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MODIFIED MECHANO-CHEMICAL PULPING

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A non-exclusive, irrevocable, royalty-free license in the invention herein described, for all governmental purposes, throughout the world, with the power to grant sublicenses for such purposes, is hereby granted to the Government of the United States of America.

This invention relates in general to the mechano-chemical pulping method of converting non-woody cellulosic fiber materials into pulp or pulp-like products. It relates particularly to a modification of the process for pulping disclosed in application Serial No. 110,868, filed August 17, 1949, which has matured into Patent No. 2,708,160, granted May 10, 1955, for the purpose of reducing materially the power requirement of the process. It relates to a mechano-chemical process carried out in 3 distinct stages of (1) intense mechanical treatment followed by (2) a quiescent period of mild chemical digestion and (3) a final brief period of intense mechanical treatment.

In accordance with the process for pulping as described in the above entitled patent, non-woody fiber-containing material is subjected to mild digestion conditions and temperatures and simultaneously is subjected to cycles of sharp impact blows while the material is submerged in the liquor. The combined chemical and mechanical action results in rapid pulping in high yields of usable pulp. Because of mechanical agitation that is involved, power costs are an important factor in the prior process.

In carrying out the mechano-chemical process disclosed in the above-identified patent, an undefibered non-woody fiber material, such as straw, bagasse, etc. is subjected to the action of a pulping liquor containing a chemical reagent in solution in a liquid medium, this reagent being capable of digesting the non-woody fiber material by removing lignin and other encrustants therefrom. The process is conducted at a temperature of about from 90° to 100° C. and at about atmospheric pressure, and under these conditions of temperature and pressure the pulping liquor is essentially non-hydrolytic. Simultaneously with the foregoing chemical action, the individual pieces of the non-woody fiber material are subjected to vigorous non-cutting impact blows while submerged in the pulping liquor and while they are in a relatively free state, these non-cutting impact blows comprising mechanically-induced cycles of expression and adsorption. Each cycle comprises compacting the pieces in an unconfined zone of impact to express liquid, immediately removing the pieces from the zone of impact to a zone of absorption of fresh liquid and returning the pieces containing absorbed liquid to another zone of impact. These blows are continued for from 30 to 60 minutes at which time a substantial proportion of liquor has been removed from the pieces and they have become broken up into individual fibers producing a pulp having a proportion of hemicelluloses at least as great as that contained in the original non-woody fiber material. Where the non-woody starting material contains nodes, rachises, seeds, and similar materials, the pulp produced by the above described process may be subjected to a riffling and screening operation to remove such nodes, rachises, etc. from the pulp.

In accordance with the present invention the aforementioned process of mechano-chemical pulping is modified by carrying it out in three rather distinct consecutive stages. The modification affords two significant advantages. Firstly, the extent of chemical hydration of the fiber is considerably lessened. Secondly, the modification results in a power saving of 30 percent up to 50 percent or more. Technological advantages of the lessened extent of hydration will be explained in detail in the following specification.

The first of the three stages of treatment which characterize this invention is a combined mild chemical and intense mechanical pulping, and is the same as prior mechano-chemical processes in all respects except its extent and duration. The mechanical action is stopped at a time before complete pulping is achieved. Most of the pulping occurs in this initial stage, stage I, which may be from 5 minutes to 20 minutes' duration. Under ordinary circumstances a period of 10 to 15 minutes is preferred for the first stage. At the end of this stage, the pulping chemicals and liquors are completely and uniformly diffused throughout the fibrous material being treated, but the delignification which characterizes pulping has not been completed.

The second stage is characterized by the absence of mechanical action. During the period, which may last from 15 minutes to ½ hour, the fibrous material is permitted to digest in situ, that is left in place without being moved, under quiescent conditions, i. e. with little or no agitation. During this intermediate period, stage II, the chemical pulping action continues, and at the end of stage II the fibers have become substantially delignified. The period of quiet digestion is followed by a brief period, stage III, of intense mechanical agitation. This mechanical agitation is preferably the same type of action as the mechano-chemical pulping of stage I. During the third stage the pulped charge is homogenized and mechanically defibered. It may be from 1 to 20 minutes; its duration being governed by the rate and extent of defibering. As soon as defibering has been completed the material is ready for the next stage in paper making.

In carrying out the mechano-chemical process of the present invention, an undefibered non-woody fiber material, such as straw, bagasse, etc., is subjected to the action of a pulping liquor containing a chemical reagent in solution in a liquid medium, this reagent being capable of digesting the non-woody fiber material by removing lignin and other encrustants therefrom. The process is conducted at a temperature of about from 90° to 100° C. and at about atmospheric pressure, and under these conditions of temperature and pressure the pulping liquor is essentially non-hydrolytic. Simultaneously with the foregoing chemical action, the individual pieces of the non-woody fiber material are subjected to vigorous non-cutting impact blows while submerged in the pulping liquor and while they are in a relatively free state, these non-cutting impact blows comprising mechanically-induced cycles of expression and absorption. Each cycle comprises compacting the pieces in an unconfined zone of impact to express liquid, immediately removing the pieces from the zone of impact to a zone of absorption of fresh liquid and returning the pieces containing absorbed liquid to another zone of impact, these blows being continued for a period of from 5 to 20 minutes. At the end of this time—which completes stage I—the pulping chemicals and liquors are completely and uniformly diffused throughout the fibrous material being treated, but the delignification which characterizes pulping has not yet been completed.

The reaction mixture is then permitted to remain quiescent in situ for a period of 15 to 30 minutes to com-

plete substantial delignification of the material which ends stage II.

Thereafter, this period of quiet digestion is followed by stage III in which the foregoing described mechanical agitation utilizing the non-cutting impact blows is continued for a final period of 1 to 20 minutes to homogenize and defiber the material.

As previously stated one advantage realized by this invention is based on the inherent reduction in the extent of chemical hydration of the fibers as manifested by the freeness values of the pulps. We have discovered that the partially delignified fibers which occur at the end of our stage I are particularly liable to chemical hydration if subjected to extensive mechanical agitation in the presence of alkali. We have further discovered that the quiescent conditions of stage II minimize chemical hydration, yet permit delignification to continue. Our novel modification, therefore, affords a finished pulp which is considerably less hydrated than other pulps. This feature broadens the range of pulpable materials, for by it many materials of relatively soft and open structure may be converted into satisfactory paper-making pulps. The advantage of a less hydrated finished pulp is readily appreciated by the experienced paper maker. Further hydration, if required, may be accomplished by the relatively simple mechanical treatments known in the art. This latter type of mechanical hydration is much to be preferred because of the ease of control that is possible compared with chemical hydrations.

This invention, as previously stated, results in a substantial power saving. Compared with continuous mechano-chemical pulping required to make the same quality and kind of pulp this saving in power may range from 30 percent to 50 percent or more. It may require a slightly longer period of time. Nevertheless, any expense owing to additional time is usually insignificant compared with the power saving. Naturally the invention may not be applicable to situations where pulping time is the controlling factor, but such situations are comparatively rare.

The following specific examples illustrate the invention.

Example 1

This example is for comparison purposes. The cook was carried out in accordance with the operating procedure disclosed in the previously mentioned Patent No. 2,708,160. Depitched bagasse was charged to a Hydrapulper containing as pulping liquor a solution of caustic soda (15 percent based on the oven dry weight of the bagasse). The rotor of the machine was operated at 800 R. P. M. for the full time of the cook, 60 minutes. The pulp had the following properties:

Yield	59.4% screened (8 cut) unbleached pulp.
Ash	1.3%.
Lignin	6.8%.
Pentosan	36.1%.
Permanganate	No. 18.8.
Freeness (Schopper - Riegler), unbeaten	760 ml.

Example 2

The procedure of Example 1 was repeated except that the rotor was stopped after 20 minutes, the cook allowed to stand quiescent for 20 minutes, and the rotor started again for the final 20 minutes of the 60 minute cook. The results were as follows:

Yield	62.1%.
Ash	1.1%.
Lignin	7.2%.
Pentosan	35.8.
Permanganate	No. 20.6.
Freeness (Schopper - Riegler), unbeaten	800 ml.

Example 3

Example 2 was repeated except that the quiescent period (stage 2) was 30 minutes, and the final period of agitation (stage 3) was 10 minutes. The total cook time was 60 minutes. The results were as follows:

Yield	60.1.
Ash	1.0.
Lignin	7.1.
Pentosan	34.6.
Permanganate	No. 20.9.
Freeness (Schopper - Riegler), unbeaten	800 ml.

Papers were made from the three cooks of the foregoing examples. The strength values for each were, in all cases, within the experimental deviation of the other two. The ranges of values were as follows:

Mullen	91–96 points per ream pound.
Tensile	173–180 grams per ream pound.
Tear	53–58 grams per ream pound.
Schopper double folds	490–510.

Similar results were obtained with wheat straw using 13.5 percent NaOH, based on the oven dry weight of the straw.

We claim:

1. A mechano-chemical process for producing pulp comprising subjecting an undefibered non-woody fiber material to the action of a pulping liquor containing a chemical reagent in solution in a liquid medium, said reagent being capable of digesting said material by removing lignin and other encrustants therefrom, at a temperature of about from 90° to 100° C. and at about atmospheric pressure, said pulping liquor being essentially non-hydrolytic under said conditions of temperature and pressure, while simultaneously subjecting the individual pieces of said material to vigorous non-cutting impact blows while submerged in the pulping liquor and while they are in a relatively free state, said non-cutting impact blows comprising mechanically-induced cycles of expression and absorption, each cycle comprising compacting the pieces in an unconfined zone of impact to express liquid, immediately removing said pieces from the zone of impact to a zone of absorption of fresh liquid and returning said pieces containing absorbed liquid into another zone of impact, and continuing said blows for a period of from 5 to 20 minutes, permitting the reaction mixture to remain quiescent in situ for a period of 15 to 30 minutes to complete substantial delignification of the material, and then continuing said blows for a final period of 1 to 20 minutes to homogenize and defiber the material.

2. The process of claim 1 in which the undefibered non-woody fiber material is bagasse.

3. The process of claim 1 in which the undefibered non-woody fiber material is straw.

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