical treatment</td>
<td>User</td>
<td>Fair</td>
<td>Good to Fair</td>
<td>Fair</td>
<td>Fair to good</td>
</tr>
</tbody>
</table>
Fiber recovery / White water system

Advantages of white water systems are,

- Recovery of expensive Fiber
- Minimizes fresh water consumption
- Minimizes heat loss
- Minimizes chemical use
- Minimizes effluent loading (waste water system)
Fiber recovery / White water system
Save Alls

Typical Saveall

- Sedimentation
- Floatation
- Krofta
- Poly Disc
Conventional Centershaft Chuted Disc Filter
Conventional Centershaft Chuted Disc Filter
Installation Parameters that Affect Disc Filter Capacity

- Number of installed discs
- Filtration area per disc, $m^2$
- Other sector design features
- Dropleg design and construction
- Feed configuration (counterflow vs. cocurrent)
- Type and model of filter
- Length of filter (number of discs and pitch)
- Center core or rotor type
- Filtrate tank design
Dropleg Considerations

Elevation drop to seal tank
- Recommended 30 ft, minimum 25 ft
- Straight drop, no horizontal offsets

Penetration into seal tank or filtrate chest
- $\frac{1}{2}$ to 1 pipe diameter, seal only
- Do not run to bottom

Filtrate superficial velocity for good vacuum
= 12 to 16 fps
Well Drain Expanded SS Covers for Increased Filtration Surface Area
## Comparison of Saveall Scenarios

### Process Conditions

<table>
<thead>
<tr>
<th>Description</th>
<th>Poor Efficiency</th>
<th>Typical Efficiency</th>
<th>Optimized</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vat Level Control</td>
<td>Poor, Cycles Manual</td>
<td>Adequate, Automatic</td>
<td>Well Tuned, Automatic</td>
</tr>
<tr>
<td>Speed, RPM</td>
<td>Fast 1.0 to 1.4</td>
<td>Moderate 0.8 to 1.0</td>
<td>Optimal 0.4 to 0.8</td>
</tr>
<tr>
<td>Vacuum, &quot;Hg&quot;</td>
<td>Poor 0 to 2</td>
<td>Adequate 4 to 6</td>
<td>Optimal 8 to 10</td>
</tr>
</tbody>
</table>
## Comparison of Saveall Scenarios

### Process Conditions - Sweetener

<table>
<thead>
<tr>
<th>Description</th>
<th>Poor Efficiency</th>
<th>Typical Efficiency</th>
<th>Optimized</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweetener Stock</td>
<td>Mixing Chest</td>
<td>Blend Chest</td>
<td>HW &amp; SW Kraft</td>
</tr>
<tr>
<td>Freeness, ml CSF</td>
<td>300</td>
<td>350</td>
<td>400</td>
</tr>
<tr>
<td>Sweetener WW Solids</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>
## Comparison of Saveall Scenarios

### Filtrate Quality

<table>
<thead>
<tr>
<th>Description</th>
<th>Poor Efficiency</th>
<th>Typical Efficiency</th>
<th>Optimized “Best Case”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cloudy ppm</td>
<td>1,000</td>
<td>500</td>
<td>250</td>
</tr>
<tr>
<td>Clear ppm</td>
<td>1,000</td>
<td>100</td>
<td>50</td>
</tr>
</tbody>
</table>
## Disc Filter Saveall
### Typical Filtrate Clarities

<table>
<thead>
<tr>
<th>Grade</th>
<th>Filtrate solids, ppm</th>
<th>Typical Split</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Clear Filtrate</td>
<td>Cloudy Filtrate</td>
</tr>
<tr>
<td>Newsprint</td>
<td>100</td>
<td>500</td>
</tr>
<tr>
<td>Fine Paper</td>
<td>50</td>
<td>250</td>
</tr>
<tr>
<td>OCC Board</td>
<td>80</td>
<td>400</td>
</tr>
<tr>
<td>Virgin Board</td>
<td>30</td>
<td>150</td>
</tr>
</tbody>
</table>
## Comparison of Saveall Scenarios Maintenance

<table>
<thead>
<tr>
<th>Description</th>
<th>Poor Efficiency</th>
<th>Typical Efficiency</th>
<th>Optimized</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sectors</td>
<td>Worn, holes &amp; tears</td>
<td>Adequate, few leaks</td>
<td>Good condition, no leaks</td>
</tr>
<tr>
<td>Seals</td>
<td>Missing, damaged</td>
<td>Adequate, few leaks</td>
<td>Good condition, no leaks</td>
</tr>
<tr>
<td>Showers</td>
<td>Many plugged</td>
<td>Few plugged</td>
<td>None plugged</td>
</tr>
</tbody>
</table>
Torn Sector Cover Zipper
Cleaning Shower Efficiency

Open Grid Sector Cleans Better
Typical Saveall Material Balance

FIGURE 1. SAVEALL FLOW AND MATERIAL BALANCE FOR BASE CASE TYPICAL FINE PAPER MACHINE
Opportunities to Increase Disc Filter Capacity

- Add discs if space available
- For low & medium freeness pulp use higher capacity corrugated sectors
- Optimize sweetener freeness and feed ratio
- Increase vacuum
  - improve drop legs (velocities, elevation drop, layout, filtrate tank penetration)
  - repair leaks (seals, cracks, valve)
  - upgrade valve
  - vacuum assist
Opportunities to Increase Disc Filter Capacity

- Improve knock-off efficiency
  - address plugged showers
  - adjust orientation
  - check pressures
  - maintain cleaning showers
- Optimize vat level set point and control
- Reduce backwash
  - improve vacuum
  - add discs if space
  - lower volume sectors
- Retention and drainage aids
Troubleshooting - High Filtrate Solids

- Compare filtrate TSS to benchmarks
- Worn or torn sector covers
- Sector to core sealing problem
  - Gasketing
  - Conformance of sector base to core
- Vat to core deckle strap seal
- Cracks in center shaft
- Sweetener for save alls for filter mat
- Speed increase can degrade filtrate quality
Wet End Chemistry
Wet end Chemistry

Wet-End Chemistry

Significance

Stock Components

- Fiber
- Fines
- Filler
- Water Interfering substances

Wet-End Additives

- Retention aids
- Sizing chemicals
- Dyes and FWA
- Dry strength resins
Wet end Chemistry

Parameters

▪ Freeness
▪ Retention
▪ pH
▪ Turbidity
▪ Conductivity
▪ Temperature
▪ Charge and measurement

Interaction

▪ Pulp
▪ Paper grades
▪ Chemical additives
▪ Machinery
Wet-End Chemistry or the importance of papermaking chemistry

Paper is made following the mechanical and the chemical process

- The mechanical process controls how a fibrous suspension is evenly distributed over a wire, drained, pressed and dried to form a sheet of paper.
- Papermakers sharing the mechanical approach consider the equipment as most important.
- The chemical process the chemical aspects of fibers and fillers have to be altered in order to create the sheet quality and machine runnability.
- Papermakers sharing the chemical approach see the PM as a production tool.
What is Wet End Chemistry?

The interactions between all the components in the papermaking system:

- Surface / Interfacial
- Ionic
- Colloidal
- The enhancement of retention and drainage control of the papermaking system through understanding of the physical and chemical characteristics of papermaking components for the achievement of desired paper properties and improved paper machine runnability
# Wet end Chemistry - The significance

<table>
<thead>
<tr>
<th>Paper properties</th>
<th>Achievement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural</td>
<td>Basis weight, formation, caliper, directionality, two-sidedness, porosity,</td>
</tr>
<tr>
<td></td>
<td>roughness, dimension stability</td>
</tr>
<tr>
<td>Mechanical</td>
<td>Tensile strength, tear resistance, burst, stiffness, folding endurance,</td>
</tr>
<tr>
<td></td>
<td>internal bonding strength, surface strength.</td>
</tr>
<tr>
<td>Appearance</td>
<td>Color, brightness, opacity, gloss.</td>
</tr>
<tr>
<td>Barrier &amp; Resistance</td>
<td>sizing</td>
</tr>
<tr>
<td>Permanence</td>
<td>Durability, color reversion, chemical stability.</td>
</tr>
</tbody>
</table>
### PM Runnability improvers to increase PM efficiency

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Retention / Drainage</strong></td>
<td>Effects speed, Steam consumption</td>
</tr>
<tr>
<td><strong>Deposits / scale</strong></td>
<td>Can be created by chemicals, can be solved by chemicals</td>
</tr>
<tr>
<td><strong>Foam / entrained air</strong></td>
<td>Can be created by chemicals, can be solved by chemicals</td>
</tr>
</tbody>
</table>

**Chemicals are involved in achieving all of the above**
Why is it important?

Achievement of Paper Properties

- Structural - formation
- Mechanical - strength
- Appearance - optical
- Barrier & Resistance - sizing
- Permanence - stability

Enhancement of Runnability

- Machine Efficiency
- Drainage – speed
- Foaming
- Spots, Holes & Deposits
Wet End Chemistry

Materials

- Types
- Characteristics

Principles

- Surface Area
- Conductivity
- Electrostatic Charge
- Coagulation & Flocculation
What are the Different Materials?

- Water
- Dissolved Electrolytes
- Suspended Fibers
- Suspended Fiber Fines
- Suspended Filler Particles
What are the Different Materials?

- Surface-active Molecules (alone or as aggregates, i.e. detergents, dispersants, wood extractives, de-foamers)
- Dissolved Poly electrolytes - i.e. PAM, cationic starch wet and dry strength resins
- Aggregated Sizing Molecules
Size & Shape of Papermaking Components

Tremendous Variation

- Fibers: 10-50 microns by 1-7 mm long
- Fines: < 1 micron wide by < 76 microns long
- Filler: 0.1-10 microns
- ASA Size: < 1 micron
- Colloidal Silica: < 0.01 microns
Characteristics of Fiber & Fines

- Composition
- Surface Area
- Charge/pH Effects
- Ion Exchange
Non-Fiber Materials

Dissolved

- Sulfates, chlorides, oxalates, acetates
- Derived from
  - Pulp
  - Bleach plant carryover
  - Water Source

Effects

- Increased Scale Deposits
- Increased Conductivity
- Reduced Effectiveness of some Additives
Non-Fiber Materials

Colloids

Dispersions of particles that are too small to settle out (<1 micron)

Hydrophilic

Hydrophobic
Hydrophilic Papermaking Materials

Hydrophilic - “Water loving”

- Starch dissolved in water
- Hemi cellulose dissolved in water
- Surfactants, dispersants, wetting agents dissolved in water
- Retention aids dissolved in water
Hydrophobic Papermaking Materials

Hydrophobic - “Water fearing”

- All pigments dispersed in water
- Fines dispersed in water
- Rosin size dispersed in water
- Wood Pitch dispersed in water
Colloidal Materials

Need to be retained

- Desired Additives
- “Interfering Substances” (Pitch, Stickies)
- Otherwise
  - Build up in Whitewater System\n  - Cause Deposits, Spots, Breaks
<table>
<thead>
<tr>
<th>Furnish Component</th>
<th>Surface Charge</th>
<th>Surface Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood Fiber (fines)</td>
<td>negative</td>
<td>high</td>
</tr>
<tr>
<td>Wet End Starch</td>
<td>moderately positive</td>
<td>high</td>
</tr>
<tr>
<td>PCC (calcium carbonate)</td>
<td>positive</td>
<td>high</td>
</tr>
<tr>
<td>Clay, Talc, Titanium</td>
<td>negative</td>
<td>very high</td>
</tr>
<tr>
<td>AKD Size (with carrier)</td>
<td>positive</td>
<td>very high</td>
</tr>
<tr>
<td>Dyes</td>
<td>negative</td>
<td>high</td>
</tr>
<tr>
<td>Fluorescent Whiteners</td>
<td>positive</td>
<td>high</td>
</tr>
<tr>
<td>Coated Broke</td>
<td>negative</td>
<td>high</td>
</tr>
<tr>
<td>De-foamers</td>
<td>highly negative</td>
<td>high</td>
</tr>
<tr>
<td>Alum</td>
<td>negative</td>
<td>high</td>
</tr>
<tr>
<td>Retention Aid Polymer</td>
<td>highly positive</td>
<td>high</td>
</tr>
<tr>
<td>Bentonite Microparticle</td>
<td>highly positive</td>
<td>high</td>
</tr>
<tr>
<td></td>
<td>moderately negative</td>
<td>extremely high</td>
</tr>
</tbody>
</table>
Influence of Particle Size on Filler Retention

% Retention

Clay fraction in microns

Filtration
What is Charge?

- Practically all materials in a papermaking furnish possess an electrostatic charge at their interface with water.
- Charge is almost always anionic
- Largely responsible for the dispersed nature of most colloids
Charge

Zeta Potential

– The electrical potential at the point where the Stern & Diffuse layers meet

Degree of Repulsion

– Determined by the thickness of the double layer or “cloud”

Must be overcome for coagulation to occur
Polymer Charge Density

- **Low**
  - Weak Absorption,
  - Weak Flocculation

- **Medium**
  - Good Absorption,
  - Strong Bridge Formation

- **High**
  - Strong Absorption,
  - Good Patch Formation
Polymer Charge Density

- **Low**
  - Weak Absorption,
  - Weak Flocculation

- **Medium**
  - Good Absorption,
  - Strong Bridge Formation

- **High**
  - Strong Absorption,
  - Good Patch Formation
Interfering Substances

Fresh Water

- Calcium and Magnesium hardness
- Organic Matter
- Residual Chlorine
- Suspended solids

Pulping Residuals

- Sodium salts
- Rosin soaps
- Fatty acid soaps
- Lignin compounds
Interfering Substances

Bleaching Residuals

- Sodium salts
- Calcium salts from Calcium hypochlorite
- Alkali-soluble cellulose and hemi cellulose

Broke

- Starch
- Adhesives
- Inks
- Coating Components
Interfering Substances

Conductivity

- Measurement of dissolved ions
- Many “interfering substances” are soluble ionized materials

High levels = High Conductivity

High Conductivity = Bad News
Conductivity of Interfering Substances

- Reduces Charge on Particles
- Reduces Affinity for Charged Polymers
- Causes “Coiling” of Polymer Molecule
- Reduces Efficiency of Polymer
Interfering Substances

Charge

- Most colloidal “interfering substances” are anionic
- “Anionic Trash”

High Amounts = Bad News
Charge of Interfering Substances

- Increases Cationic Demand
- Competes with desired materials for interaction with cationic polymers
- Neutralizes cationic charge on polymers reduces efficiency
- Adsorbs onto Bentonite
- Acts as a dispersant
Approach Flow System
Process simplification

- Smaller process
- Accurate system
- Direct feed to the machine
- Smaller equipment can be utilized
- Lower energy consumption

- Large volumes
- Plenty of recirculation
- Long stabilization time

Conventional Approach Flow

Modern Approach Flow
Approach flow system

Overview
Approach flow system

Typical approach system for modern paper machine
Approach flow system

Typical approach system for modern board machine

[Diagram showing flow system with components such as WIRE PIT, WIRE WATER, WIRE SILO (PASSIVE DEAERATION), DILUTION LINE, MACHINE SCREENING ROOM, W HITE WATER HEADER, and water flow paths]
Approach flow system

Proportioning Control
Approach flow system

Fast and accurate consistency control – Conventional

- Difficult tuning
- Sensitive for production changes
- Needs more mixing volume in the chests after
- Control is slow
Approach flow system

Fast and accurate consistency control – Modern

- No need for re-tuning
- Independent from production changes
- Smaller mixing volumes can be used
- Stable consistency
- Fast control
- 1 flow meter more
White water system

- Dilution of stock to PM headbox consistency takes place in short circulation.

- Final cleaning of stock takes also place in short circulation, because:
  - White water might contain sand and other impurities.
  - Broke might contain tapes and other impurities.
  - Fiber flocks and slime can be formed in the system.
  - In wire section air is mixed with water.
White water system

Short circulation

- Pulp is fed to PM headbox at 1 % consistency.
- The consistency after wire section is about 20 %. Thus 95 % of water is removed already in the wire section.
- This water goes back through the chutes into the wire pit and it is used for thick stock dilution.

Long circulation

- Excess water from the short circulation is led to the white water chest and is used for dilutions in the stock preparation and broke system.
Short circulation

General requirements
The short circulation should feed the headbox with a flow
- Free from pressure / flow variations (Pulsations)
- Free from consistency variations

To avoid basis weight variations
- The approach flow should be as free from air as possible to increase the de-watering speed and reduce bio activity
- The head box, wires and product should be protected from debris, spinning and fiber bundles by appropriate machine screening
White water system

Open system

Fresh water
- PM showers
- Chemicals
- Sealing water

Evaporation

Pulp → Cons. Control water → 5 % → Dilution for headbox → 3 % → Headbox → 1 % → White water from wire section → White water from press section → Paper

Fresh water consumption 120...150 m³/t
Fiber loss 20 ... 40 %
White water system

Short Circulation

- Pulp
- Cons. Control water
- Headbox
- Wire Pit
- White water from press section
- White water from wire section
- Dilution for headbox
- Fresh water
- Evaporation

Fresh water consumption 40...80 m3/t
Fiber loss 4 … 8 %
White water system

Short Circulation – Water Handling

Deaerator

To Mixing Reactors

Consistency Control Water

To W.W. Storage

Former Water Tank

Suction Box Water tank

White Water Tank

To Save All
White water system

Short Circulation – Approach flow
White water system

Paper Machine - Short Circulation
White water system

Short Circulation

Pulp  5%  Recovered fibers  Cons. Control water

Dilution for headbox  3%

White water from wire section

Head box  1%

White water from press section

Wire Pit

Fiber recovery

Evaporation

Fresh water

Clear filtrate

Fresh water consumption 5...15 m3/t
Fiber loss < 1 %
White water system

Long Circulation – Save All
White water system

Long Circulation – Stock Preparation System
Trouble Shooting
Problems

Anionic trash

Loss, or variation, of sizing efficiency

Reason: AKD not retained or variable retention

Cause: AKD preferentially adsorbed on anionic trash

Solution:
- Establish the source
- Treat with ATC or polymer
- Move size addition to after ATC
- Check system charge
Problems

Anionic trash

Example - Loss of sizing efficiency

Sizing off machine 25 - 30 gsm increased to 45 - 50 gsm

Establish the source ▪ Charge of furnish measured
▪ Softwood found to be more anionic
▪ Individual pulps tested
▪ Bleached CTMP 10x more anionic!

1st action Remove pulp from furnish

Result Sizing off machine - 25 - 30 gsm

Treat with ATC Alum added to softwood chest

Result Sizing off machine - 35 - 40 gsm
Pulp washing

Residual lignin etc.

Type of bleaching

Soluble anionics etc.

Broke

Coatings and non-ionic starches

Fillers

Surface areas

Ca(OH)$_2$ content (PCC)
Problems

Deposits – Wet End

Deposits in stock approach or on wires/foils/presses

Reasons
- Size instability
- Size hydrolysis

Causes
- High stock temperature
- High shear
- Chemical imbalance
- Poor filler/fines retention
- Chemical incompatibility

Solutions
- Cool stock/add size late
- Add size at different point
- Improve retention
- Adjust chemical balance
- Check compatibility
Build-up on presses and doctor blades

Caused by
- Poor retention
- Excess cationic additives

For sizing
- Loss of sizing, as 80-90% of size is retained on fines

Easy solution
- Press treatment
- Freshwater addition

Correct solution
- Improve retention
- Reduce cationic additives
- Balance the wet end charge
High temperature in thick stock or white water causes poor sizing

**Reason**
- System closure
- Steam injection to aid drainage or broke pulping

**Causes**
- Size hydrolysis
- Size instability
- Loss of size retention

**Solution**
- Add size late
- Improve 1st pass size retention
- Add freshwater to cool
Problems

pH – Wet End

Poor cure on machine

Reason
- Slow reaction (AKD)
- Hydrolysis of size (ASA/AKD)

Cause
- pH below 6 (AKD)
- pH above 8.5 (ASA)
- pH above 9.5 (AKD)
- High alkalinity

Solution
- Increase pH (CaCO₃, NaHCO₃, Na₂CO₃)
- Reduce pH (7 - 7.5 ASA, 7.5 - 8.5 AKD)
- Control alkalinity (100 - 500 ppmCaCO₃)
## Problems

### Foam

Foam in stock systems and white water

<table>
<thead>
<tr>
<th>Reason</th>
<th>Causes</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excess chemicals</td>
<td>Wet end imbalance - Excess additives, which reduce surface tension, stabilizing 'bubbles'</td>
<td>Reduce additive levels,</td>
</tr>
<tr>
<td>CaCO₃ reacting with acid</td>
<td>Air leaks in system</td>
<td>Reduce air leaks</td>
</tr>
<tr>
<td>Surfactant addition</td>
<td>Low pH</td>
<td>Increase pH</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Add de-foamer?</td>
</tr>
</tbody>
</table>
Problems

Deposits - Dryers

Deposits on drier felts and doctor blades

Reason
- Poor fixation of size
- Hydrolysis of size (ASA)

Cause
- Chemical imbalance
- Poor filler/fines retention
- Poor drying profile

Solution
- Adjust chemical balance
- Improve retention
- Change drier profile
Problems

Temperature – Dryers

Poor cure on machine

Reason
- Slow reaction (AKD)
- Hydrolysis of size (ASA)

Cause
- Wrong drier profile
- Insufficient heat
- High ex-press moisture

Solution
- Improve drainage
- Reduce moisture on machine
- Change drier profile
Optimum Drying Profile

Paper temperature °C

Cylinder No

AKD

Rosin / Alum or ASA
Problems

Slow Cure

Paper takes a long time, or fails to reach oven cured value

Reason
- Size particles not 'broken'
- Size not reacted

Cause
- Insufficient heat input
- Wrong drier profile
- High moisture (7%+)

Solution
- Decrease ex-press moisture
- Improve drying
- Improve drier profile
- Reel up hot
Problems

Reorientation

*Fully sized paper before the size press loses sizing at the reel*

**Reason**
- Hydrogen bonded ‘un reacted’
- AKD disrupted by size press starch

**Cause**
- Insufficient heat input
- Wrong drier profile
- High moisture (7%+)

**Solution**
- Decrease ex-press moisture
- Improve drying
- Improve drier profile
- Increase reacted AKD
Problems

Two Sidedness

Harder sizing on top side than wire side

Reason

▪ Loss of size from wire side

Cause

▪ High vacuum
▪ Excessive drainage
▪ Chemical imbalance
▪ Poor filler/fines retention

Solution

▪ Reduce vacuum/drainage
▪ Improve retention
▪ Adjust chemical balance
# Problems

## Two Sidedness

**Example - Improvement of fines/filler retention**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cobb top</td>
<td>21 %</td>
</tr>
<tr>
<td>Cobb bottom</td>
<td>25 %</td>
</tr>
<tr>
<td>Filler retention</td>
<td>31 %</td>
</tr>
<tr>
<td>Total retention</td>
<td>77 %</td>
</tr>
</tbody>
</table>

**Action**

Change from polymer retention aid to Compozil P

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cobb top</td>
<td>20 %</td>
</tr>
<tr>
<td>Cobb bottom</td>
<td>21 %</td>
</tr>
<tr>
<td>Filler retention</td>
<td>53 %</td>
</tr>
<tr>
<td>Total retention</td>
<td>84 %</td>
</tr>
</tbody>
</table>
Factors influencing pick up of surface size

Properties of base paper

(Degree of sizing, porosity, moisture level)

Paper machine influences

(Speed, size press nip pressure, type)

Surface size solution parameters

(Viscosity, concentration, other additives)
Sizing disturbances

Corrective measures

- Check size dosage viz actual paper production
- Excess size may cause foaming and / or deposits
- Substantial alterations in PM conditions?
- Consider sizing / retention relation. Frequently monitor fines / filler retention
Possible reasons for poor AKD sizing

Reacted AKD is too low (<0.01%)

Conditions have not favored AKD to fiber reaction, because

**Low first pass retention**
- Aggregates / poor distribution

**Too low pH on fiber surface**
- Low tendency towards AKD / cellulose reaction

**Filler contains free alkali (certain PCCs)**
- Alkali contributes to hydrolysis of AKD

**Presence of high level of anionic trash**
- AKD consumed, undesirable side-reactions occur
Take care of the Earth and she will take care of you

Thank You