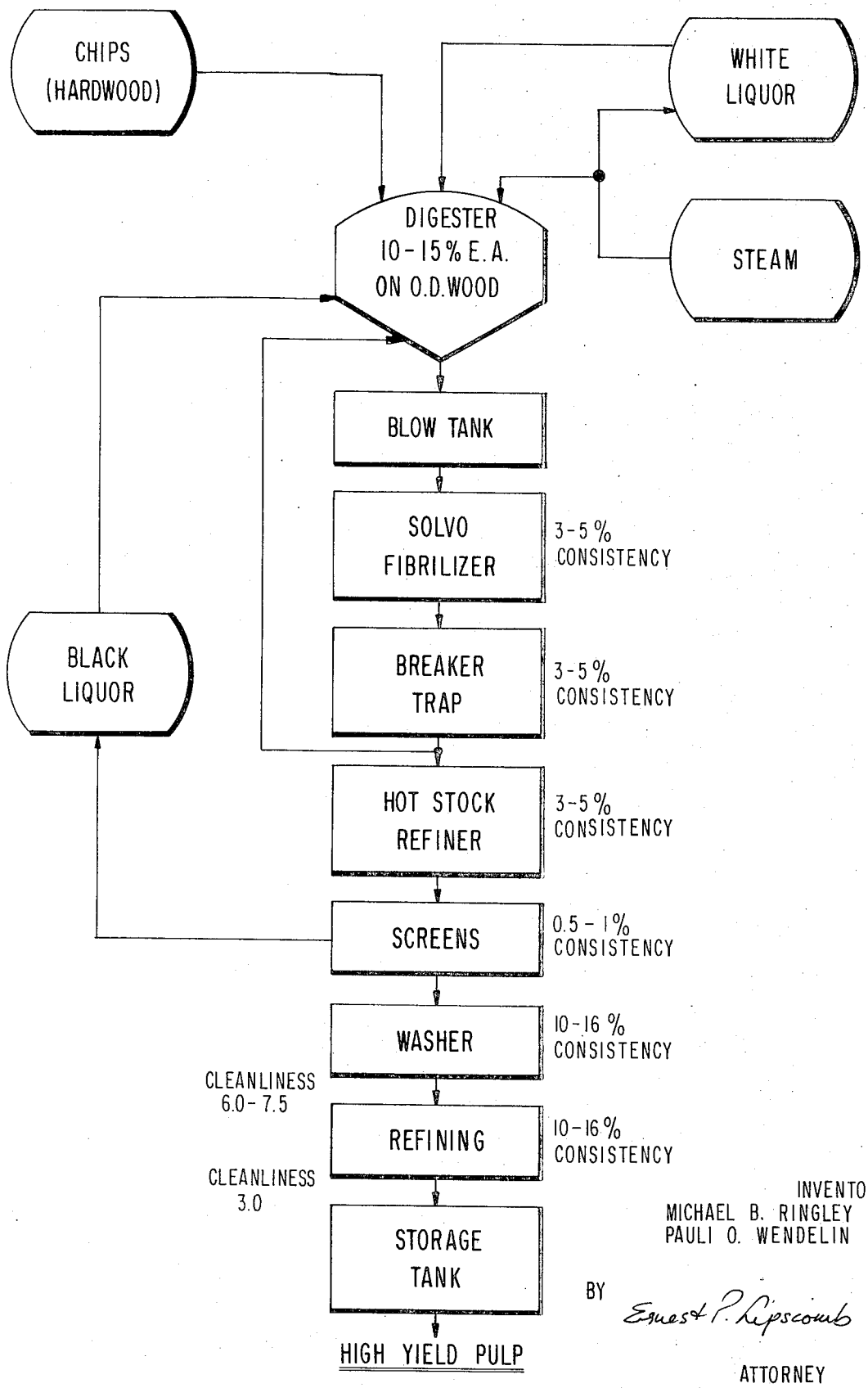
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PROCESS FOR PRODUCING HIGH STRENGTH, HIGH YIELD HARDWOOD PULP

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INVENTORS
MICHAEL B. RINGLEY
PAULI O. WENDELIN

BY Ernest P. Lipscomb

ATTORNEY

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PROCESS FOR PRODUCING HIGH STRENGTH, HIGH YIELD HARDWOOD PULP

Michael B. Ringley, Charleston Heights, and Pauli O. Wendelin, Charleston, S.C., assignors to Westvaco Corporation, New York, N.Y.

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ABSTRACT OF THE DISCLOSURE

High strength, high yield hardwood pulps are produced by partially fiberizing hardwood fibers during digestion, removing digestion chemicals from the fibers by applying sufficient mechanical force to the fibers to separate said fibers and thereafter washing said fibers and further refining said fibers at a rate sufficient to cause fiberization along the fiber surfaces by interfiber friction without substantially fracturing said fibers. The hardwood pulp produced has a William slowness of less than 18 seconds for a 3-gram sample, a 200 ml. K number of at least 500 and a dirt level of less than 4.0.

BACKGROUND OF THE INVENTION

This invention relates to high strength, high yield hardwood pulps, an improved process for producing these pulps, and the saturating papers made from these hardwood pulps.

Saturating paper is primarily designed to be impregnated with resins. The resin impregnated paper sheets are pressed, heat cured, and consolidated into multi-ply laminates. To perform satisfactorily in this service, a saturating paper must have a very special combination of controlled properties. These include moderate strength, high bulk, uniform porosity, good formation, uniform basis weight, freedom from shives and unfiberized wood, and other objectionable foreign matter. These various properties are somewhat mutually antagonistic. In trying to improve one property, other properties are often degraded. For example, if the pulp furnish is subjected to increased refining power to increase strength and reduce dirt level, a number of undesirable side effects are also observed. Principal among these will be the undesirable effect on paper bulk and porosity. The bulk and hence the void volume available for resin will be reduced. The average pore size will also be reduced thus restricting the rate of resin flow into the paper. Reducing refining on the other hand increases bulk and improves the rate of resin penetration into the paper but only at the expense of increased dirt level and decreased paper strength.

Sheet formation is another important property of a saturating sheet. "Formation" of a paper describes the uniformity of fiber distribution within a given area and hence influences the uniformity of fiber-void ratio in the paper to be saturated. Any hard lumps apparent in the formation of the paper may resist resin penetration. The resulting void then becomes a defect in the laminate. Formation generally improves as fiber length is shortened. Fiber flexibility also influences the paper formation although to a somewhat lesser degree. The more flexible a fiber the better its chances of becoming entangled with its neighbors giving rise to a non-uniform fiber distribution.

In practice, it has been found difficult to make satisfactory saturating paper from an all pine furnish. The relatively long pine fibers preclude the attainment of formation of acceptable quality. If the pine fibers are shortened by passing them through refiners equipped with cutting tackle, the resulting pulp is still not satisfactory. On the other hand, hardwood pulps are ideal furnish components in this respect for saturating papers. Hardwood fibers have

less than half the length of pine fibers. With a minimum of refining, they often make paper having excellent formation and plenty of bulk as well. However, papers made from 100% hardwood pulps prior to this invention are deficient in strength. Frequently a minor portion of pine pulp, i.e., 20–40% is added to improve paper strength. With this combination, most saturating paper properties can be maintained in an acceptable range.

Dirt in the form of bark particles, shives, and unfiberized wood are particularly undesirable contaminants in saturating paper. These foreign materials resist resin penetration. They, thus, become potential sites for laminate blisters to form which are caused by water and water vapor entering the laminate structure. Large dirt particles in the paper may also cause unsightly surface blemishes in the laminate. They also represent points of nonuniformity and hence points of stress concentration in the laminates. To avoid dirt in laminates, it has been found necessary to overcook the kraft pulps and to resort to elaborate and expensive screening and cleaning procedures. This results in low yield, high cost pulps with mutually antagonistic properties.

More recently, it has been found that relatively high yield kraft pine pulps can be utilized in saturating paper with conventional yield hardwood pulps if they are subjected to treatment in a counter-rotating double disc refiner. Here the pulp at moderate, i.e., 10–15%, consistency is subjected to an intense shear field. This mechanical action does an excellent job in fiberizing any fiber bundles and in pulverizing bark particles. At the same time, the water drainage and bonding characteristics of the pulp are hardly changed. The Fourdriner paper machine operation is unaffected and so is the resulting sheet bulk and porosity. Unfortunately, attempts to apply this technique to hardwood pulps in the past have been unsuccessful. Treatment of higher yield hardwood pulps in the double-disc refiner resulted in the expected pulp cleanliness improvement, but invariably the resulting pulp was so slow draining water that it could not be used on the paper machine. Apparently, hardwood fibers are sufficiently different from softwood fibers in chemistry and morphology so as to behave completely different during processing. With pine pulp, the increase in draining resistance is hardly measurable. With hardwood, the increase is so tremendous as to render the process useless for Fourdrinier paper machines.

It is therefore a general object of this invention to provide a high strength, high yield, clean hardboard pulp without substantially increasing drainage resistance and a process for obtaining this high quality pulp. Another object of this invention is to produce a saturating grade paper possessing superior formation characteristics either with or without the supplemental use of pine pulp. Still another object of this invention is to produce a saturating paper containing high strength, high yield hardwood pulp giving paper with improved resin penetration characteristics. Yet another object of this invention is to produce a saturating paper of normal bulk and void volume but of greater than normal strength. Even another object of this invention is to provide a high yield hardwood pulp that can be satisfactorily used in other grade papers, such as linerboard and sack paper.

Other objects, features and advantages of this invention will be apparent from the following disclosure with reference to the drawing, which shows a schematic block diagram of a process flow sheet illustrating a process for making the high strength, high yield hardwood pulps of this invention.

SUMMARY OF THE INVENTION

It has been found that a hardwood pulp at 55–80% yield (O.D. pulp on O.D. wood) can be processed to

give a high strength, well fiberized, clean rapid water draining pulp. This hardwood pulp gives all the desired properties that heretofore were not obtainable at one time in a conventional kraft paper. The pulps are prepared by modifying the alkaline chemical pulping treatment and subsequent mechanical treatment. The modifying chemical treatment is characterized by digesting with a lower effective alkali concentration, i.e., 6–15% (as Na_2O on O.D. wood), and less severe cooking conditions. Hardwood pulps of high yields are only slightly fiberized when blown from the digester. They are then sufficiently mechanically fiberized to permit the washing out of residual cooking chemicals and dissolved wood substances. After washing, the partially fiberized pulp is completely mechanically fiberized at 10–16% consistency in a counter-rotating double-disc refiner. Even though ordinary plates render good pulps, best results have been obtained using "wave line" plates in the refiner. Under these new process conditions, the resulting pulp possesses high strength, is adequately clean, and the drainage resistance is satisfactory.

DETAILED DESCRIPTION OF THE INVENTION

The essence of this invention, resides in a particular combination of modified steps in an alkaline pulping process. The superior and unexpected properties possessed by the hardwood pulps of this invention result from modifications to both the chemical and thermodynamic treatment of hardwood chips during digestion and the institution of mechanical process steps to the hardwood materials.

The conventional method to produce unbleached hardwood pulp via the kraft process is to charge the digester with hardwood chips and cooking liquor having an effective alkali charge of 15–20% (as Na_2O on O.D. wood), and a white liquor sulfidity of 20% to 30%. The digester is brought to cooking temperature between about 345° F.–350° F. in about 30 minutes and held for about 1½ to 2 hours. The procedure generally produces pulp having a yield of about 46% (O.D. pulp on O.D. wood). This pulp is nearly completely fiberized in the blowing from the digester. It requires, therefore, no mechanical refining prior to washing or mechanical fiberizing after washing to produce a pulp having a Williams slowness (3 gram) of about 15 seconds and a dirt level of 3. The Williams slowness is the amount of time in seconds for one liter of water to drain through a 3 gram sample of pulp. The dirt level is determined by comparison of the occurrence of shives, bark and unfiberized wood in a handsheet of the subject pulp with a series of standard handsheets having graduated dirt levels. The cleanest sheet contains approximately 2 objectionable dirt particles per 1.5 gram handsheet of pulp and is identified as a dirt level of 1. Each dirt level differs from the next lower dirt level by a factor of 2. A handsheet of dirt level 3 thus has twice as many dirt particles as one of dirt level 2 and 4 times as many as a sheet of dirt level 1.

The procedure of this invention, on the other hand, is to reduce the effective alkali charge to between 6–15% (as Na_2O on O.D. wood) depending on the desired yield and likewise lower the digesting temperature to between 230–310° F. while maintaining a comparable cooking time which results in part to high strength hardwood pulp having increased yields. The amount of increase being dependent upon the particular conditions used.

The slightly fiberized pulp is removed from the digester or blown in a conventional manner and suspended in residual black liquor at a consistency of between 3 and 5%. It is passed through a Solvo Fiberilizer and Breaker Trap to break up knots and divide large chunks of partially fiberized ligno-cellulose. This serves to obtain a more uniform slurry. The cooked, slightly fiberized pulp still in black liquor is further fiberized in a single disc refiner. This refining is called hot stock refining as the temperature is approximately 190–200° F. at a consistency of 3–5%. The power is regulated as desired to fiberize the pulp to an amount sufficient to permit the screening and the washing out of the residual pulping chemicals and dissolved wood substances. The slowness after hot stock refining should be maintained from 7.5 to 8.0 seconds (Williams slowness of a 3 gram sample) or lower. If the slowness after hot stock refining is over 8.0 seconds the power input required to deshive the pulp in the subsequent refining will raise the slowness beyond the desired amount of, for instance, 18 seconds and render the pulp useless for saturating paper made on Fourdriner paper machines. An increase in hot stock refining power improves the fiber separation of the cooked chips, but at the same time increases the slowness of the liberated pulp fibers making washing difficult. In other words, the slowness of the pulp is dependent on the amount of hot stock refining power employed. It should be noted, however, that the refining done in this process step is not restricted by the particular refiner or plates used.

The pulp is then screened and washed to remove the residual pulping chemicals and dissolved wood materials, i.e., black liquor. From the washing, the partially fiberized pulp at about a 10% to 16% consistency is again passed through a refiner using sufficient power to give a clean, well-fiberized pulp. The net result is that more work can be put into fiberizing and cleaning without developing intolerable slowness. Particularly good results have been obtained in a counter-rotating double-disc refiner using wave-line plates. While it is advantageous to use a counter-rotating double-disc refiner for this purpose, the invention is not limited thereto. Other high shear refiners where the differential speed between the plates is on the order of 25,000–35,000 f.p.m. also permit good fiberizing and minimize the development drainage resistance. From this refining step the pulp may be stored or sent to the paper mill for conversion into paper.

Typically, the amount of total power (including Solvo Fiberilizer, hot stock refining and high consistency refining) applied to kraft hardwood pulps of this invention should be in the range of between 5 and 18 H.P. days per air dried ton of pulp depending on the yield and slowness desired as compared to less than 1 H.P.D./A.D. ton for conventional yield pulps.

Regardless of power applied, it is important to transmit mechanical forces from the refiner surfaces under sufficient power input so as to maintain a vigorous shear field among the fibers during their passage through the space formed between the two refiner plate surfaces. This is obtained by exerting a high compression force on the fibers while they are being worked upon. The feed rate of the pulp into the space between the refiner plates (throughput) will depend on several conditions, including the type of pulp being processed, its consistency, the horsepower input, the type of apparatus employed and the clearance between the opposed plate surfaces. In general, the refiner plate surface spacing at any given input horsepower is adjusted in accordance with the pulp feed rate and the quality of pulp desired.

The increase in yield and quality of the hardwood pulps of this invention is in part accomplished by decreasing the degree of chemical application and thermodynamic treatment. The mechanical work at the proper consistency is in part required to obtain the pulps having the characteristics necessary to make a satisfactory saturating paper. The cooking temperature was reduced instead of the cooking time in an effort to obtain as uniform impregnation and delignification of chips as possible without degrading the fibers. Cooking temperatures of between 230° F. to 310° F. are suitable for 55 to 80% yield pulps; whereas 345 to 350° F. is commonly used for the conventional 46% yield pulps. To obtain a yield over 70% and still maintain a uniform cooking required a reduction of the cooking temperature down to 265° F.

In the 46% yield level pulps the fiber separation is primarily accomplished during cooking and only a rela-

tively small amount of power is needed, if any, in refining to obtain a required cleanliness for saturating papers. When the pulp yield is increased, progressively more power is needed for fiber separation and cleaning in the refining stages. Pulp yields of 45, 55, 60 and 73% require approximate total net refining power (both hot stock and 10–16% consistency refining) inputs of 1.3, 4.0, 6.0 and 11.0 HPD/A.D. ton respectively. At these power input levels the slowness of different yield pulps is controlled below 15 seconds (Williams slowness), which is considered a rigid requirement for saturating grade pulps, and the dirt level is about 3.0. It is important that the consistency not be allowed to drop much below 10% or excessive slowness development will occur during the post washing fiberizing operation. In general the higher the consistency during this fiberizing step the lower the drainage resistance or slowness of the resulting pulp. Consistencies above 16% in general cannot be attained by dewatering on a washer and hence require another process step to attain. To obtain a high yield hardwood pulp having satisfactory drainage requirements, it is necessary for the pulp to have a K Number above 50, preferably between 55–80. The K Number as used herein is of a 200 ml. sample measured according to the procedure set forth in TAPPI test RC–242 (modified).

The production of 100 pounds of conventional hardwood pulp (oven dry basis) at 46% yield requires 218 pounds of chips (O.D. basis). A similar quantity of pulp prepared according to this invention at a yield of 64% requires only 152 pounds of chips (O.D. basis). This means an equal quantity of pulp is prepared from a 30% smaller quantity of chips.

It is generally observed that when the yield of pulp is increased the bulk of paper at a given slowness is also increased, despite the smaller number of fibers per unit area when compared with a conventional 46% yield pulp. This is usually interpreted as a poorer conformability of the higher yield fibers. In contrast, the high yield (60%) pulps of this invention give saturating paper which have about 5 to 7% lower bulk than similar conventional 46% yield pulp paper. A portion of the mechanical energy supplied using the process of this invention for satisfactory fiberizing is apparently consumed for swelling the fiber wall to give more conformable fibers.

As stated above, the saturating hardwood papers of this invention are most often impregnated with various resins. Rate of resin penetration tests run to determine the saturability of papers made from the pulps of this invention showed this property to be equal or faster than that in 46% yield papers. The improved penetration increases the assurance that uniform resin distribution will be accomplished even when a heavier basis weight paper is used. The heavier weight saturating paper is advantageous in that it permits laminators to use fewer sheets of paper to achieve the same final panel thickness.

The practice of this invention may clearly be seen in the following examples.

Example 1

Hardwood kraft pulps were produced in a laboratory digester by a conventional kraft pulping process at 46% yield for comparison to pulps produced at 60% yield according to the process of this invention using a chip mixture of 50% sweet gum and 50% red oak. The solid content of the chips was 55.6%. The cooking conditions are shown in the table. To improve the uniformity and reduce the temperature degrading effects of high yield pulps a lower temperature was used and also the total cooking time was in most cooks increased compared with cooking of the conventional yield pulps.

The partially fiberized pulps were further fiberized at a consistency of approximately 3% in black liquor with Bauer 8″ laboratory single disk refiner using #8117 plates. The power input for hot stock refining was regulated for different cooks by adjusting the plate clearance. The temperature during hot stock refining was approximately 200° F.–210° F. The hot stock refined pulps were washed. Yield and slowness (Williams) determinations were made. Several of the cooks were screened after washing in a flat screen using 14 cut plates. The rejects were neglible. The pulps at about 10% consistency were heated to about 130° F. for further refining. Refining at 10% consistency was made with the same equipment as was used for the hot stock refining. The pulp pH during the high consistency refining was approximately 8.5. The results are shown in the table below.

TABLE I.—FIBERIZING DATA OF DIFFERENT YIELD HARDWOOD PULPS

	Conventional		Invention				
	1	2	3	4	5	6	7
A. Conditions:							
Amount of O.D. wood (gms.)	2,000	2,000	2,000	2,000	2,000	2,000	2,000
Liquid-to-chip ratio	4:1	4:1	4:1	4:1	4:1	4:1	4:1
Effective alkali on O.D. wood (Na_2O), percent	17.8	17.8	11.6	10.9	7.8	10.9	6.2
Time from 80° C. to cooking temp. (min.)	60	60	60	60	60	60	60
Cooking temp. (° F.)	347	347	311	302	266	302	248
Time at temp. (min.)	75	75	80	109	60	109	30
B. Results:							
Yield, percent	45.1	45.6	55.1	59.1	72.9	58.5	79.8
K. No. (200 ml.)	12.6	11.3	57.9	78.0	125	73.5	150
HSR power (HPD/A.D. ton)	.6	.7	1.5	2.3	7.3	2.1	16.2
High cons. power (HPD/A.D. ton)	.7	.4	2.4	2.9	3.3	5.9	1.4
Total power	1.3	1.1	3.9	5.2	10.6	8.0	17.6
Slowness after HSR	11.2	-------	7.8	9.0	8.2	-------	7.7
Slowness final	13.4	13.9	13.7	14.9	8.8	21.3	8.9

Example 2

To determine if the high yield hardwood pulps of this invention are suitable for saturating, paper handsheets and pilot machine papers were prepared and tested.

The different yield pulps from Example 1 were beaten in a Valley beater to adjust the slowness to an approximately comparable level before preparation of saturating paper handsheets and pilot machine papers. Saturating paper handsheets were prepared using a standard TAPPI sheet mold and sheet press. The sheets were dried on rings. A Whatman No. 2 filter paper was always put between the handsheet and plate to prevent a polished surface on the saturating paper bandsheets. All handsheets were made to approximately 150 g./m.^{2} basis weight. The pilot machine saturating papers were made from about 46 and 60% yield pulps. Both papers were made using comparable machine conditions. The physical properties of the saturating paper handsheets are presented in Table II, and of the pilot paper machine saturating papers in Table III.

TABLE II.—PHYSICAL PROPERTIES OF SATURATING PAPER HANDSHEETS

Cook number	1	3	4	5
Average hardwood pulp yield, percent	45.1	55.1	59.1	72.9
Bulk, cc./g.:				
Before calendering	2.04	1.86	1.88	2.35
After calendering	1.75	1.75	1.75	1.75
Burst factor:				
Before calendering	24	29	30	15
After calendering	21	29	-------	15
Tensile, 100 M:				
Before calendering	45	51	52	30
After calendering	40	51	-------	31
Stretch, percent: Before calendering	3.23	3.88	-------	2.67
	2.87	3.88	3.55	2.53

TABLE III.—PHYSICAL PROPERTIES OF SATURATING PAPERS MADE ON PILOT PAPER MACHINE

Cook number	2	6
Average yield, percent	45.6	58.5
Bulk, cc./g.:		
Before calendering	2.56	2.35
After calendering	1.77	1.78
Tensile after calendering, 100 M:		
MD	43	65
CD	27	44
Tensile ratio after calendering, MD/CD; MD/CD	1.59	1.48
Stretch after calendering, percent:		
MD	1.1	1.6
CD	1.6	2.8
Initial modulus after calendering lbs./inch:		
MD	8.3×10^3	14.3×10^3
CD	6.3×10^3	11.1×10^3

The saturating paper handsheets were tested both at a bulk obtained from the sheet making process and at a constant bulk of 1.75 cc./g. after calendering. The pilot machine saturating papers were tested only after calendering to a constant bulk. The calendering of the saturating papers was done to provide a constant void volume in sheets for a subsequent resin treatment.

The handsheet results in Table II indicate that 55 and 60% yield pulps had about 8 to 9% lower uncalendered bulk than 45 yield pulp. Also, a similar bulk difference was measured in pilot machine saturating papers as is shown in Table III. When the yield was further increased to 73% (Cook No. 5) the uncalendered bulk did not decrease but was about 15% higher than 45–46% yield pulps. The sheet strength properties, burst and tensile were inversely related to the uncalendered bulk. The calendering did not change the strength properties of 55, 59 and 73% yield saturating paper handsheets. About 10% reduction in burst and tensile was measured when 45–46% yield handsheets were calendered from 2.04 cc./g. to 1.75 cc./g. The stretch of the saturating paper handsheets and of pilot machine saturating papers was similarly related to the pulp yield and to the sheet bulk as were tensile and bursting strengths. The papers made from 55 and 59% yield pulps had the greatest stretch. The initial modulus of the pilot machine saturating papers made from low (45.6%) and high (58.5%) yield pulps was measured from calendered sheets in both MD and CD directions. Although papers made from high yield pulp had a higher stretch they had considerably higher initial modulus than papers made from the conventional pulp. However, the high yield papers also had a considerably higher tensile strength than the conventional. Papers from the high yield pulps were shown to contain fewer fiber, and more and deeper voids than the conventional papers.

Example 3

Kraft pulps were prepared from a 1:1 mixture of sweet gum and red oak according to the process of this invention at high yield and compared to a conventional 46% yield pulp.

The mixtures of chips were cooked in a digester of a kraft pulp mill in liquor of an amount of 9–16% effective alkali (as Na_2O) on O.D. wood. The chip mixtures were heated from ambient temperature to 300° F. in 60 minutes and maintained at 300° F. for another 60 minutes. The pulps obtained from the digester were diluted to 3–5% consistency and passed through a Solvo Fiberilizer having 1" diameter perforation in the plate and a Breaker Tarp. The pulps were fiberized in a Bauer single disc refiner at a temperature between 190° F. and 210° F., a consistency of 3–5%, and a hotstock refining horsepower input of 2–3 H.P.D./A.D. ton. The pulps were then screened at 0.5 to 1.0% consistency on a rotary screen with 12/1000 inch diameter perforations and washed. The pulps had a dirt level of 10–11. At 10–16% consistency the pulps were further fiberized in a Bauer double disc refiner to a dirt level of 6–8. Centrifugal cleaners brought the dirt level in the pulps down to 3–4, which is acceptable for making saturating sheets. Test data are shown in Table IV.

TABLE IV

	Conventional, 46%	Invention 1	Invention 2	Invention 3	Invention 4
A. Conditions:					
Amount of wood (tons)	40	40	40	40	40
Liquor-to-chip ratio	4.1:1	3.8:1	3.7:1	3.7:1	3.4:1
Effective alkali, (percent)	19	12.4	12.3	11.6	10.9
Cooking temp. (° F.)	347	300	300	300	300
Cooking time (min.)	120	230	130	120	130
Total power (HPD/A.D.T.)	.8	9.2	9.3	12.3	7.3
B. Results:					
Yield, (percent)	44.3	50.2	55.3	57.0	58.9
K number (200 ml.)	13.5	28.0	56.0	63.3	73.2
Dirt level	4.5	5.8	7.0	6.9	7.0
Slowness washer	12.5	15.7	10.0	7.9	9.5
Slowness after refining (Williams)		25.3	14.4	15.5	15.5

The results show that hardwood pulps produced according to this invention and having a K Number between about 55 and 75 possess a drainage resistance within the necessary limits. Pulps produced having a K Number between 20 and 50 usually possess desirable dirt levels but often possess undesirable drainage resistance. The high yield pulps of this invention shown in Table IV are of acceptable cleanliness as the centrifugal cleaner brought the dirt level to 3–4 without adversely effecting drainage resistance.

Hardwood pulp made according to this invention was substituted for conventional hardwood pulp in a furnish consisting of 25% pine pulp and 75% hardwood pulp. This furnish was used to prepare a saturated sheet of 110 lbs./3000 sq. ft. basis weight. The furnish containing the high yield hardwood pulp drained in an identical manner on the paper machine but appeared to be slightly harder to dry. The resulting product met all of the specifications for the conventional sheet. This was truly surprising. In general, as the yield of a pulp is increased, the fibers become stiffer and less conformable. As a result, sheets of paper made from them tend to be bulkier. It was expected, therefore, that the substitution of the high yield hardwood pulp made according to this invention for the conventional hardwood pulp would result in a bulkier sheet. This was not the case. The sheet bulk was the same as obtained for conventional pulps.

The saturating sheet containing the high yield pulp was significantly stronger than the sheet made with conventional pulp. This suggested that in practice the pine pulp content could be reduced. This would aid in the attainment of good formation.

The saturating paper described above was saturated with phenolic resin on a treater equipped with a dip-pan followed by squeeze rolls. The sheet imbibed the resin solution at the same rate as conventional papers. The resin appeared to penetrate the sheet somewhat faster than it did conventional sheets. This decreased the tendency toward "dry centers" and other operational defects in the saturated sheet.

While the invention has been described and illustrated herein by references to various specific materials, procedures and examples, it is understood that the invention is not restricted to the particular materials, combinations

of materials, and procedures selected for that purpose. Numerous variations of such details can be employed, as will be appreciated by those skilled in the art.

What is claimed is:

1. The process for producing high strength, high yield hardwood pulp which consists essentially of,

(A) partially fiberizing hardwood cellulosic fibers during digestion at an effective alkali concentration of 6–15% and a temperature between 230° F. and 310° F. and thereafter blowing said fibers,

(B) applying sufficient mechanical refining force to said blown hardwood fibers at a fiber consistency of 3 to 5% to separate said hardwood fibers to remove residual pulping chemicals when washed,

(C) washing said partially fiberized and mechanically refined cellulosic fibers, and

(D) further refining in a refiner said washed hardwood pulp at a fiber consistency between 10% and 16% in a single pass through said further refiner at a rate sufficient to cause fiberization along the fiber surfaces by interfiber friction without substantially fracturing said fiber,

to thereby obtain a pulp having a yield between 55% and 80%, a Williams slowness of less than 18 seconds of a 3-gram sample, a 200 ml. K Number of at least 50, and a dirt level of less than 4.0, said pulp being suitable for saturating grade paper.

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S. LEON BASHORE, Primary Examiner

A. L. CORBIN, Assistant Examiner

U.S. Cl. X.R.

162—90

PO-1050
(5/69)

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,827,934 Dated August 6, 1974

Inventor(s) Michael B. Ringley and Pauli O. Wendelin

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 22, "500" should read --50--.

Column 2, line 26, "double disc" should read --double-disc--.

Column 2, line 48, "hardboard" should read --hardwood--.

Column 6, in Table I under the heading, A. Conditions:, "(Na^2O)," should read --(Na_2O),--.

Column 6, in Table I under the heading, 7, "79 8" should read --79.8--.

Column 6, line 55, "bandsheets" should read --handsheets--.

Column 8, line 5, "Tarp" should read --Trap--.

Signed and sealed this 29th day of October 1974.

(SEAL)
Attest:

McCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents