ABSTRACT: A method of preparing a paper pulp from a fibrous nonwoody lignocellulose plant material by first wetting said material, wet depithing said plant material by subjecting a slurry of the plant material to a shredding operation, further diluting the slurry of released pith and fiber, separating the pith from the fiber, dewatering the resultant fiber slurry, impregnating said fibers by addition of a base such as an alkali metal hydroxide solution, and chemically digesting the resultant liquor containing said fibers by cooking at a relatively high temperature and under pressure.
The bulk of paper articles, of course, are produced from woody materials. Thus, for example, printing paper such as newsprint and book paper are conventionally made from a combination of ground wood and a chemical wood pulp. The ground wood pulp supplies the required opacity, smoothness, resiliency and bulk to the paper, while the chemical wood pulp provides the necessary strength. However, the high consumption of newsprint and other types of paper made by present processes requires enormous quantities of wood pulp and results in a depletion of forests particularly with respect to preferred soft wood species employed in the manufacture of ground wood.

Thus, continuing efforts have been made to provide a paper pulp made entirely from or in part from a fibrous, nonwoody lignocellulosic plant material. A typical material of this type is sugar cane bagasse. This material is readily available and easily accessible in a great many countries of the world and is especially abundant in some of the wood-poor countries. From a quality standpoint, bagasse pulp is particularly suitable for the making grades of paper, including writing and printing papers of various types, bleached tissue, toweling and glassine and greaseproof papers. Other fibrous nonwoody plant materials useful as a source of paper pulp include abaca, Manila hemp, sisal, kenaf, ramie, straw, esparto, etc.

It is almost uniformly agreed that the key to the successful utilization of bagasse and similar fiber-containing plant materials lies in economically and efficiently removing the pith and other extraneous materials from the fiber. These extraneous materials may include leaves, weeds, sheath material, undesirable fine fibrous material, colloidal soil, dust and other types of extraneous matter. These undesirable components must be removed, preferably before digestion, if the desired high quality pulp is to be produced in an economical manner.

It therefore becomes an object of the invention to provide a method of making a paper pulp from a fibrous, nonwoody lignocellulosic plant material such as cane bagasse.

A further object of the invention is to provide the above method which may be carried out in an efficient and economical manner without resort to sophisticated and expensive apparatus or resort to a complicated multistep process.

A further object of the invention is to provide a pulp from said nonwoody lignocellulosic materials such as bagasse which after processing contains little, if any, pith or other undesirable constituents that are normally present in such material.

A further object of the invention is to provide a nonwoody lignocellulosic pulp which may be employed per se in the production of a variety of paper articles such as newsprint or other printing paper of commercial quality or in the alternative, may be combined with a wood pulp such as chemical or mechanical wood pulp.

Other objects, features and advantages of the invention will be readily apparent from the following description of certain preferred embodiments thereof, although variations and modifications may be effected without departing from the spirit and scope of the novel concepts of the disclosure.

In accordance with the invention, a novel method of preparing a paper pulp made of fibrous, nonwoody lignocellulosic plant material has been discovered. In its broadest aspects, the process of the invention comprises the sequential steps of wetting the fibers of the plant material thus forming an aqueous slurry of said plant material, and thereafter wet depithing said plant material by subjecting the slurry to a shredding operation. The pith is thus detached from the fibers in this operation by now released pith and fibers is further diluted and the pith and fibers separated from one another by a screening operation. The resultant fiber slurry is partially dewatered and then impregnated by adding to the fiber slurry a liquor which at least contains dissolved therein a basic substance such as an alkali metal hydroxide. The fiber and liquor are then chemically digested by cooking at a high temperature and under condition of pressure.

The discussion below will be directed to processing of a sugar cane bagasse. However, it should be understood that the invention is equally applicable to processing of a wide variety of nonwoody, fibrous lignocellulosic plant materials of the type mentioned above and others of a similar nature.

The first step in the invention involves wetting the bagasse with an aqueous liquid. However, prior to this step a preferred expedient is to partially depith the bagasse as it comes from the sugar mill. Moist or "humid" depithing methods of a conventional nature are used here in which the bagasse, normally about 50 percent dry, has about two-thirds of its pith removed.

While the bagasse can be wetted with an aqueous liquid such as fresh water or white water from the savæall, for economical reasons black liquor is the preferred wetting agent here. The black liquor preferably used is that returned as filtered liquor from the first-stage washing. Since the black liquor is hot, 150°-175°F, it also prewarms the incoming bagasse and thereby reduces the steam demand in the digester. The black liquor also contains a small amount of residual active alkali which is beneficial for impregnation. Usually, the partially depithed bagasse wetted here has been stored for a period of 30-45 days until sucrose fermentation has ceased and moisture content has gone down to about 30 percent (70 percent solids). The bales of bagasse are broken up and fed to the system by mixing them with black liquor house. Also, by completely removing the pith one substantially lowers the liquor and steam consumption used to further process the bagasse fibers.

The depithing here is best carried out by shredding the bagasse. The best mode of this operation consists in passing the bagasse between disks provided with teeth. In the usual case a typical machine of this type has a stationary and rotating disk with the latter mounted on a vertical shaft driven at high speed by an integral motor or V-belts. The disks are provided with angular rows of fine-pointed diamond or pyramidal-shaped teeth and can be adjusted with tip-to-tip clearance or even with overlapping of the teeth if finer shredding is desired. Through the shredding operation the pith is then loosened from the fiber. The shredding operation also opens up the fibers, thereby allowing dirt to be washed out. In addition, the shredded material becomes more uniform in size and since it is opened up it is more susceptible to chemical cooking or any other further pulping treatments.

It is important that the bagasse be shredded wet. If it is shredded dry, the fiber and the pith become shortened and separation becomes difficult if not impossible. Through the prewetting operation the fibers become flexible and remain in long fibrous form after shredding, whereas the pith turns into short fine dust and is easy to separate.

Following the just described step, the slurry of now released pith and fiber is then further diluted. The dilution is preferably accomplished in a chest with suitable agitation. This mixing helps to break up bundles and facilitates separation of the pith from the fiber in the subsequent washing step. Again, the mixture of fiber and loose pith may be diluted with any type of aqueous liquid. However, for reasons of economy, it is preferred that the mixture be diluted with black liquor. In any event, the fiber and loose pith slurry should be diluted to say about 1-5 percent solids, more often 2-4 percent solids, typically 3 percent.

The next step in the overall operation involves separation of the loosened pith from the fibers. This is best accomplished by a screening procedure. For example, a vibrating flat screen can be used whereby the stock travels in thin layers across a series of showers. The pith is collected as a slurry under the screen while the fibers are retained on the screen surface.
A rotating screen washer is also useful here. For example, a drum washer which has a rotating screen drum tilted toward the discharge end may be utilized. It is preferably provided with several internal showers. The dilute fiber and pith mixture is washed out of the end of the screened bagasse fiber emerges at the other end. Generally the solids content of the fiber in the slurry is about 8–14 percent, and more often has a 10–12 percent consistency. Due to the overall efficiency of the operation it has been determined that the washed fibers retained on the screen are almost completely free from pith. Moreover, the fiber losses through the screen are quite minimal, generally about 1 percent or lower.

The slurry of pith is then collected, and the pith allowed to settle over a period of time wherein the top water layer is drawn off and the wetted pith collected or the pith slurry is subjected to centrifugation or other dewatering processes. As noted above, the pith may then be used as a source of cattle feed or as a fuel source.

The slurry of bagasse fibers is then partially dewatered. Any conventional apparatus may be used here such as a screw press. Usually the dewatering operation is carried out such that the resultant fiber consistency is 25–40 percent by weight, and more often 30–35 percent. The dewatering step is necessary in order to achieve a proper liquor-to-fiber ratio, say about 3.5 to 1 in the furnish going to the digester and thereby keep the steam consumption low. If, on the other hand, the consistency of the dewatered bagasse was too low and liquor added, the desired liquor-to-fiber ratio would be exceeded and the steam consumption would be raised.

After the fibers have been partially dewatered as suggested above, they are subjected to an impregnation step by addition of a base. This step is carried out for a sufficient time to achieve the desired degree of wilting.

In this step the bagasse fibers are placed in a suitable vessel and an aqueous solution of an alkaline hydroxide added comprising either an alkali metal hydroxide or an alkaline earth metal hydroxide. Examples are sodium hydroxide, potassium hydroxide, lithium hydroxide, calcium hydroxide, barium hydroxide, and strontium hydroxide. These may be used singly or in admixture with each other. Sodium hydroxide is a preferred member of the group. Bleaching agents and other chemicals useful in imparting desirable properties to the resultant pulp may be included in the liquor as desired.

The foregoing alkali hydroxides are employed in an amount sufficient to produce a liquor of a desired concentration, that is, a concentration sufficient to soak and soften the bagasse fibers to the desired extent under selected reaction conditions. In general, liquor containing from about 5 to about 15 percent by weight of the hydroxide, calculated as sodium hydroxide, may be used. A sufficient quantity of the liquor is employed together with the fiber to produce a mixture having a liquor-to-fiber ratio of from 3:1 to 4:1. The bagasse is treated with liquor at a temperature lying broadly between 50° and 150° F. The treatment is continued for a time sufficient to soften and wilt the fibers without causing any substantial delignification. The duration of treatment in this step is determined by many factors including concentration of the liquor, temperature, the liquor-fiber ratio, etc. In general, however, where the reaction conditions are as indicated above, a treatment time of temperatures of from 5 to about 120 minutes, preferably from 20 to about 60 minutes, will be required, the longer reaction times being employed with the lower temperatures.

The last step in the operation comprises producing a fully cooked chemical pulp from the bagasse by subjecting it to a digestion step. Here the bagasse pulp may be made either of the unbleached or bleachable grade and all types of pulping procedures are applicable such as the kraft, soda and neutral sodium sulfite methods. The best results are found if the kraft process or a modification of the soda process, combined with a small amount of elemental sulfur are used. In some instances a neutral sodium sulfite method can be used for high quality unbleached and bleached pulps. Acid or bisulfite processes are to be avoided here since use of these processes tends to result in a brittle pulp of low-strength properties, as compared to bagasse pulp produced by the alkaline processes. As noted above, if it is desired to increase the pulp brightness, the pulp may be easily bleached using conventional bleaching agents in an amount sufficient to attain the desired brightness value. For example, a hydrosulfite bleaching agent may be usefully employed here.

Digestion is then carried out in a digester in the presence of steam at pressure ranging from say about 100 to 150 p.s.i.g. and over a temperature range of 330°–380° F., more preferably, 340°–370° F.

In a preferred embodiment, in order to achieve optimum cooking conditions, one may utilize a rotary valve feeding the bagasse into the digester tube which is uncompacted and open for immediate penetration with steam. Normally employed screw feeders compact the fiber into a solid plug at entry point to the digester and seal against steam pressure. More time and effort is required to break down the plug. On the other hand, if the stock consistency is too low the plug will not form and blowbacks occur.

After the bagasse pulp is prepared essentially as described above, it may be utilized in making paper articles alone or, if desired, may be mixed with any convenient conventional chemical or mechanical pulp. The two pulps may be mixed together in any convenient manner, such as, for example, by addition of lap pulp to the beater with the roll raised, or by simple fluid mixing in slush pulp aqueous systems. After a substantially uniform fibrous slurry has been produced, it is run over a conventional paper machine in the normal manner for the production of paper articles such as printing papers.

The following example illustrates a typical way of carrying out the process of the invention. It is understood, of course, that this example is merely illustrative and that the invention is not to be limited thereto:

**EXAMPLE 1**

Thirty pounds (B.D.) of baled dehydrated bagasse from Louisiana was first broken up manually and then fed into a screw conveyor while water was being added. This constitutes the prewetting step. The bagasse had already been partially neutralized at the sugar mill. To increase the mixing operation, the discharge end of the screw conveyor was raised about 5° from the horizontal and the wetted bagasse was discharged into a tip bucket. The prewetting operation is essentially carried out to render the fibers flexible so that after the shredding operation they remained in long fibrous form, whereas the pith becomes short, fine dust and separation then became possible.

The bagasse absorbed water very readily in this step and the rolling action of the screw conveyor was found to be quite satisfactory for mixing the bagasse with water. A very short, if any, retention period for water absorption was found necessary for good wetting.

The next step in this operation was shredding of the bagasse to release the pith from the fibers. This shredding not only loosened the pith but also opened up the fibers, allowing the dirt to be washed out. The shredded material was uniform in size and due to its being opened up was more amenable to chemical cooking.

The shredding itself was carried out by subjecting the charge to fine toothed disk knives of conventional design. Optimum tip-to-valley disk clearance was determined to be about 0.1000 inches. The wetted bagasse was fed onto a belt conveyor and discharged to a feeder and thereafter into the shredding machine. The discharge from the shredding machine was blown into another tip bucket.

The next step involves separation of the pith from the fibers. A vibrating screen, whose perforation size was about the size of a pith from the fibers and dewater the fibers. That is, one-half the screen was used for the washing operation and the other half used for dewatering. Two water nozzles were installed on
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top of the screen and a third nozzle installed to improve lump breaking. The third nozzle was also installed to give a flat pattern, high-pressure water jet situation.

The shredded bagasse was fed continuously into the screen from a belt conveyor and lumps of the shredded bagasse broken up to a thin layer by two of the nozzles. A square spray nozzle was placed on top of the two break up nozzles to supply washing water.

The dehydrated fibers on top the screen were collected in a tip bucket and the pith with the water was collected in another tip bucket. After allowing 10 minutes for the pith to settle down, the water with the settled pith was decanted into a 150 mesh screen box.

The washed fibers contained only very small amounts of pith. Moreover, the fiber loss through the screen was estimated to be only in the order of about 1 percent of the B.D. weight of the whole bagasse.

To the freshly dewatered fiber slurry was then added an aqueous solution of sodium hydroxide. Specifically, 100 pounds of a 35 percent consistency B.D. fiber was taken, to which was added 16 percent of sodium hydroxide based on fiber weight, or 16 pounds. The sodium hydroxide added was in the form of a 10 percent solution. The liquor-to-fiber ratio then was 3.46 to 1. The impregnation with this cooking liquor was carried out by providing a holding time of about 30 minutes. This allowed complete penetration of the fibers in this wilting step.

Digestion was then carried out by cooking the liquor and fibers at about 100 p.s.i.g. and at a temperature of about 350°F.

It will be understood that modifications and variations may be effected without departing from the spirit and scope of the novel concepts of the present invention.

I claim as my invention:

1. A method of preparing a paper pulp from a fibrous non-woody lignocellulose plant material having fibers and pith therein, comprising the sequential steps of wetting said plant material with an aqueous liquid wetting substance selected from the group consisting essentially of fresh water, white water, black liquor and mixtures thereof, so as to form an aqueous plant material slurry having a solids content of about 10-25 percent by weight; wet depthing said plant material by subjecting said aqueous plant material slurry to a shredding operation so as to detach substantially all of the pith from the fibers in said plant material and produce a slurry of released pith and fibers; diluting said slurry of released pith and fibers with an aqueous liquid; separating the pith from the fibers in said slurry of released pith and fibers so as to obtain a resultant fiber slurry; partially dewatering said resultant fiber slurry; impregnating the fibers in said resultant fiber slurry with an aqueous solution of an alkaline hydroxide by adding said aqueous solution of an alkaline hydroxide to said resultant fiber slurry so as to produce a mixture of impregnated fibers and aqueous solution of an alkaline hydroxide; and chemically digesting said mixture of impregnated fibers and aqueous solution of an alkaline hydroxide by subjecting said mixture to a temperature in the range of about 330°F to 380°F and steam pressure in the range of about 100 to 150 p.s.i.g.

2. The method of claim 1 wherein said plant material has been initially partially depthed.

3. The method of claim 1 wherein said plant material is a sugar cane bagasse.

4. The method of claim 1 wherein said plant material is wetted with black liquor.

5. The method of claim 1 wherein said solids content is 15-20 percent.

6. The method of claim 1 wherein said plant material is depthed by subjecting said plant material to shredding between disks provided with teeth.

7. The method of claim 1 wherein the slurry of released pith and fiber is diluted to 1-5 percent solids.

8. The method of claim 4 wherein the slurry of released pith and fiber is diluted to 1-5 percent solids.

9. The method of claim 7 wherein said solids content is 2-4 percent.

10. The method of claim 8 wherein the solids content is 3 percent.

11. The method of claim 7 wherein said separation of pith and fibers is effected by means of a vibrating flat screen whereby said fiber is retained on said screen and said pith passes through.

12. The method of claim 7 wherein said separation of pith and fibers is effected by means of a rotating screen drum whereby said fiber is retained on said drum and said pith passes through said rotating screen drum.

13. The method of claim 8 wherein the slurry of released pith and fibers is dewatered to a 25-40 percent solid content.

14. The method of claim 13 wherein said solids content is 30-35 percent.