New approaches to fines and pins screening

Desmond E. Smith and Shannon R. Javid

Recent improvements in fines and pins separation in whole chips, chip residues, flakes, shavings, and sawdust have allowed final product-specific targeting of small-particle fractions present in many raw materials.

What is the value of screening out chip fines? It depends. Are the fines free of contamination and decay? Are the particles short in the wood grain direction so that a high percentage of the fibers are cut? Will the fines be processed through batch or continuous digesters? How are critical pulp properties affected by the unique properties of fine wood particles?

Pin chips, chunks, thin chips, bits, sawdust, fines, dust: What is the right way to define the smaller chips found in all chip samples? Don't spend too much time looking in the literature. There is no North American pulp and paper industry standard method to define this important raw material property, and little work has been done in the recent past to remedy the situation (*1*). The industry needs a consistent and technically defensible definition of small-chip fractions.

Chip quality continues to increase in importance as pulp mills place more emphasis on the pulping process and product variability (*2*). The technology to precisely screen chips has advanced to the point that a mill can precisely control the chip quality it needs to within narrow limits. Defining these limits has become critical. Without them a mill runs the risk of selecting the wrong screen system for its needs, installing insufficient screening capacity or too much screen capacity—in short, not getting the value that they paid for.

Origin of small-chip particles

The mechanical properties of wood are not equal in the transverse, radial, and tangential planes. Consequently, when a chipper knife passes through a log, the shearing forces are not equally transferred in all directions. As a result, chip dimensions (thickness and width) have a distribution around a statistical mean value. Small wood particles separate and break free in the chipping process, as does bark and other debris present on the log surface. Some wood particles are long slivers, and some are chunky (**Fig. 1**). The amount of these small particles depends on chipper condition and maintenance, stability at the wood-knife interface, wood moisture content, presence of decay, and wood temperature (*3*).

Smith is U.S. sales manager and Javid is vice president, general manager, at Acrowood Corp., 4425 S. Third St., P. O. Box 1028, Everett, WA 98201-1028.

Bark that is attached to the wood when it is chipped is also reduced in size during the chipping process. But bark has lower mechanical strength than wood, and as a result its size distribution is much smaller. Of course, small particles of dirt and grit attached to the wood and bark will also be found in the fine fractions of chips.

Some chips break along the grain during chipping and handling. The length and thickness of these fractured chips may be nearly the same as normal chips, but they are narrow. These are commonly called pin chips. Look closely at a chip, and you will see small fragments adhering to it, barely held by slivers of fibers. In a green-condition classification, these fragments may not show up as fine particles, but with some amount of handling they will break free. The increase in fine particles observed in relatively gentle chip pile storage and conveying systems is unavoidable due to these loosely bound particles. If handling is more forceful (as in pneumatic conveying or bulldozer reclaim), large numbers of chips are fractured, and the entire chip size distribution is shifted downward.

Some chip types are more fragile than others. Chips made by chipping headrigs are the weakest, especially those shaped like planer shavings (about 5–10% by weight). Veneer chips are also quite fragile due to lathe checks produced along the grain in the veneer peeling process. With only moderate mechanical action, these checks break completely through and form pin chips and fine particles. Even whole-log chips cannot withstand the rough handling of many passes of a chip dozer and the high-velocity, abrasive impact at the elbows of poorly maintained pneumatic chip conveying systems. In these extreme cases, chip size distributions are shifted downward, and fines levels increase by 10 times or more.

Some small particles found in chips have nothing to do with the chipping process. Sawdust and shavings from sawmill operations are sometimes mixed with chips by design or due to conveyor leakage and cross-overs. Unlike chipper fines, sawdust tends to be more chunky in shape and nearly free of bark and grit. Planer shavings are similarly clean, but are easily broken into smaller fragments in handling systems.

How to compare fines, pin chips, and thin chips

The absence of a chip size classification standard reflects the relatively recent revolution of chip screening technology and the diversity of opinion about what the value of fines are to the pulping process. **Table I** compares the most common classifiers used to measure chip size distributions and how they typically define small chips. Classifiers with easily interchangeable trays (ChipClass, for example) can be used to test new tray configurations.

The basic variables used for classification are particle length and thickness. There is much that can be learned by completing the length vs. thickness matrix shown in **Table II**. While tedious and not to be done for every sample, it does give a detailed distribution that is useful.

For example, note the relationship of length and thickness. In the upper left corner, notice that longer chips are also thicker. As a general rule of thumb, the mean thickness of a distribution of chips produced in a whole-log chipper is one-fifth the setup chip length. But we are interested in the zone in the lower right (highlighted) corner.

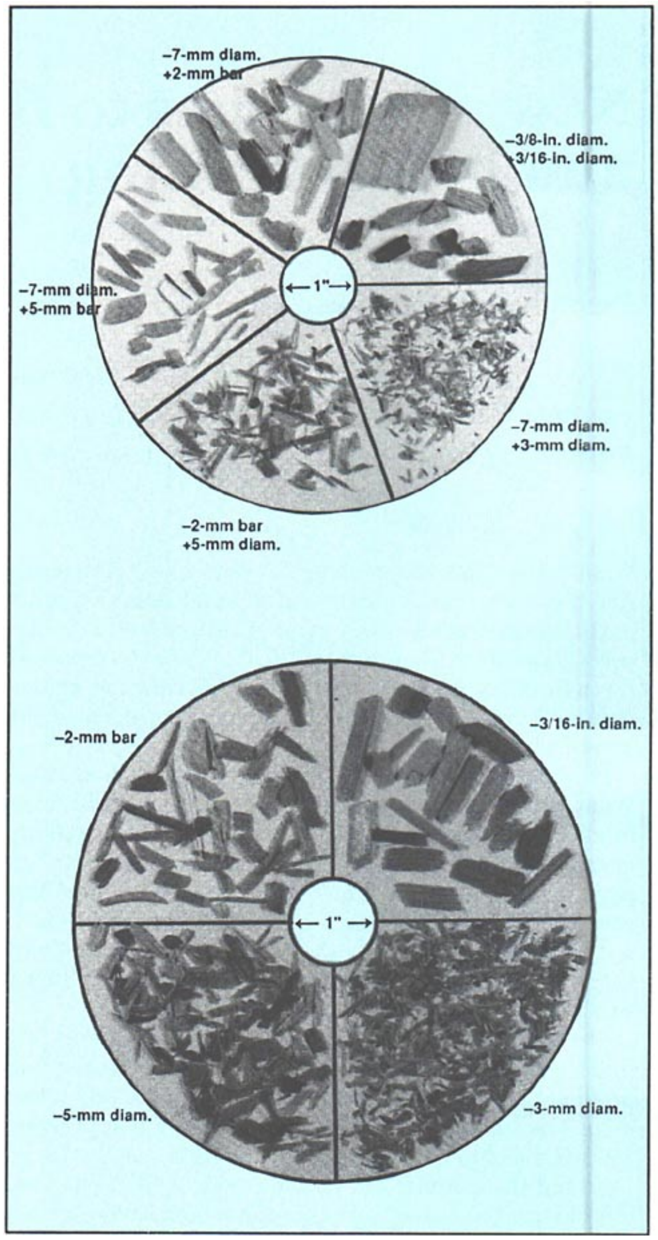
Good pulp from small-fiber fractions?

Every pulp mill is unique. There are always significant differences in chip type and quality, in pulping system design, and in finished product specifications. Basic process principles might apply to similar mills, but in the area of chip screening each mill has different needs. This is important to understand. A chip screening system designed for a bleached mill with batch digesters will not meet the needs of a linerboard mill with continuous digesters. The critical maximum chip thickness will fall between 5 mm and 7 mm, a fairly narrow range. However, the requirements for fines, pins, and thin chips will be very different. The screening system design must match the process and product requirements to the properties of small-chip fractions. If these relationships are not known for the mill, some literature results might be applied or a study initiated.

Process sensitivity

Batch digesters are usually thought to be insensitive to small-chip fractions. Some mills have even tried mixing up to 10% or more clean sawdust and shavings with the chips. The idea is that the small fractions will fill in the spaces between chips and thereby increase the tonnage of fiber in each digester charge. However, as mills study pulping uniformity within both directly and indirectly heated digesters, it is clear that fines can disrupt liquor circulation. Mills that implement liquor displacement cooking also report that small-chip fractions can flow with the liquor. During displacement, the extraction screens are more likely to plug. Few mills have attempted to operate this new pulping concept without efficient chip screening systems in operation.

1. Small particles and pin chips intergrade at the small end of the chip distribution.



Continuous digesters have long been known to be sensitive to small-chip fractions. Maintaining liquor flow is essential to keeping the chip column moving down the digester uniformly. If the extraction screens begin to blind due to fines, the digester will probably experience liquor channeling, high extraction pressure, and wide swings in kappa number.

Liquor and wash water must flow freely during brownstock washing. Small-chip fractions contain high amounts of cut and short fiber particles. These small fibers pack tightly and restrict wash-water flow in both drum and diffusion washers. In addition, the smallest of these become suspended in the dilute black liquor. This fiber

I. A comparison of chip classification methods showing the dimensions used to define the fractions of fines, pins, accepts, and overs. D = diameter of hole used, T = thickness of opening used (*10*).

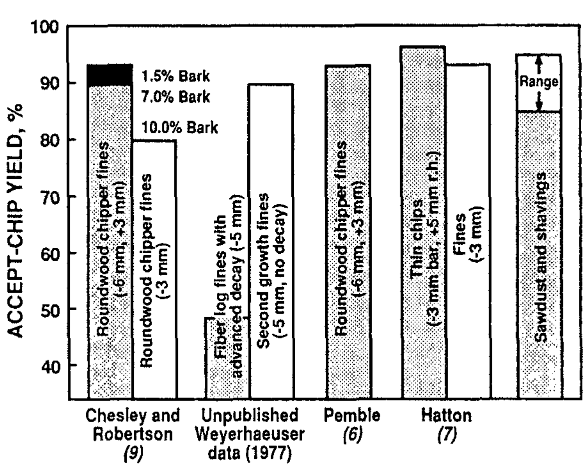
Classifier type	*Fines*	*Pins*	*Accepts*	*Overs*
Williams[a]	-3/16-in. D	+3/16-in. D,-3/8-in. D	+3/8-in. D, -1 1/4-in. D	+1-1/4-in. D
Stalsvets[b]	-3-mm D	+3-mm D, -7-mm D	+7-mm D, -8-mm T	+8-mm T
Domtar[c]	-3-mm D	+3-mm D, 2-mm T	+2-mm T, -8-mm T	+8-mmm T
Consilium-Bulk	-3-mm D	+3-mm D, -1.5-mm T	+1.5-mm T, -8-mm T	+8-mm T

[a]Includes Sweco
[b]Includes Everett Metal Products (EMP), ChipClass, Gradex
[c]Includes Rader, Price

II. Comparison of a single sample of chips cross-classified by both thickness and round hole methods. Column totals equal the percentage of the sample retained on that thickness tray, row totals equal the percent retained on the round hole tray. Individual table values illustrate the length by thickness distribution of the chips.

Round hole	*+10 mm*	*+8 mm*	*+6 mm*	*+4 mm*	*+2 mm*	*-2 mm*	*Row Total*
+29 mm	2.97	1.88	0.82	0.71	0.07	0.00	6.44
+22 mm	1.26	1.42	3.61	4.05	0.69	0.02	11.05
+16 mm	0.71	1.17	4.98	9.81	5.29	0.04	21.92
+10 mm	0.20	0.46	2.63	10.41	16.96	1.55	32.21
+ 5 mm	0.09	0.02	0.33	2.08	**11.64**	**7.20**	21.36
- 5 mm	0.02	0.02	0.04	0.09	**0.75**	**6.09**	7.02
Column total	5.25	4.98	12.33	27.14	35.40	14.90	100.00

2. Yield comparison of small-chip fractions as a percentage of accept-chip fraction yields



loss causes fouling of evaporators and increases the organic load to the recovery boiler.

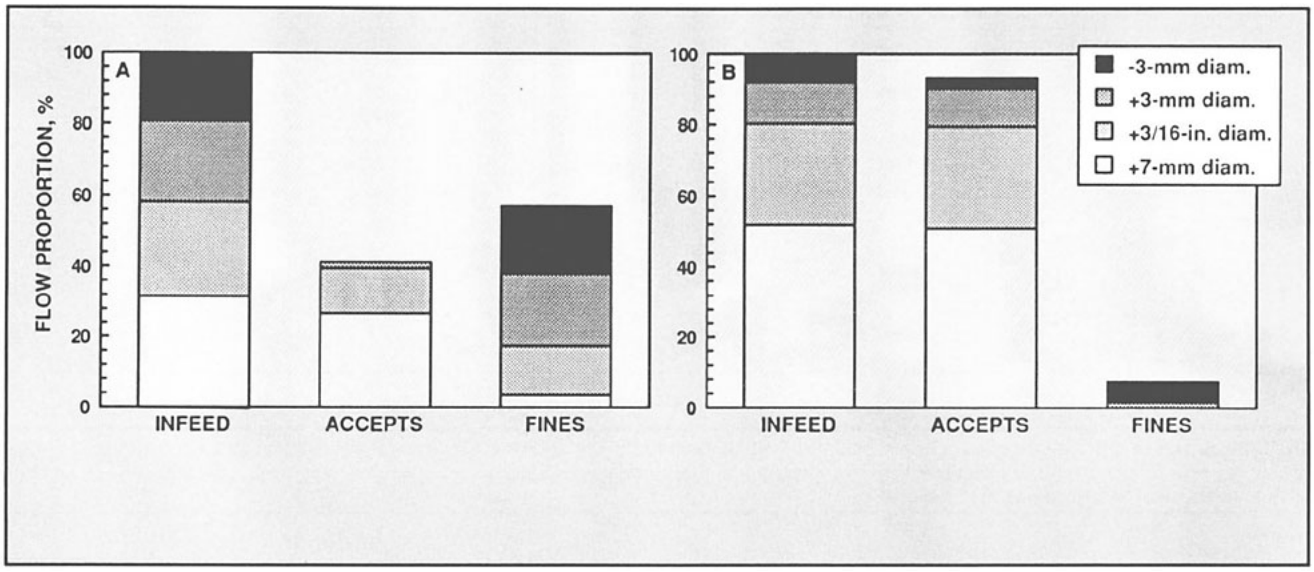
Yield

The source, size, and composition of small-chip fractions determines the pulp yield. It will always be less than the normal chip yield, but unless there is contamination from bark or decay, it is usually about 90% of accept-chip yield. Fines overcook to a lower yield because liquor penetrates more quickly and reactions proceed more thoroughly. **Figure 2** shows the yield comparison for a variety of small-chip types. While some believe fines "cook away" completely, this data shows that pulp yields from fines are fairly high. However, if the mill has limited digester capacity or is limited by organic solids loading to the recovery boiler this yield loss may be economically significant.

Fines removal: designing the right system

Once a mill has defined the type, amount, and composition of the small chips in its chip flow, it can make a decision on what to remove. For batch digester mills where liquor circulation is not influenced by pin and thin chips, the screening strategy is usually to retain as much long fiber

3. Roll screening allows the selective retention of larger pin chips and accepts (A) or any material larger than a 3-mm-diam. hole.



as possible, and remove only the small, short, and contaminated fines that pass a 3-5-mm round hole classifier screen. This is accomplished with several methods currently: historically with flat-plate-type rotary or shaker screens (*4*), more recently by roll-screen technology (*5*).

Classic flat-plate screens suffer from plugging with pins, high fiber loss, only moderate fines removal efficiency, sensitivity to fluctuations in loading rate and moisture content, and mechanical vibration effects on screen maintenance and support structures. From a pulping standpoint, the inefficiencies in fines removal and good fiber retention significantly reduce the benefits the fines screens were installed to obtain.

Roll-screen technology (patented) achieves separation of the 3-5-mm fraction through a novel, new arrangement of parallel shafts. Each shaft surface is machined with spiral grooves of a depth to accept the chunky, particulate fraction. As the shafts turn forward, the larger materials are propelled down the screen length, while the "captured" fines are passed through the opening between the shafts and are removed from the chip flow. The selectivity of the screen is controlled by the depth of the surface grooves, the spacing between the shafts, and the speed at which the shafts are turned (*5*).

Pulping system requirements

The selectivity of the DiamondRoll screen allows an arrangement of screen setup parameters to be tailored to the specific process requirements of an individual mill's process. In batch kraft processes, a usual target is 90% removal of -3-mm RH (round hole) fines. In thermomechanical pulping a smaller target may be used in an attempt to efficiently remove bark, sand, and grit while retaining all fiber-continuing fractions (targeting zero fiber loss). Mills with continuous (Kamyr) and displacement batch digesters need to more carefully screen fines, keeping only the largest particles while controlling the level of thin and pin chips. This could mean as much as 5-15% of the chip flow is not acceptable and must be processed through another system. Most mills cannot afford to downgrade this potentially large quantity of chip material to boiler fuel. The difference between chip value and boiler fuel value is simply too great.

In **Fig. 3**, two strategies for small-fiber use are shown. In part A, an infeed chip furnish composed of about equal parts accept chips (+7-mm diam.), large pins (+3/16-in. diam.), small pins (+3-mm diam.), and fines (-3-mm diam.) is screened to recover only the largest fraction. These chips and large pins are well suited to the continuous digester process. The fines and small pins which restrict liquor circulation are removed for boiler fuel.

In part B, the infeed furnish is composed of approximately 50% good chips larger than 7 mm, with an additional 35% with diameters between 3 mm and 7 mm. By arranging the roll-screen shafts with a close gap (1.5 mm inter-roll opening), shallow surface cut depth, and fast roll speed, only the smallest fraction is removed. The recovered accepts are passed to the process, in this case the batch digester with direct steam heating. Since this digester is less sensitive to upset by small-chip fractions, the greater value of pins (large and small) to the mill is as pulp rather than as boiler fuel.

Possible alternatives are to meter the small fractions to a batch digester, sell the fines and pins to another mill, or use a small continuous digester designed for small chips and sawdust. If these alternative pulping options are not available, it may be desirable to isolate the pins fraction and add it back into the chip flow at a known, constant rate.

It has been difficult to achieve a high-efficiency separation between fines, pins, and acceptable chips with the screening technologies of the past. Punched-plate hole dimensions have simply failed to achieve the needed selectivity, though one mill is reporting success with an unusual design (*6*). The parameters of roll screens that allow high-efficiency fines separation also can be modified to provide excellent pins separation. Recent installations feature fines removal (-3 mm RH), pins separation (-7 mm

RH, +3 mm RH), and accepts retention (+7 mm RH), each being passed to a separate collection system.

Summary

Many articles have dealt with the easily identifiable benefits of effective screening for overthick-chip control (*7, 8*). Small-chip fraction screening and management for pulping response optimization has been more difficult, partly due to the many ways in which these small fractions can be processed. Until recently, highly efficient screening methods have not existed to selectively separate undesirable fines from potentially desirable pins. Rollscreen technology offers a means to achieve this separation.□

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