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PRODUCTION OF GROUNDWOOD PULP FROM HARDWOOD

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The invention relates to the production of groundwood pulp from hardwood, and relates more particularly to the production of groundwood pulp by subjecting hardwood blocks to a chemical treatment under special conditions as hereinafter described, prior to grinding them into pulp.

This application is a continuation in part of our co-pending application Serial No. 19,877, filed April 8, 1948, now abandoned.

Most of the wood pulp now used in the manufacture of paper is obtained from the soft or coniferous woods. The processes heretofore used for pulping the hardwoods, woods of broad-leaved trees, have either produced a weak pulp or, due to low yields or high processing expense, their utility has been restricted.

The primary object of the present invention is to provide a practical, economical method of obtaining from hardwoods a high yield of high quality groundwood pulp suitable for use in paper manufacture.

The wood pulping processes presently in extensive commercial use may be divided into two general types, the chemical processes and the mechanical processes. The chemical processes start with wood chips or other relatively small wood particles, subject them to a relatively severe digestion with chemicals, and thereby render the wood fibers readily separable. These chemical processes produce a high quality chemical pulp, of which the well-known spruce sulphite pulp of commerce is an outstanding example, but they are relatively low in yield, a yield of 40–50% of dry pulp based on the dry wood charge being customary. The mechanical processes produce a groundwood pulp by subjecting relatively large blocks of wood to the action of a revolving grindstone, which tears and ruptures the wood fibers by a relatively intense mechanical action. The wood blocks may be used in their natural state, producing raw groundwood pulp, or may be pretreated to soften them somewhat so as to reduce the power required for grinding. A conventional pretreatment comprises steaming or boiling the wood blocks with plain water. The yield of the mechanical processes is high, being in the neighborhood of 90%, but the quality of the pulp produced is low as compared, for example, to sulphite pulp.

Our invention relates to a pulping process lying between the above described chemical and mechanical processes, and may be called a chemo-mechanical process. Wood blocks are used and a groundwood pulp is produced as in the mechanical processes, but the wood blocks are first subjected to a chemical pre-treatment or digestion which is relatively mild as compared to that used in the chemical processes. Chemo-mechanical processes of this general type are not broadly novel, but so far as we are aware, the precise steps which we employ have never previously been used in the combination in which we employ them, nor has any prior process, to our knowledge, succeeded in producing a high yield of high quality groundwood pulp from hardwood. In fact, the pulps produced by our process are so distinctive that we have found it desirable to give them their own names. The product of our single

cycle process is now known commercially as "chemigroundwood," and we prefer to call the product of our double cycle process "dichemigroundwood." As described below, these two variations of our process differ substantially only in employing either one or two mild chemical pre-treatments. Chemigroundwood looks more like unbleached sulphite pulp than it does groundwood pulp, and has a strength about midway between the two. Dichemigroundwood has less strength than chemigroundwood, but is more bulky and considerably brighter in color, and possesses characteristics more like those of soda pulp than of sulphite pulp.

The hardwoods to which our invention is applicable may be divided into relatively low density hardwoods, such as poplar, and relatively high density hardwoods, such as beech, birch and maple. Various differences in treatment are appropriate for these different woods, and they produce differing qualities of pulp, but the general steps of our process remain the same regardless of the particular hardwood being treated.

In general, our single cycle process in its preferred form comprises charging the hardwood blocks into a suitable digester, which may be of conventional construction; subjecting the blocks to a relatively high vacuum to remove air therefrom; charging into the digester, without breaking the vacuum, and in sufficient quantity to fill the digester, a treating liquor adapted to produce a relatively mild digestion, or, in other words, adapted to soften the binding material between the wood fibers without substantial removal of said binding material; bringing the contents of the digester to a relatively high digestion temperature, say 140° C., and maintaining that temperature for a comparatively long time, say six hours; subjecting the blocks during this digestion to a hydrostatic pressure greatly in excess of that corresponding to the digestion temperature, say 150 pounds gage pressure, by superimposing a hydraulic pressure on the liquor in the digester, for example, by pumping liquor into the digester; relieving the pressure and removing the blocks from the digester; and subjecting the blocks to a more or less conventional grinding operation. Optionally, the blocks may be stored for a considerable time after removal from the digester and before grinding. The double cycle process is the same except that before removing the blocks from the digester, the used liquor is withdrawn, and the steps of evacuating, charging with liquor and digesting as above described, are repeated.

Preferably, we include in the treating liquor a wetting agent adapted to lower the surface tension of the treating liquor with respect to the wood surfaces to be wet, and thereby enhance the penetration of the treating liquor into the wood blocks. Although the use of such a wetting agent produces a superior result, it is not essential to our invention, and good results may be obtained despite its omission.

Although the character of the treating liquor and the other factors are undeniably important, we attribute the success of our process primarily to its superior penetration of the treating liquor into the hardwood blocks. This superior penetration results in a high yield of good quality pulp, and permits the use of a relatively high digestion temperature without burning the wood with resultant production of dark or discolored pulp.

The pre-evacuation, the application of hydraulic superpressure, and the use of the wetting agent, have in common the ultimate function of facilitating the penetration of the treating liquor into the wood blocks. We have found that no one of these alone suffices to produce a high yield of high quality groundwood pulp from hardwood blocks. The effect of the wetting agent appears to be purely additive, that is to say, the wetting agent increases the penetration of the treating liquor by about

the same amount when used alone as when used in conjunction with the pre-evacuation and hydraulic super-pressure steps. Surprisingly enough, however, the penetration obtained by the successive use of pre-evacuation and hydraulic super-pressure is not additive but is superior to the mere sums of the penetrations obtained by the use of either pre-evacuation or hydraulic super-pressure alone. We regard the successive use of pre-evacuation and hydraulic super-pressure as being of the essence of our invention, and as enabling, perhaps more than any of the other factors or steps, the realization of the above-stated primary object of our invention. Although the successive use of pre-evacuation and hydraulic super-pressure is thus of the utmost importance, the pre-evacuation step may be carried out after partial introduction of the treating liquor into the digester, although this is less desirable from the standpoint of economy of operation, and the application of hydraulic super-pressure to the treating liquor may precede the raising of the liquor to the digestion temperature, as described below.

The explanation of the effectiveness of pre-evacuation and hydraulic super-pressure when thus used successively, apparently resides in the basic phenomena of the penetration of liquids into wood. These phenomena have received a large amount of study by many researchers, but the penetration of liquids into wood is even yet not thoroughly understood. Previous studies have indicated that such penetration is of two main types, which may be called "natural penetration" and "forced penetration." Natural penetration includes penetration accomplished by sorption, adsorption and absorption, and is substantially synonymous with diffusion. Natural penetration is therefore governed by the osmotic pressure differential and is independent of the hydrostatic pressure differential. Forced penetration has as its common distinguishing characteristic, the mass movement of the liquid into the wood under the influence of the hydrostatic pressure differential. The amount of penetration of a liquid into wood in any particular instance, depends upon many factors, including the properties of the wood itself, the properties of the treating liquid, the time of contact, the temperature, and the pressure differential. The size and shape of the piece of wood are also important. The important properties of the wood depend primarily upon its species, its density and moisture content, and radical differences are observed between the sapwood and the heartwood.

It has long been known that the presence of air in wood interferes with natural penetration of liquid. Pre-evacuation of wood has been used in an effort to improve such penetration, but has effected only a moderate improvement in liquid penetration, a result which we have confirmed. The application of hydraulic super-pressure has likewise been used to increase forced penetration of liquids into wood, and our experiments have confirmed the fact that this step alone greatly increases penetration. The successive use of pre-evacuation and hydraulic super-pressure, so far as we are aware, has not previously been used in wood pulping processes, perhaps because earlier investigators assumed that the hydrostatic pressure would alone suffice to drive out the air. However, as stated above, this combination of steps has been shown by our tests to effect an increase in penetration greater than the cumulative increase due to pre-evacuation and hydraulic super-pressure when either of these treatments is used alone. We are not prepared to explain this surprising phenomenon, but that it exists, and that it produces, in our pulping process, better pulps than are obtained with either pre-evacuation or hydraulic super-pressure taken alone, has been conclusively demonstrated by the results of our experiments.

Our invention will be more clearly understood from the following specific examples of procedures which we have found to be effective, but it will be understood that these examples are illustrative only and that our invention is not to be limited to the precise conditions recited therein..

Our experiments were conducted on a semi-commercial, pilot plant scale, using the facilities of the New York State College of Forestry at Syracuse, New York. The equipment used included a digester, a grinder, and screens for the groundwood pulp.

The digester was of the vertical type, made of stainless steel, and had a capacity of 65 cubic feet. In commercial operations, a horizontal digester would probably be preferable, for convenience in loading and unloading. The digester was equipped with air-actuated pressure and temperature controller-recorders, and with a potentiometer for recording the temperature of the digester system at six points. The heating system was so arranged that either direct steam or indirect heating of the liquor by circulating it through a heat exchanger could be used for cooking, but in the experiments recited below, we used the indirect heating. The digester system also included two stainless steel liquor make-up tanks, and the necessary pumps, piping, and valves enabling the system to be maintained either under vacuum or under hydraulic pressure.

The grinder was a standard semi-commercial grinder, having two magazines and two pockets. The grinder was equipped with air-actuated controllers for pit temperature, pocket pressure and shower water temperature. The grinder had a stone 32" in diameter with an 11" face, driven by a 250 H. P. direct current motor having a speed range of 300 to 900 R. P. M. Each pocket had an area of 112 sq. inches, and the grinder was capable of grinding blocks of wood 8" long and 14" in diameter. In commercial operations, it is desirable to treat blocks at least two feet and preferably four feet long, and a grinder would be used capable of taking blocks of the full length treated. In the semi-commercial tests described below, blocks of commercial length were used during treating, and, before grinding, they were sawed into shorter lengths to fit the above-described grinder.

The laboratory testing methods used were the standard ones prescribed by The United States Forest Products Laboratory, Madison, Wisconsin, and the Technical Association of the Pulp and Paper Industry. The testing equipment used included a Canadian Standard freeness tester, British Standard Style sheet mold, a classifier, a burst tester, a tear tester, a thickness gage, and a brightness tester. All physical tests were made at 73° F., and 50% relatively humidity.

A great many runs were made to test the effect of different processing conditions, and the runs described in detail below are representative of the results obtained with optimum conditions for the different woods used. In all of the runs described, clean, debarked wood was used, because the presence of bark would result in a dirty pulp.

In Cook No. 124, poplar blocks 48" long and 9.6" in diameter were loaded into the digester and subjected to a vacuum of 26 to 28" of mercury for a period of 30 minutes. Without breaking the vacuum, the digester was then nearly filled, leaving some room for expansion, with a neutral sulphite treating liquor comprising sodium sulphite and sodium bicarbonate having a concentration, calculated as sodium carbonate, of 1.5 lbs. per gallon. The ratio of sodium sulphite to sodium bicarbonate was six to one, and the hydrogen ion concentration was 10–9.17, or the pH was 9.17. The liquor was prepared by dissolving dry sodium sulphite and sodium bicarbonate in water in the correct proportions, but it would be equally feasible to prepare the liquor by gassing a solution of sodium carbonate with sulphur dioxide gas. After thus filling the digester, the vacuum was shut off, and the liquor heated to a temperature of 140° C. Upon reaching this temperature,

with its corresponding steam pressure of 38 lbs. per square inch gage, the pressure was raised to 150 lbs. gage by pumping in liquid, thus establishing a hydraulic super-pressure of 112 lbs. gage. The digester was maintained at this temperature of 140° C. for a period of ten hours, during which period the pressure increased from 150 lbs. gage at the beginning to 200 lbs. gage at the end of the digestion period, due to evolution of gas. After this cooking, the pressure was relieved and the blocks removed from the digester.

During the digestion, 21% of the chemicals in the liquor were consumed, the relief liquor having a concentration of 1.244 lbs. per gallon, calculated as sodium carbonate, with a ratio of sodium sulphite to sodium bicarbonate of 6.08 to 1, and a pH of 9.24. The poplar blocks increased 42% in weight.

The poplar blocks were then ground at a stone speed of 400 R. P. M., corresponding to 3,408 ft. per minute, with a pocket pressure of 40 lbs. per square inch, a shower water temperature of 50° F. and a pit temperature of 130° F. The consistency of the pulp in the pit was 3.37%.

The production, production rate and power consumption were calculated using the following formulas:

$$\text{Production in tons/day} = \frac{\text{lbs. of wood ground} \times 24}{2000 \times \text{time of run (hrs.)}}$$

$$\text{Production Rate in tons/sq. ft./day} = \frac{\text{tons/day}}{\text{pocket area (sq. ft.)}}$$

$$\text{Power Consumption in H. P. days/ton} = \frac{\text{kilowatt hours}}{\text{time of run (hrs.)} \times 0.746 \times \text{tons/day}}$$

Calculated as above, the production was 4.64 tons/day, the production rate was 2.99 tons/sq. ft./day, and the power consumption was 28.25 H. P. days/ton.

The pulp produced had a Canadian Standard freeness of 157 ml.; a fiber classification of 67.9% intermediates; a brightness of 37.1; a burst factor of 1.16 points per lb.; and a tear factor of 0.94 gram per lb.

The calculated yield of Cook No. 124 was 93.1% of dry pulp based on the dry wood charge. Due to the conditions under which the work had to be performed, this figure and the other yield figures given later, are necessarily rather approximate. However, it may safely be asserted that the pulp yields of our process are substantially equal to those of conventional groundwood pulping processes. Speaking generally, our process permits the recovery of approximately one ton of groundwood pulp from one cord of less dense hardwood, such as poplar, and one and one-half tons from the denser hardwoods.

Cook No. 139 was generally similar to Cook No. 124, the principal differences being that the treating liquor included a wetting agent and that the digestion time was shortened to 8 hours. The wetting agent was "Triton N–100," a polyether alcohol, and was added to the liquor in such amount as to form a 0.05 percent solution of the wetting agent. The liquor had a concentration of chemicals of 1.55 lbs. per gallon, a ratio of sodium sulphite to sodium bicarbonate of 5.5 to 1, and a pH of 8.82. The consumption of chemicals was 24%; the relief liquor having a concentration of 1.246 lbs. per gallon; a ratio of sodium sulphite to sodium bicarbonate of 6.05 to 1; and a pH of 8.8. The wood had a diameter of 8.9" and gained 51% in weight. The processing conditions were otherwise the same.

In Cook No. 139, the pit consistency was 5.11%, the production was 3.87 tons/day, the production rate was 2.49 tons/sq. ft./day, and the power consumption was 30.88 H. P. days/ton. The pulp produced had a Canadian Standard freeness of 177 ml.; a fiber classification of 65.3% intermediates; a brightness of 44.4; a burst factor of 1.17 points/lb.; and a tear factor of 0.90 gram/lb.

It will be observed that the poplar pulp produced in Cook No. 139 with the wetting agent was superior to that of Cook No. 124 without the wetting agent, with respect to freeness and brightness, and, as respects other pulp qualities, the differences are insignificant. An additional advantage of Cook No. 139 was the two hour shorter digestion period, which represents a decided economy. The use of the wetting agent, therefore, appears to offer advantages more than justifying its cost. The calculated yield of Cook No. 139 was 93.4%, not significantly better than that of Cook No. 124, in view of the yield figure uncertainties mentioned above.

In Cook No. 131, birch blocks 48" long and 7.0" in diameter were subjected to a vacuum of 26 to 28" of mercury for 30 minutes, and then digested for 6 hours at 150° C. under a pressure ranging from 150 to 200 lbs. gage, the general operating conditions being the same as above described. The neutral sulphite treating liquor had a concentration of chemicals of 1.55 lbs. per gallon, the ratio of sodium sulphite to sodium bicarbonate was 5.95 to 1, and its pH was 9.28. The birch blocks gained 5% in weight. The grinding conditions were the same as above given. The pit consistency was 4.98%; the production was 3.82 tons/day; the production rate was 2.46 tons/sq. ft./day; and the power consumption was 42.89 H. P. days/ton.

The birch pulp from Cook No. 131 had a freeness of 92 ml.; a fiber classification of 45.9% intermediates; a brightness of 42.8; a burst factor of 0.89 point/lb.; and a tear factor of 1.13 grams/lb. The calculated yield was 95%.

In Cook No. 132, beech blocks 7.1" in diameter and 48" long, were digested for 9 hours at 140° C., the operating conditions otherwise being substantially the same as for Cook No. 131. The beech blocks gained 19% in weight. Upon grinding as before, the pit consistency of 5.38%; the production was 4.69 tons/day; the production rate 3.02 tons/sq. ft./day; and the power consumption 30.19 H. P. days/ton.

The pulp produced in Cook No. 132 had a freeness of 112 ml.; a fiber classification of 54.5% intermediates; a brightness of 39.5; a burst factor of 0.50; and a tear factor of 0.81. It will be noted that this beech pulp is of poorer quality than the pulps produced from poplar and birch; this difference apparently being due principally to the native differences among these species of hardwoods.

Where a bulkier and brighter pulp is desired, and some sacrifice in pulp strength can be tolerated, we have found it desirable to use a two cycle process embodying two chemical pre-treatments of the wood blocks before grinding.

In Cook No. 257 P–2, poplar blocks 48" long and 7.8" in diameter were pre-evacuated for ½ hour at 26 to 28" of mercuy; the digester was filled with liquor without breaking the vacuum and the pressure then raised to 160 lbs. gage by pumping in liquor; next the temperature was raised to 130° C. in two hours and held at that temperature for an additional hour while maintaining the pressure; the liquor was blown from the digester; the wet blocks were pre-evacuated at 20 to 25" of mercury for ½ hour; the digester was again filled with liquor without breaking the vacuum and the pressure raised to 140 lbs. gage by pumping in liquor; the temperature was next raised to 160° C. in one hour; and then the liquor was blown from the digester and the blocks removed for grinding. The liquor in both cycles was a neutral sulphite liquor with a concentration of 1.50 lbs. per gallon, a ratio of sodium sulphite to sodium bicarbonate of six to one, and a pH of 8.73. The blocks were ground with a stone speed of 400 R. P. M., a pocket pressure of 40 lbs. per square inch, a pit temperature of 150° F., and a pit consistency of 3.43%.

The characteristics of the product produced by this two

cycle process may perhaps best be seen by a comparison with the product of the single cycle Cook No. 124 described above:

	Single Cycle Cook No.	Double Cycle Cook No. 257 P–2
Freeness, C. S., ml	157	510
Burst factor, pts./lb	1.16	0.14
Tear factor, gm./lb	0.94	0.90
Bulk factor	1.20	3.84
Brightness	37.1	65.8
Percent Intermediates	67.9	80.2
Tons/sq. ft./day	2.99	2.89
H. P., days/ton	28.2	31.7

In Cook No. 242 Bi–2, birch blocks 48" long and 8.7" in diameter were treated in a two cycle process similar to that described for Cook No. 257 P–2, except that in both cycles the temperature was raised to 150° C. before the application of a super-hydraulic pressure of 150 lbs. gage; this temperature was held in both cycles for a digestion period of two hours while maintaining the pressure; the liquor had a pH of 8.92; the pocket pressure was 50 lbs. per square inch; and the pit consistency was 4.83%. The product compared with the product of Cook No. 131 as follows:

	Single Cycle Cook No. 131	Two Cycle Cook No. 242 Bi–2
Freeness, C. S., ml	92	261
Burst factor pts./lb	0.89	0.30
Tear Factor, gm./lb	1.13	0.78
Bulk factor	1.44	2.64
Brightness	42.8	60.5
Percent Intermediates	45.9	58.5
Tons/sq. ft./day	2.46	3.40
H. P., days/ton	42.9	29.8

It will be evident to those skilled in this art that our mild chemical pre-treatment could be carried out more than twice if desired, and we have successfully employed a three cycle process, producing a trichemigroundwood. This product, however, displayed no advantages that would seem to justify the added expense of the extra pre-treatment.

As would be expected, the pulp properties vary with the temperature and time of digestion, and with the concentration of the liquor and its ratio of sodium sulphite to sodium bicarbonate. All of these factors may be varied somewhat without greatly changing the results, particularly if offsetting changes be selected, such as an increase of digestion temperature accompanied by a decrease of digestion time. We have used with good results digestion temperatures ranging from 120° C. to 170° C. The values of these factors given above are believed to be the optimum values for seasoned wood of the species and size stated. Green wood appears to require, for best results, a somewhat higher liquor concentration than used in the foregoing cooks. Our tests also indicate that the larger the blocks, the higher the liquor concentration should be. Thus, for 24" long blocks of substantially the same diameters as those above described, we have found liquor concentrations of from 1.0 to 1.25 lbs./gallon, to be quite satisfactory.

Our tests have shown that the time of pre-evacuation treatment is not especially critical, and we have successfully used pre-evacuation times ranging from 30 minutes to two hours. The shorter time appears to be ample for birch and beech, but with poplar, we found a slight improvement by increasing the time of the pre-evacuation to one hour. The height of the vacuum could be increased, but this would be uneconomical of power, and the vacuum could likewise be decreased somewhat, especially if accompanied by an increase in the time of evacuation. We have had satisfactory results using a vacuum as low as 23" of mercury in the single cycle process, and as low as 20" in the second cycle of the two cycle process.

The actual amount of the hydraulic super-pressure of our process is also not especially critical. We have successfully used total hydrostatic pressures (steam pressure due to digestion temperature plus hydraulic super-pressure) ranging from 100 to 300 lbs. gage. Naturally, the higher pressures produce better penetration. We prefer to use an initial total pressure of not materially less than 150 lbs. gage, and allow this to increase naturally during digestion, due to evolution of gas as above described, to a maximum of about 200 lbs. gage. We have found that this pressure range of from 150 to 200 lbs. gage gives adequate penetration, but of course higher pressures could be employed if desired. Also, as shown by the preceding specific examples, it is possible to apply the hydraulic super-pressure either before or after raising the digester to the digestion temperature. No decided advantage is presented by the one procedure over the other.

Our experiments have also shown that a considerable improvement in the quality of the pulp results from storing the wood blocks for from two to four days after digestion and before grinding. In the cooks described in detail above, this procedure was not followed, the blocks being ground fairly promptly after removal from the digester, being allowed to stand only overnight. It is probable that during the longer storage period of several days, the chemicals in the wood blocks migrate somewhat and continue to react with the wood, giving an improved pulp.

We have successfully employed other wetting agents than the "Triton N–100" described in connection with Cook No. 139. We have had good results using "Aerotex Softener H", a synthetic type softener; "Solvadine R", the sodium salt of an aryl alkyl ether sulphate; and "Alrosol C," a non-ionic fatty amid wetting agent. All three were used in a 0.1% solution of the wetting agent in the treating liquor.

While we prefer to use a neutral sulphite treating liquor as above described, we have produced usable though less satisfactory pulps by employing other treating liquors. Thus, we have successfully treated hardwood blocks under alkaline conditions using (1) caustic soda, (2) a mixture of caustic soda and sodium sulphide, and (3) ammonia gas; and under acid conditions using (4) calcium bisulphite liquor prepared by gassing a slaked lime suspension with sulphur dioxide, and (5) sulphur dioxide gas with heating by live steam. All of these digesting reagents and their manner of use are well-known to those skilled in this art. In general, the alkaline treatments are to be preferred to the acid treatments in connection with our process.

The brightness of the pulps produced from hardwoods in accordance with our invention can be considerably enhanced, if desired, by a bleaching operation. The bleaching may be accomplished in a known manner using conventional reagents. We have successfully bleached our pulps using standard aqueous bleaching solutions containing from 2 to 4% of "Solozone" (sodium peroxide), from 5 to 10% of sodium silicate, and from 0.0 to 2.7% of sulphuric acid. We found that better bleaching was obtained at a pulp consistency of 15% than at a relatively low consistency of 5%. Using 3% "Solozone" at 15% consistency, we obtained brightness increases as high as 22.2 units on freshly ground poplar pulp (Bleach No. 56), 17.0 units on birch (Bleach No. 10), and 11.7 units on beech (Bleach No. 71). The final brightnesses of these particular pulps were 56.4 for the poplar, 74.5 for the birch, and 55.9 for the beech. We have also successfully used standard hydrogen peroxide bleaching solutions. In general, it may be said that pulps produced in accordance with our invention may conveniently be bleached to brightnesses nearly equal or exceeding the av-

erage brightness of conventional raw spruce groundwood, which is about 60 brightness units.

The high quality of the chemigroundwood pulps produced from hardwoods in accordance with our invention as above described, will be apparent to those skilled in this art. As pointed out above, we obtain a high yield comparable to the yield obtained in conventional mechanical processes. Among the important advantages of our process are that these results are accompanied by a production rate two to three times the production rate customarily obtained in grinding normal raw spruce groundwood, and by a power consumption of from one-half to two-thirds of that required for such grinding of raw spruce.

Although we have thus described our invention in considerable detail in the best form of which we are aware, in accordance with the patent statutes, it will be evident that various changes and modifications may be made by those skilled in the art without departing from the spirit of our invention. Accordingly, we desire to be limited only by the scope of the appended claims.

We claim:

1. The method of producing groundwood pulp from hardwood, which comprises confining in a digester hardwood blocks not substantially shorter than two feet nor longer than a small multiple of that length, evacuating air therefrom, filling the digester without breaking the vacuum with a chemical digesting liquor adapted to soften the binding material betwen the wood fibers without substantial removal of said binding material, heating the liquor and blocks to a digestion temperature substantially above the boiling point of the liquor at a pressure of one atmosphere, subjecting the liquor and blocks in the digester to an hydraulic pressure such that the total pressure is greatly in excess of the steam pressure corresponding to said digestion temperature while maintaining said digestion temperature, relieving the pressure in the digester, removing the blocks therefrom, and subjecting the blocks to a grinding operation.

2. The method as claimed in claim 1 in which the digesting liquor contains a wetting agent having the property of lowering the surface tension of the liquor with respect to the wood surface.

3. The method as claimed in claim 1 in which the blocks are stored for a period between about two and about four days after removal from the digester and before grinding.

4. The method as claimed in claim 1 in which the digestion temperature is between 120° C. and 170° C.

5. The method of producing groundwood pulp from hardwood, which comprises confining in a digester hardwood blocks not substantially shorter than two feet nor longer than a small multiple of that length, subjecting the blocks in the digester to a vacuum of not substantially less than 26 inches of mercury, filling the digester without breaking the vacuum with a digesting liquor comprising a non-acid aqueous solution of a soluble sulphur-bearing salt and an alkali, heating the liquor and blocks to a digestion temperature substantially above the boiling point of the liquor at a pressure of one atmosphere, subjecting the liquor and blocks in the digester to an hydraulic pressure such as to raise the total pressure to not substantially less than 150 pounds gage while maintaining said digestion temperature, relieving the pressure in the digester, removing the blocks therefrom, and subjecting the blocks to a grinding operation.

6. The method as claimed in claim 5 in which the digesting liquor contains a wetting agent having the property of lowering the surface tension of the liquor with respect to the wood surfaces.

7. The method as claimed in claim 5 in which the blocks are stored for a period between about two and about four days after removal from the digester and before grinding.

8. The method as claimed in claim 5 in which the digestion temperature is between 120° C. and 170° C.

9. The method of producing groundwood pulp from hardwood, which comprises confining in a digester hardwood blocks not substantially shorter than two feet nor longer than a small multiple of that length, subjecting the blocks in the digester to a vacuum of not substantially less than 26 inches of mercury, filling the digester without breaking the vacuum with a chemical digesting liquor adapted to soften the binding material between the wood fibers without substantial removal of said binding material, heating the liquor and blocks to a digestion temperature substantially above the boiling point of the liquor at a pressure of one atmosphere, subjecting the liquor and blocks in the digester to an hydraulic pressure such that the total pressure is greatly in excess of the steam pressure corresponding to said digestion temperature while maintaining said digestion temperature, relieving the pressure in the digester and removing the liquor therefrom, subjecting the blocks in the digester to a vacuum of not substantially less than 20 inches of mercury, filling the digester without breaking the vacuum with digesting liquor, heating the liquor and blocks to a digestion temperature substantially above the boiling point of the liquor, subjecting the liquor and blocks in the digester to an hydraulic pressure such that the total pressure is greatly in excess of the steam pressure corresponding to said digestion temperature while maintaining said digestion temperature, relieving the pressure in the digester, removing the blocks therefrom, and subjecting the blocks to a grinding operation.

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