This invention relates to an improved method and apparatus for the production of bamboo pulp and paper products, and more particularly, to an improved method and apparatus for modified mechanical pulping of bamboo.

It has been stated in the literature and by various research investigators that mechanical pulping of bamboo is not practical or feasible. For example, after an extensive investigation by the Herty Foundation, it was reported that "Most of the known methods of pulping have been applied to bamboo. Least promising of the conventional methods is mechanical pulping."

UNITED STATES PATENT OFFICE

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PRODUCTION OF BAMBOO PULP AND PAPER
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6 Claims. (Cl. 162-26)

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Still another important object of the instant invention is to provide an improved process of producing bamboo pulp comprising the step of subjecting bamboo culms having a moisture content in excess of 40% to a shredding action produced by 8,000 to 12,000 longitudinal tooth strokes per inch width per inch feed of bamboo to individualize the fiber and cut it into lengths averaging likely between ¾ inch and 1 inch.

Other and further features, objects and advantages of the present invention will become apparent to those skilled in the art from the following detailed disclosure thereof and the drawings attached hereto and made a part hereof.

On the drawings:
Figure 1 is an essentially diagrammatic elevational view showing the device of the instant invention;
Figure 2 is a detail view of an individual tooth in the device of the instant invention; and
Figure 3 is a view in perspective of the drum employed in the instant device, with certain associated parts.

As shown on the drawings:

The device of the invention, indicated generally at 10 in Figure 1, comprises a rotary drum 11, a motor indicated diagrammatically at 11b for rotating the drum 11, a myriad of short dull closely spaced teeth 12 projecting radially from the drum surface, and means (indicated at 13) for feeding bamboo culms B against the teeth 12 on the rotating drum surface generally tangentially to the drum surface. Such means 13 being indicated here has a motor 13a driving a worm gear 13b which moves a screw 13c axially and the screw 13c mounts a backing member 13d at one end thereof for urging the bamboo culm B against the teeth 12 at a predetermined rate.

As indicated in Figure 2, each tooth 12 has an average radial dimension R of ½ inch to 1 inch, the radial dimension here shown being ⁷⁄₈ of an inch. Each tooth 12 has an average dimension d at its base of ⅛ inch to ¼ inch; and the tooth 12 here shown has a diameter of ⁷⁄₁₆ inch.

In the practice of the instant invention it is possible to individualize the fibers by a bearing and combing out of the pitch between the fibers. The instant invention differs from the usual or conventional carding process which employs relatively thin teeth spaced closely together for literally combing out the fiber. In contrast, in order to achieve the desired result of the instant invention, it is necessary to provide a rotating drum of certain size, with teeth of a definite size and shape, spaced in a particular manner and with a definite speed of rotation, using a definite speed and manner of feeding the bamboo culms against the rotating drum. The action against the culms resulting in the practice of the instant invention is a combination of impact, attrition, and combing.

It is, therefore, an important object of the instant invention to provide an improved method and apparatus for producing bamboo pulp and paper.

Another important object of the instant invention is to provide an improved apparatus for producing bamboo pulp comprising a rotary drum, means for rotating said drum, a myriad of short dull closely spaced teeth projecting radially from the drum surface, and means for feeding bamboo culms against the teeth on the rotating drum surface generally tangentially to the drum surface.
surface speed of 2,000 to 2,500 feet per minute. The best results are obtained using a surface speed of 2,200 feet per minute which is 250 revolutions per minute with a 3 foot drum. Such are the operating conditions here used.

The bamboo culm B is fed against the teeth 12 on the drum 11 generally tangentially to the drum 11 at a predetermined rate of about 4 inches to about 6 inches per minute. A certain number of tooth strokes for a given area of bamboo are required. Rotating the 3 foot diameter drum 11 at 250 rpm, it will be appreciated that in the peripheral area A, which is 1 inch in width, there are 48,000 tooth strokes per minute. These tooth strokes are, in effect, longitudinal of the bamboo culm. If the culm is fed at a rate of 6 inches per minute then each inch of bamboo fed receives 8,000 longitudinal tooth strokes per inch of width of the bamboo culm. It has been found that the best results are obtained using 8,000 to 12,000 longitudinal tooth strokes per inch width per inch feed of bamboo. The 12,000 longitudinal tooth strokes per inch width per inch feed of bamboo are obtained feeding at a rate of only 4 inches per minute.

It should also be noted that in a small peripheral area a only of 1 square inch, the average tooth density is 2. Two tooth centers 12a, 12a are shown in the inch square peripheral area a of Figure 3. The tooth density per square inch may vary from 1 to 3 teeth, but 2 teeth is the preferred tooth density, and that is the tooth density on the drum 11 here shown. Of particular importance, is the actual drum surface speed of 220 feet per minute. As the drum diameter is varied the tooth densities are varied to effect the desired number of tooth strokes at the drum surface speed of about 220 feet per minute.

It has been found that this arrangement is carried preferably with bamboo culms having a moisture content of above 40 (weight) percent, and the best results are obtained using culms with a moisture content of at least 50%. Bamboo culms having a moisture content of less than 40% are first soaked in water to obtain the desired moisture content.

Under the instant shredding conditions superior results are obtained in the form of highly individualized fiber masses containing a minimum of powered material and having an optimum average fiber length with very remarkably low power consumption. The percentage of powdered material (largely pith) is for low 10%. The average fiber length will be in the range of 3 inch to 1 inch, with relatively small amounts above 2 inches and below 1/4 inch. The power consumption is in the order of 10 to 20 horsepower per ton of bamboo per day (dry basis). This is only a small fraction of the power consumed in the conventional mechanical pulping of wood, which is about 60 to 100 horsepower per ton of wood ground per day.

It has further been found that the products of the instant shredding process can readily be converted to paper pulp stock by beating in the conventional type beater with certain precautions. The loading of the drum should be relatively light as the fibers cut easily. If the pH is held above 12 during beating it has been found that a sheet of greatly increased strength is obtained, and that the power consumption is lowered by 10%. The beating or pulping is carried out in a drum with high speed mixing. Fiber is reduced in length and further individualized and hydrated, as in the beater. In this instance, the pH may be conveniently maintained even higher than 12.5 with no harm done to the equipment, for example, by the addition of caustic up to 2%. The caustic soda thus used may range from 1 to 2%

For a crude type of pulp, useful in hard board production, the shredded product is simply pulped in the beater for several minutes to condition it, and then formed into sheets and hot pressed in the usual manner. A similar processing will be found suitable for some types of cardboard and the like. In this instance, the time of pulping may be extended somewhat and the pH raised to above 12. Other additions may be made in line with the usual practice for this type of product. In the case of finer grades of pulp and paper stock, it is advantageous to first screen the shredded product to remove the powdered portion which is largely pith and non-fibrous node particles. The non-fibrous powdered portion is less than 10% and it may be regarded merely as filler, if it is left in the shredded product.

If a particularly fine grade of pulp is desired, it is advantageous to raise the caustic content during pulping and to carry out this step at elevated temperatures with direct steam heating. It is not necessary to use pressure cooking with all its expensive problems and drawbacks. Open caustic pulp mills are designed for direct steam heating and high speed agitators are sufficient. As previously indicated, comparatively low concentrations of caustic will suffice for most purposes (within the range of 1/2 to 2%). The chemical treatment, pulping, and conditioning for individualization of the fiber and partial hydration and reduction of fines is also accomplished at the same time with the simplest kind of equipment at a minimum of power consumption. Excess unused caustic is recovered by washing the fiber in the usual manner.

The washed fiber may be screened in the usual manner to obtain high quality pulp, which may also be subjected to a bleaching action using, for example, zinc hydroxysulphite, as in the case of mechanical wood pulp. The instant pulp stock may be given a final beater treatment to more completely hydrolyze the fiber and to make the usual sizing and loading additions for specific types of paper. Sheet formation is carried out in the conventional manner for base stock.

The shredded product of the instant invention is unique in that it may be used in conventional wood pulp beating, conditioning, and the like operations including sheet formation. The instant pulp is advantageously suggested for pulp and paper at a pH of 12 or more.

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. The process of producing bamboo pulp and paper products comprising subjecting bamboo culms having a moisture content in excess of 40% to a shredding action produced by 8,000 to 12,000 longitudinal tooth strokes per inch width per inch feed of bamboo to individualize the fiber and cut it into lengths averaging largely between 1/2 inch and 1 inch, said teeth having an average height of 1/2 to 1 inch and an average diameter of 1/2 to ¼ inch, and producing less than 10% of powdered material of below 100 mesh; then subjecting the shredded product to a mechanical pulping at a pH of 12.5 maintained during beating of 0.44. This also represents a 100% gain in strength. It will be appreciated that these test sheets were made without any additions.

2. The process as claimed in claim 1, in which the shredded product is screened before pulping, in order to remove the powdered non-fibrous material.

3. The process as claimed in claim 1, in which the
pulping step is carried out using a suspension containing ½% to 2% caustic soda.

4. The process as claimed in claim 1 in which the shredded product is screened to remove powdered non-fibrous material before pulping and in which the pulping step is carried out in a suspension containing up to 2% of caustic soda, and in which the pulped fiber is washed and screened to remove excess caustic and any undesirable particles still remaining prior to sheet formation.

5. The process as claimed in claim 4, in which the washed and screened pulp is given a bleaching treatment with zine hydroxyphite prior to sheet formation.

6. The process as claimed in claim 5, in which the washed, screened and bleached pulp is given a second beater treatment to more completely hydrolyze the fiber and this is followed by making various sizing and loading additions prior to sheet formation.