SCREENING OF WOOD CHIPS FOR THE PULPING PROCESS

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INTRODUCTION

This paper is based on results and ideas for the screening of wood chips for pulp mills.

The importance of chip quality for pulp mills, specifically the kraft process, dates back in history to the 1920's.

Wood, as a raw material, is the single most expensive element in the manufacturing of pulp for the paper industry; and yet, not enough emphasis is given to what actually can be done with the quality to optimize the pulping process.

The first part of this paper emphasizes the physical chip parameters for the pulping process and how to integrate them into the process.

The second part is dedicated to how these parameters solve and optimize the pulping process.

The third part covers the application of equipment to change the chip quality and the chip parameters to enable process changes.

INTRODUCTION

PARAMETERS FOR THE PULPING PROCESS

This paper is guided towards the physical parameters of wood chips and how we can process and classify the wood chips in the woodyard to our advantage for the pulping process.

For the pulp and paper industrial process, and for other industrial processes, the most important infeed factor is uniformity in the raw material—i.e, the chips.

The raw material we are handling, however, comes from Mother Nature, who presents us with a product having different forms and varieties. The variety comes from wood of different species, from natural forest or from plantation stock. The trees will, of course, be of different ages and grown in different soil conditions; and can be the result of a thinning process or clear cut. The tree parts that we receive can come from branches, tops, stems, stumps, or roots (see FIGURE 1). These are just variations that occur before the wood arrives at the mill. After the wood arrives at the mill, the logs are sorted, debarked, and chipped—processes that further exacerbate the nearly uncontrollable inconsistencies of the raw material.

Modern woodyards are designed to handle this chaotic mix of material in such a way as to minimize the fluctuations (variations) and try to integrate the material into the process.

Ideally, the primary goal of chipping logs in the woodyard is to produce chips of a certain size. The chipping process, however, follows the physical laws of fragmentation: the size distribution, when checked, shows a normal bell-shaped distribution curve. There are chips of every dimension, thickness, length, and width. FIGURE 2 shows the distribution of chips from the chipper.

The newer chipper generations developed during the 90s are designed to increase the percentage of thinner chips while, at the same time, reducing the generation of fines and pins. FIGURE 3 shows a typical distribution curve for 25 mm chip length for softwood and an other one for 19 mm chip length for hardwood.

Chip handling and chip storage equipment are installed to prevent wood chips from deteriorating while ensuring that a ready supply is always on hand.

Fiber deterioration is a significant problem. Wood chips lose approximately 1% of usable fiber for every month of storage. Fungal decay and compaction cause chips to splinter, producing soft cooks. (See FIGURE 4 showing some decay figures.)

Another key to efficient chip storage is the use of "FIFO" (First-In, First-Out) inventory control. Automated reclaimers move through the chip pile to achieve an even blend of chips to the furnish, preventing the random fluctuation of chips that can occur when bulldozers are used.

In addition, prolonged storage also causes discoloration, which adds to chemical and energy costs required for bleaching. Uneven coloring also contributes to loss of process control, adversely affecting the uniformity of the end product.

Other reasons not to use bulldozers include high operating and maintenance costs in addition to fiber loss caused by chip damage and fines/pins generation.

This observed variation of chips has to be converted into pulp by different process methods—all the way from mechanical to chemical pulping processes. The optimum would be if we could have all the chips of an ideal size for a given pulping process. This would, in turn, result in the highest possible pulp quality and pulp yield.

In the broad and realistic sense, pulp yield should really relate the amount of available fiber in the forest to the amount of salable pulp produced. Perhaps this should be called the "total yield." Considering this broad approach, there are a number of losses that occur that affect total yield. These are:

1. Harvesting loss
2. Transportation loss
3. Debarking/chipping loss
4. Storage and chip handling loss
5. Chip screening loss
6. Pulping loss
7. Bleaching loss

The total yield could then be subdivided into forest yield, which would account for efficiency of harvesting and getting fiber to the mill.

Debarking/chipping/storage/screening yield would relate the amount of fiber reaching the mill to the amount reaching the digester, and *pulping yield* would relate the amount of fiber reaching the digester to the amount of salable pulp produced. *Forest yield* will not be discussed in this paper.

Yield is the bone dry weight of fiber that was put into the digester. Perhaps the greatest need in the industry today is a device to measure this quantity accurately. Typical of present methods of measuring chip input are:

1. M^3-sub of wood chipped in the woodroom.
2. Displacement of the low pressure feeder.
3. Belt weighing systems.
4. Yearly inventory checks.

Factors that are not accounted for by these methods are:

1. Moisture of the wood.
2. Density of the wood.
3. Density of the chips.
4. Chip size distribution.

Unfortunately, these are commonly not accounted for on-line and time absorbing manual samples are taken.

WOOD CHIPS AND THE PULPING PROCESS

The principle for kraft pulping is clear to all of us and can be described in two principal goals:

1. Distribution of cooking liquor to all parts of the chip mass.

2. Creating the right conditions for chemicals to the interior of the chips through penetration and diffusion.

The ideal chip for the process would be the one that just cooks completely, enabling all the fibers to be separated without leaving unseparated wood.

The alkali swells the cell walls, producing wider and more numerous diffusion paths across the fibers and permitting diffusion in approximately equal rates in longitudinal, tangential, and radial directions. This makes the restriction the smallest dimension of a chip -- the thickness -- a determining factor for homogeneity of delignification. (See FIGURE 5 for dominant transport mode as a function of pulping conditions and Table I, Pulping Conditions.)

The cooking cycle should be adjusted until the percentage of rejects is of no problem. Rejects reduce yields so, at minimum rejects, yields should be maximum.

This line of thought holds true until you look at the meaning of "K" number. Many people believe that the "K" number developed in a pulp test is the average for the cook. For each chip cooked to average conditions, there must be one cooked to a higher number and one cooked to a lower number. Yield must be lower for lower "K" numbers. There is still no clear-cut relationship between particle size and "K" number, apart from the fact that larger chips can be undercooked and pulp from these chips would have a high "K" number.

For species such as those in western Canada, "K" numbers of 18 to 20 are as low as the lignin content can go before considerable carbohydrate loss will occur. If small particles cook to low "K" numbers, then a high percentage of small particles could result in a low yield.

Many of these factors can be determined on a laboratory basis, but there are so many differences between these and plant operating conditions that there is a reluctance to put much faith in laboratory tests.

OVERTHICK AND OVERSIZE CHIPS

From the larger and especially the thicker chips, uncooked cores will be found after the cooking cycle. The term used as *rejects* in the laboratory and *knots, screenings*, and *shives* in the mill are all names that reflect a negative effect in the pulping process:

- Larger rejects are removed in the knotter screens and recycled through the digester, using capacity and liquor that might be used for incremental production. The recycled material passes through the digester and will be overcooked with a loss of overall yield.
- Screened rejects are usually refined and added to the unbleached pulp for bleaching. This requires lignin to be removed during bleaching, but lignin removal could have been more efficiently done in the cooking process.
- Unbleached pulp going to the bleaching process is non-uniform and contains material ranging from low kappa recooked material through high kappa shives. This will require extra chemicals to achieve the determined brightness, with a penalty in yield and quality.

To increase the yield and to narrow the kappa variation in the pulp numerous mills have installed thickness screening systems. Thickness screening is a tool that helps the pulp mill narrow the thickness variation. FIGURE 6 shows the expected efficiency figures of screening chips by thickness. In addition to screening out the larger and thicker pieces reject treatment has also been introduced. In the past as chip slicers and during this last 10 years the reject treatment has moved rapidly over to chip conditioner. The comparison in FIGURE 7 shows the difference between the technologies and the focus on raw material yield as well as enhancing the pulping process. (See FIGURE 8)

PINS

At present, in a kraft digester, a kilogram of pins is believed to give almost the same yield of pulp as a kilogram of chips. In Sweden, if chip yield is expected to be 48%, then yield from pins of the same wood is expected to be 44% - 45%. See FIGURE 9.

Pins are good material until they are of such size that they plug the digester screen. In the first digesters, slot width was 3 mm. This has been increased to 7 mm and partially overcomes the pin problem, but the actual effect is not known.

The other problem with pins is the uncontrolled amount in the chips. For optimum pulping, all chips should be screened to remove pins and fines, and then these portions remixed back into the chips at some desired rate.

SAWDUST OR FINES

The terms *sawdust* or *fines* cover a wide range of material, such as:

1. Material produced by saws when cutting wood. Saws can be fine or coarse and so can the sawdust.
2. Small particles developed in the chipping, storing, and handling of chips.

Sawdust is generally referred to as the material that passes through 5 mm round holes in a classifier. Probably the main difference between sawdust and pins is the extent of fiber damage in the particle.

Few facts are known about the actual results of cooking sawdust (and even pins) with good chips. The following general statements can be made:

1. Sawdust pulp should have inferior qualities compared to pulp from chips.
2. The general rule in batch digesters is that when 10% sawdust is added to good chips, the quality of the pulp starts to suffer.
3. Tests have found that if sawdust is cooked with chips, when the cooking cycle is adjusted for chips: if the expected yield from chips is 48%, then yield from sawdust can be lower than 30%.
4. In all parts of the world, as the fiber shortages get common, more sawdust-type material will have to be used.
5. Until a way is developed to accurately determine bone dry weight of material, the real results of cooking sawdust with chips will not be proved.
6. There is no complete and conclusive laboratory test program on the effects of cooking sawdust, pins, and chips to a cycle for properly cooking chips.
7. Fine sawdust that will easily pass through the holes or slots in the strainers can be recirculated in the liquor system until it is totally consumed. It is therefore possible that there is no yield from part of the sawdust put into the digester, only a consumption of liquor. If there is no yield, then pulp quality will not be affected either. See FIGURE 10.

Chip screening developed as a result of vague or limited design criteria for the pulping process. During the last couple of years, changes requiring a new approach to the design principles have been evolving.

Today's newer, modified pulping processes with extended delignification and ECF bleaching, require new theories, since no ideal quality or size of wood has been defined. Studies have been carried out to determine the performance of the chip thickness in this new type of pulping process. The FIGURE 11 and 12 show how the thickness still is an important factor although in some cases the critical thickness has increased.

CONCLUSION

As a conclusion the following can be said about chip quality versus yield and pulp properties:

- Poor quality chips usually contain a high percentage of fines that should be screened out. This is a loss that can be determined.
- Poor quality chips that cause circulation problems in a digester cause lost production and improperly cooked pulp.
- Poor quality chips with a high percentage of thick chips or knots will cause a high reject rate from the knotters. The reject rate is a loss in digester capacity. Bleaching costs should be high for this type of pulp.
- It should be possible to cook uniform chips to a higher average permanganate number before rejects become a problem. At higher permanganate numbers, yield should be higher.
- Poor quality chips, with a high percentage of short or damaged chips, should produce pulp with lower average fiber length and lower tensile and tear. Freeness should also be lower.
- With uniform quality of chips, the digester operator has better control on the digester and **can** vary cooking conditions better to suit end product.
- With uniform quality of chips, packing in the digester—and, therefore, digester production—should be higher.

The existing equipment and new development in the woodyard to produce, sort and classify the chips will be important to ensure uniformity of the incoming material - the chips - for the pulping process.

The chips will continue to be a cornerstone for high rawmaterial yield and high quality pulp production. The new pulping processes developed in recent years are being optimized and more detailed studies will be carried on to further determine the chip characteristics for optimal pulp properties.