

PULP AND PAPER

A variety of fibrous raw materials may be used in making paper. The highest quality papers are made from rags. Today, almost all paper products are made from wood pulp.

In the papermaking industry, woods are designated “softwoods” or “hardwoods”. This does not refer to hardness or softness in the normal physical sense. “Softwoods” are the needle bearing trees (conifers) such as pine, spruce, fir, balsam, and hemlock. “Hardwoods” are the leaf bearing trees (deciduous) such as oak, maple, birch, gum, aspen, and cottonwood.

The fibers of “softwoods” are longer than the fibers of “hardwoods” and, as a result, produce a stronger pulp.

An excellent reference to the entire papermaking process is “Paper and Paperboard Manufacturing and Converting” 2nd Edition by James E. Kline (Miller Freeman Publishing).

In this discussion, we will concentrate on the areas with the greatest sales potential for EMI/Cleveland Mixers.

THE PROCESSES AND KEY TERMINOLOGY

PULP MANUFACTURE: “Pulp is any fibrous, disintegrated papermaking material, whether in a wet or dry state”. The key word in this definition is “disintegrated” which means that the fibers are freed from the binding materials.

Mechanical Pulping separates fibers by frictional grinding of logs with grinding stones. This produces *Ground wood* pulp that is most commonly used to make a cheap, low quality paper such as newsprint.

Chemical Pulping separates the fibers by dissolving the lignin that holds them together. The two most common processes are “**KRAFT**” and “**SULFITE**.”

THE KRAFT PROCESS

The Kraft pulping process is, by far, the most common in the industry. The reasons for its success are:

1. The strength of the pulp
2. The ability of the process to handle a wide range of raw materials.
3. The ability to recover and recycle most of the chemicals used.

The Kraft process is a modification of the earliest pulping process called “Soda Pulping.” In this process, lye (sodium hydroxide) and wood chips were fed to a pressure cooker (digester) where lignin was dissolved.

The modification involved the direct addition of “saltcake” (sodium sulfate) with burned lime. This resulted in a liquor with another ingredient, sodium sulfide, which acted as a buffer and provided a more gentle reaction with the wood chips and a stronger pulp. Hence, the name Kraft from the German word for strength.

Kraft pulp is also known as “Brownstock” due to the color of the unbleached pulp, or a “Sulfate” pulp. The chemical composition and color of the liquid; changes from stage to stage of the cycle. In papermaking parlance, the liquors are simply known by their color.

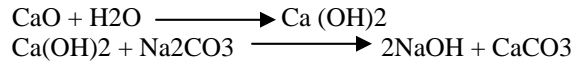
1. White Liquor (or cooking liquor) dissolves the lignin binder freeing the cellulose fibers. The dissolved lignin turns the liquor black.
2. Black Liquor is concentrated, mixed with saltcake, and lignin burned in a smelter leaving an ash, or smelt, which is dissolved in the water producing green liquor
3. Green Liquor is reacted with lime to produce white liquor for reuse.

During the initial black liquor concentration, saponified fatty and resin acid salts separate as "Tall Oil" soaps. These can be skimmed off and acidified to produce a crude tall oil, which can then be fractionated into fatty acids.

MIXING APPLICATIONS

The Kraft Recovery System has a number of good mixer applications with general guidelines as follows. A schematic of the system is shown on page 4.

Lime Slaking and Causticizing: Green liquor is reacted with quicklime to convert the inactive sodium carbonate to sodium hydroxide. It involves a two-stage reaction, the first called "slaking" and the second "causticizing."



The slaker will require about two motor hp/1000 gallons with an XTF3 impeller at 0.4 D/T ratios. To approach equilibrium, causticizing requires three tanks in series; each with 0.6 hp/1000 gallons and XTF3's at 0.35 D/T ratios.

Lime Mud Storage: After causticizing, the white liquor is sent to a clarifier where the lime and (CaCO₃) is separated. The mud is washed, stored in large tanks, and fed to the kiln where it is reconverted to calcium oxide. Use 0.3 hp/1000, XRF3, 0.35 D/T.

Dregs Washing: Dregs are solid impurities in green liquor, which must be removed before causticizing. Washing will dissolve any lumps of sodium carbonate for recovery. The rest of the dregs are discarded. Use 1.2 hp/1000 gallons, XTF3 at 0.35 D/T ratios.

Saltcake Dissolving: Saltcake is added to black liquor before the recovery furnace. The solids are often as large as 1" and can clog the pump if not completely dissolved. This problem is often solved by installing a screen at the vertical midpoint of the tank with a radial flow impeller above and below the screen. Use 3 hp/1000 gallons, RAD4's at 0.35 D/T ratios.

Tall Oil Reactor: Soap, which floats to the top of weak black liquor storage tanks, is pumped to a reactor and treated with a solution of sulfuric acid and sodium sulfate. Tall oil is the product and decanted off. The lignin's that remain are disposed of by burning the furnace. Use 0.6 hp/1000 gallons, dual XTF3s at 0.35 D/T ratios.

Smelt Dissolving Tanks: The mass of molten sodium salts, or smelt, that flows out of the recovery furnace through water-cooled spouts is broken into particles by "shatter nozzles" and is dissolved in water. The mixer must aid in the dissolving and help distribute heat to prevent explosions. Side Entry Smelt Dissolvers tend to be very high maintenance items.

For this severe service we will quote only Top Entry using:

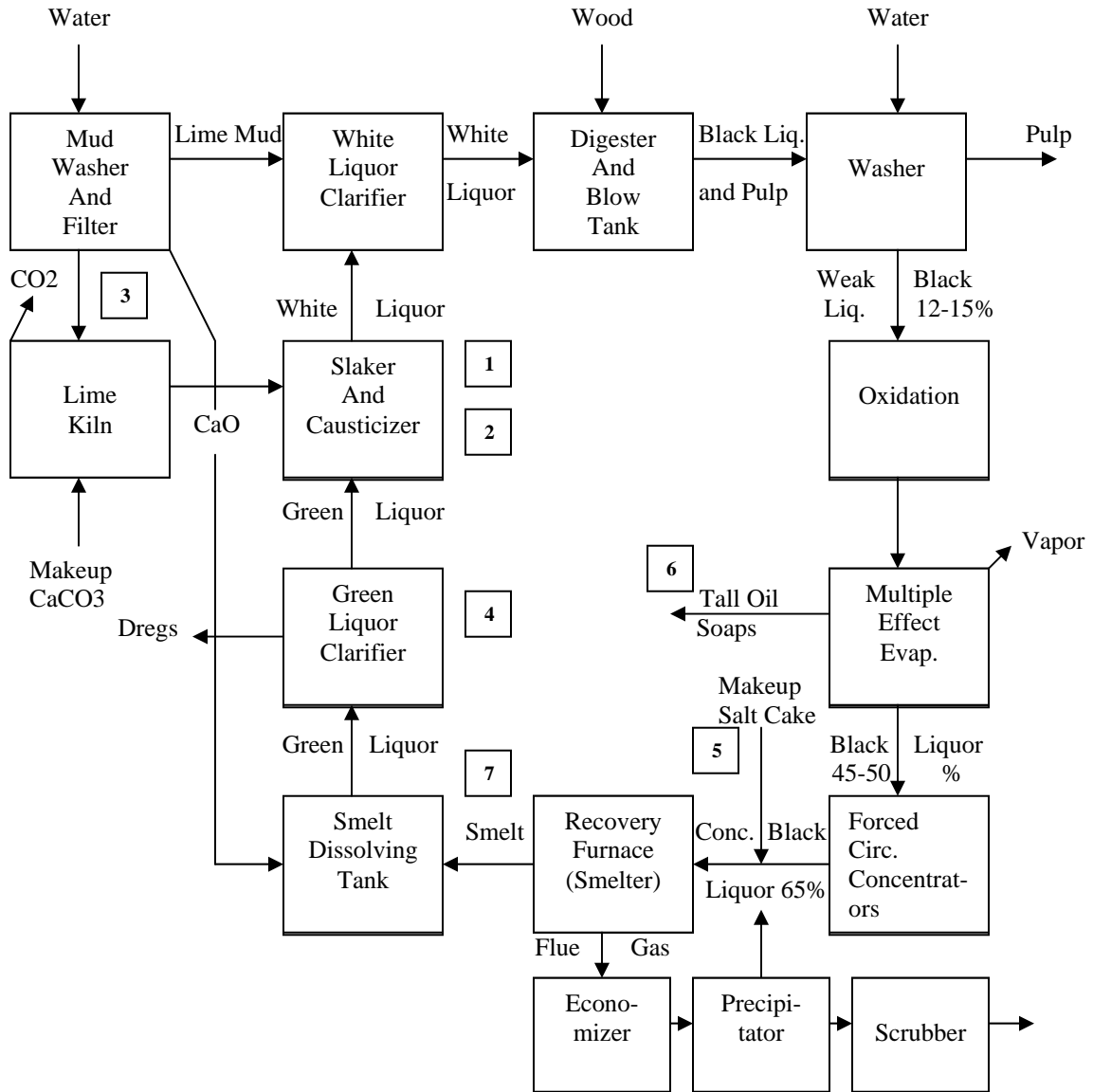
- BHD Series reducers with 1.5-2.0 service factors,
- The largest shaft diameter available with a given cae size,
- A curved blade radial (CRD-4) with stabilizer,
- 316 SS construction
- Sizes in the 15 – 60 hp range depending on tank diameter or length x width if oval shaped.

THE SULFITE PROCESS

The second major pulping process is called Sulfite pulping. It can produce a very high quality pulp, but the process is on the decline because:

1. Yields and strength are lower than Kraft.
2. The cooking liquor is not easily recycled and waste disposal is a major problem

TYPICAL KRAFT RECOVERY SYSTEM



1 - 7 See Table A on next page.

TABLE A

SUMMARY OF KRAFT RECOVERY SUSTEM MIXER APPLICATIONS

#	APPLICATION	HP/1000 GAL.	D/T RATIO	IMP. TYPE
1	Lime Slaking	2	0.4	XTF3
2	Causticizing	0.6	0.35	XTF3
3	Mud Storage	0.3	0.35	XTF3
4	Dregs Washing	1.2	0.35	XTF3
5	Saltcake Dissolving	3	0.35	RAD4
6	Tall Oil Reactor	0.6	0.35	XTF3
7	Smelt Dissolving	0.5 – 1.0	0.25 – 0.30	CRD4

PAPERMAKING

THE PAPERMAKING PROCESS

In a typical mill, there are a large number of towers and chests where the pulp is bleached, diluted to the desired consistency, and blended with other pulps, sizes, wet strength agents, fillers, and dyes.

These stock chests have historically been handled with V-belt drive side entry mixers with water-flushed stuffing boxes. Some mills have started to use top entry mixers because of (1) a horsepower savings for equivalent agitation, (2) elimination of shaft seals and the associated maintenance costs, and (3) the elimination of a large volume of flushing water.

At present, EMI does not offer side entry mixers for stock agitation. We will bid a top entry unit on a selected basis.

Additives and Dyes: The preparation of additives and dyes is usually done with PORTABLE MIXERS. At most mills these will simply be ½ or ¾ hp gear drive portables that are kept in stock in the storeroom. They are ordered, 4 – 6 at a time, from inventory cards by the “stores” buyer. Make it a point to meet him/her!

PAPER COATINGS AND FILLERS

A large number of mills use filler clay, added to the stock, as an extender and to modify the optical properties of the sheet.

Mills producing coated papers will have an area called the coating kitchen where pigmented surface coatings are prepared.

Clay Makedown requires that the dry solids be rapidly wetted out in the liquid. This is especially important during the last stages of the addition (above 60% solids) when the bulk density of the clay is approximately equal to the slurry density. With out a good vortex, the clay will float, resulting in partial wetting and balling.

Proper wetting does not completely describe the process requirement. Additional energy is required to physically disrupt the clusters of pigment and produce the required degree of dispersion. A typical specification might call for 0.03 - 0.05 % maximum retained on a 325-mesh screen. Relative sediment volume (RSV) is another measure of dispersion since dispersed particles will occupy a smaller settled volume than clusters or agglomerates.

Kaolin clay slurries are normally made down to 68 – 72% solids. Clay is received in 50 ton to 100- ton rail cars. A 10,000-gallon tank is required for 50 tons of clay at 70% solids.

Typical physical properties for clay slurries are 1.75 specific gravity and 100-300 centipoise viscosity. Dispersing agents are used to help in wetting and to keep the viscosity at this level. Filler clays are often made down to 60% solids with a specific gravity of 1.58 and 100-300 cps viscosity.

COMMON METHODS OF CLAY MAKEDOWN & MIXER APPLICATIONS

Direct Makedown: Water and a dispersing agent are added to the tank. With the mixer running, the dry clay is added at rates up to 15 tons per hour. An upper axial flow impeller (for wetting) and lower radial flow (for shear) are used, with baffles cut off even with the axial. This helps to maintain the vortex. Typical horsepower levels are in the range of 6 – 12 hp/1000 gallons, at 0.3 D/T ratios.

Direct Makedown with Recirculation: Here, a pump is used to recirculate slurry into the tank with the incoming clay to aid in the wetting process. This method is most often used with filler clays. Hydrofoil impellers may be used at 2 – 3 hp/1000 gallons, and 0.3 D/T.

Makedown with High Shear Tank: This system utilizes a main tank for wetting out the clay and a 500 – 1000 gallon recirculation tank with a high shear mixer. This will generally mean less installed horsepower but a longer mix time resulting in a comparable energy use per ton. It also permits the best degree of dispersion. The makedown tank can use hydrofoils at 1 – 2 hp/1000 gallons. The high shear tank will be 15 – 25 hp/1000 gallons with a disc impeller or bar turbine.

Some mills use the Direct Makedown design and have a high shear tank as a “polishing” system, or backup.

Calcium Carbonate and Titanium Dioxide are used in coating formulations to supply higher brightness, better opacity and ink retention to the coating.

Higher energy levels are required for dispersion of these pigments than for kaolin clays. High shear mixers at 75 – 100 hp/1000 gallons are typical. Because usage is lower, these pigments are often purchased in slurry form, so only storage is required at the mill.

Slurry Storage requires that the product remains uniform, but little horsepower is needed because the dispersed pigments have extremely low settling viscosities. Square and rectangular tanks without baffles are very common. On- center mounting with baffles or off-center mounting without baffles can be used with cylindrical tanks.

Power level will vary from 0.05 – 0.25 hp/1000 gallons, D/T ratios around 0.4 and low speeds are preferred.

“COOKING” – TYPICAL MIXER APPLICATIONS

Adhesive Cooking: The most common adhesive used to bind the pigments to the sheet are starches, casein and protein, used alone or in combination.

Batch Cooking involves mixing the dry starch granules with water and enzyme, heating to 160 – 170 °F with direct steam injection, and holding for 30 minutes. The viscosity will reach a peak at the “strike point” and then drop rapidly to the 200 – 500 centipoise range. Peak viscosities will vary with formulation, as will the power requirements.

Peak Viscosity	Power Required
To 5,000 cps	2 hp/1000
To 20,000 cps	5 hp/1000
To 50,000 cps	10 hp/1000

Continuous Cooking has become much more common than batch cooking. Jet cookers provide an accurate control of cooking temperature and rapid swelling and bursting of the starch granules. The mixing requirement is simply to provide uniform feed slurry to the jet cooker. A typical feed will have a specific gravity of 1.15 and a viscosity of 100 cps. Hydrofoil impellers at 2 – 3 hp/1000 gallons, and 0.35 – 0.40 D/T are suitable.

In some cases dry starch is mixed with clay slurry ahead of the jet cooker. The product coming out of the cooker is called Hot Color. Pre-cook blending will involve S.G. = 1.8 – 1.9 and viscosities around 1000 cps. Because the slurry viscosity helps hold the starch granules in suspension, power requirements are similar to above.

Batch Blending of cooked starch and pigment slurry requires axial impellers as follows:

Final Viscosity	Power Required	D/T Ratio
5,000 cps	5 hp/1000	0.4 – 0.5
20,000 cps	10 hp/1000	0.5 – 0.7
100,000 cps	20 hp/1000	0.5 – 0.7

Coating Storage requires that the final coating be kept uniform. Use axial impellers as follows:

Final Viscosity	Power Required	D/T Ratio
5,000 cps	2 hp/1000	0.4 – 0.5
20,000 cps	5 hp/1000	0.5 – 0.7
100,000 cps	10 hp/1000	0.5 – 0.7

Polymer Emulsions are also used as binder with pigment slurries. The latex will have a low viscosity, which allows higher coating solids for the same final viscosity. Use blending and storage selections based on final viscosity, as above.

SUMMARY: PAPER COATING & FILLER MIXER APPLICATIONS

APPLICATION	VISCOSITY RANGE CPS	HP/1000 GALLON	D/T RATIO	IMPELLER TYPE
Direct Clay Makedown	100 - 300	6 - 12	0.3	u-AXF4 l-RAD4
Makedown with Re-circulation	100 - 300	2 - 3	0.3	XTF3
Makedown with High-Shear Tank	100 - 300	1 - 2 Main Tank ----- 15 - 25 Hi- Shear Tank	0.3 0.2	XTF3 Disc. Bar Tub.
CaCO ₃ & TiO ₂ Makedown	100 - 300	75 - 100	0.25	Disc. Bar Tub.
Clay Slurry Storage	100 - 300	0.05 - 0.25	0.4	Axial (1)
Batch Starch Cooking	To 5,000 cps To 20,000 cps To 50,000 cps	2 5 10	0.3 0.4 0.4	AXF4 AXF4 AXF4
Continuous Cooker Feed	100	2 - 3	0.35 - 0.40	XTF3
Pigment- Adhesive Blending	5,000 20,000 100,000	5 10 20	0.4 - 0.5 0.5 - 0.7 0.5 - 0.7	Axial (1) AXF4 AXF4
Coating Storage	5,000 20,000 100,000	2 5 10	0.4 - 0.5 0.5 - 0.7 0.5 - 0.7	Axial (1) AXF4 AXF4

(1) If Reynold's Number above 200, use XTF3 unless impeller must be less than D/2 off-bottom.