FACTORS INFLUENCING THE VALUE
OF PULPWOOD

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Observations on the Storage of Pulpwood for the Manufacture of Sulphate Pulp

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During the last year, the writer was in close touch with a sulphate pulp mill in the southern States and had occasion to observe the relation of the condition of the pulpwood to the pulp output of the mill. The matter came up in consequence of a marked decrease in the yield of pulp per digester at the beginning of summer. Investigation of the amount of wood charged per digester, species and age of the trees used, amount and composition of the cooking liquor, and pressure and time of cooking together with the pressure curves on the recording gauge charts for each cook, showed that no noticeable change had been made. The source of the trouble evidently must have been in the condition of the wood. It happened that careful records had been made throughout the preceding year of the number of digesters blown, the amount of wood used, and the tons of pulp delivered. On summarizing
and studying these records, it was found that through considerable periods the pulp delivered per digester was fairly constant but that the average for the different periods varied considerably. The cause of this seemed to be that the time the wood was held in storage varied considerably for different seasons of the year on account of the location of the mill and the policy of wood buying. The wood used was the various species of pine growing in that locality and included: Loblolly pine (Pinus taeda) locally known as loblolly, old field, and spruce pine; scrub pine (Pinus virginiana), locally known as scrub and short shucks pine; and shortleaf pine (Pinus echinata), locally known as shortleaf and bull pine.

The mill was situated on tide water and the pulp-wood supply was obtained on the banks of three navigable rivers and their estuaries and towed to the mill on lighters. During the winter there were times when the upper reaches of these rivers were frozen and most of the wood was taken from storage in the mill yard or on tracts located nearby. During the spring the country was so wet that most of the wood came from the higher and well drained tracts and since they usually were quite accessible the time the wood lay in piles was comparatively short. During the summer and fall the more inaccessible tracts became accessible so that these
tracts furnished a large portion of the wood used at that season. Some of the wood on these tracts had laid in piles as long as three years. The quality of wood used was similarly dependent upon the condition of the mill's tug boat. When the tug was in use, wood could be supplied from a considerable distance, but when it was out of commission, gasoline launches were depended on for towing the lighters and, owing to strong tide, lighters could only be towed from nearby tracts rapidly enough to keep the mill supplied.

The following divisions of the year represent periods of variation in average yield of pulp per digester, the source of wood being shown for each period:

Fall. Wood stored in piles in the woods or on landings two and three years.

Winter. Wood stored in mill yard or nearby landings one to two years.

Spring. Wood from nearby landings stored one and two years.

Early summer. Wood from more remote landings stored two and three years.

Midsummer. Tug boat engine being repaired. Wood from nearby landings stored one and two years.
one week (summer). Lunches unable to bring in wood. Wood from remote corner of yard near rotten slabs. Stored two and three years.

Two weeks (summer.) Wood from remote landings, stored two and three years, but with the visibly infected wood, amounting to between 25 and 50 per cent, culled.

One day (early summer). Freshly cut wood.

In the accompanying table are given average amounts of wood charged per digester, air-dry pulp delivered per digester and air-dry pulp delivered per cord of wood for each of the periods named.

<table>
<thead>
<tr>
<th>Period</th>
<th>Cords</th>
<th>Tons air:</th>
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<tr>
<td></td>
<td>Time</td>
<td>wood</td>
<td>dry pulp</td>
<td>wood</td>
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<tr>
<td></td>
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<td>per</td>
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<tr>
<td></td>
<td></td>
<td>cord</td>
<td>digester</td>
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<tr>
<td>Fall</td>
<td>2 and 3</td>
<td>6.22</td>
<td>2.57</td>
<td>.41</td>
</tr>
<tr>
<td>Winter</td>
<td>1 and 2</td>
<td>6.29</td>
<td>2.90</td>
<td>.46</td>
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<tr>
<td>Spring</td>
<td>1 and 2</td>
<td>6.50</td>
<td>3.11</td>
<td>.48</td>
</tr>
<tr>
<td>Early summer</td>
<td>2 and 3</td>
<td>6.41</td>
<td>2.72</td>
<td>.42</td>
</tr>
<tr>
<td>Mid summer</td>
<td>1 and 2</td>
<td>6.40</td>
<td>2.37</td>
<td>.48</td>
</tr>
<tr>
<td>One week (summer)</td>
<td>2 and 3</td>
<td>6.29</td>
<td>2.61</td>
<td>.42</td>
</tr>
<tr>
<td>Two weeks (summer)</td>
<td>2 and 3</td>
<td>6.49</td>
<td>3.31</td>
<td>.51</td>
</tr>
<tr>
<td>One day (early summer)</td>
<td>green</td>
<td>6.75</td>
<td>3.62</td>
<td>.54</td>
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On analysis of the table it is evident that the more nearly green the wood is used the larger the charge of
wood per digester, the greater the yield of pulp per digester
and the greater the yield of pulp per cord of wood. Exami-
nation of the chips and the wood before chipping showed that
the older the wood the lighter it was when brought to a
bone-dry condition, even though it may have weighed more be-
fore the moisture had been removed. In the old wood also
many of the chips had holes through them, caused by insect
attack, and the presence on a considerable portion of the
sticks of fruiting bodies of various fungi showed that decay
was already well under way. The loss in pulp production was
evidently due to the loss of wood substance from the ravages
of insects, wood-destroying fungi and bacteria.

The loss in the case of wood attacked by insects
is the result of the excavation of burrows or galleries by
beetles, round and flat-headed borers, and timber worms.
While there are differences in the manner in which each kind
of insect proceeds about its work of destruction, a descrip-
tion of the habits of one species of round-headed borers, the
Southern Pine Sawyer (Monohamus titillator), will serve to
illustrate the mode of attack. The female adult digs an
egg pit in the bark of cut or fallen timber, in which she
deposits her eggs. In about five days these eggs hatch and
the larvae. Feeding upon the soft inner bark, work their way through it, making irregular galleries next to the wood. Within thirty days, in which time they have attained considerable growth, they commence scoring the surface of the sapwood, and finally burrow tunnels into the wood, packing the borings between the bark and wood. During these operations, the larva excavates a chamber in which to pupate, and remains in this chamber during its transition to the adult stage. It then emerges and the cycle is completed.

The period for laying eggs extends from the first of March to the middle of October. In order to avoid injury from attack from these insects, wood felled in this period, if not to be converted into pulp within a few weeks, should be barked at once to remove the food supply of the young larvae. Wood cut at other seasons, if not converted into pulp, should be barked or piled in open piles so that it may become well dried before the borer season arrives.

The habit of borers of burrowing between the bark and wood has been used to advantage by certain pulp mills for facilitating the removal of the bark. The subsequent tunneling of the wood, however, not only entails a loss of wood but means that the digester charge contains less wood...
and the level of liquor in the digester is lowered, which increases the difficulty of properly immersing the chips during cooking, to secure uniform pulp.

While the loss from insects was serious and very evident, the most serious loss was due to the destruction of the wood substance by fungus or mould, even though not so easily detected. The average observer does not recognize decay in wood until the attack has so far advanced that certain portions are punky or dozy. Often long before this stage has been reached, however, a considerable portion of the wood substance has been consumed, and the bone-dry weight of the piece greatly reduced.

Wood becomes infected with fungi from contact with other infected wood, from contact with ground infected with fungi, or from spores carried by the air from fruiting bodies on decaying wood in the vicinity. If the conditions are favorable, the infection grows, spreading throughout the wood in the form of threadlike filaments called mycelia. The mycelium is a living plant and must have food, a suitable amount of moisture, a favorable temperature, and a small supply of air; its food is the wood substance which is broken down to forms readily assimilable by enzymes or ferments secreted.
by the mycelium. Thus the fibers are penetrated and absorbed until only a skeleton of their former self remains and their value for pulp is greatly reduced.

From the standpoint of the pulpmaker, the harmful effects are rendered worse from the fact that many fungi break down the cellulose constituents of the wood to a greater extent than the lignin constituents, and thereby the yield of pulp is diminished more than the amount of constituents that must be dissolved by the cooking liquor. This is probably the reason why the same quantity of cooking chemical per charge of old wood was required as for green wood, even though with the latter considerably more wood substance was in the charge.

The liability of wood to infection and attack by fungi is influenced by the amount of moisture present in the wood and by the temperature. When in the air-dry state, such as is possible in dry weather, when piled in open piles where the air has opportunity to circulate freely, wood will not ordinarily be affected. In damp weather, however, and when piled closely, in the shade, or surrounded with shrubbery, vines, etc., so that the air cannot freely circulate, it retains its moisture, and serious fungous infection is
almost certain. The temperature at which fungi thrive best varies with the species, but it may be said to be usually between 75 and 90 degrees Fahrenheit. Although growth is possible below the lower of these limits, the lower the temperature, the more it is retarded. The effect of temperatures above the optimum is more marked, a rise of from 4 to 8 degrees causing death in some species. Although air is necessary for the growth of the fungi, the amount is very small and a sufficient quantity is to be found almost anywhere that pulpwood is liable to be placed. Wood immersed in water, with the cell cavities completely filled, will, however, resist decay indefinitely.

The external evidence, before wood has become punky or dozy, that it is infected is either the presence of mycelia or mould on its surface or the formation of fruiting bodies.

The latter is another means by which fungi are propagated. The fruiting bodies give off spores in enormous numbers, which are carried by the wind, and infect any wood on which they may lodge under favorable conditions. By the time fruiting bodies appear on wood it is thoroughly infected in their vicinity, even though it may appear sound, and the yield of pulp obtainable has usually been seriously curtailed.
A certain amount of the decay of pulpwood may be due to bacteria. Although their action in the destruction of wood is not well known at the present time, the methods used in combating fungi have been found effective against them also.

The susceptibility of wood to decay varies greatly with the species, as is known to every farmer, who will use black locust or red cedar fence posts whenever they are available. The writer knows of no data showing the relative resistance of various pulpwoods to decay when piled under average conditions. The following table, however, gives the average life of fence posts of various species used for pulpwood, as observed in a considerable number of trials by the U. S. Forest Service. Durability is dependent upon the proportion of sapwood to heartwood, as well as upon species, but since pulpwood, as well as fence posts, is usually taken

<table>
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<tr>
<th></th>
<th>Years</th>
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<tbody>
<tr>
<td>Redwood</td>
<td>14</td>
<td>Tamarack</td>
<td>6</td>
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<tr>
<td>Chestnut</td>
<td>10</td>
<td>Hemlock</td>
<td>6</td>
</tr>
<tr>
<td>Longleaf pine</td>
<td>8</td>
<td>Aspen or poplar</td>
<td>5</td>
</tr>
<tr>
<td>Douglas fir</td>
<td>7</td>
<td>Lodgepole pine</td>
<td>4</td>
</tr>
<tr>
<td>Western yellow pine</td>
<td>6</td>
<td>Balsam fir</td>
<td>4</td>
</tr>
<tr>
<td>Spruce</td>
<td>6</td>
<td>Loblolly pine</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Red Gum</td>
<td>3</td>
</tr>
</tbody>
</table>
from smaller trees with a relatively large proportion of sapwood, the comparison will shed a certain amount of light on its relative durability.

By the 'life of fence posts is meant the time necessary for them to decay to the point where they will no longer support themselves and the wire. Long before this point is reached they would be too seriously attacked to be fit for conversion to pulp.

Bearing in mind the causes of decay and deterioration in wood as just outlined, the conditions at the mill under consideration appear to be very bad. In the first place the species of wood used have a very large proportion of sapwood and are extremely susceptible to decay. The location on tide water in the southern States means that the conditions of moisture and temperature are such that insect and fungus attack will be extremely active. Furthermore, the local custom of storing the wood closely piled near the water's edge often on decaying litter, shaded by trees and overrun with shrubbery, vines, and weeds, contributes greatly to its decay.

The remedy for this situation would seem to be to govern the cutting of the wood by the daily demands of the
mill and only accumulate enough reserve to keep the mill running over periods when the lighters can not be operated, or when, owing to unfavorable weather, planting, harvesting, or other reasons, the supply of labor for woods operations is limited. The woods operations should be so governed that all wood can be converted to pulp as nearly freshly cut as possible and none should be allowed to stand over six months. Whatever reserve is necessary for the winter should be cut and moved after the middle of October, and all of this reserve should be converted to pulp before the first of March. By following this procedure, the attack of insects on the wood is greatly reduced, since between October and March very few eggs are laid. Moreover, the attack from fungi is reduced to a minimum, since during these months the temperature is such that their growth is greatly retarded.

The gain by following this procedure at a mill that has been in the habit of using old wood is enormous, not so much in the saving of wood as in the increased capacity with the same overhead, labor, and consumption of other raw materials. The gain at the mill where these data were obtained is a concrete example.

The production of the mill was governed by the capacity of the diffuser department to wash the pulp, the
recovery and causticizing departments to convert the black liquor into cooking liquor, and the boiler room to supply steam. The other departments were of greater capacity than that at which they were usually called upon to operate. The recovery and causticizing rooms had capacity sufficient to provide cooking liquor for ten digester charges per day and this number would tax the diffuser room and boiler room to their utmost. It was therefore apparent that the only method of increasing the capacity of the mill without new equipment was increasing the yield of pulp per digester without increasing the liquor charge, difficulty in washing, or steam consumption.

The gain in production by using green wood over that obtained in using old wood showed how this could be accomplished to a surprising degree. In the early summer the average charge per digester using wood stored two and three years was 6.41 cords, and the average yield of pulp per digester was 2.72 tons air-dry or 0.42 tons a cord. On the day using green wood, also in early summer, the average charge per digester was 6.75 cords of wood, and the average yield of pulp per digester was 3.62 tons air-dry or 0.54 tons per cord. The charge of wood increased one-third of a cord.
owing to the more compact manner in which green chips pack in comparison with chips from old wood. The amount of liquor and steam used per cook was the same in both cases. The yield of pulp obtained from green wood showed an increase, however, over that obtained from old wood, of .9 of a ton or 33 percent, whereas the time necessary to wash the cooks from green instead of old wood showed no noticeable increase. The daily production, when making ten cooks using old wood, was 27.2 tons air-dry pulp; the production obtained from the same number of cooks by changing to green wood was 36.2 tons, or an increase of nine tons. This gain of nine tons was obtained without any increase in the daily cost of production more than that of the additional 3.3 cords of wood, with the possible exception of half a dozen laborers added to the force to remove bark, and two or three men to handle the increased number of laps of pulp. The pulp at that time was selling in the neighborhood of $100 a ton, so that the daily increase in profit to the mill by changing to green wood was between $800 and $900. While the price received for pulp at that time may be considered abnormal, the increased profit when selling at $50 a ton would be between $400 and $450 a day - surely worth considering.
The use of green wood would greatly increase the cost of barking the wood by hand, but this difficulty could be overcome by the investment of between $15,000 and $20,000 in barking drums and equipment which would reduce the cost of barking the wood to below 25 cents a cord, much below what it is costing at present.

The deterioration of the pulpwood mentioned in this article undoubtedly is extreme on account of the species used, climate, location of the mill, and the prevailing method of purchasing and handling the wood. It seems probable, however, that these conditions prevail to a greater or lesser extent in many mills, and proper attention to this, the first step in the manufacture of pulp, will yield ample returns to even the best regulated pulp mills.