ABSTRACT: A method and apparatus for the continuous pulping of fibrous materials utilizing powered fiberizing means embodied in a closed system wherein applied power is optimally converted to thermal energy. The resultant heat is continuously reapplied to chemicals in the system at prevailing pressure conditions which inhibit the formation of steam. This limits the need for added chemicals and reduces power requirements for optimal pulping.
1 REFINING SYSTEM AND PROCESS

This application is a continuation-in-part of Ser. No. 600,113 filed Dec. 8, 1966 and now abandoned.

BACKGROUND OF THE INVENTION

This invention relates to an improved method and novel system for processing raw fibrous materials to a pulp form. It has particular application to wood and like materials the fibers of which are used in paper and board products and will be so described.

In the conventional processing of wood pulp the raw wood is converted to chip or like form and then passed through a series of refining operations to reduce the wood to its fiber content. During this procedure the wood is subjected to mechanical and chemical treatment to plasticize and dissolve its lignin content, facilitating a separation of the fibers, and to remove the lignin and water soluble substances which are extracted in the reduction process. This process requires the expenditure of a considerable amount of energy producing power, a goodly portion of which is normally wasted.

With the present invention one provides for an optimal utilization of applied energy, as a result of which power needs and the attendant costs thereof are minimized. One also achieves a greater and more concentrated working efficiency.

An invention system is characterized by its sealed nature and operating conditions which conserve and concentrated, enabling thereby that the material reduction equipment may function under minimal load conditions.

A further object of the invention is to provide an improved system for reducing fibrous materials to a pulp form enabling a significant reduction in the normally anticipated costs of maintenance.

An additional object of the invention is to provide a closed pulping system capable of operating with a high degree of efficiency on slurries having as much as a 20 percent or greater solids content.

Another object of the invention is to provide a method of dewatering fibrous materials to a pulp form wherein the energy developed in the working process is conserved and concentrated, enabling thereby that the material reduction equipment may function under minimal load conditions.

A further object of the invention is to provide a method and system for dewatering fibrous materials possessing the advantageous features, the inherent meritorious characteristics and the means and mode of use herein mentioned.

With the above and other incidental objects in view, as will more fully appear in the specification, the invention intended to be protected by Letters Patent consists of the features of construction, the parts and combinations thereof, and the mode of operation as hereinafter described or illustrated in the accompanying drawings or their equivalents.

DESCRIPTION OF A PREFERRED EMBODIMENT OF THE INVENTION

Referring to the accompanying drawing, wherein is shown one but not necessarily the only form in which the system of the invention may be embodied or employed.

FIG. 1 diagrammatically illustrates a closed pulping system utilizing a double disc refiner and a "Pressafiner" in accordance with the present invention;

FIG. 2 is a diagrammatic view of the stock and liquor flow through a system such as illustrated in FIG. 1, and

FIG. 3 shows a modification of the invention as illustrated in FIGS. 1 and 2.

Like parts are indicated by similar characters of reference throughout the several views.

The closed pulping system, in the form illustrated, comprises a double disc refiner 10 including a housing 11 containing opposed, relatively rotatable, refiner discs 12 and 13. These discs respectively mount to and are powered by the drive shafts 14 of the motors 15.

The housing 11 includes an inlet opening 16 immediately to the rear of the disc 12. The latter has formed therein, immediately about its drive shaft 14, a circular series of flow passages 17. The passages 17 have a generally coaxial alignment with the opening 16. The raw material to be worked in the disc refiner is delivered to the opening 16 in a slurry form by way of a rotary inlet valve 18 and a feed chute 19. The chute 19 has a vertical inclination so that its lower or discharge end being connected to the housing 11, sealed about and in a rimming relation to the opening 16. The valve 18 is of a type effective to form a pressure seal at the upper or inlet end of the feed chute. Such a valve is illustrated in the U.S. Patent to James Starrett No. 3,219,593 dated Dec. 17, 1957. The bottom of the housing 11 has an opening 20 defined by one end of a vertical discharge chute 21. The remote end of the latter rims the inlet opening 22 of a Pressafiner 23. The Pressafiner, in this instance, is contemplated as a pressurized screw press such as seen in U.S. Patent No. 3,181,454 issued to M. E. Ginaven et al. on May 4, 1965. As there illustrated, the screw press is encased to maintain the contents thereof in a fully pressurized state. The screw 24 has an outlet 25 defined by a discharge conduit 25. The discharge end of the conduit 25 is bridged by a rotary discharge valve 26. The valve 26 is similar in character to the valve 18 and in the operation thereof maintains a pressure seal across the conduit 25.

The Pressafiner 23 includes a drain outlet 27 connected by way of a sealed conduit 28 to the inlet of centrifugal pump 29.

The uppermost or inlet end of the chute 19 has a laterally divergent branch 30 defining a passage for delivery therethrough of pulp conditioning media in a fluid form. Noting FIG. 1 of drawings, in the one embodiment of the invention there illustrated a flow conduit 31 extends from the outlet of the pump 29 to connect through a suitable opening to the branch 30. The branch 30 connects also to a source of dilution fluid (not shown), the conduit 32 for this purpose including suitable valving means which may be used in a manner to be further described. Further connected in the conduit 31 is a branch 33 incorporating a normally closed drain valve 34. The latter is used to relieve the above-described closed system as and when required.

In accordance with the invention, the previously described is a pressurized system, sealed respectively at its inlet and discharge ends by the rotary valves 18 and 26. In the operation thereof the system pressure is maintained above atmospheric conditions, up to about 160 p.s.i.g. The system temperature is in correspondence with the pressure and is correspondingly maintained between 212° and 365° F. In some instances the temperature may be higher. Of course, the pressure and temperature will vary, depending on the application of the system. However, in the practice of the invention the system temperature and pressure are so controlled, by conventional means, as to inhibit the formation therein of steam. By this means one optimally converts a major amount of the electrical energy applied to the pulping process to a thermal form. By retaining this energy in the pressurized system one reduces the required electrical input and thereby achieves a substantial saving in its operating cost. An attendant benefit is that the pulping apparatus may function under lesser load conditions and thereby achieve a longer and more satisfactory operating life, relatively free of severe maintenance problems.

The conditions of the system's operation are such it is quite capable of handling high consistency slurries, 20 percent or more of which may consist of fibrous solids such as wood chips. This and other distinctive features of the invention should become more obvious from the following.

In a preferred operation of the above system, a slurry consisting of a fluid vehicle embodying 20 percent or more of raw wood particles is metered to the rotary inlet valve 18. As conventionally provided, the valve rotor is formed with radial
vanes which define peripheral pockets adapted to receive and carry successive charges of the slurry to the feed chute 19. As mentioned previously, the nature of the valve 18 is such to continuously maintain a pressure seal at the inlet to the feed chute.

On initiating the flow of a chip slurry to and through the chute, the aforementioned suitable valve means in the branch 30 may be opened, where required, to initially provide for a flow therethrough of a diluting fiber conditioning medium. This medium may be merely water or may contain dissolved chemicals suitable for delignification or bleaching of wood fibers. As this conditioning medium enters the uppermost end of the chute 19, it intermixes and entrains with the incoming chip slurry. Thus, the conditioning of the wood chips in the slurry is commenced with the contact thereby of the conditioning medium as it moves therewith to the housing 11 by way of its inlet opening 16. As the slurry moves through the inlet opening, it is induced to continue its flow through the passages 17 to enter the central space between the relatively rotating refiner discs 12 and 13. The discs 12 and 13 are conventionally formed and operative to induce the slurry to move radially outward between the relatively adjacent opposed refiner plates which mount thereon. In this particular instance the system is operated to maintain a refining temperature of approximately 340°F. In moving to the discs 12 and 13 in contact with the conditioning medium, and under the influence of the established temperature and pressure, the lignin in the wood chips is partially plasticized. This facilitates a substantial chip defiber operation in the disc refining procedure.

Flung peripherally outward from the refiner discs, the slurry embodying the resultant fibers and fiber aggregates drops through the housing 11 to the discharge opening 30 at its bottom. From this opening, the fluid-embodied fibers and fiber aggregates move to and through the conduit 21 to enter the Pressafiner 23 at its inlet 22. Within the Pressafiner the slurry contents are subjected, in sequence, to a successively increased squeezing and fiberizing action. This causes a separation of the fluid vehicle from the fibers together with an optimal amount of the lignin and other water-soluble extractives from the wood chips during the pulping process. This fluid which embodies the fluid portion of the slurry as well as the dilution and conditioning medium added thereto at the feed chute 19 has had its temperature raised to that of the sealed system in the course of its movement to and within the Pressafiner. In this example illustrated, the temperature would be 340°F. Substantially at this system temperature, the fluid which now has the form of a hot liquor passes from the Pressafiner 23 by way of the outlet 27 to move through the conduit 28 and under the influence of centrifugal pump 29 to the conduit 31. This hot liquor is then recycled through the pressurized system by being delivered in a contained fashion to the branch 30 of the feed chute 19 to enter the chute and to mix and entrain with further incoming slurry. It will of course be obvious that once the system is started the valving means, originally opened to provide the conditioning medium for the incoming slurry, may be closed. Since the recycled extracted liquor enters at system temperature it redelivers to the system a large amount of thermal energy deriving from the initial input of electrical energy to drive the system components.

Of course, in the operation of the Pressafiner the resultant fibrous elements which reach its outlet 24 move through the conduit 25 and are then discharged from the system by way of the rotary valve 26.

Thus one may start the invention system with a limited amount of dilution or conditioning fluid which may be effectively used and reused. This becomes an essential component of the hot liquor which is extracted at the Pressafiner in each cycle of the systems operation.

To illustrate the significance of the above let us consider the efficiency of the described system predicated on the following mathematical presentation.

Given:
- Oven dry wood chips-2,000 lbs.
- Moisture content-50%
- Slurry consistency-20%
- Slurry temperature—70°F.
- System refining temperature—340°F.
- Applied electrical energy—95 H.p.d./2,000 lbs.
- Assumed: 10 H.p.d./2,000 lbs.—utilized as mechanical energy.
- Balance: Energy required to increase temperature of 20% consistency slush from 70°F. to 340°F.:
  \[ \frac{2,000 \times 0.5 \times 70}{0.6} = 2,345,000 \text{ B.t.u.} \]

Energy required for shortening:
  \[ \frac{95 \times 95}{10} = 9,040 \text{ B.t.u.} \]

Energy required to compensate for radiation loss—96,120 B.t.u.
- Total energy required—85,386,380 B.t.u.
- Total energy supplied: 65 H.p.d./2,000 lbs.—utilized as mechanical energy.
- Thermal energy available in the extracted liquor at 34°F. (reduced from 340°F. by reason of radiation losses) 7,000 B.t.u.

Potential reduction of electrical energy utilized if total extracted liquid is introduced as replacement for fresh dilution water at 70°F. 1,528,200 B.t.u.

2,547 H.p.d./2,000 lbs.

More than this, there are other advantages which inherently result from the invention practice. For example, in the present instance there is a substantial reduction in the "liquor to wood ratio" below the level required in existing pulping processes. Moreover, there is a substantial reduction in the quantity of chemicals which need be applied to achieve delignification or, as the case may be, bleaching or brightening of the refined pulp. In the use of the invention also avoids the need for a complex chemical recovery system since the recycled liquor reaches a highly concentrated form before disposal. Recovery being simplified, the normally inherent disposal and pollution problems attendant to a pulp refining procedure are minimized.

As a matter of fact, the invention system is quite easily maintained at a desired temperature and pressure and in a manner to inhibit the formation therein of steam. The pressure required to maintain a desired temperature in a pulping zone is developed automatically as a conversion of electrical to thermal energy takes place. Temperature is controlled by adjusting the rate of electrical energy applied to the refiner motors, the rate being related to the unit raw material supplied to the system. As has been noted previously, it is of some significance that the pressure and corresponding temperature of the system is so maintained as to inhibit the occurrence of steam. In this way one saves considerable energy while the working capabilities of the operating components are greatly enlarged per unit applied power. The invention system thereby achieves a high operating efficiency and the condition of the resultant pulp product which issues from the Pressafiner is optimal.

FIG. 3 of the drawings shows a modification of the invention system illustrated in FIGS. 1 and 2. In this instance rather than delivering extracted liquid directly to the chute 19 by way of a conduit 31, the pump 29 discharges to a conduit 31'. The conduit 31' may direct the entire quantity of hot liquor extracted from the system to and through a heat exchanger 35 by way of a normally open valve unit 36. The heat exchanger, in turn, is inserted in a conduit 37 which connects between a source (not shown) of a pump diluting and/or conditioning medium and the branch 30 of the feed chute 19.

In the alternative, a bypass line 38 interconnects the lines 31' and 37 in advance of the heat exchanger 35 and the valve 36. The line 38 incorporates a flow control valve 39.

Outside of these changes, the remainder of the system is as shown in FIGS. 1 and 2 of the drawings.

In the function of the system so modified, the conditioning medium is continuously delivered from the predetermined source by way of the conduit 37 to enter the chute 19 and move with the incoming slurry delivered by the rotary valve 18 in a manner and for the purpose described in reference to the embodiment of the invention first defined. In any case, in moving to the feed chute 19 the conditioning fluid is brought
substantially to system temperature on passage through the interposed heat exchanger 35.

In the one alternative, the total amount of hot liquor developed in the closed pulping system may be passed through the heat exchanger and the energy content thereof utilized indirectly by providing means therein for extracting its heat content and transferring it to the incoming conditioning fluid, thereby reutilizing the same. This procedure requires that the bypass valve 39 be closed and the valve 36 open. Again, a substantial amount of energy is conserved by this process.

In the other alternative, bypass valve 39 may be partially open and the valve 36 partially closed, whereupon a part of the hot liquor extracted may be recycled through the refining system in an obvious manner while the heat content of the balance may be transferred by way of the heat exchanger to the simultaneously flowing diluting or conditioning medium passed through the conduit 37.

Either alternative provides a preferred highly advantageous system which is useful for various applications of the invention.

In an event the use of the invention method and system in a form and manner such as here described facilitates the optimal use of applied energy. It also results in a significant reduction of the problems normally obtaining in efforts to achieve quality controlled pulp products. Most important, it is inherent in the system as provided by the invention that it can handle pulp at a high density and chemically control such pulp at high density with minimal amounts of applied chemicals. Also, in the use of the invention there is enabled a definite reduction in the capital cost of the equipment normally required to produce conventional pulp.

It is emphasized applicant's method and apparatus is concerned with a continuous treatment system. Materials flow completely through the refiner 10 which is isolated to form a pressurized zone by valves 18 and 26. This arrangement is such so there is simultaneously applied and with maximum effect all of the factors involved in effective pulping of fibrous materials. The factors of heat and pressure are developed as a function of the electric energy applied and expanded in rotating the discs 12 and 13. In a bootstrap concept, heat which may normally be expected to be lost by the continuous flow through the refiner is returned to the refiner. Thus, a part of the thermal energy applied within the refiner at all times is that removed from outflowing material. As a consequence, the expenditure of electrical power is less than that which would otherwise be required to maintain selected conditions of temperature and pressure within the refiner. The arrangement is, moreover, one yielding the other advantages. The quantities of chemicals conventionally applied to obtain a given pulp yield and brightness may be substantially less since the proportions of liquor to raw material is below the level required in existing pulping processes and systems. The need for complex chemical recovery systems is avoided as extracted lignin and related wood components are made available at high concentration for recovery or disposal.

Applicant's invention has been developed out of a consideration that the principal forces or factors involved in a pulping process are thermal, chemical and mechanical energy and retention time. It was theorized that if all these factors could be applied simultaneously and with maximum effect a streamline pulping process offering advantages of an economic nature and quality products would result. The inventive concept is amply sustained in practicing the invention, which is believed to significantly advance the state of the art. The art has been pursued for centuries. There is, however, relatively little information available on the basic science of the raw material and no evident recognition of the advantages that might ensue by utilization of the principal factors in the manner presented herein.

In summary, the invention system enables the application, at maximum intensity, of the forces necessary for plasticizing the lignin in the raw wood particles and developing their individual fiber elements in the fiberizing process. Moreover, it enables an optimal application of the chemicals applied for delignification and bleaching, resulting in a consequent optimal development of the individual fiber elements in a quality pulp form.

From the above description it will be apparent that there is thus provided a device of the character described possessing the particular features of advantage before enumerated as desirable, but which obviously is susceptible of modification in its form, proportions, detail construction and arrangement of parts without departing from the principle involved or sacrificing any of its advantages.

While in order to comply with the statute the invention has been described in language more or less specific as to structural features, it is to be understood that the invention is not limited to the specific features shown, but that the means and construction herein disclosed comprise but one of several solid modes of putting the invention into effect, and the invention is therefore claimed in any of its forms or modifications within the legitimate and valid scope of the appended claims.

Having thus described my invention, I claim:

1. Pulp refining apparatus comprising refiner means in a sealed system having a direct inlet thereto and outlet therefrom, said refiner means having housing accommodating said inlet and outlet being at remote portions of said housing means, opening directly to and from said refiner means, valve means maintaining a seal of said system at said inlet and said outlet which define the extremities of said system, a first of said valve means being connected, formed and arranged to continuously deliver to and through said inlet and directly to said refiner means a high consistency slurry embodying solid raw materials while inhibiting a loss from said system of pressure, a second of said valve means being connected, formed and arranged at said outlet to receive from said refiner means, for discharge, basic components of said solid materials and aggregates thereof which have been conditioned thereby, said second valve means inhibiting loss from said system of pressure, means connected to direct into said system immediately following said inlet to said refiner means, and concurrently with the delivery thereto of said slurry, conditioning fluid to move to and through said refiner means with the slurry and its solid raw material content, the seal of said system and the refiner means producing therein, in the operation thereof, a pressurized environment, there being means to power said refining means and in the operation thereof convert the applied power to thermal energy which transfers to the fluid in said refiner means and heats the same, means providing said power input being controlled to limit the thermal energy produced to a level to inhibit the fluids in the system from being flashed to steam in the refining process, said refiner means being operable to extract and separate fluid from the solid materials refined thereby, said system having a system for extracting such fluid from an area of the refiner means adjacent the outlet therefrom and returning the thermal energy applied thereto in the form of heat to an area within said system to apply to slurry as it enters said refiner means from said inlet, whereby within the limits of said refiner means there is a refining and conditioning of solids in a process in which thermal energy produced by reason of the applied power is continuously maintained and reutilized, minimizing basic power needs and conditioning fluid for the refining procedure.

2. Pulp refining apparatus as in claim 1 characterized by means for delivery of conditioning fluid to intermix with the incoming slurry in said system incorporating a heat exchanger, and said fluid extracting means having means in connection therewith for delivery of heated fluid from the system to and through said heat exchanger to transfer the heat content thereof to conditioning fluid directed to said system whereby to maintain the heat produced in the system within the system, delivering thereby the conditioning fluid at substantially the temperature of the system.

3. A pulp refining system as in claim 1 characterized by means for channeling the extracted fluids to per se reenter
said refiner means to mix directly in the incoming slurry substantially at the system temperature to expedite the conditioning and reduce thereby the energy necessary for refining the slurry contents.

4. A pulping system as in claim 1 characterized by means for channeling the separated fluid to have at least a portion thereof return to said refiner means adjacent said inlet in a manner to flow directly with the incoming slurry and apply thereto substantially the system temperature and reduce thereby the energy necessary to refine the slurry contents, means for delivery of a conditioning fluid to said system, to move to and through said directing means, to intermix with the incoming slurry, said last-mentioned delivery means incorporating a heat exchanger and said channeling means being arranged to deliver the remainder of the separated fluids to and through said heat exchanger to transfer the heat thereof to delivered conditioning fluid to supplement the energy content thereof and bring it substantially closer to system temperature.

5. Apparatus as in claim 1 wherein there are a plurality of directly connected and series-related refiner units at the limits of which are said inlet and said outlet, the inlet providing that the slurry is first delivered to the first refiner means of the series and the extracting means being applied adjacent the last refiner means of the series.

6. Apparatus as in claim 1 wherein said refiner means comprise a double disc refiner and a series-related unit for squeezing solids and separating therefrom fluids, and said extracting means is applied to the fluids immediately preceding the outlet from said squeezing and separating means.

7. Apparatus as in claim 6 wherein said refiner means consists of said double disc refiner and said unit and said refiner and said unit are in open communication providing for said double disc refiner to discharge the solids refined thereby and attendant fluid directly to said unit for further refining and conditioning of the refined solids thereby.

8. A process for the continuous pulping of solids, including fibrous material, comprising the steps of establishing refiner means in a relatively sealed environment, continuously introducing to said refiner means a high consistency slurry embodying solid raw materials while inhibiting a loss of pressure from said environment, simultaneously and initially introducing to said environment and to said slurry in the process of entering said refiner means within said environment a conditioning fluid to flow to and through said refiner means with the slurry and the solid contents thereof, applying power to said refiner means to refine the solid materials and in the operation thereof convert the applied power to thermal energy and transfer the same to the fluid in said refiner means to heat the fluid to system temperature, controlling the power applied to limit the thermal energy produced to a level tending to inhibit the fluid in the sealed environment from being flashed to steam in the refining process and continuously transferring heat of the heated fluid in said environment to incoming slurry at the entrance to said refiner means whereby to reutilize in continuing fashion the thermal energy resulting from the power input to said refiner means and minimize the requirements for both power input and conditioning fluid in the refining process.

9. A process according to claim 8 characterized by continuously recycling, within the limits of said sealed environment, heated fluid produced in the refining process to repeatedly apply such fluid to slurry entering the refiner means to apply thereto the temperature of said sealed environment.

10. A process for the continuous processing of fibrous material utilizing refiner means including a double disc refiner, comprising the steps of establishing the double disc refiner in a sealed environment, introducing to said refiner, within said sealed environment, in a continuous flow, a high consistency slurry containing raw fibrous solids, applying power to effect counter rotation of the discs of said double disc refiner to refine therebetween said solids, converting thermal energy produced thereby to heat which is applied to the fluid attendant the fibrous solids, flowing within said environment, from the discs of said double disc refiner, the refined solids and the attendant fluid which has been heated in the process of refining, in the course of flow subjecting the flowing refined solids and attendant fluid to a pressing and squeezing action to separate the heated fluid in the process, controlling the power applied to the double disc refiner and for the pressing and squeezing action to inhibit the heated fluid in the sealed environment from being flashed to steam in the refining process and recirculating separated heated fluid in a closed circuit embodied in connection with said sealed environment to provide that at least the heat content of the separated fluid is applied to the slurry at said double disc refiner whereby to minimize the power required for the refining process and repeatedly reusing the thermal energy resulting from conversion of applied power in the refining process.

11. A process according to claim 10 wherein, at least initially, conditioning fluid is introduced to the double disc refiner in said sealed environment and at least a portion of the heat content of the fluids separated in the course of the pressing and squeezing action in said sealed environment is applied to said conditioning fluid.

12. A process according to claim 11 wherein in the course of delivery the conditioning fluid is heated to the temperature of the sealed environment by way of a heat exchange with at least a portion of said separated fluid.
UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,627,629 Dated December 14, 1971

Inventor(s) Sofus Miller

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

Column 4, line 18, "2,5 H.p.d./2000 lbs." should read -- 25 HPD/2000 lbs. --.

Column 5, line 21, "an" should read -- any --.

Signed and sealed this 18th day of July 1972.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR. ROBERT GOTTSCALK
Attesting Officer Commissioner of Patents