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GRINDING OF STEAMED AND BOILED SPRUCE

Excerpts from Forest Service Bulletin 127 (1913) and U. S. Dept. Agri. Bull. 343 (1916) by J. H. Thickens

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(From Bulletin 343)

Effect of Preliminary Treatment of Spruce

Spruce has been used for many years as a raw material for groundwood pulp, but the effect of the production of pulp from it under varying conditions has never been given very careful study. Depending on the quality of the product desired, different conditions of grinding must be selected, and in some cases the wood must even be given a cooking treatment prior to grinding. In the manufacture of container board, where great strength is desired and the color is of lesser consequence, strength is often increased by the addition of sulphite or sulphate pulp, screenings, or old paper stock. In the manufacture of newsprint paper, strength is desired too, but not nearly so much strength, the color, yield, and finishing characteristics here being the prime consideration. The work which has been done on spruce has been carried on with the idea of attempting to increase the efficiency of grinding both from the standpoint of reducing the power consumption and increasing the yield from a cord of the raw material in either the cooking or ordinary groundwood process, and to ascertain the influence on the quality and quantity of pulp produced by the variation of the grinding variables, such as surface of the stone, pressure on the cylinders, speed, temperature, etc.

The cooking of wood prior to grinding is attended with a number of changes in the physical characteristics of the wood which greatly influence the quality of the pulp manufactured from it. The cooking condition must be chosen according to the use to which the pulp is to be put. For the manufacture of newsprint paper from pitchy woods it is essential that the treatment be a very mild one, and that the duration of boiling or steaming and the temperature at which it is carried on be such as to allow of the fiber being as light in color as possible. Either the pressure, or corresponding temperature, must be low and the cook of long duration, or the pressure higher and the cook of much shorter duration. It is generally claimed that cooking the wood under pressure while immersed in water will yield a lighter pulp than steaming at the same pressure and for the same length of time, but this result has not been noted.

Boiling wood has certain disadvantages which are not found when the steaming process is used. There is a considerable loss of heat, and it is necessary to draw off condensed liquors to maintain the temperature at any desired value. This makes it necessary to pay greater attention to the process. If the temperature and duration of the cook are the same, the steamed or boiled wood should be practically the same in color and other physical characteristics. One decided advantage of steaming is the possibility of draining off the condensed liquors in a concentrated form. This is of great benefit when byproducts are to be recovered.

In all of the experiments conducted in cooking wood prior to grinding, the temperature corresponded to the temperature of boiling at the steam pressure under which the cook was being made. Attempts were made to secure byproducts, but the amounts of wood used were so small that this could not be done satisfactorily.

(From Bulletin 127)

Physical Condition of the Wood

The question of the influence of the physical condition of the wood is a very important one. Wood for pulp is almost invariably allowed to season for a long period before it is used, and as a result there is considerable loss due to rotting, and the wood becomes darker in color. It is more difficult to secure a long-fibered pulp from wood which has been seasoned for a long period than from green material. The treatment of wood by steaming, boiling, or some similar process prior to grinding is important, because by such treatment better fibers can be obtained than when woods are ground without treatment. This makes possible the use of woods which, if ground in the natural state, would yield very short-fibered pulps. In this way, too, pitchy woods can be made usable by the mechanical process.

(From Bulletin 343)

Influence of Pressure, Temperature, and Time of Cooking

When the length of time of the cook is kept constant and the cooking pressure or temperature is varied, it is found that the color of the pulp made darkens greatly when these factors are raised, all other conditions being the same. This is demonstrated by reference to the curves in figures 4 and 5, where the amount of black in the color as determined by a tintphotometer is plotted against the cooking pressure and temperature. At some steam pressure the wood will char and the resultant pulp will be black; under this condition a maximum of 300 parts black would be secured. It is probable that this steam pressure would not be very high, since the values of parts of black increase rapidly after 60 pounds pressure is reached.

The strength of the pulp increases with the length of the steaming period (fig. 6) and seems to reach a maximum in about 8 hours for both pressures. In figure 7 is shown the variation of the yield of pulp per 100 cubic feet of solid rossed wood, with the pressure of steaming and the duration of the cook. The marked effect of the duration of the cook, especially at high pressure, is evident. The yield decreases rapidly with increased pressure due to the dissolving action of the water and the transformation of portions of the wood into water soluble material which is washed out in the grinding process.

Variation of the period of cook also has a marked influence upon the horsepower consumption per ton of pulp. When wood is ground under the same conditions of grinder pressure, speed, temperature, etc., it is found that after a period of four to six hours of cooking the maximum value of power consumption is obtained. For a greater or lesser length of time of cooking the horsepower consumption per ton decreases (fig. 8).

(From Bulletin 127)

Influence on Power Consumption and Rate of Production

It is shown in figure 9 that when the wood had been steamed prior to grinding for six hours at a steam pressure of 60 pounds per square inch, the horsepower consumption per ton varied but slightly with variation in pressure. There is a decided contrast, however, in the forms of the curves of power consumption and rate of production obtained on untreated and steamed wood, as may be seen in figure 15.

The relation of the pressure on the grinder cylinders to the horsepower consumption per ton, horsepower to grinder, and the production in 24 hours, when green, seasoned, and steamed woods were ground is shown in figure 16. At low pressures the power consumption per ton of pulp is higher for seasoned wood than for steamed wood, while at high pressures the reverse is true. For green wood the average power consumption is lower than for either seasoned or steamed material. The power to the grinder for either seasoned or green wood under like conditions of speed and pressure is practically the same, but it is less for steamed wood. This is due, undoubtedly, to the more slippery condition of the steamed material. The rate of production of pulp from green wood is more rapid than from either seasoned or steamed wood.

Influence on Yield and Quality

Figure 17 shows graphically the weight per cubic foot of various woods and the yields secured from them under like conditions. The woods tested had been steamed for a period of 6 hours at a pressure of 60 pounds. The species, with numbers corresponding to those in the figure, were:

1. Western yellow pine (*Pinus ponderosa*).
2. Lodgepole pine, Montana (*Pinus contorta*).
3. Western larch (*Larix occidentalis*).
4. Lodgepole pine, California (*Pinus contorta*).
5. White spruce (*Picea canadensis*), normal growth.
6. Red fir (*Abies magnifica*).
7. Aspen[1] (*Populus tremuloides*).
8. Balsam fir (*Abies balsamea*).
9. Jack pine (*Pinus divaricata*).
10. Hemlock (*Tsuga canadensis*).
11. Tamarack (*Larix laricina*).
12. Paper birch[2] (*Betula papyrifera*).
13. Sitka spruce (*Picea sitchensis*).
14. Western hemlock (*Tsuga heterophylla*).
15. White spruce (*Picea canadensis*), rapid growth.

The yields are almost directly proportional to the bone-dry weight of the wood per cubic foot. In the same figure the relation between yield and dry weight is shown when unsteamed wood was used. In this case also the two factors vary directly.

The yield of pulp per 100 cubic feet of solid wood appears to be approximately the same from seasoned and green wood. It is very probable, however, that on the basis of a cord of rough wood, the yield would be smaller for seasoned material on account of the decayed portions. The yield of pulp from steamed wood is a great deal lower than from seasoned or green material. This may be due to the solvent action of hot water on wood, and the assumption is strengthened by the fact that the yield becomes less as the treatment is prolonged or the steaming pressure raised. The relation between yield and duration of treatment is shown in figure 18 (see note below).

The quality of the pulp does not seem to be influenced greatly by the moisture content of the wood or weight per cubic foot. However, by treating the wood prior to grinding the strength is much increased and the color darkened. Therefore, when strength is the important factor steaming prior to grinding raises the quality of the pulp, but when light color is one of the chief considerations the quality is greatly lowered.

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[1] Generally called "popple" in Wisconsin.

[2] Generally called white birch in Wisconsin.

Note: This is the same as figure 7 in Bul. 343. See page 3.

(From Bulletin 343)

Other Factors

The variation of the yield of pulp from 100 cubic feet of solid wood with the duration of cook and temperature of cooking has been pointed out. It would seem that most of the loss would occur in the cooking process itself, but determinations of the amount of wood charged (oven-dry basis) to the cooker and the amount of material taken (oven-dry basis) from it after steaming show that the loss in cooking as volatile materials and water-soluble substances which leach out when the wood is in the 2-foot lengths is remarkably low, being from 5 to 8 percent. It appears that the great loss which takes place in the production of steamed wood pulp occurs in the grinding process, either due to the dissolving of material which has been converted to a soluble state or the grinding of the softer portion of the wood -- the springwood -- to flour and the subsequent loss of it in the white water. There is a characteristic odor of burned sugar during the steaming of wood, and possibly some of the wood fiber is converted into sugar.

The condensed liquor from the steamer has a very corrosive action on the iron and it is possible that in order to satisfactorily protect the metal it might be desirable to add small quantities of sodium carbonate to the water when the boiling process is used. This, of course, would not apply when the wood is steamed.

The liquors which condense during the steaming of the woods may have considerable commercial value, particularly when resinous woods are used. The equipment employed in the Wausau laboratory was not of sufficient capacity to make it possible to study this problem carefully, but an indication of the nature of the condensed liquor can be obtained from the following analyses of material secured from a mill steaming wood commercially, in which case approximately 5 cords of wood were used for each charge. Unfortunately no means were available for measuring the total condensed liquor, and for that reason the amount of the materials cannot be expressed in quantity per cord.

It will be noted that two samples were analyzed, one of which was a residue from evaporation of a condensed liquor and the other a sample of the liquor from another cook. The woods steamed were a mixture of jack pine and tamarack in the ratio of 67 percent of the former to 33 percent of the latter.

	Residue from evaporation of liquor	Sample of liquor
	Percent	Percent
Total solids		2.05
Soluble solids	70.10	1.95
Reducing sugars	15.89	.83
Tannins	13.60	.092
Ash	9.85	.049
Acetic acid (total)	5.71	.162
Formic acid (total)	1.41	.042
Moisture	4.31	97.95

The total and soluble solids and tannin were determined according to the methods outlined by the American Leather Chemists' Association.

The boiling or steaming of woods results in the formation of a natural size from the wood substance or some of its constituents. This sizing action is particularly noticeable in the production of pulps from the hardwoods -- birch and aspen -- which are not pitchy. All paper produced from cooked woods, pulped by the mechanical process, show the characteristic water-resistance qualities and hardness of hard sized papers.

Tests on papers made from steamed and unsteamed woods show that the unsteamed pulps do not give as high percentage stretch as the steamed, even though the unsteamed pulps were mixed with 20 percent of bleached spruce sulphite. Pulps made from cooked woods should be given satisfactory beating treatments to make them usable for different purposes. Like chemical pulp, there is a marked influence on the resultant paper when the pulps are given different beating treatments. The sheets become more brittle after a prolonged beating, but give high strength tests.

<u>Steamed Wood Pulp and Its Uses</u>

The pulp made by grinding steamed wood can be used for different purposes, depending largely upon the nature of the grinding process. If a sharp and coarse stone is used a large number of shives will be present and the pulp will serve for the manufacture of box board or similar materials. When ground to a finer state, however, it has been demonstrated that with a mixture of a small amount of chemical fiber bogus kraft paper can be produced which will serve for a cheap wrapping paper. It is hardly likely that spruce could be used for the manufacture of cheap wrapping paper in this manner on account of its price, but other woods also give remarkably good