



Woodyard *Chip Handling*

Article 5

From: A Series of Articles...

Case Studies in Improving Your Chip Supply
Pulping System Sensitivity to
Chip Quality

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Pulping System Sensitivity to Chip Quality

In several previous papers on chip quality published in this magazine, I have discussed the ways and means used to separate chips by size. I have then shown how to modify the sizes of the individual chips (as for oversize through Cracking or Slicing) or to modify the distributions of chips through screening (as for fines and pin chips). At points I have noted that some pulp producing processes may use one method or another to their best advantage, and certainly there are trends in the use of many of these pieces of equipment and processes in different segments of the industry. In this paper I will show how the base processes are sensitive to particular elements of chip quality, and how chip size distribution modification methods have been developed and applied to best suit the pulping outcomes desired.

Please consider this to be a very elementary introduction to the pulping systems used in our industry. In order to focus on the key components of chip quality I necessarily generalize about the pulping systems mentioned, and if I have omitted some particular characteristic of a pulping system with which you are very familiar, please understand that there are a myriad of local conditions and differences which I simply cannot describe in such a general summary paper as this. My intent is to cover a broad range in generalities, and not in specifics. As always, it seems, local conditions have a huge impact on the needs of a particular mill, so that even these general comments and recommendations have been modified and molded to suit the perceived needs of a particular mill.

Mechanical Pulping

As a broad classification, mechanical pulping is any method that uses

grinding as the elemental means to separate fibers from solid wood to produce a pulp. In the cases where chips are used (and not whole logs, as in stone grinding), there are 2 fundamental ways this is accomplished, where the chips are either pre-heated and softened in a pre-steaming bin, or where they are ground under as-received conditions without heating (atmospheric refining).

Atmospheric refining is a rather tolerant process, where only the sand and grit need be removed to preserve refiner plate life, and the largest chunks and pieces are removed to prevent handling plugs in the feed system. To accomplish this a rotary screen is typically used, where the top deck is fit with a round hole screen of 45mm diameter, and a 4 mesh wire fines screen (open area is approximately 5 mm square opening, or $3/16''$) for fines removal. Rejected overs are rechipped and re-screened, and fines are passed to the power boiler or to land fill. Pin chips are refined without problem, and fines are really only objectionable because of their high grit and bark content. In grinder operations the refiner plate life is a high cost of the process of making pulp, and processing steps upstream of the refiner that extend the time between plate changes are very important to the overall cost.

In many mills the pin chip losses can be limited by the use of a DiamondRoll™ screen on the rotary screen fines. The roll screen can trim the amount of wood that passes out as boiler fuel.

Moisture content of the chips is not terribly important in mechanical pulping systems, provided it is uniform and above the fiber saturation point (FSP). Dry wood produces a pulp that contains a high amount of un-separated wood, called

shives. For this reason mechanical pulp mills in the vicinity of trees killed by beetles or fire can suffer from poor pulp quality if this dead standing timber, which is air dried over time, is introduced into the process without warning. Methods to identify the dry wood and to blend it in to green wood at a particular rate have been successful in limiting the effects in the pulp mill, so that I note in the table that moisture content is not important as long as it is above this critical moisture content called FSP.

Footnote: Fiber saturation point (FSP) is that moisture content in a piece of wood where the fiber cell walls are fully saturated with water but where the lumens or open volume of the fiber is empty. Above this moisture content the fiber fills with liquid water, as you might imagine a glass fills with water. Below the FSP the fiber walls dry out, with the effect that they shrink and harden. Water bonds mildly with the cellulose molecules in the cell wall causing them to swell and soften, so wet wood is easier to separate by grinding than dry wood.

The FSP is typically about 25% on a wet basis for most woods in North America, and the air dry condition is usually about 10-12%, so there is a significant difference between "green" wood at 45% moisture content, and air dry wood at 12%.

Pressurized refining adds a stage where the chips are passed through a pressure vessel that exposes the chips to heated steam under some amount of pressure. This has the effect of adding some moisture to the chips, drives out air that might be in the cell lumens, and most importantly, softens the cell components with heat so that they weaken and separate more easily during refining. The middle layer between the cells (middle lamella) softens fastest, and

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Summary of Pulping System Sensitivity to Chip Quality						
Pulping System	Oversize/OT	OT Processing?	Preferred Accepts	Pins	Fines	Moisture Content
Atmospheric Refining	+45 mm RH*	Rechipper		None	-3 mm RH	+FSP
Pressurized Refining	+ 6 mm T**	ADS only		None	-3 mm RH	+FSP
CTMP, BCTMP	+6 mm T	ADS only		None	-3 mm RH	+FSP
Steam Explosion Defibering	+30 mm RH	Rechipper		None	-5 mm RH	None
Directly Heated Batch Kraft	+8 mm T	Cracking	+4, -8 mm T	No Sensitivity	-3 mm RH	Very sensitive
Indirectly Heated Batch Kraft	+8 mm T	Cracking	+4, -8 mm T	-	-3 mm RH	Very sensitive
Standard						
Continuous Kraft	+8 mm T	Cracking	+4, -8 mm T	-7 mm RH	-3 mm RH	Very Sensitive
MCC and EMCC Continuous Kraft	+10 mm T	Cracking	+6, -10 mm T	-2 mm T	-3 mm RH	Very Sensitive
Sulfite	+ 8 mm T	Slicing	15-18 mm chip length	-7 mm RH	-3 mm RH	Moderate
Neutral Sulfite Semi-Chemical Refining (NSSC)	None	None	Clean chips	None	None	None
Sawdust Digesters for Kraft (M&D, Pandia)	+ 10 mm RH	Send to chip system	Sawdust***	None	None	None

* RH means round hole, based on ChipClass-style classification trays.
 ** T means thickness, based on ChipClass-style classification trays.
 *** Sawdust from sawmill operations: as in "real sawdust".

the cellulose-rich fiber walls are resistant to softening at this temperature, so the fibers remain essentially intact.

The net impact of this processing on chip quality requirements is that the largest chips may be too thick to be penetrated by the steam under the conditions used, so they may contribute to some shives. In many cases this problem is solved through the action of the plug feed screw that feeds the chips into the refiner. This high compression, high shear screw smashes the large chips before they get to the refiner, and the environment inside the screw casing is hot and steamy, softening the center of the largest chips adequately.

Overall the only really objectionable "chips" are the knots present in the infeed flow. These are removed through the use of an Air Density

Separator (ADS). Knots are the embedded branches that break out of the stem during chipping making large, resin-soaked, curly-grained dense wood chunks that do not grind into pulp but produce shives and "stickies". The use of a rotary screen or simple thickness screen will isolate these large knots and the larger chips into a flow that can then pass through the ADS where the knots are removed. Small knots less than 6-8 mm thick do not seem to cause much trouble, but the large knots do. A properly adjusted ADS will produce a pile of knots and rocks in an 8 hour shift that the pulp mill manager will attest would never make proper pulp.

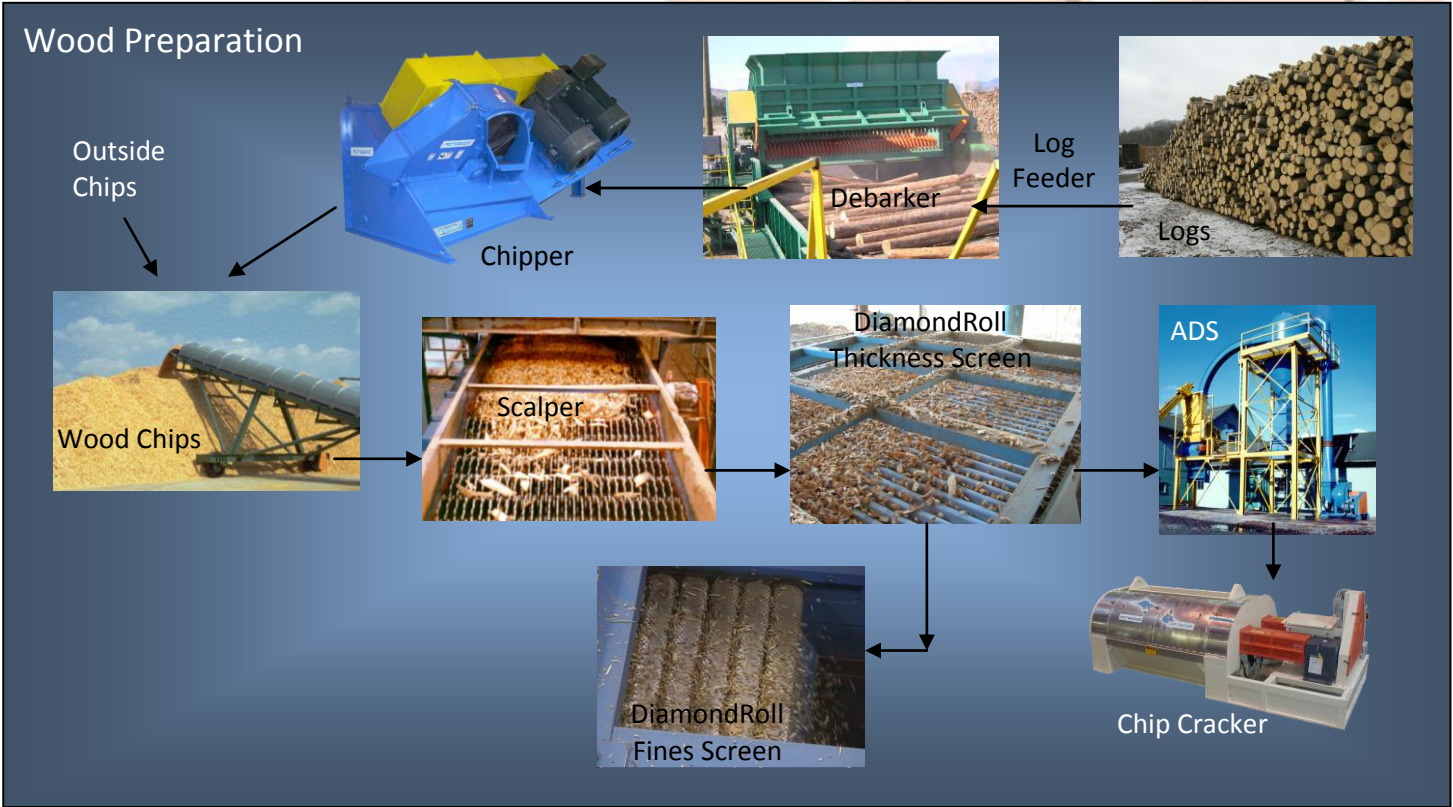
Various modifications to this basic process have been developed, but do not really change the chip handling requirements described for pressurized refining. Adding some pulping chemical to the pre-heating

bin or inside the plug feed screw (CTMP), or bleaching the resulting pulp (BCTMP) still rely on the application of refining energy on a heated chip and the rules still apply. Again, local conditions can affect the system needed, as if the mill has a high dirt content in the chips, or if there are significant whole log chips in the feed with a high knot content, additional steps may be needed to control the overall flows and splits.

Chemical Pulping Systems

Chemical pulping systems use a process where chips are subjected to a chemical extraction that removes the key binding material that exists between the fibers that holds them together. This binder is called lignin, and it is subject to selective chemical attack when the temperature, pressure, and chemical conditions are just right. Two chemical systems

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predominate in our industry to do this: sulfite and Kraft (sulfate). As the largest mills using the most chips are Kraft, I will start on this process first.

Kraft Pulping

In Kraft cooking the pulping liquor penetrates the chip in all directions at the same rate, meaning the penetration of the extraction process is just as fast into the face and sides of the chip as it is through the cut ends of the chip. What this means is that the rate limiting dimension of the chip is its smallest dimension, which is its thickness. This was the critical discovery that resulted in Chip Thickness Screening (CTS), and the resultant rush to install CTS systems in every Kraft mill in the world.

Directly Heated Batch Digesters:

The simplest method to extract lignin from chips is to put them into a large pressure vessel with the pulping liquor (extraction chemicals) and heat it all up by adding steam directly into

the vessel. This is called directly heating a batch digester. The chips and liquor remain inside until the process is completed and everything comes out at once.

In this environment the chip thickness is critically important. Many mills cook to a certain knoter rejects level, using this pulp mill pulp screening system to give them feedback about the adequacy of the cook, along with many other measures of the completeness of the process. If there are significant numbers of thick chips in the blend of chips used, these will predominate in the knoter rejects. Thick chips make pulp knots. (Note: Knots in the sense where I described them as embedded branches in stems are known as biological knots, and before CTS, these were the dominant sources of knots in the pulp mill. With the advent of CTS and ADS removal of biological knots, the pulp knoter screens reject insufficiently cooked chips and knots, but in many cases the

biological knots are almost absent in this flow.)

Fines contribute to pulp dirt, and can form pockets within the digester where they rapidly deplete the pulping liquor and create locally "uncooked" areas. Pin chips may also do this when they concentrate in a zone. This can happen if pin chips are concentrated in some way, such as on one side of a conveyor belt which then feeds the pins into one side of the storage bin, etc. Otherwise, pin chips in a uniform blend of chips are generally not a problem in direct heated batch digesters.

Moisture content (MC) in Kraft systems is important for all digester types. The problem is that the action of the pulping chemical is dependent on its concentration, and this concentration is affected by dilution from water that enters with the chips. It is typical for an operator to get a sample of chips and have the lab dry them for 16-24 hours to get a MC, but

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of course the digester load from which the chips were collected has been made into pulp for hours before the test results are known! The operator only hopes that the MC he/she must assume the chips have for the cook is at least close to the actual MC, and that he/she does not under or over cook the chips. On-line systems exist that can measure chip MC accurately, and as the chips enter the digester, so the operator (and the digester control system) can know exactly the MC at the time the digester is filled without guessing.

Indirectly heated batch digesters: It is possible to extract the liquor from the batch digester and heat it through a process of heat exchange without adding steam directly, thereby maintaining the liquor's concentration throughout the cook. This requires that the liquor move from within the chip mass within the digester to extraction locations around the center of the vessel as new (heated) liquor is added at the top and bottom. This liquor movement occurs through the spaces between the chips, so that the chip mass must have a sufficiently open texture to allow it to occur.

Generally speaking, the chips should be large, and not have too many pin chips, as pins soften early in the cooking process and then migrate with the moving liquor to blind the extraction screens. The preferred accepts would be less than the arbitrary maximum of 8 mm but as close to it as possible (shifted to the large end of the Accepts distribution). Overs should be processed through Cracking or Slicing to pulp like

Accept chips. Pin chips should not exceed a certain maximum, dependent on the characteristics of the digester. In some cases the tolerable level is 6% or less. Fines should be minimized.

Standard Continuous Digesters

Known generally by the name Kamyr Digesters, these workhorses of pulping have revolutionized the way chips are converted to pulp. Generally speaking the chips and liquor are added at the top of a long tube or column. They move together under

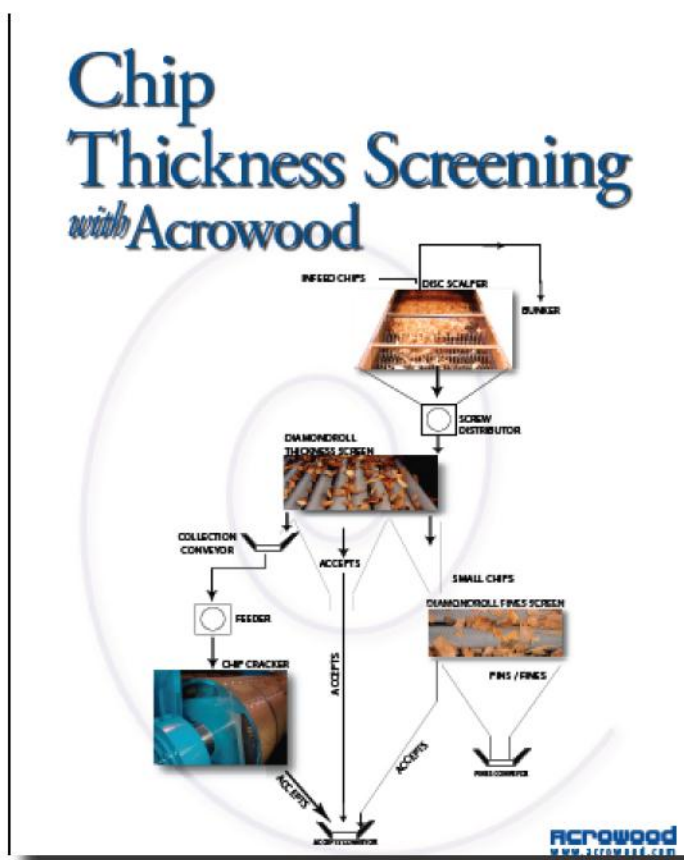
pulp, and are passed continuously into the pulp mill for further processing.

Generally the chip quality requirements for standard continuous digesters are similar to batch digesters. As the chemistry is the same, the rate limiting chip dimension is still the thickness, and thinner chips cook faster than thicker chips. The liquor circulation involved here is similar to the indirectly heated batch digesters, and the pins sensitivity can be the same. In some digesters the extraction screens have been modified

to allow the pin chips to pass through and the pumping system upgraded to tolerate this pulp in the extracted liquor, so the pins sensitivity is less, but generally, the model of liquor flow between chips remains the correct one to use. Fines and grit must be removed, and overs must be processed into Accepts. The pin chips, if screened out, can be sent to the batch digesters in the same mill allowing the continuous digester to operate at a maximum rate.

MCC and EMCC Continuous Digesters: These letters stand for Modified Continuous Cooking and Extended Modified Continuous Cooking, two process modifications made to

continuous digesters that extend the time chips spend in the column to facilitate the process of delignification (creating a more complete cook). These rely on higher volumes of liquor extraction and re-introduction, and this occurs later in the cooking cycle. What this means is that the liquor has to flow between chips (not



heat and pressure as the chips begin to soften. Liquor is extracted and heated outside the column as the chips descend. Zones within the digester create different pressures and temperatures, and new or heated liquor is added and removed at different locations to control the pulping process. By the time the chips reach the bottom of the tube they are

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just pin chips) that are beginning to soften so that the hydraulic permeability of the chip mass is critical.

Larger chips are needed to allow the liquor to flow. The target chip size has shifted upwards to 10mm control on the top end, and to 2mm thickness on the bottom end. Chips less than 2mm thick should be screened out before they get to the digester, and passed to some other process (presumably maintaining their value as chips). Within the accepts range the larger chips are favored, with the >6, <10mm thick fraction preferred. When the objective of the pulp mill is maximum throughput, using larger chips allows the modified digester to pass the highest tonnage through the digester. Diverting the smaller chips to other processes then optimizes the system.

Sawdust Digesting

As a variant of Kraft pulping, sawdust digesters have been designed to take advantage of what is usually thought of as being a waste product, sawdust from sawmills. This material is typically sold as boiler fuel, and at fuel prices that are 20% of chip prices in most locations. The pulp mill with a sawdust digester can purchase this very cheap fiber material and make pulp from it, blending it with the usual long fiber pulp at a 10-20% rate yielding a significant cost savings as a result.

Preparing the sawdust usually only requires that chips and larger pieces are excluded from the digester feed. In a sense, this is the opposite of the down-grading of pin chips from the chip flow: in this case chips which may be present in the sawdust flow are up-graded and sent to the chip pulping system at the mill. The angled tube that is used for pulping is a short retention-time, continuous digester where a paddle conveyor drags the

sawdust through a liquor which rapidly penetrates and separates the sawdust material. As this comes from sawmills it is considered to be free of dirt and grit so fines screening is not necessary.

Sulfite Pulping

In contrast to Kraft (sulfate) cooking, sulfite pulping liquor penetrates chips through the fiber lumens. This means that the rate limiting dimension of the chip is its length, and that thickness is not important. In most sulfite mills a chip length of 15 to 18mm is used, and a rotary screening system is used to insure that over length and oversize chips are rechipped. Fines are critical, as most sulfite pulps are used for fine papers and papers where grit content is most undesirable (tissue, bathroom tissue, and sanitary products).

There have been sulfite mills that have evaluated CTS and found it to their benefit. Certainly chip size uniformity is its own reward, where consistency of supply leads to uniform operating conditions and improved digester performance. Modern CTS systems are excellent at removing fines and grit, and this must help. Thickness control at 8mm coupled with Slicing leads to a feed where oversize and over thick are limited to a very low level. Pin chips seem not to be that important, and the size distribution within the Accepts is likewise, not critical.

Neutral Sulfite Semi-Chemical (NSSC)

This is a pulping process associated with producing a rough pulp used for corrugating medium in cardboard construction. It is a fast and forgiving process, sometimes used as a “dumping ground” for poor chips that didn’t make the grade for other processes. It essentially involves a process like the pressurized refining process, with the addition of a

pulping chemical to aid in softening chips prior to refining. Thickness is not important, and neither are fines or pins. Most NSSC processes do not employ fines screening, and so tolerate the plate wear life reductions they may accrue. Some NSSC processes use recycled wood (urban waste wood that has been hogged) as a raw material.

Conclusion

Pulping is a process that has been developed to produce certain final products. Wood chips form an important component in this production chain, strongly affecting the cost and quality of the pulp produced in the pulp mill that receives them. Methods to control and modify the size and condition of wood chips can be employed to tailor the size distribution of wood chips so that they can reduce cost and improve the quality of the pulp being made. The pulping process has a fairly rigid requirement for the quality of chips it receives, and these requirements can be met effectively, and consistently, through the use of Chip Thickness Screening, and other methods.