

Glossary

CONTAINERBOARD: Linerboard and corrugated medium used to manufacture shipping containers.

CORES: Paper tubes on which rolls of paper may be wound for shipment.

CORRUGATED CONTAINERS: Shipping containers made with kraft paper linerboard and corrugated medium.

CUTTINGS: Paper stock by-product of paper converting operations.

FILLER/FILLED: Denotes papers that have minerals (clays or other pigments) added for improving quality or color.

FLYLEAF/SHAVINGS: Trim scrap from printing operations.

FREESHEET: Paper that contains less than 10% ground-wood fiber (synonym: groundwood-free).

GROUNDWOOD: Paper made with fibers produced without chemical pulping.

GILT: Metallic (gold or silver) inks used in printing.

HOGGED: Paper that has been mechanically torn or ripped to reduce its original size.

HOT-MELT: A type of glue or adhesive applied while hot/warm. Considered a contaminant in some grades.

IMPACT (PRINTING): A paper printing process that physically applies ink to the paper surface.

INSOLUABLE GLUES: Glues that won't dissolve (break down) in water.

JUTE: Strong, long-fibered pulp made from hemp.

ROTOGRAVURE: A paper printing (intaglio) process typically used to create the highest quality of smoothness on coated and uncoated papers. Excess quantities are considered an outthrow in grades #7, #8, and #9.

SECTIONS: Unbound, unused printed material with full ink coverage.

SHAVINGS: Trim from converting and bindery operations.

SIGNATURES: A section of book obtained by folding a single sheet of printing paper.

SLABBED: Type of paper stock normally generated by cutting rolls.

SULFITE: Papers and boards made from pulps made from an acid process.

SULPHATE: Papers and boards made from alkaline processed pulps.

TEST LINER: Liners, which are the outer ply of any kind of paperboard, containing 100% recycled material.

TMP: Thermomechanical pulp.

TREATED: Paper manufactured with additives.

TRIM: Cuttings of paper stock generated at converting or bindery operations which normally have little or no printing.

ULTRA-VIOLET (UV) INKS/COATINGS: Papers having inks or coatings dried by utilizing an ultraviolet radiation method. Considered a contaminant in deinking grades.

WET STRENGTH: Papers that have been treated with a moisture-resistant chemical that inhibits pulping.

Lecture:

Common Contaminants in Recovered Paper



Common Contaminants in Wastepaper

⑥ Large Junk

- ❑ metals: nuts, screws, foil, cans
- ❑ plastics: films, bags, envelopes
- ❑ dirt
- ❑ cloth, yard waste, leather, etc.,

⑥ Inks & toners

⑥ Stickies

⑥ Coatings

⑥ Fillers

⑥ Papermaking additives



Common Contaminants in OCC

Common Contaminants To Corrugated

Your paper processor or market (mill) will help you make the final determination regarding which materials are unacceptable, but the following is a typical list:

- **Packing material** - such as polystyrene foam pellets
- Excessive amounts of **plastic tape or plastic packing envelopes** (small amounts ok)
- **Wood** stapled or otherwise attached to the box
- **Non-paper insulation layer** between the layers of corrugated
- **Metal** (generally, small numbers of staples do not have to be removed)
- **Wax or plastic coated corrugated** (usually used to pack produce, usually darker and shinier than uncoated corrugated)
- Other **extraneous materials** - materials stored in boxes, sweepings, etc.
- **Asian corrugated** - is not acceptable for most recycling purposes at this time. You can distinguish Asian corrugated by its yellow/green tinge (usually used for products shipped from Asia). Check with your paper processor or market about the acceptability of this particular material.

Printing

- ⑥ Approximately $\frac{1}{2}$ of all paper produced is printed.
- ⑥ Printing is constantly changing:
 - New inks
 - New techniques
 - New demands on paper
- ⑥ Slides courtesy of Joel J. Pawlak, NCSU.

Inks & Toners

⑥ Primary constituents

- ❑ Pigments- colored portion, most often carbon black
- ❑ Resins – binds the pigments to the surface of the paper, supplies gloss, resists the pigment from penetrating the paper
- ❑ Solvent – makes the ink fluid so it will run on the press
- ❑ Additives to provide viscosity, tack, lightfastness, oil resistance, rub resistance

Ink Jet

Propel droplets of ink onto paper.

Often made of water, glycol, dyes, or pigments.

Most widely used computer printer and very cheap.

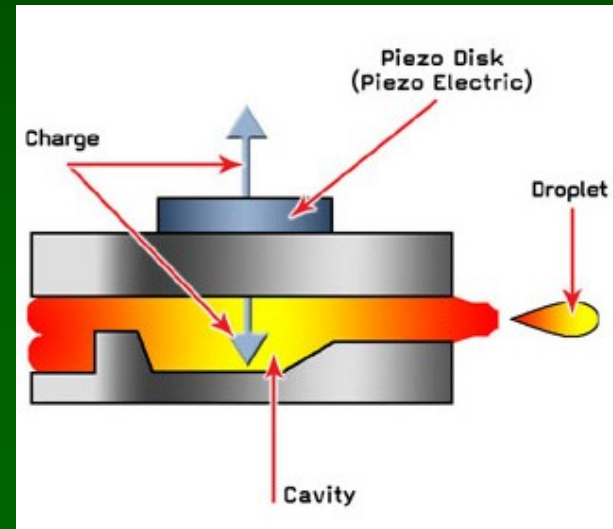
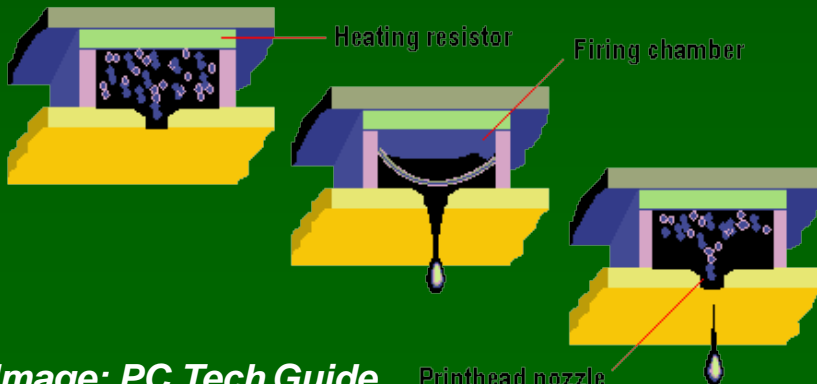


Image: OKI Printing

AmeriGas
America's Propane Company

Invoice www.amerigas.com

Contact Information
For Billing, Service or Delivery Inquiries
800-123-4567

Mailing Address
AmeriGas
PO Box 123
Anytown, USA 12345

Payment Options
☒ **AutoPay** Enroll in our automatic payment program! Log on to www.amerigas.com or call 1-888-243-5478.
☐ **E-Pay** www.amerigas.com Pay online
☐ **Telephone** 1-888-243-5478 Pay by phone
☐ **Mail in A Check or Money Order** Send your check with the remittance slip.

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Join us for an AmeriGas Open House! Visit Saturday from 1 p.m. to 6 p.m. FREE Refreshments and appliance discounts!
Protect your outside propane gas line and your BUDGET with LineGuard. Call today and we'll even give you 6 months FREE!


THANK YOU FOR YOUR BUSINESS!
Please hold on perfection below, below and make with your payment.

Account Information
 1 Account Number: 0000000000
 2 Invoice Number: A0000-000000
 3 Due Date: 08/20/14
 4 Billing Cycle: 08/01/14
 5 Delivery Service Location: 135 Main Street, Anytown, USA 12345

Account Information
 1 Account Number: 0000000000
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Detail of Current Charges
 Date Description Amount
 08/08/14 Payment Due From Previous Invoice \$88.00
 08/15/14 Payment Received - Thank You! -98.00
 09/01/14 Current Payment Due 98.00
TOTAL AMOUNT DUE \$88.00

Payment Plan Summary
 1 Plan Type: AmeriGasPay
 2 Payment Month: June
 3 Reference Number: 323274
 4 Date: 08/15/14
 5 Previous Balance: \$225.22
 6 Payment Received: Thank You! \$88.00
 7 AmeriGasPay Fee (incl. in Paym): 7.00
 8 Propane: 132.39
 9 Meter/Valve Surcharge: 3.27
 10 Plan-to-date Balance: \$169.87

THANK YOU FOR YOUR BUSINESS!
Please hold on perfection below, below and make with your payment.

Account Information
 Account Number: 0000000000
 Invoice Number: A0000-000000
 Due Date: 08/20/14
 Amount Due: \$88.00

11 TOTAL AMOUNT ENCLOSED \$

12 Please do not send correspondence with payment. Send correspondence to mailing address shown above.

13 Account or user address change?
If yes, please check box and complete reverse side.

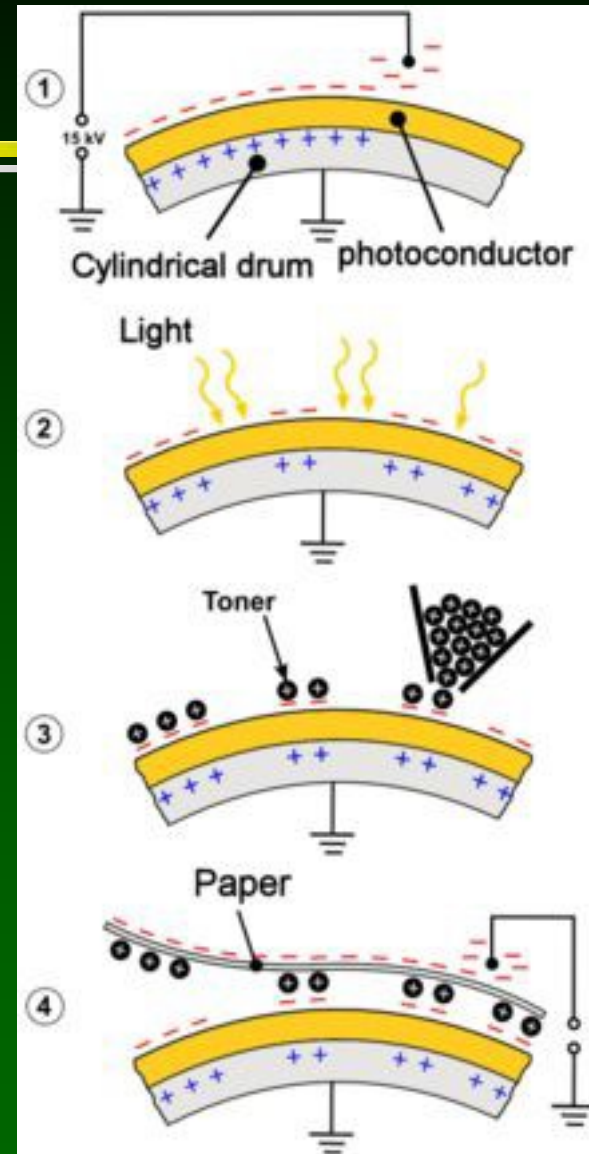
14 RENTY ADDRESS LINE 1
STREET ADDRESS
CITY STATE ZIP
00000-0000

15 RENTY ADDRESS LINE 1
STREET ADDRESS
CITY STATE ZIP
00000-0000

80 PP 1 8 1 1 A 10001 19881 **16 007
SEND ADDRESS LINE 1
SEND ADDRESS LINE 2
CITY STATE ZIP
00000-0000

Xerography

- ⑥ Commercially important for short run printing.
- ⑥ Toners are thermoplastic resins (water insoluble plastics) with carbon black
- ⑥ Melted onto the sheet
- ⑥ Produces large plastic flakes that are insoluble in water

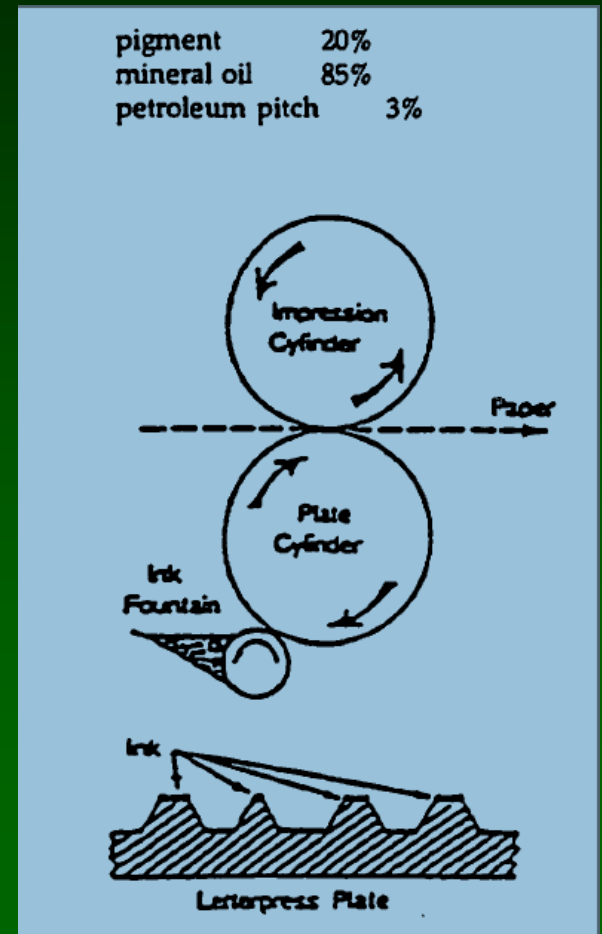
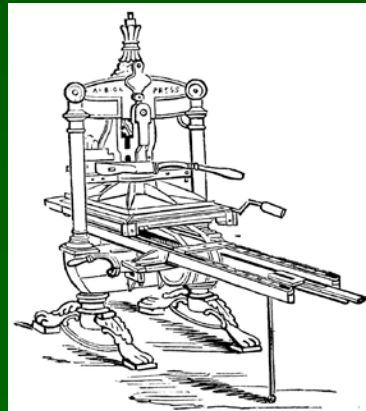


Then heat to melt the toner to the surface of the paper.

Letter press

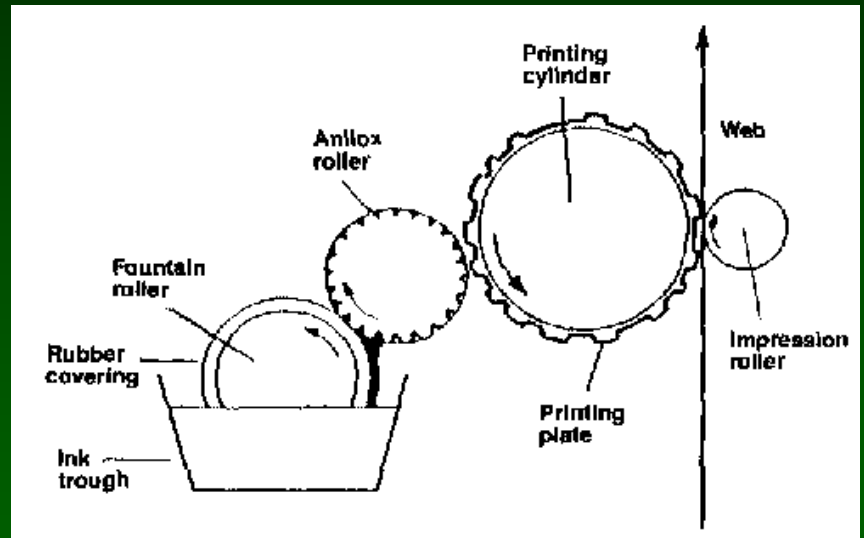
⑥ Letterpress- one of the oldest processes

- Ink applied to raised surface only



Flexography

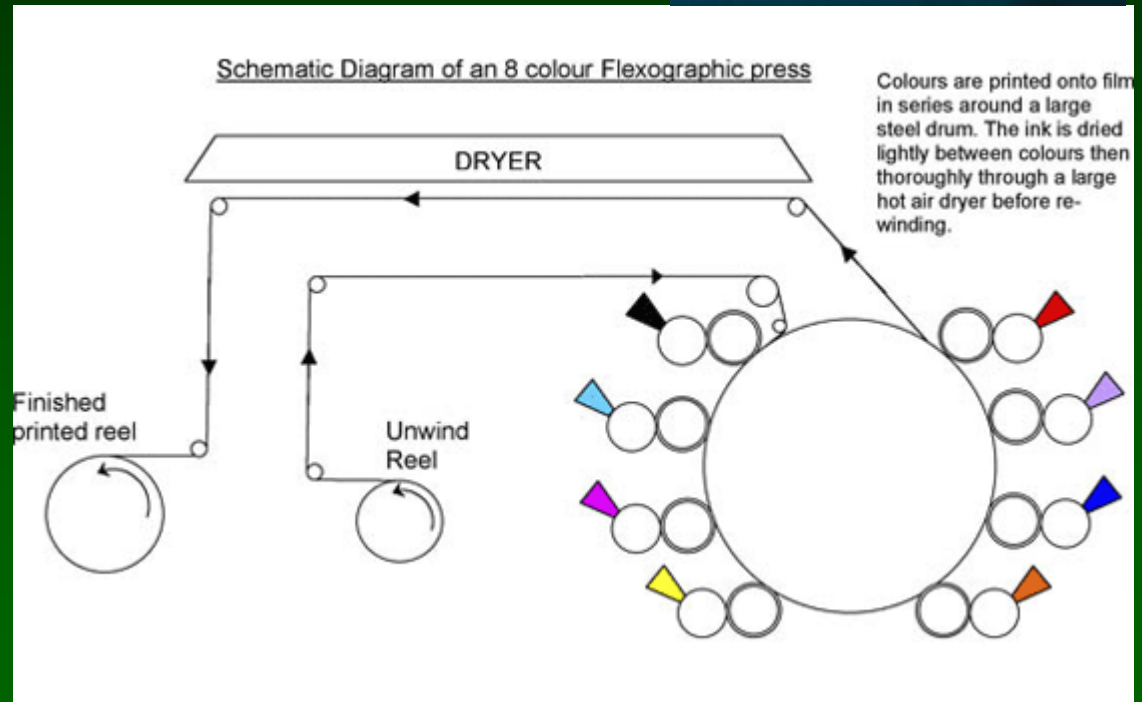
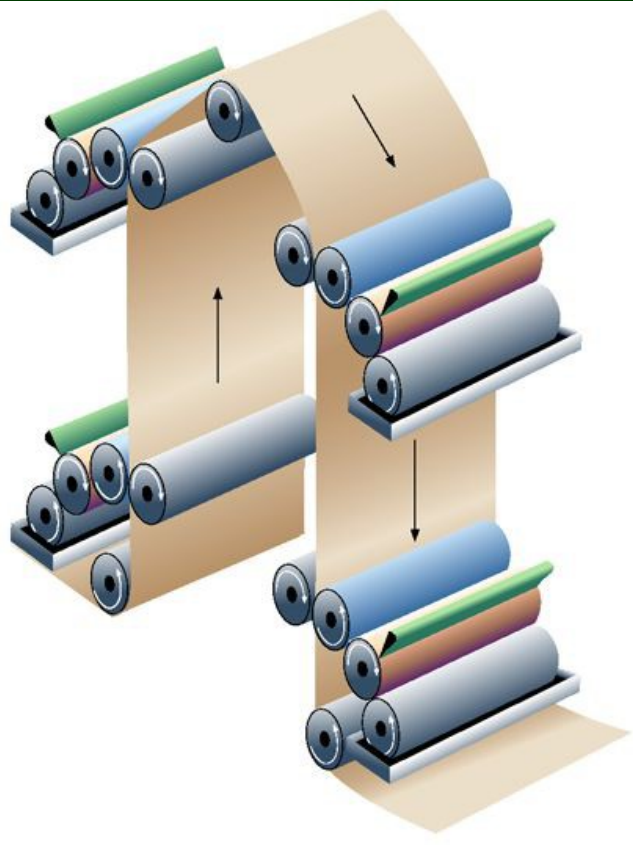
- ⑥ Flexography – Flexible letterpress
 - Very few requirement for the paper
 - Water or solvent
 - Usually used for “low quality” applications
 - Grocery bags
 - Corrugated Container



Flexography



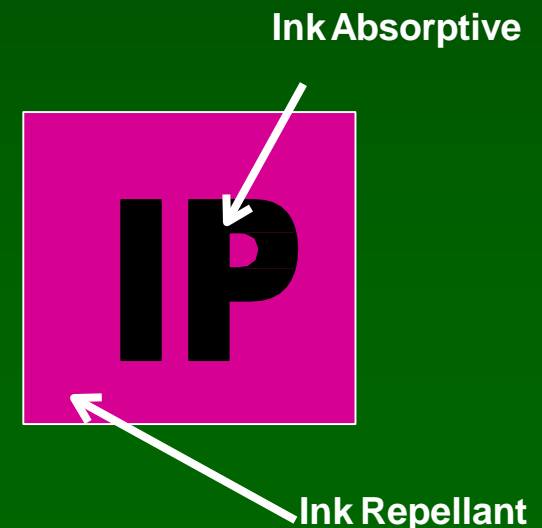
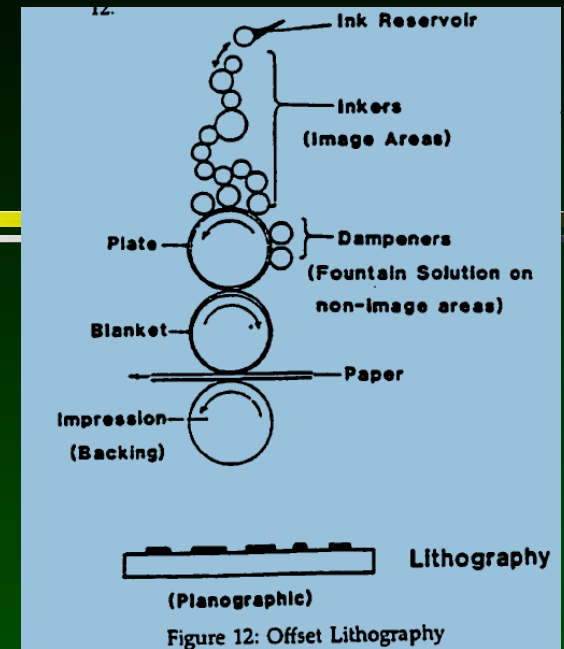
Four Color Flexo Stack



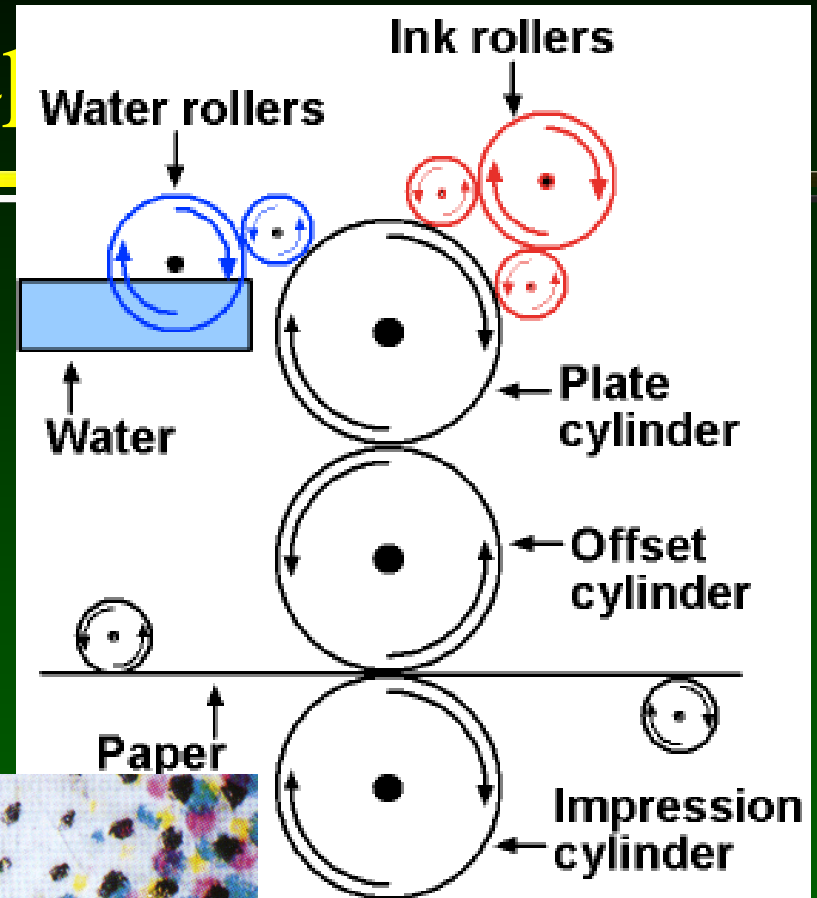
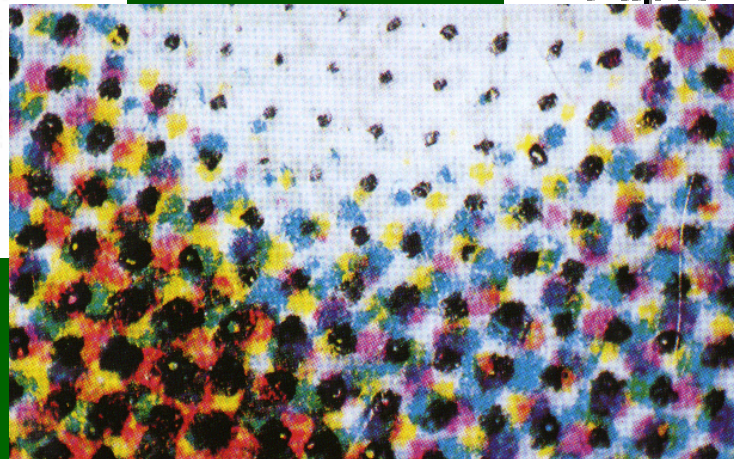
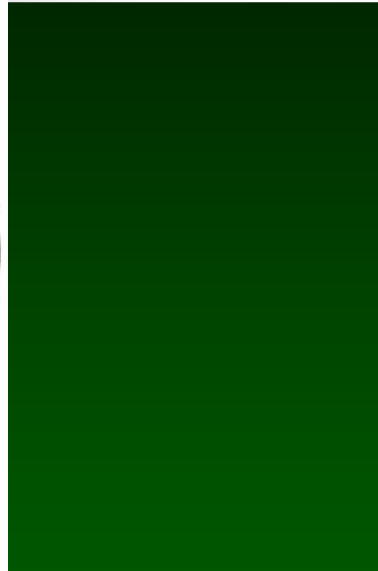
Offset Lithography

- ⑥ Lithography – Flat surface with ink absorptive and repellant areas.
- ⑥ Offset means the chemically modified plate doesn't touch the paper.
- ⑥ Dominant share of the printing market

Offset News		
pigment	20%	
mineral oil	53%	
high boiling distillate	17%	
petroleum pitch	2%	
aromatic hydrocarbon resin	8%	
Heatset Offset		
pigment	15%	
linseed/isophthalic alkyd	9%	
aromatic hydrocarbon resin	24%	
pentaerythritol rosin ester	3%	
phenolic modified rosin ester	7%	
polyethylene wax	4%	
high boiling distillate	38%	
Quickset Sheet-Fed Offset		
pigment	23%	
phthalic alkyd resin	10%	
linseed oil	41%	
phenolic modified rosin ester	15%	
high boiling distillate	5%	
polyethylene wax	3%	
cobalt soap drier	3%	

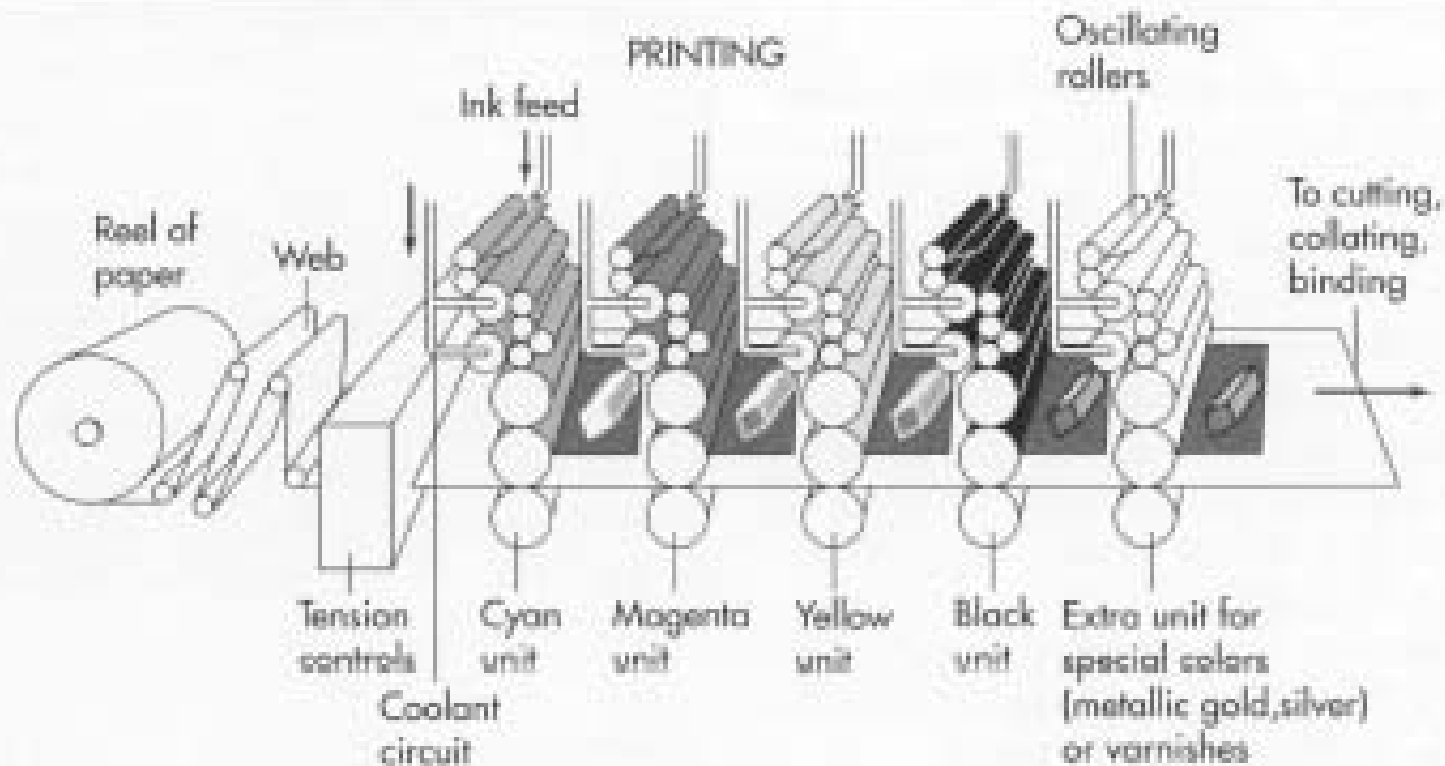


Lithography



Four color
litho print

Lithography



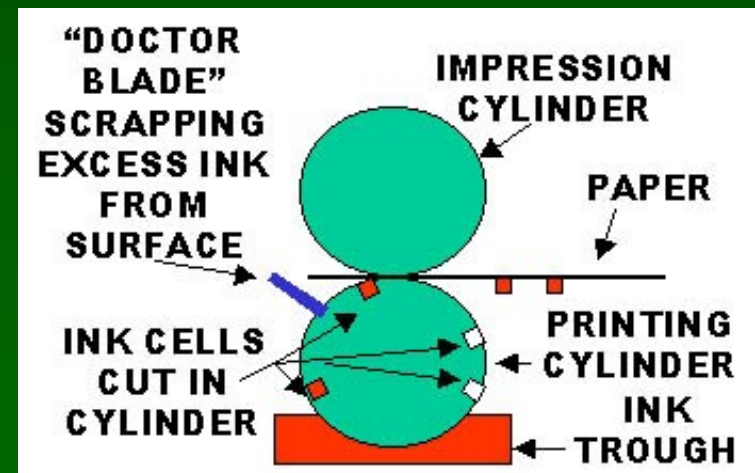
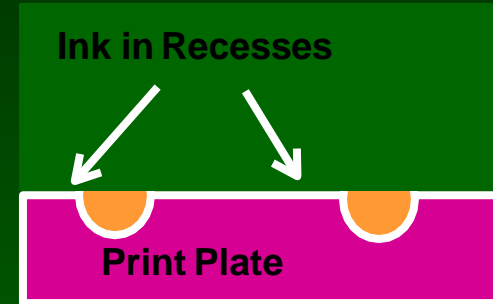
Basic Offset Lithography Printing Press

Rotogravure Printing



⑥ Gravure

- Ink transported in recesses of printing cylinder
- Highest quality printing process
 - Pigment: 27%
 - Zinc resonate: 22%
 - Toluene: 51%
- Used for high quality printing like currency



Inks & Toners

Type	Component	Drying System	Ink Resin Film	Particle Size (microns)	End Products
Simple Letter Press	Pigment + Mineral Oil	Absorption into Web	Weak	1-15	Letterpress Early Newsprint
Newsprint and Offset	Pirgment + Soft Resin & Mineral Oil	Penetration of Vehicle into Web + Resin Oxidation	Soft Film Hard Film	2-30	Newsprint, Books We Offset, Letter Press
Rotogravure	Pigment +Hard Resin & Solvent	Solvent Evaporation	Hard Film	2-250	Magazines, Catalogues
Flexographic	Pigment + Resin & Water Emulsification	Amine Absorption, Evaporation	Water Resistant Film	N/A	Newsprint inserts, Corrugated
UV Cured	Pigment +Monomer	UV Photopolymeri zation	Non swelling, Non saponif. Hard Film	50-100	High Speed Coated Papers
Specialty	Various Pgiments and Rosins	Heat set or Other	Hard, Coherent Films	40+	Xerography Laser Printers Electronic Forms

Issues with some inks

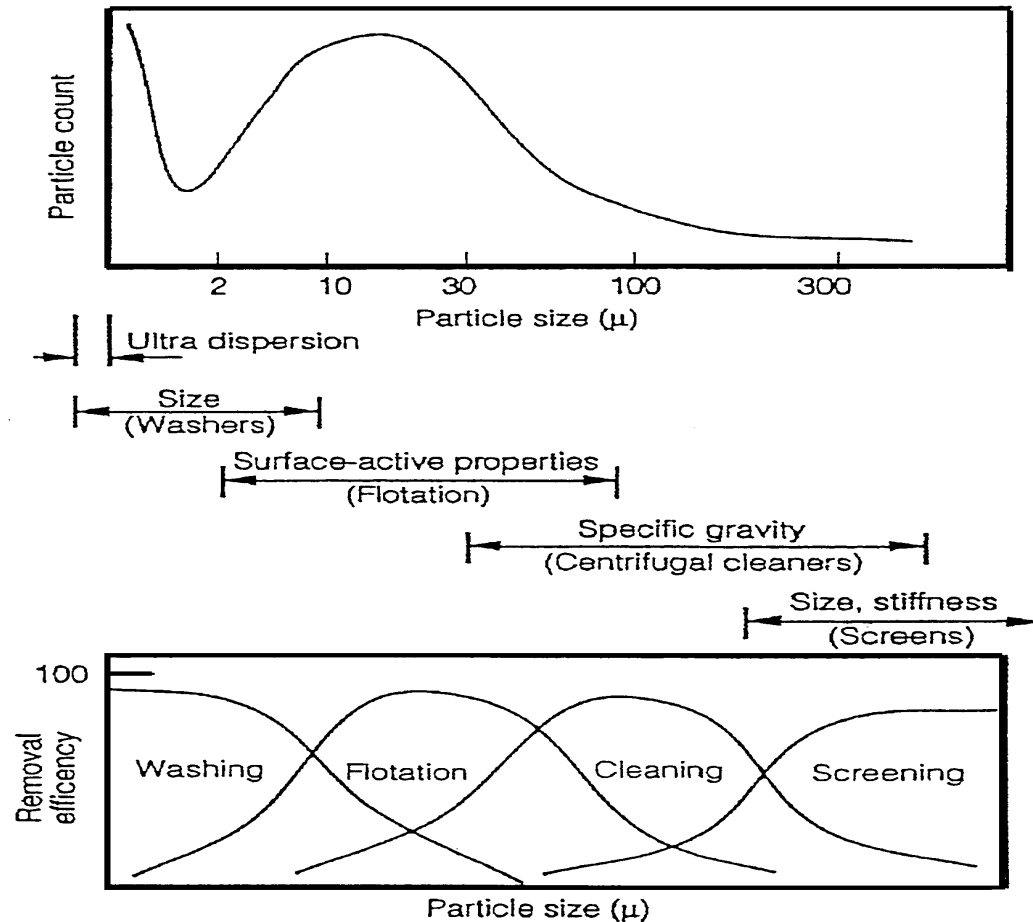
⑥ Xerographic inks (toners)

- ❑ Small toner particles are melted together to form letters for instance
- ❑ After pulping, these can generate large plate like particles (40-400 microns) that can not be floated or screened
- ❑ Sometimes have fibers attached or ~~are~~ attached to fibers, are not ink-like

Issues with some inks

- ⑥ Water based flexographic inks in ONP:
 - Disperse in the water system readily but make the water black and unusable
 - Are too small (0.3-1 microns) and hydrophilic to be floated

Contaminant Size vs. Removal Efficiency

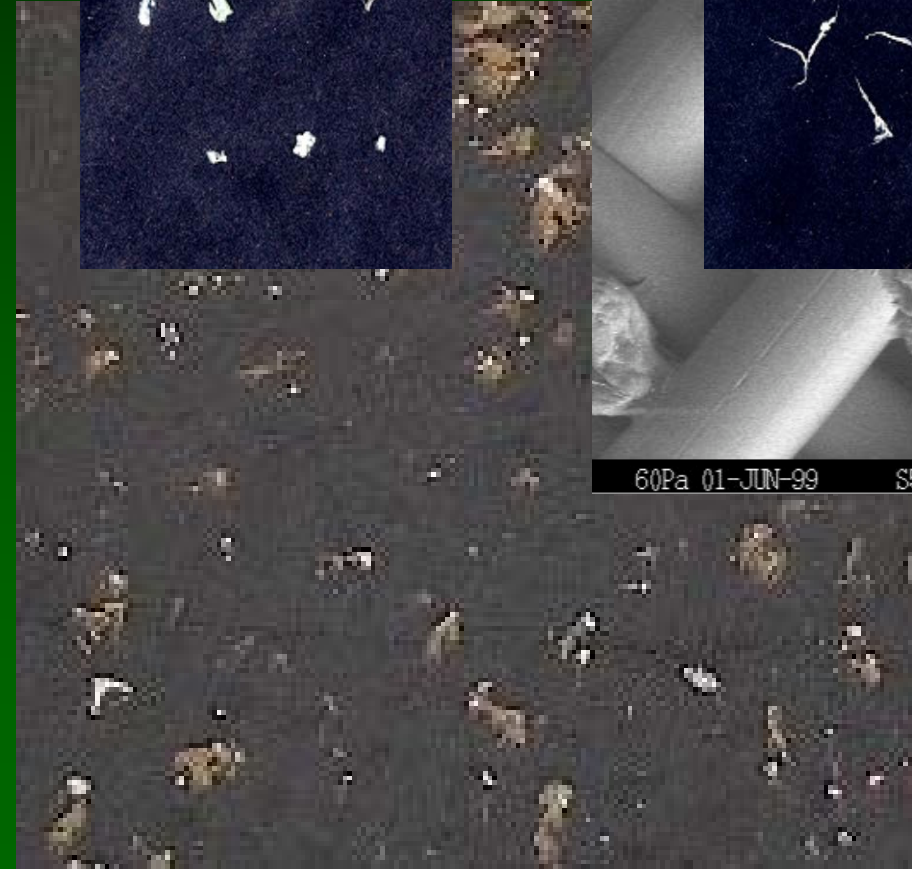
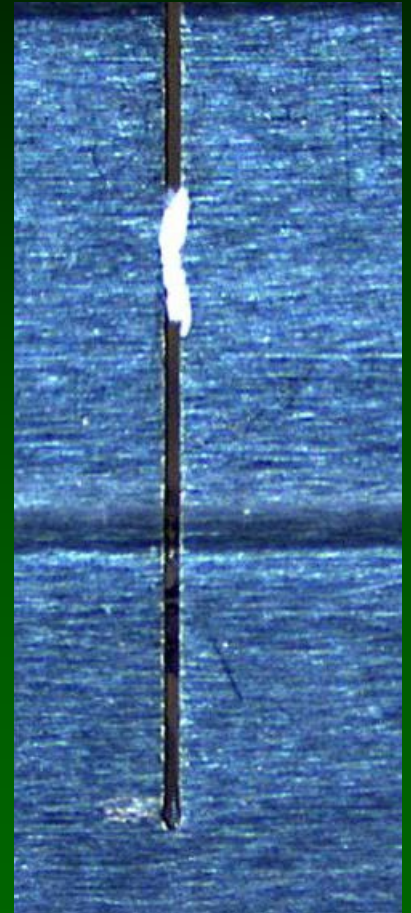
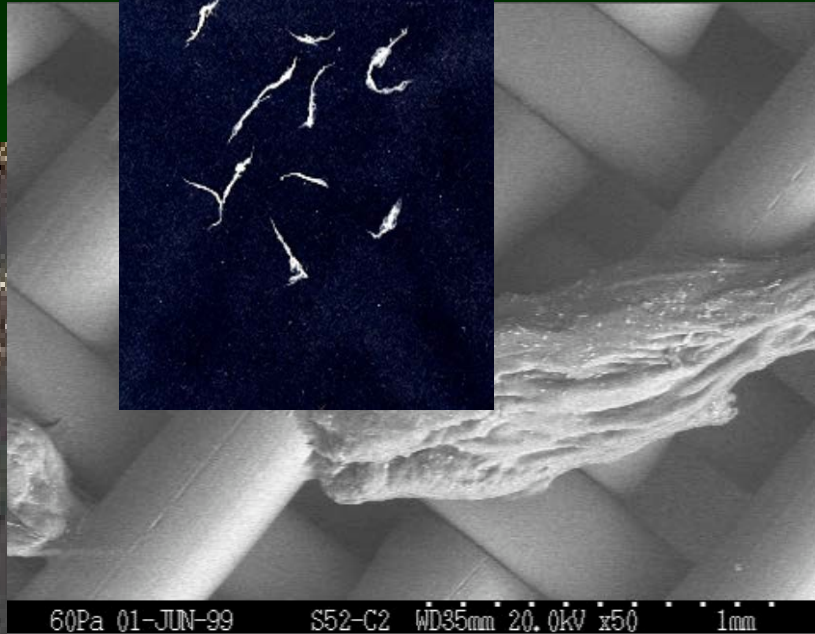


Stickies

- ⑥ Currently the most challenging problem in paper recycling
- ⑥ Stickies: contaminants in pulp that have the potential to deposit on solid surfaces
- ⑥ Typically organic materials:
 - Man made stickies: adhesives, coatings...
 - Natural stickies: pitch, resins..
- ⑥ May deposit on papermachine wires, press felts, dryer fabrics, calendar rolls and cause significant down-time on machine
- ⑥ Are hard to remove in recycling due to often having a neutral density, and an ability to flow and change shape



Stickies



Stickies

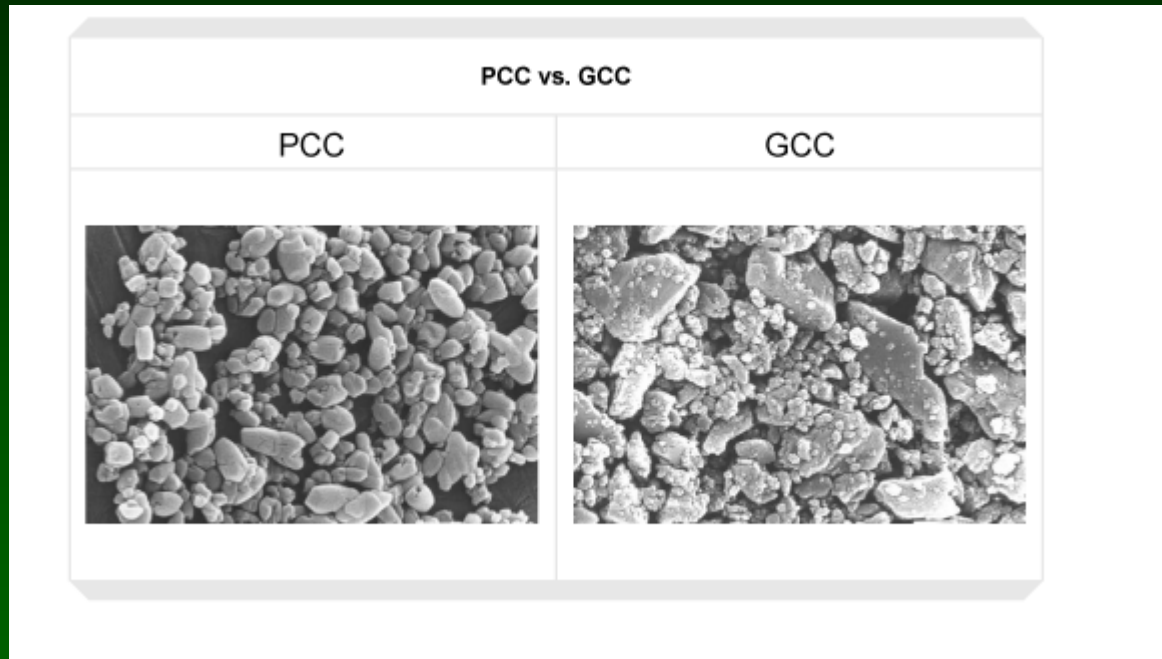


Fillers as a Contaminant

- ⑥ Fillers are added to paper to improve brightness, smoothness, and printability
- ⑥ Fillers are cheap
- ⑥ Fillers decrease the strength of paper
- ⑥ Common fillers:
 - clay
 - CaCO_3
 - TiO_2
- ⑥ ***Fillers are washed out of the pulp and lower the overall yield of the recycling process***
- ⑥ ***Fines are characterized as having a length of less than 200 microns, or 0.2 mm, most filler materials are in the 0.1-10 micron range***
- ⑥ Fillers are not desirable in some paper products such as tissue paper
 - Hurt softness
 - Hurt the creping blade during tissue making

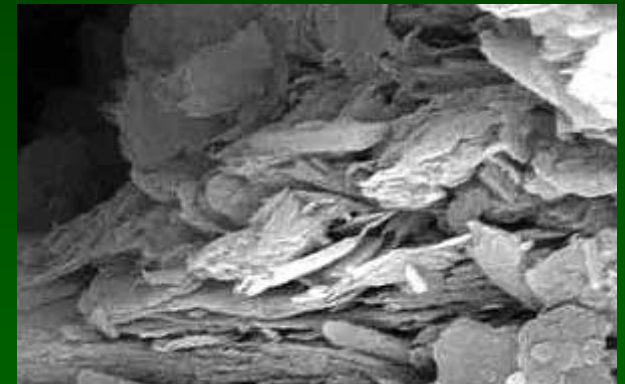
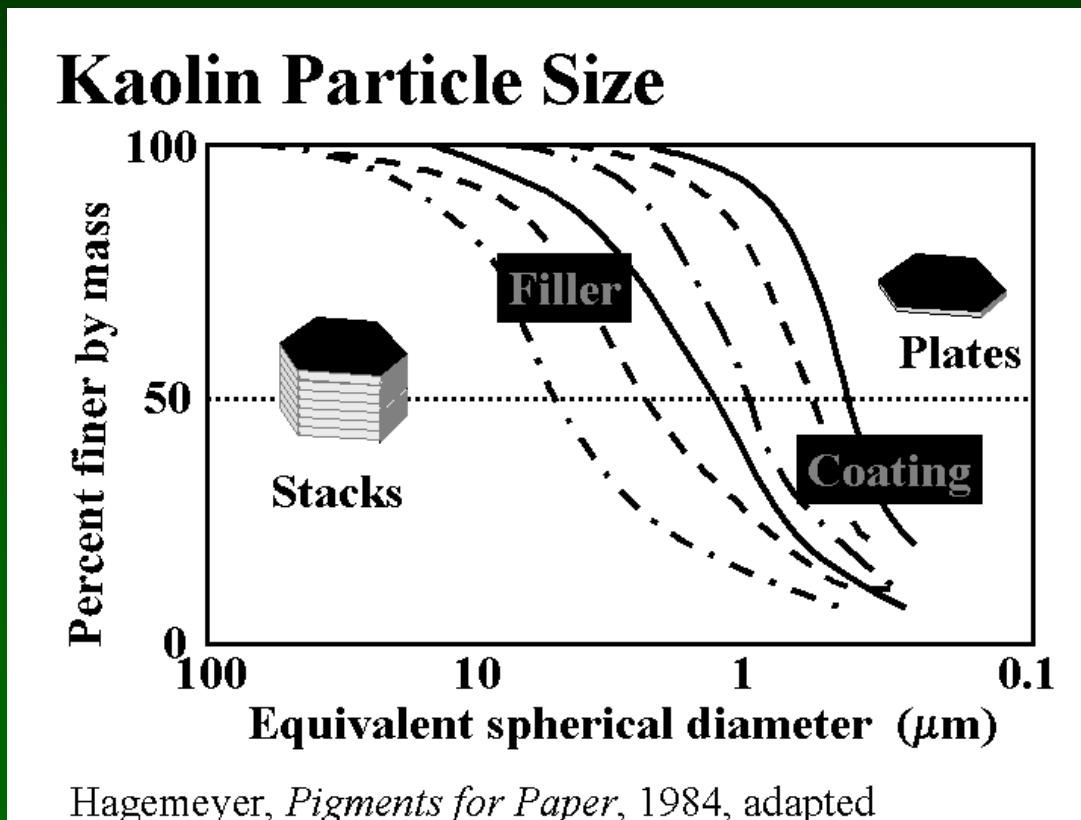
Fillers as a Contaminant

- ⑥ These are calcium carbonate filler particles of about 0.7 micrometers median size.



Fillers as a Contaminant

- ⑥ Clay, from Hubbe (left). Clay particles magnified by an electron microscope. drainchem.com.au (right)



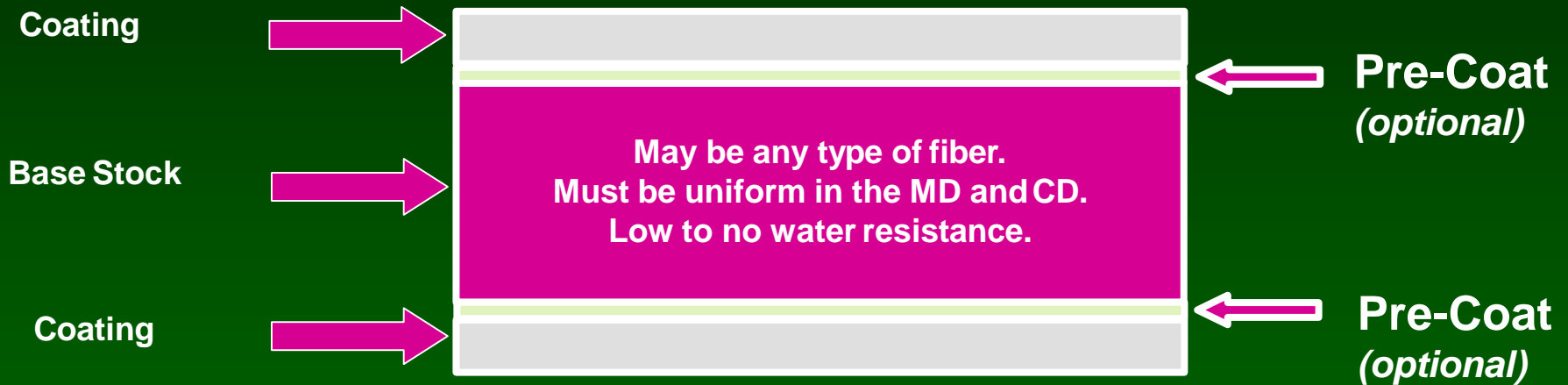
Papermaking Additives

- ⑥ Additives such as starch, gums, retention aids, etc., are lost during recycling and lower yield
- ⑥ Additives such as dyes can cause the fibers to not make color specifications, this is also a problem with fluorescent dyes
- ⑥ Wet strength additives cause the paper to be unpulpable in many cases, making the entire paper product unusable and thus, a contaminant
 - For instance the wet strength beverage carrier boxes that hold sodas and beers...

Coatings as a Contaminant

- ⑥ Coatings typically contain inorganic fillers and polymeric binders
 - Coating binders can behave as stickies, sometimes termed white pitch
 - Coating fillers are washed out of the pulp and lower the overall yield of the recycling process
- ⑥ Board is often coated with wax
 - Wax can cause recycled paper to be weak and slippery
 - Wax can deposit on machinery

What is coating?



Coating Formulation

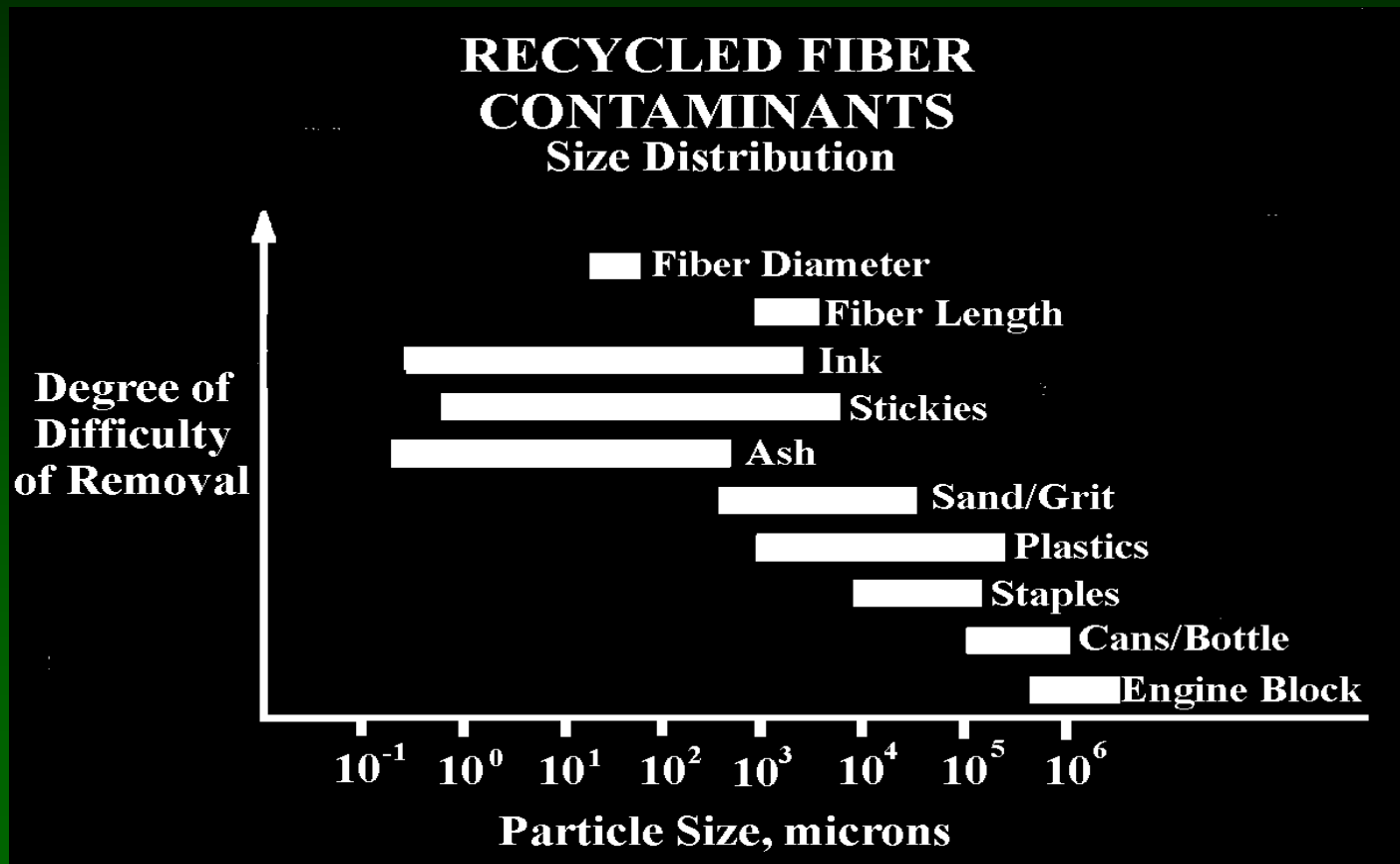
- ⑥ There are three main components to a coating color:
 - ❑ Water
 - ❑ Pigment
 - ❑ Binder
- ⑥ All but the simplest formulas will have additional components known as *additives* such as:
 - ❑ Flow modifiers
 - ❑ Colorants
 - ❑ Optical Brighteners
 - ❑ Etc.

Coating Formulation

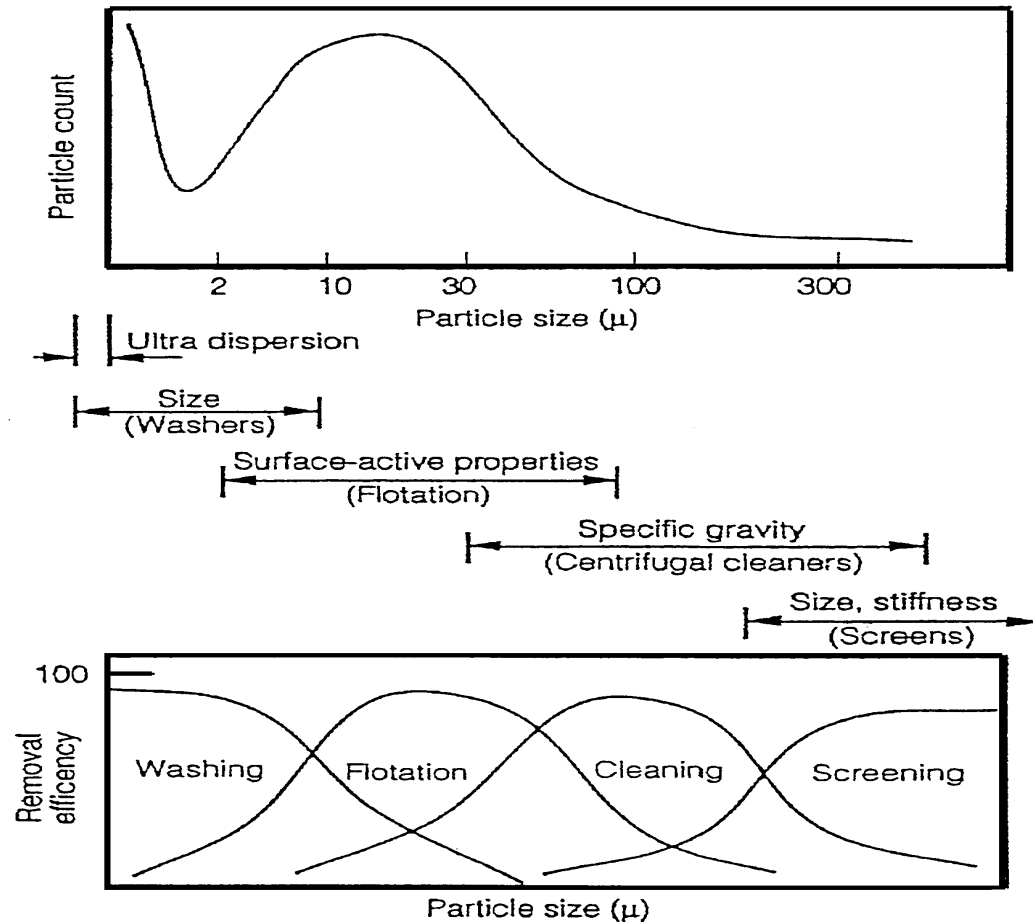
Pigments

- ⑥ Pigments – the *major component* of the coating color. Usually made up of inorganic particulate material similar to fillers.
- ⑥ Typical pigments include:
 - Clay – most widely used
 - Calcium Carbonate – second most widely used
 - TiO_2 – high brightness, but expensive
 - Aluminum Oxide – usually used in combination with TiO_2

Contaminant Removal



Contaminant Size vs. Removal Efficiency



Lecture:

Collection, sorting, storage of recovered paper



Collection of Recovered Paper: Sources

- ⑥ Recovered paper dealers or brokers
- ⑥ Directly from the site of a recovered paper collection drive
- ⑥ From recovered paper collection facilities owned by the recycling paper company
- ⑥ From paper converting facilities
- ⑥ From large office complexes
- ⑥ From stores
- ⑥ From individuals in their private vehicles

Collection of Recovered Paper

- ⑥ Commercial Recycling
 - ⑥ Businesses supply recovered paper or board to collectors
 - ⑥ Often collectors give businesses a baler for employees to place the paper, and a trailer, only if the volume warrants the investment
 - ⑥ The collector and business agree on a contract about volume, pricing and length of contract
 - ⑥ Collector picks up the paper

Collection of Recovered Paper

- ⑥ Typical volumes of OCC produced from different sources:

Small convenience stores	700-1000 lbs./month
Grocery stores/supermarkets	8-30 + tons/month
Department stores	8-20 + tons/month
Hospitals	5 tons/month

Collection of Recovered Paper

- ⑥ Residential Recycling
 - ⑥ People put curbside waste out for disposal
 - ⑥ Single stream recycling means that all paper, plastics, glass, and metals that can be recycled are put together
 - ⑥ Yields of recyclables go up when people don't have to sort at their house
- ⑥ Municipalities pick up single stream waste streams
- ⑥ Municipalities enter into contracts with material recovery facility
- ⑥ MRF pays for the waste stream
- ⑥ This material is separated for OCC, newspaper, mixed papers
- ⑥ Also recover aluminum, steel, glass, plastics and others
- ⑥ Also produces a residue

Transportation of Recovered Paper

- ⑥ Recovered paper can be transported by truck, barge, container, rail
- ⑥ Recovered paper is typically
 - Baled
 - Loose

<i>Newspaper</i>	
Loose, unbaled	445 pounds / cubic yard
Compacted	800 pounds / cubic yard
Hand stacked	35 pounds / 12 inch stack
<i>Corrugated Cardboard</i>	
Loose, unbaled	200 pounds / cubic yard
Compacted	460 pounds / cubic yard
<i>Other Paper</i>	
Telephone Books	250 pounds / cubic yard
Mixed Paper	490 pounds / cubic yard

Warehouse Operations Bales:

- ⑥ ONP bales from municipal waste sorting facility



Warehouse Operations Loose Paper:



Example Bale Sizes and Weights

GRADE	SIZE (W H L)	WEIGHT (lb)
No. 6 News	36x48x60 in	2000
	30x40x72 in	1400
OMG	30x40x72 in	1700
No. 41 Manifold White Ledger	30x36x60 in	1400
Mixed Office Waste	30x30x50 in	1000
OCC	30x48x60 in	1000

Tappi Deinking Short Course, 1995

Storage of Recovered Paper: Warehouses

⑥ Storage of the paper in a warehouse includes protection from:

- ❑ Sunlight
- ❑ Wetting by rain
- ❑ Fires
- ❑ Excessive humidity
- ❑ Aging (rotation of the inventory)
- ❑ Animals

Storage of Recovered Paper: Warehouses

- ⑥ Rotating the inventory can be important, for example for ONP:
 - Brightness of pulp decreased by 6% when the paper was aged by 3 years
 - Tensile strength of the paper decreased by 30-50% when the paper was aged by 3 years

Storage of Recovered Paper: Warehouses

- ⑥ The size of the warehouse depends on how much inventory must be carried, typically they run from 3-90 days of inventory
- ⑥ Inventory desired depends on:
 - ❑ Price fluctuations
 - ❑ Nature of contracts entered into
 - ❑ Short and long term supply of recovered paper
 - ❑ Space available for the warehouse
 - ❑ Availability of off-site storage
 - ❑ Average distance of recovered paper transportation
 - ❑ Operating hours for receiving paper
 - ❑ Capital cost of warehouse
 - ❑ Manpower to run warehouse
 - ❑ Cost of operation of the warehouse

Storage of Recovered Paper: Warehouses

⑥ After the inventory size, other factors determine how big the warehouse must be to **store bales:**

- ❑ Height of stacks of bales
- ❑ Height allowance between top of stacks and sprinklers
- ❑ Length and width of bale piles
- ❑ Width of corridors
- ❑ Other space requirements, such as conveyors, wire cutters, truck docks, locker rooms, offices
- ❑ Areas for loose paper

Storage of Recovered Paper: Warehouses

⑥ After the inventory size, other factors determine how big the warehouse must be to **store loose paper**:

- ❑ Height of the recovered paper stored within the walled areas
- ❑ How many walled areas
- ❑ Length and width of the walled areas
- ❑ Height allowance between top of piles and sprinklers
- ❑ Allowance for room to allow vehicles to operate
- ❑ Other space requirements, such as conveyors, wire cutters, truck docks, locker rooms, offices

Storage of Recovered Paper: Warehouses

- ⑥ Prior to use or putting recovered paper into inventory, *inspections* are sometimes done
 - Bale structure
 - Visually inspected for appearance of unwanted papers
 - Checked for identification tag
 - Sometimes broken open and inside inspected, but not often

Storage of Recovered Paper: Staging for Pulping

⑥ For a **batch** pulper,

- ❑ the required number and type of bales must be assembled to meet the batch requirement
- ❑ Often batches are blended, for example ONP and OMG are added at a definite ratio (OMG assists in brightness and in deinking)
- ❑ Strapping wires sometimes must be taken off and cut
- ❑ Bales are often broken, providing a better inspection of the paper
- ❑ Often want to rotate the inventory

Storage of Recovered Paper: Staging for Pulping

- ⑥ For a **continuous** pulper,
 - the proper mix of ages and grades are assembled on a conveyhor
 - Wires or straps are cut and removed sometimes
 - Bales are often broken, providing a better inspection of the paper
 - Often want to rotate the inventory

Warehouse Operations Bales:

- ⑥ Old newspaper and old magazine warehouse
- ⑥ Unloading bales out of a truck



Warehouse Operations Bales:

- ⑥ Old newspaper and old magazine warehouse
- ⑥ Bales
- ⑥ Bobcat forklift



Warehouse Operations Bales:

- ⑥ Old newspaper and old magazine warehouse
- ⑥ Moving a Bale



Warehouse Operations Bales:

- ⑥ Raw material for a municipal waste sorting facility



Warehouse Operations Bales:

- ⑥ Bales of old newsprint coming out of a baler at the MRF



Warehouse Operations Bales:

- ⑥ ONP bales from municipal waste sorting facility



Warehouse Operations Bales:

- ⑥ Mixed Bales from municipal waste sorting facility



Warehouse Operations Bales:

- ⑥ Low quality OCC from municipal waste sorting facility



Warehouse Operations Bales:

- ⑥ OCC from municipal waste sorting facility



Warehouse Operations Bales:

- ⑥ Low quality mixed waste from municipal waste sorting facility



Recovered OCC bale storage



Recovered OCC bale storage



Bobcat with front clamps





Loading OCC bales on pulp conveyor

Wire bale cutter



Pulp conveyor





Bale falling into pulper

A photograph showing a large, rectangular bale of cardboard boxes falling into a pulper. The pulper is a large, dark, cylindrical machine with a textured, reddish-brown interior. A thick plume of white steam or smoke rises from the top of the pulper, partially obscuring the background. The cardboard bale is composed of various boxes, some of which are clearly visible, including one labeled "ANDRE" and another labeled "48600 02262 Ham Fun Kit". The scene is set in an industrial environment, likely a paper mill.

Pulper



Bale falling into pulper

This photograph shows a large, cylindrical industrial pulper machine in a factory setting. A large, rectangular wooden bale is in the process of falling into the top of the machine. The machine is surrounded by various pipes, structural beams, and other industrial equipment. The lighting is somewhat dim, with a warm, orange-brown tint.



Pulper

This photograph provides a closer view of the same industrial pulper machine. A metal railing is visible in the foreground, partially obscuring the view. The machine's body is dark and metallic. A small, rectangular label with the text "TOP PULPER" is visible on the side of the machine. The background shows more of the industrial environment, including pipes and structural elements.

Warehouse Operations Loose Paper:

- ⑥ Old newspapers and old magazine warehouse



Warehouse Operations Loose Paper:

- ⑥ Old newspapers and old magazine warehouse



Warehouse Operations Loose Paper:



Warehouse Operations Loose Paper:

⑥ Pre-consumer old magazines



Warehouse Operations Loose Paper:

- ⑥ Old newspapers and old magazine warehouse



Outdoor storage of bales uncovered:



Outdoor storage of bales covered:



- ⑥ ONP Recycling in Canada

Lecture:

Papermaking fiber types and the effect of recycling on strength properties



Effect of Recycling on Fiber Properties

⑥ Learning objectives

- Understand how recycling affects chemically pulped fiber
- Understand how recycling affects mechanically pulped (lignin containing) fibers

Different Wood Pulping Mechanisms

**NO LIGNIN
REMOVAL**



**MECHANICAL
PULPING**

**SOME LIGNIN
REMOVAL**



**SEMI-CHEMICAL
PULPING**

**TOTAL LIGNIN
REMOVAL**



**CHEMICAL
PULPING**

Mechanical Pulping
Yield (85+%)

groundwood
(27% lignin)

thermo mechanical pulp
(27% lignin)

- newsprint
- lower grade writing
- lower grade printing

Hard Wood



Soft Wood



Chemi-mechanical Pulping
Yield (55-85%)

Neutral sulphite
(24.8-28.1% lignin)

- printing
- writing
- tissue
- packaging board
- fluted medium for boxes

Chemical Pulping
Yield (55%)

unbleached kraft
(15% lignin)

- paper bags (3.5-8% lignin)
- wrapping paper
- writing paper
- packaging board
- linerboard for boxes

bleached kraft
(0% lignin)

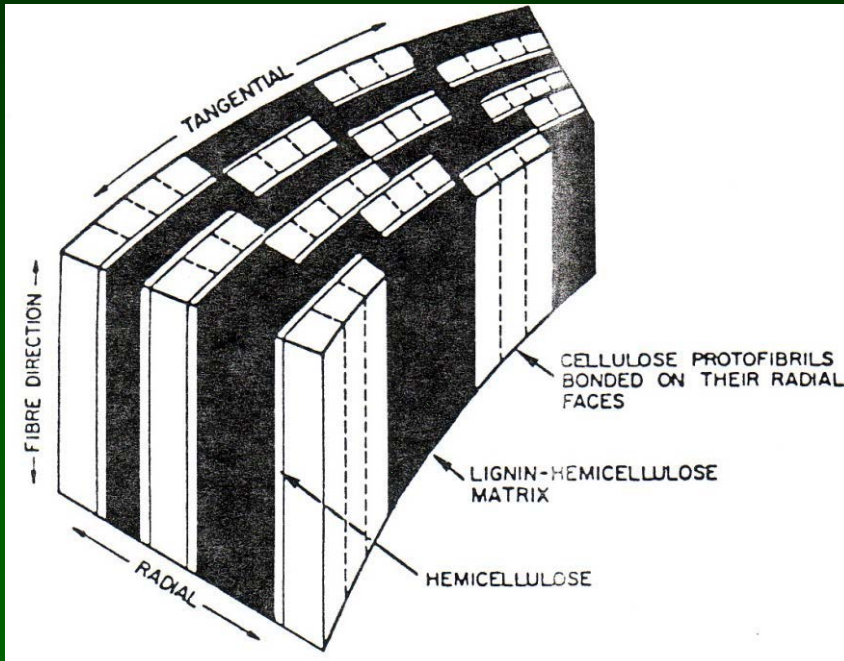
- writing paper
- copy paper
- bleached paperboard

bleached sulfite
(0% lignin)

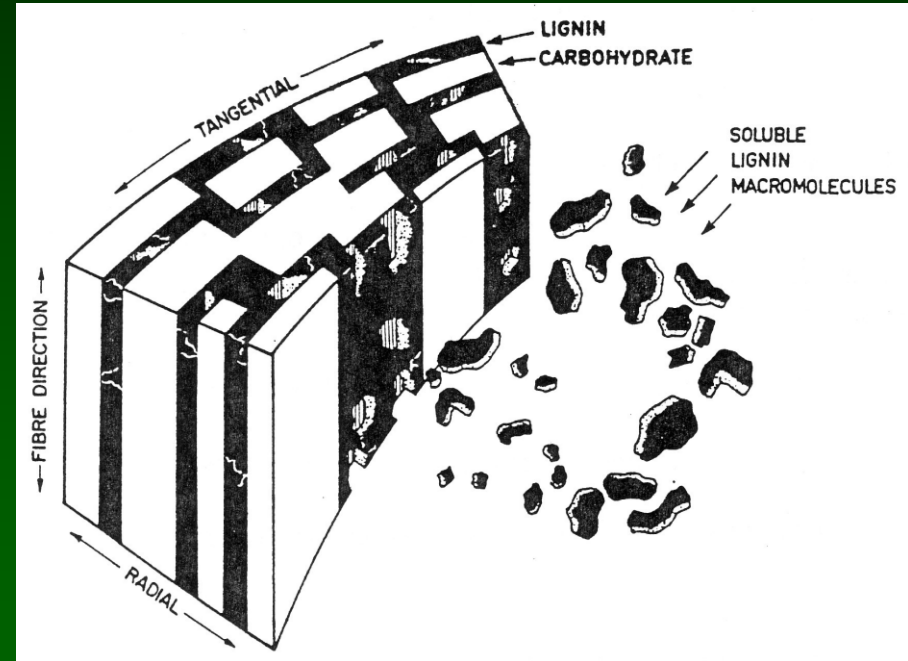
Effects of Recycling on Chemical Pulps

- ⑥ Mechanical damage
- ⑥ Loss of fines
- ⑥ Hardening and stiffening (hornification)
- ⑥ Weakening of bonding
 - less fiber conformability
 - less absorptive
 - loss of hemicellulose
- ⑥ Decreased cleanliness

Effect of Virgin Chemical Pulping

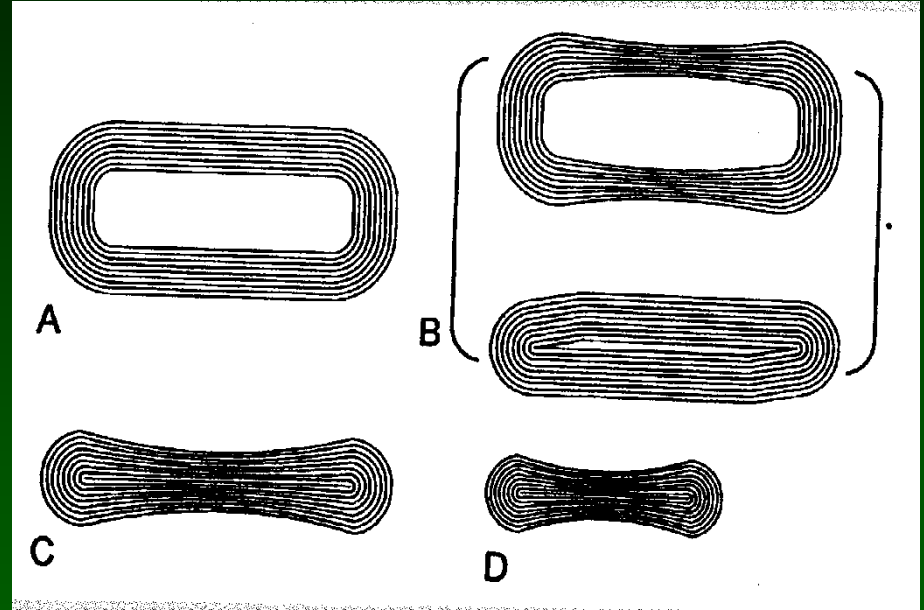
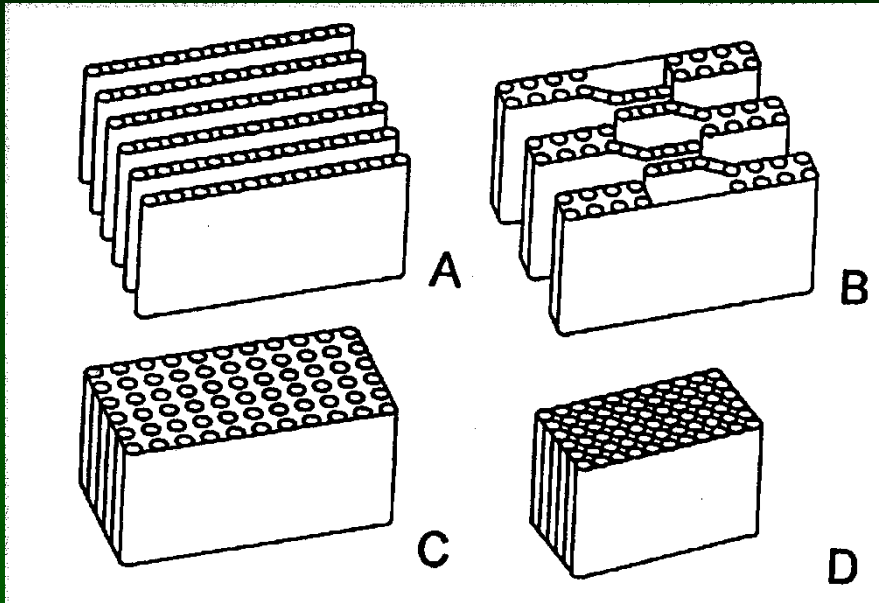


Fiber wall structure as in the tree.



Chemical pulping removes lignin from cell wall. The cell wall is swollen with water when refined.

Hornification: Irreversible



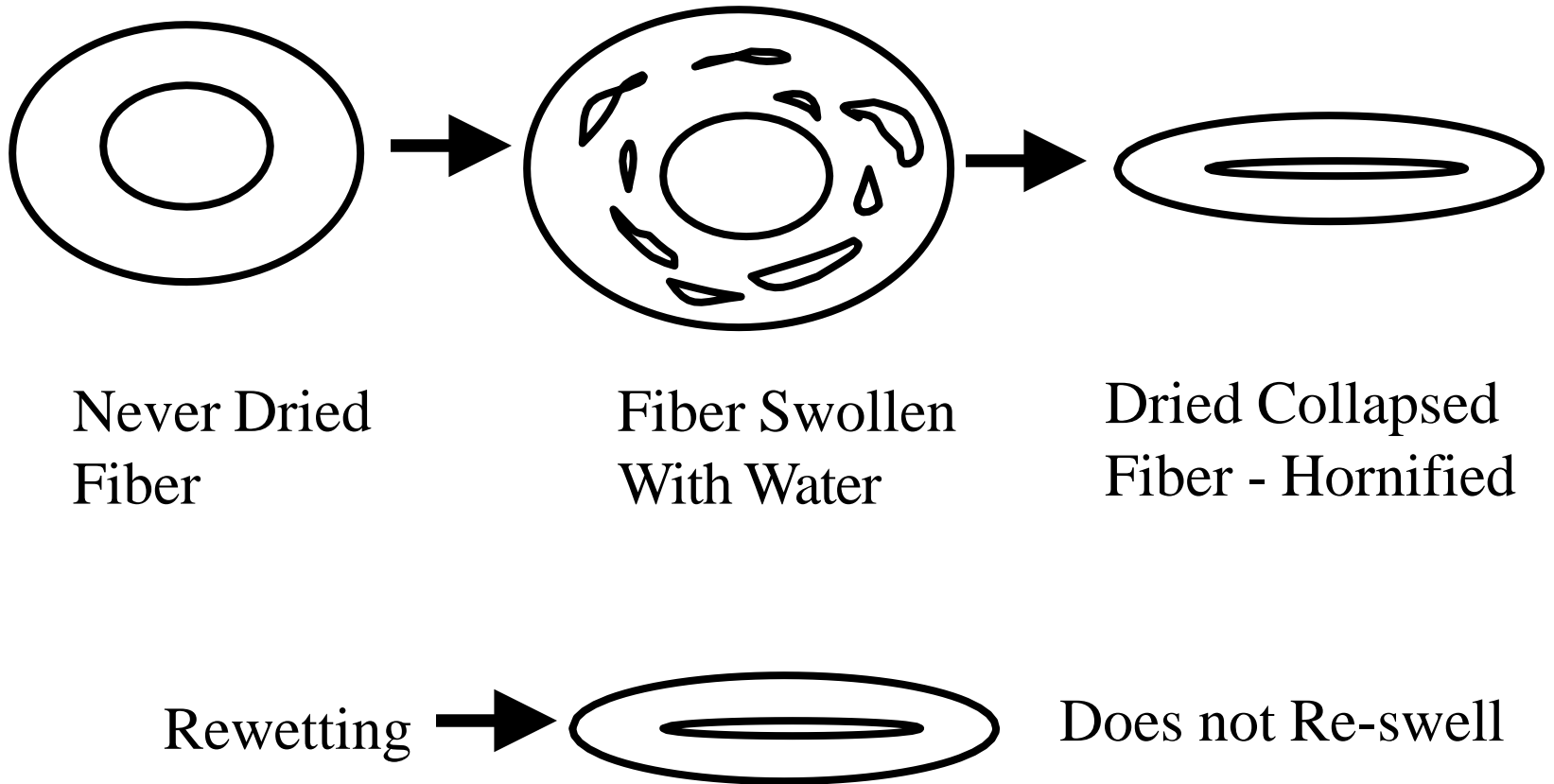
A. Wet kraft fiber before drying

B. 30% consistency (Irreversible processes begin to occur)

C 30-75% consistency

D >75% consistency

Hornification: Irreversible



Effect of Recycling on Chemical Pulps

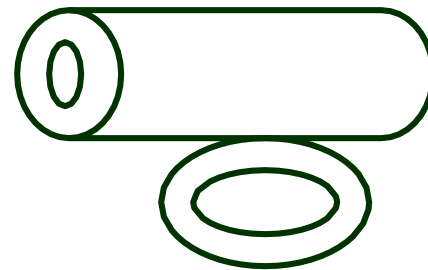
- ⑥ Chemically pulped fibers that have never been dried:
 - have the ability to swell with water which makes the fibers flexible
 - can be mechanically treated (refining) to increase the swelling and flexibility
- ⑥ The flexible never dried fibers are able to conform in the paper sheet which increases the fiber bonded area making strong paper
- ⑥ When dried, the fibers become rigid, termed hornification
- ⑥ They do not swell on re-wetting as much
- ⑥ They do not bond as well in paper

Effect of Recycling on Chemical Pulps

- ⑥ Previously dried fibers, upon exposure to water, do not swell and do not become flexible
- ⑥ These rigid fibers break upon refining: causing fines
- ⑥ When paper is made, the rigid fibers do not conform in the paper sheet and the resulting low fiber bonded area produces a weak sheet

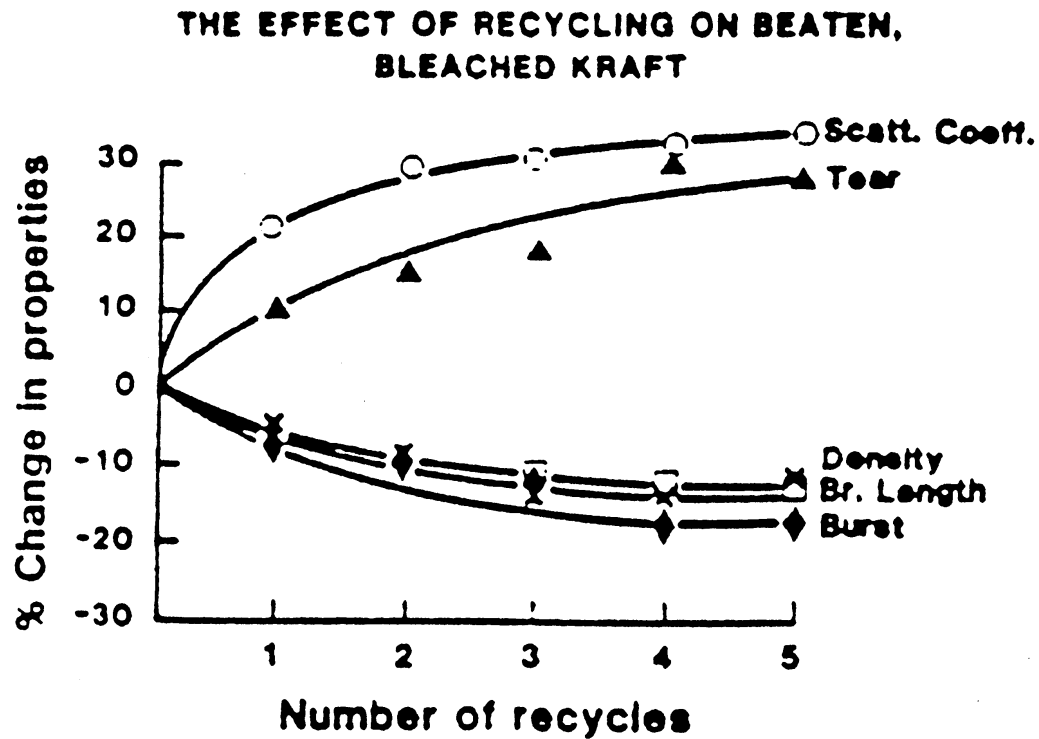


Flexible Fibers



Stiff fibers

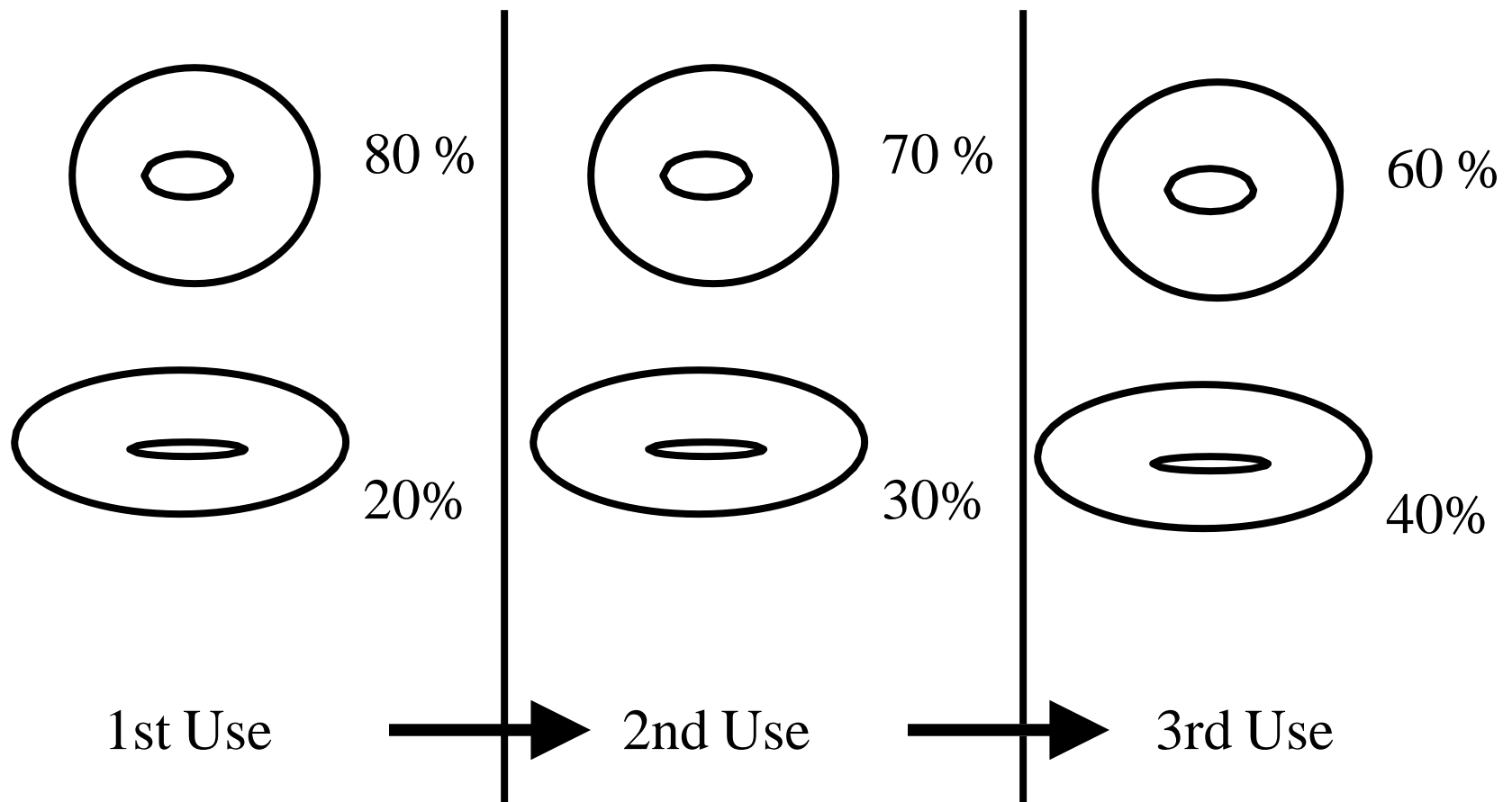
Effects of Recycling on Chemical Pulps



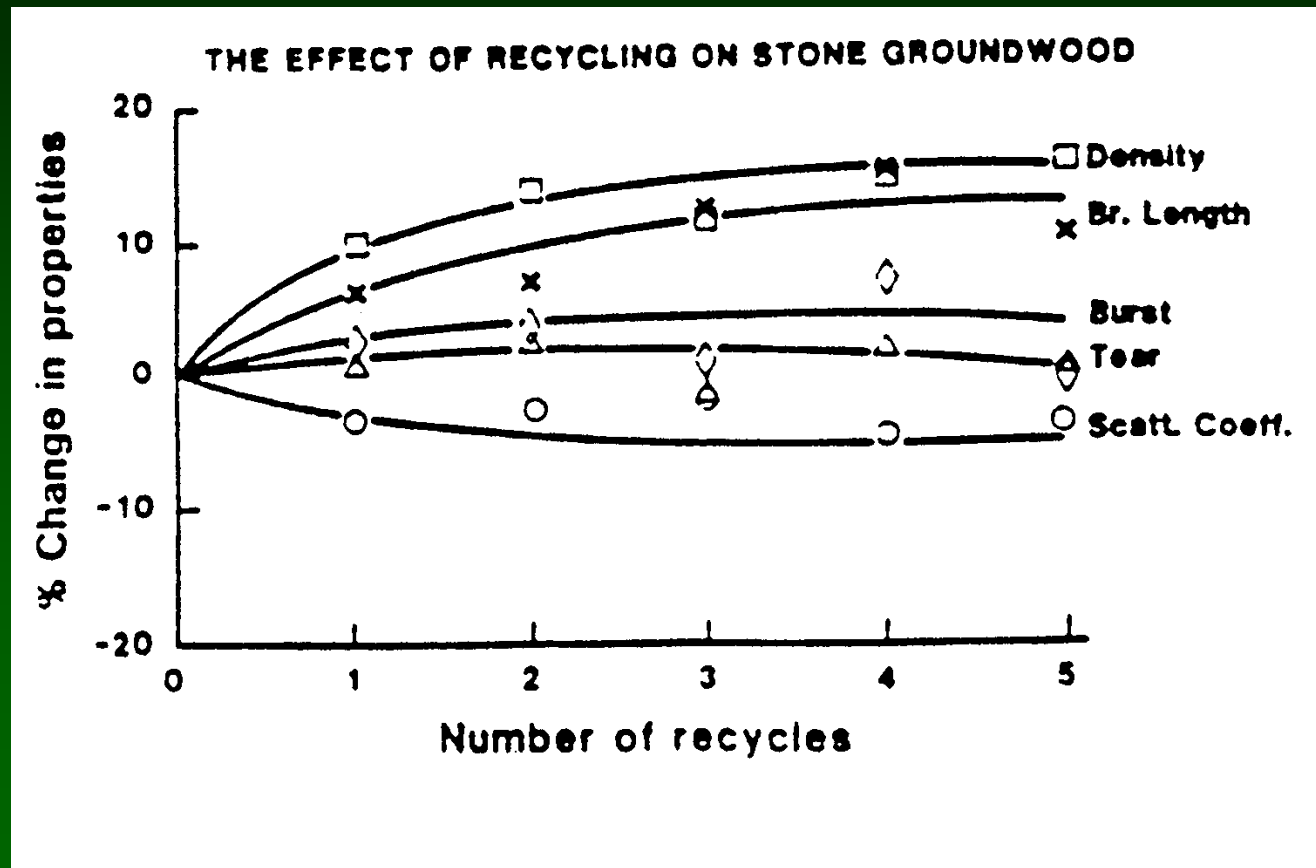
Effect of Recycling on Mechanical Pulps

- ⑥ Wood containing pulps from mechanical pulping processes have lignin (a three-dimensional crosslinked polymer) which makes fiber walls stiff and deters water swelling
- ⑥ The stiff, somewhat round cross section fibers make virgin paper with low fiber bonded area and weak fiber bonds
- ⑥ Therefore, the strength of never dried mechanical pulps is generally lower than of never dried chemical pulps
- ⑥ Recycling may improve properties of mechanical pulps by flatening and flexibilizing the fibers
- ⑥ “Different behavior than chemical pulps on recycling”

Effect of Recycling on Mechanical Pulps

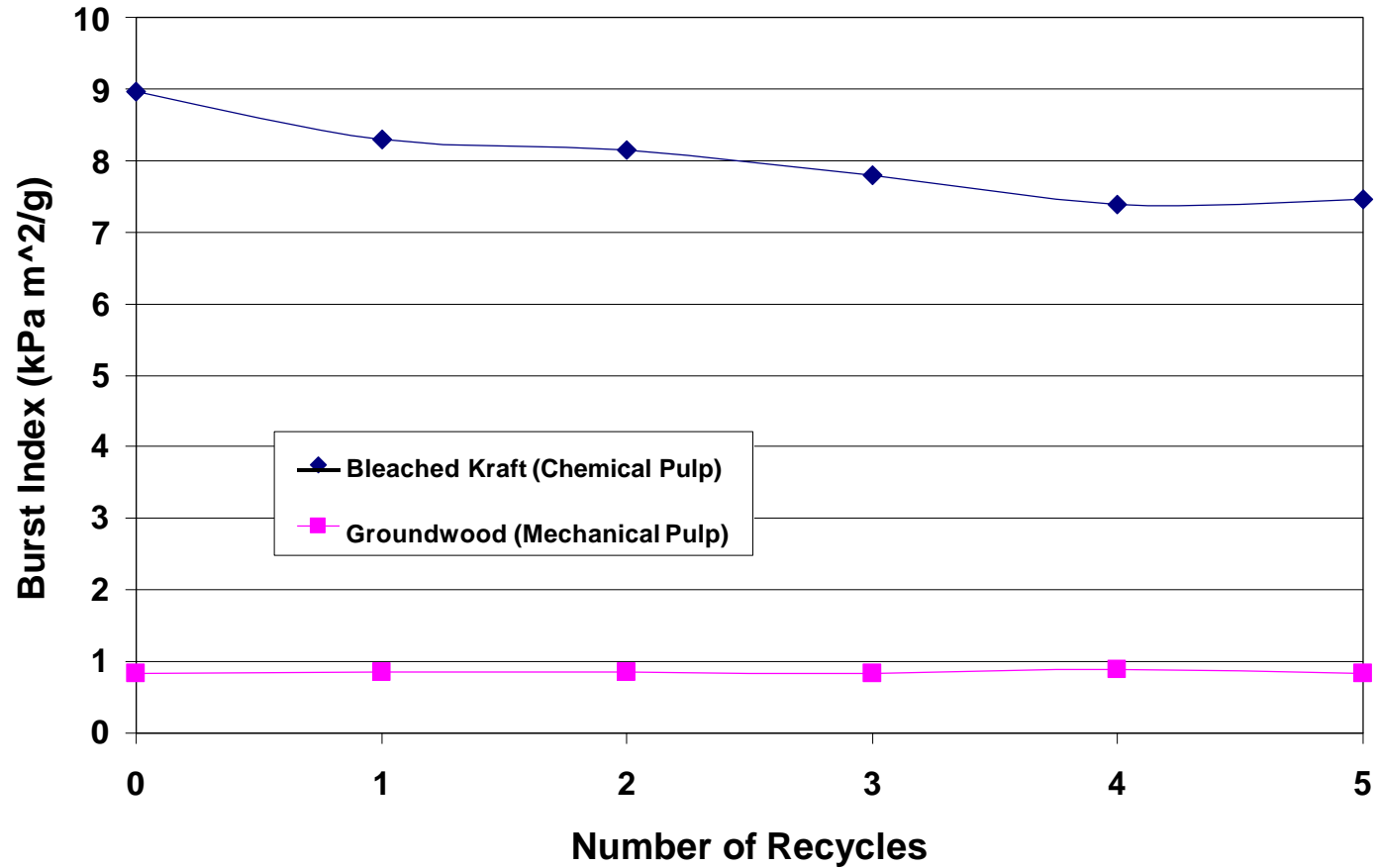


Effects of Recycling on Mechanical Pulps



Paper Strength vs. Number of Times Recycled

(Howard and Bichard, 1st Res Forum on Recycling, Oct 1991, CPPA)



Effects of Recycled Fibers on the Papermaking Process

- ⑥ Lower freeness: decrease machine speeds or add drainage aid
- ⑥ Lower paper strength: more sheet breaks
- ⑥ Low efficiency of chemical additives (fines and anionic trash)
- ⑥ Increased deposits
- ⑥ Decreased cleanliness

Refining of Recycled Fibers

- ⑥ Because recycled fibers are more brittle, the refining process that is used must be of low intensity in order to avoid too much fiber cutting and fines generation

Lecture:

Basic Paper Recycling process terms



Learning objectives

- Understand the following terms
 - ☐ Moisture Content
 - ☐ Consistency
 - ☐ Dissolved solids
 - ☐ Charge on Pulp
 - ☐ Yield
 - ☐ pH

Moisture content (%)

- The term moisture content, as used in the pulp and paper industry, is defined as the percentage of weight of water in the paper
- $MC (\%) = 100\% \times \frac{\text{mass of water}}{\text{mass of water} + \text{mass of solids}}$
- $MC (\%) = 100\% \times \frac{\text{mass of water}}{\text{mass of paper}}$
- Mass of paper or solids includes fibers, additives, fillers, coating.....
- Typically measured by weighing the paper and then drying the paper at 221 F and weighing the bone dry paper.
- Some slides in this section courtesy of Dr. Med Byrd and Dr. Hasan Jameel at PSE NCSU

Moisture content (%)

- Paper is hygroscopic, meaning it has a natural tendency to absorb
- The MC in paper depends on the humidity of the air
- The MC in paper depends on the composition of the paper

- Ref: The Effect of Moisture on Paper. Helen U. Kiely, Chief Chemist American Writing Paper Company, Inc. 1927. The text contained herein was written by Helen U. Kiely, and delivered by Joseph H. Burgen before the Joint Session, Connecticut Valley Mill Superintendents and Printing House Craftsmen, March 5th, 1927.

Temperature 70 F.

% Relative Humidity	% Moisture in Paper
100	21.5
90	13.5
80	8.9
70	8.4
60	6.5
50	5.6
40	3.4
30	2.3
20	1.8

Consistency

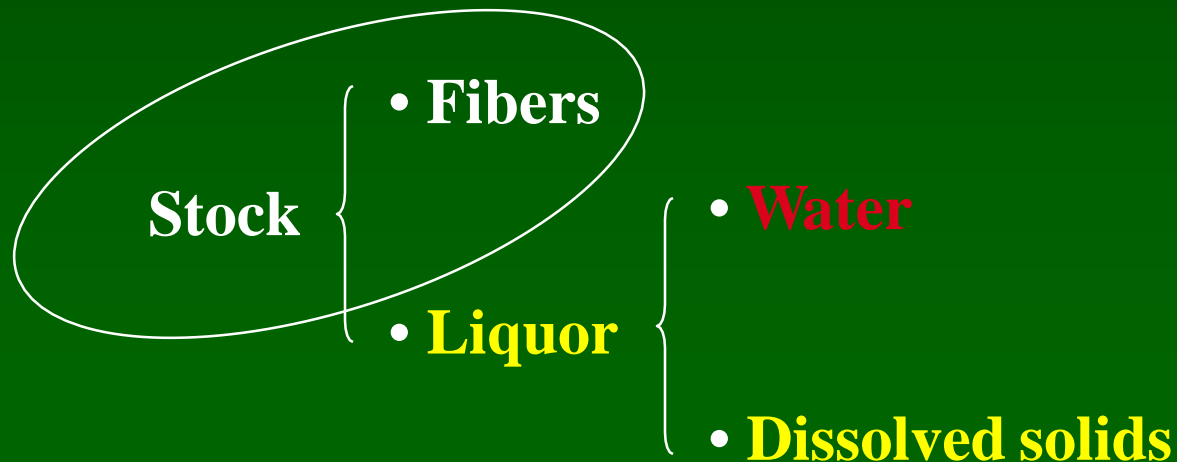
- The term consistency, as used in the pulp and paper industry, is defined as the percentage of weight of oven dry fibrous material in stock (pulp and additives) and water.
- It is very similar to % solids, the difference is that % consistency only measures the suspended materials and not the dissolved solids.
- Fibers in water: suspended solids
- Table salt in water: dissolved solids
- When fibers are involved, consistency is the more appropriate term to use.

Consistency

- The definition of consistency may be expressed as:



$$\text{Consistency, \%} = \frac{\text{Dry weight of fiber}}{\text{Total weight of stock}} \times 100$$

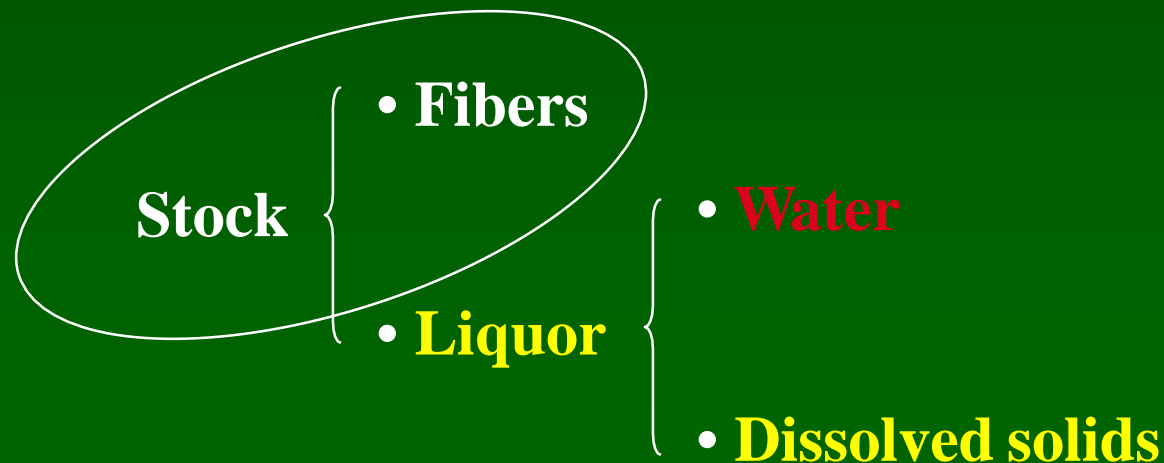


Consistency

- When you think about it, knowing the dry fiber content of a given process stream is critical.
 - We measure production rate based on dry fiber, not water.
 - We dose (charge) chemicals into the process based on dry fiber, not water.
 - We calculate the yield of a given process based on dry materials, not water.
 - *But most of our process streams have both water and fiber!*

Consistency

- The moisture-free portion of a given sample of pulp or pulp slurry is known as the *oven-dry (OD) weight*, sometimes known as the *bone-dry (BD) weight*.
- It is standard in our industry to use an oven at 105 C to gently dry samples for consistency testing, until they no longer lose weight.
- ⑥ T 240 om-88. The hand sample method consists of manually selecting and weighing a representative sample, removing the water, drying the sample, and weighing the remainder.



Consistency: Example 1

- A scoop is used to take a sample of pulp slurry from an agitated tank that is known to have 44,000 pounds of total slurry in it.
- The contents of the scoop are weighed, and the weight is 385 grams. The sample is put into a beaker and placed in an oven at 105 C overnight, so that all the water is driven off. In the morning, the dry contents of the beaker are weighed, and the weight is 23.2 grams (more properly, 23.2 OD grams).
- A. What is the consistency of the tank contents?
- B. What is the total dry fiber content of the tank?