Method, process and apparatus for converting wood, wood residue, vegetable fibre and biomass into pulp.

Lignocellulosic materials like tree chips, sawmill or vegetable fibres are converted into a high yield pulp in an integrated mill wherein parameters like time intervals, concentration of chemicals in relation to fibre dry weight, and feed rates for the individual steps are predetermined and controlled.

The apparatus for carrying out the continuous process comprises means for chemical pretreatment (2) of the lignocellulosic material with sulphonating or oxidating agents and with complexants for metal ions. Compression and dewatering (8), pressure steaming (10), decompression (12), non-compulsory washing (14), refining (16) and bleaching (20) of the pulp.
BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an apparatus for converting tree chips, sawmill, or other wood residues, or vegetable fibres into pulp and more particularly, to a continuous process of handling, conveying, chemical pretreating, compressing, defibrating, dewatering, pressure steaming, pressure releasing, refining and non compulsory bleaching into pulp of various properties.

2. Description of the Prior Art

It is well known the conventional production of pulp by chemicals using Kraft or sulfite process removes the fibres from the wood by dissolving the lignin that holds them together, produces low yield pulp.

Stone ground wood pulp SGW is produced from wood logs by grinders under atmospheric pressure.

Chemical ground wood CGW is chemically pretreated either atmospheric or pressurized way and ground under atmospheric pressure.

Pressurized ground wood PGW is ground under pressure at a high temperature.

Refiner mechanical pulp RMP is produced by refining wood chips under atmospheric refining conditions with no pretreatment.

Thermomechanical pulp TMP is produced from chips in refiners, similar to conditions in RMP process, except chips are presteamed at 100°C - 120°C, prior to refining.

Thermomechanical pulp TMP is produced from chips first presteamed at 100°C with the first stage of refining at 100°C under pressure and other refining stages are at atmospheric pressure.

Tandem TMP is produced from chips by first presteaming at 100°C - 125°C and followed by first and second-stage refining at elevated temperature 110°C - 130°C.

Chemomechanical pulp CMP is produced from chips using a chemical pretreatment at a temperature below 100°C, followed by atmospheric refining.

Chemomechanical pulp CMP is produced from chips pretreated with sodium sulfite Na₂SO₃ prior to or during presteaming and first refining stage at temperatures between 100°C and 135°C and other refining stages at atmospheric pressure.

Semichemical mechanical pulp SCMP is produced from chips pretreated with chemicals at temperatures between 100°C and 130°C and then refined at atmospheric pressure.

Neutral sulfite semichemical pulp NSSC used mainly for hardwood species uses continuous digester of short time and low temperature cook before refining under atmospheric pressure.

All the above described processes are highly capital intensive, high energy consuming and environmentally restrictive. The Kraft and sulfite processes are of low yield contributing to fast depletion of forest and other vegetable fibre resulting in high cost of produced pulp. The above mentioned mechanical or refining pulping processes are of high yield, when compared to the chemical pulping processes, but require high energy input, resulting in high cost of the produced pulp.

SUMMARY OF THE INVENTION

It is an aim of this present invention to provide a simple, relatively low capital cost equipment, in such an order as to handle vegetable fibre in an economic manner, with low energy requirements, minimum of rejects, low manual input and environmentally non restrictive.

The invention is directed toward a new pulping process and the pulp and paper products resulting therefrom. The pulp produced by the process of the present invention is of very high yield 94% when unbleached and in a range of 88% to 92% when bleached, it requires less caloric energy, also less refining energy, in a range of 40% to 60%, of any other known refining process of virgin fibres.

In order to retain high yield, it is further aim of the present invention to retain all of the hemicellulose and to avoid the lignin from being solubilized. The process alters some of the lignin and pitch in such a way as to form a new uncoloured complex in the pulp. The chelating agents added before the chemical pretreatment, during the hydrolysis and after the decomposition of the chips or fibrous vegetable matters form, during the hydrolysis, during decompression and during refining, extremely strong bond with divalent and trivalent heavy metals and complete successfully with lignin complex to form colourless chelating complexes.

Not only laboratory hand sheets prepared from the pulp but also sheets made by industrial applications of the pulp have superior tensile strength, tear strength, burst and opacity when compared to sheets made of SGW, CGW, PGW, RMP, TRMP, CMP, TMP, TANDEM TMP, CTMP, SCMP and NSSC. The pulp when used as an extender to the Kraft furnish does not degrade the physical properties of the produced paper.

A process in accordance with the present invention includes the steps of conveying the wood fibres in a continuous operation for a pretreatment, under atmospheric pressure, with chemicals, then the compression of said fibre to extract air between them and to extract some of the liquid from the fibres.

The compressed vegetable fibres are then conveyed in a continuous manner through a pocket valve, or loading screw or vegetable fibre plug created by mechanical or hydraulic means into a pressurized steam vessel. In the pressurized steam vessel the vegetable fibres are freely moved by means of a worm or ribbon conveyor toward the opposite side of the vessel. The speed of the movement of the vegetable fibre in the pressure steaming vessel is variable. It is directly related to the rate of feed and volume of the pretreated vegetable fibre and the desired steam treatment. At the end of the pressure vessel, the chemically pretreated and pressure steamed vegetable fibres are released by means of a decompression chamber into a dozing bin. This action shatters the lignin and defibrates most of the vegetable fibre. 20% to 30% of the fibres have been found to be acceptable and 70% to 80% in form of shives or shattered fibre bundles need further refining. From the dozing bin the defibrated fibres are transported or conveyed into refiners. Refining is executed by disc refiners under pressurized or atmospheric discharge operation. Prior to
non compulsory bleaching the refined pulp is washed, screened and preferably bleached in a single stage process. The brightness increase of up to 28 points have been experienced during laboratory bleaching trials with Hydrogen Peroxyde H2O2, Sodium Peroxyde Na2O2, Oxygen O2 and Ozone O3 at pulp consistency of 12% to 22%. Brightness reversion protection have been successfully achieved by post treatment with Sulfur dioxide SO2.

An apparatus in accordance with the present invention includes an integrated system having a chemical pretreatment means in to the vegetable fibre flow, metering means of fibres into a fibre compression chamber, fibre compressing means, air and moisture relieve means from a fibre compression means, means to activate pocket valve, loading screw or vegetable fibre plug of a compression means, means to discharge a pocket valve, or loading screw or vegetable plug into the pressurized steam vessel, means to move the vegetable fibre inside the steam pressure vessel, means for activating the worm, screen or rib conveyor according to predetermined information received from the fibre metering means, means of unloading vegetable fibre from a steam pressurized vessel into a decompression means, means to release the vegetable fibre from decompression means to a dozing means, means transporting or conveying the decompressed vegetable fibre into the refining means and non compulsory means to transport the refined pulp to bleaching means.

A further feature of the present invention includes a control system which includes a first scanning means at the infeed of wood fibre, input data receiving means for interpreting the data received from the first scanning means and for measuring the moisture content of the fibre and weight-volume input according to the predetermined parameters, means associated with said control system for activating a speed control of the fibre infeed, measuring means controlled by the control system means of the fibre flow control system based on said data to introduce chemicals in solution or in a dry form into the fibre flow, means for controlling the pocket valve, or loading screw or vegetable fibre plug activity, means to activate the discharging of vegetable fibre into a pressure vessel, means related to flow of vegetable fibre into a fibre compression means, means to interpret rate of feed to control the fibre movement in a steam pressure vessel according to the predetermined schedule stored in a memory, sensing means associated with discharge of fibre from steam pressure vessel, input data receiving means for interpreting and controlling the refining mechanism and refining according to predetermined refining patterns stored in the memory.

Having thus generally described the nature of the invention, reference will now be made to the accompanying drawings, showing by way of illustration, a preferred embodiment thereof and in which:

Figure 1 is a diagram illustrating the various steps of a continuous process;

Figure 2 is a diagram illustrating the various reactions and changes of properties of vegetable fibre from chips, shavings or sawdust type form to pulp type form;

Figure 3 is illustrating step-by-step the process sequence of converting vegetable fibre into a marketable pulp and products thereof.

Referring now to the drawings and particularly to figure 1, there is shown an integrated processing mill for conversion of wood chips, or vegetable fibre into pulp. An embodiment of the integrated processing mill includes a chip or vegetable fibre conveyor 1 for conveying vegetable fibre, a pretreatment stations 2 for application of chemicals, chips or vegetable fibre level detector 17 for controling the flow of chips or vegetable fibre through the pretreatment stations and for controlling the level of chemicals 4 in the first pretreatment station 2 further a worm, or screw or rib conveyor 3 for conveying residues from first pretreatment station 2 on to vegetable fibre conveyor 8 leading into second pretreatment station 6. A further scanner 18 may be provided for again measuring the vegetable fibre volume from the second pretreatment station 6 into the compression chamber 8 operating under a predetermined pressure, compressed fibres are then advanced through a pocket valve, or loading screw or vegetable fibre plug 9 through a steam pressure vessel 10, through a decompression chamber 11 and 12 into a non compulsory dozing bin 13 through a non compulsory washing station 14 directly on to worm, screw or rib conveyor 15, bypassing, if desired the washing station, leading into the refiner 16. Refined pulp is discharged into latency chest 19 and futher the pulp is introduced into the bleaching station 20.

Figure 2 shows reactions of chemical pretreatment of fibres 20 by complexing agents 21 and formation of hydrophilic groups 22, 23, 24 on surface of vegetable fibres 20 by creating a bond 28, it also demonstrates formation of hydrophilic group 22, 23, 24 on surface of vegetable fibres 20 by oxydation agents 21.

Figure 3 is the step by step process sequence of chemical reactions by various pretreatment of vegetable fibres:

Step 1 - Trys to eliminate free metallic cations which may catalize oxidation of SO2 to SO3, elimination is done by complexing with complexing agent DTPA or others. Free metal + DTPA----------Metal-DTPA (non-reactive complex) Example: Fe, Mn, Cu, Al, etc. Metals may be present in different valences.

To protect against oxydation, residues are pretreated with DTPA-Sodium Diethylentriaminopentaactate (5.3%) or TPT - Sodium Triplyphosphate

EDTA - Ethylene Diaminetartaric Acid - Nitroacetic Acid

Further treatment is done by the following agents:

Sodium Sulphite Na2SO4 (Equilibrium pH 9.3) or Ozone - O3 or Oxygene or Peracetic Acid or ClO2-Bioxide of chlore or NaClO2 or NaHSO3 or H2O2-Hydrogene Peroxide or N2O5 or Sodium peroxide or
Steps 2-5 are designed to form Hydrophilic group by:
- sulfonation or oxidation.
The formation of Hydrophilic groups either by oxidation or sulfonation is proportional to the concentration of chemical products, vegetable fibre, time and temperature.
At constant concentration of fibres and chemicals use, the process is controlled by time and retention temperature.
In Step no. 2 and 3 determining factor for chemical reaction is time, since the temperature is very low.
In the step number 4, it is the temperature which controls the extent of sulfonation or oxidation. The speed of the sulfonation or oxidation may be also varied by concentration of the chemical products.
Further figure 3 depicts step by step the sequence of the process of pretreatment of residues, its defibration and its refining as follows:

Step 1 - To prevent degradation by burning of vegetable fibre which may take place in fibre pressure steaming vessel, vegetable fibres are mixed in complexing solutions in a concentration of 0.1-5.0% related to dry weight of fibres at ambient temperature and under atmospheric or increased pressure.

Step 2 - In order to form hydrophilic group on the surface of vegetable fibres the following treatment is made:
- with sulphonating agents; DTPA Sodium-diethylenetriaminopentaacetate and others
- with oxidative agents; TPF as sodium tripolyphosphate, ethylen diaminetetraacetic acid.

This begins a topochemical reaction which consist in diffusion of chemical agents inside of the vegetable fibres and subsequently chemical reaction with the wood or fibre substrate.

Step 3 - In order to increase the efficiency of the reaction and or the rate of diffusion the fibres are introduced into a compression-decompression chamber.

Step 4 - After the compression-decompression of fibres vegetable fibres are transferred into pressure steaming vessel, to complete the saturation process of fibres, final part of chemicals may be introduced by steam at the beginning of steam pressure vessel, major parts of hydrophilic groups are formed in the vessel due to high temperature and time of retention.

Step 5 - Treated fibres leave the pressurized vessel into a decompression chamber where defibration of fibres occurs. Further, fibres are conveyed to a dozing bin.

Step 6 - Defibrated vegetable fibres are conveyed through a washing station or they are conveyed without washing into refiners.

Step 7 - Depending on the pre-determined quality of pulp, refining of defibrated vegetable fibres is directed to achieve Canadians Standard Freeness varying from 600 to 50 CSF. This is achieved by using atmospheric or pressurized refiners. According to the final product requirement, the pulp is used as is or it is transferred to other treatments as follows: bleaching treatment, curl setting, latency removal, screening, or cleaning.
fibres from decompression means to dozing means, followed by transportation and conveying means of the decompressed said fibres to diffusion washers or applicators of chemicals followed by transportation and conveying means of washed and chemically treated said fibres into the refining means, followed by transportation or conveying means of refined fibres into the bleaching means.

5. A control system which includes a first scanning means at the infeed of wood residues, input data receiving means for interpreting the data received from the first scanning means and for measuring the moisture content of the residue and weight-volume input according to the predetermined parameters, means associated with said control system for activating a speed control of the residue infeed, measuring means controlled by the control system means of the residue flow control system based on said data to introduce chemicals in solution and/or in dry form into the residue flow, means for controlling the pocket valve activity, means to activate the discharging of residues into a pressure vessel, means related to flow of residues into a residue compression means, means to interpret rate of feed to control the residue movement in a steam pressure vessel according to the predetermined schedule stored in a memory, sensing means associated with discharge of residues from pressure steam vessel, input data receiving means for interpreting and controlling the refining mechanism and refining according to a predetermined refining pattern stored in the memory.

6. An integrated control system as claimed in claim 4 which further includes a first scanning means at the infeed of wood or vegetable fibres in form of chips or residues, input data receiving means for interpreting the data received from the first scanning means and for measuring the moisture content of the said fibres and weight-volume input according to the predetermined parameters, means associated with said control system for activating a speed control of the said fibres infeed, measuring means controlled by the control system means of the fibre flow control system based on said data to introduce chemicals in solution or in dry form into the fibre flow, means for controlling one of the following: pocket valve, or loading screw or fibre plug activity, further includes means to activate the discharging of said fibres into a pressure vessel, means related to flow of said fibres into a fibres compression means, means to interpret rate of feed to control the said fibre movement in a steam pressure vessel according to the predetermined schedule stored in a memory, sensing means associated with discharge of said fibres from steam pressure vessel, input data receiving means for interpreting and controlling the refining mechanism and refining according to a predetermined refining pattern stored in the memory, sensing means associated with discharge of the refined pulp from the refining mechanism, input data receiving means for interpreting and controlling the bleaching mechanism and bleaching according predetermined bleaching patterns stored in the memory, the measurement is done by sensing means located in strategic areas of each step.

7. A process of converting wood chips, wood residues and biomass into wood pulp including process of protection of wood residues against subsequent degradation, by binding of metal cations present, with complexing agents, process of chemical treatment with sulfonating agents in order to introduce hydrophilic sulfonated group in wood or vegetable fibres, process of chemical treatment with oxidating agents in order to form hydrophilic groups, hydroxyl groups, hydroperoxide groups, aldehyde groups on wood or vegetable fibres or residue surfaces, process of chemical treatment with antragen in combination with sodium hydroxide and sodium sulfate or sodium bisulfite in order to form hydrophędic groups on residues and to facilitate lignin modification, process of said fibres compression, decompression and process of alternating compression, decompression, in order to assure air removal and subsequent chemical penetration of chemicals into wood, vegetable fibre or residue, process of complementary chemical treatment of said fibre when introducing it into a pressurized steam vessel, process of physico-chemical reaction inside of pressurized steam vessel, process of defibration in a decompression chamber, process of washing and displacement of chemicals from defibrated products in diffusion washers, process of atmospheric refining or process of pressurized refining, process of screening, cleaning and process of noncompulsory bleaching of the produced pulp.

9. Process of complexing of wood residues, woodchips, biomass by DTPA Sodiumdiaminopentaneacetate in concentration from 0.1% to 5.0% based on dry weight of residues, process of complexing of wood residues, wood chips by TPF Sodiumpolysilicic acid, process of complexing of wood residues, wood chips, biomass by ethylen diaminetetraacetic acid EDTA, process of complexing of wood residues, wood chips, biomass by DTPA Sodiumdiethylenetriaminopentaacetate in concentration from 0.1% to 5.0%, process of sulphonation, concentration of NaSO₃, Sodium sulphite from 0.5% to 15.0% based on dry weight of residues of conifers, process of sulphonation, concentration of NaSO₃, Sodium sulphite from 0.8% to 15% plus NaOH Sodium hydroxide in concentration from .5% to 7.5% in case of broad leaf species based on dry weight basis, process of oxidation, concentration of hydrogen peroxide from 1% to 20%, Sodium silicate 5%, Magnesium sulphate 0.5%. All percentages are based on dry weight residues basis, pH 10.5 is adjusted by presence from .5% to 5% of Sodium hydroxide, process of oxydation, concentration of by sodium peroxide NaO₂, from 1% to 20%, Sodium silicate 5%, Magnesium sulphite 5%, process of oxydation, concentration of Cl₂, from 1% to 20%, pH 4-6, temperature 40-60°C process of oxydation, concentration of NaClO₂ from 1% to 20%, pH 4-12, temperature 40-60°C, process of oxydation with peracetic acid, concentration from 1% to 20%, process of oxydation with ozone, concentration 1 to 8%, MgSO₄, 1%, NaOH from 1% to 4%, process of oxydation with oxygen O₂, concentration 1% to 10%, MgSO₄, 1%, NaOH from 1% to 4%, process of oxydation with BIS...
t-butylperoxid disisopropylbenzene, concentration 1% to 10%, process of oxidation with Di-t-butyl peroxide 1% to 10%, process of oxidation with Di-cumylperoxide 1% to 10%, process of oxidation within-buty1 cumyl peroxide, process of compression and decompression, 5-2-5-2 atm., 5atm., time 1 to 15 minutes, temperature 30° - 120°C consistency 5%-30%, process of complimentary chemical addition, 1% - 5% of sulfonating or oxydating agents at the entry in to steam pressurized vessel, temperature 130°C to 220°C, pressure 1.7 to 22 bars, time 1 minute to 10 hrs., process of defibration in decompression chamber, to an atmospheric pressure, process of diffusion washing, process of atmospheric refining, consistency 5% to 25%, freeness from 600 to 50 CSF (Canadian Standard Freeness), process of pressurized refining, 1.5-15 atm., consistency 5%-40%, freeness from 600 to 50 CSF.

10. Process according to claim 1 includes the step wherein complexing of the said wood and vegetable fibre is carried out employing one or more of the following complexing agents:

11. Process of protection of wood residues against subsequent degradation by binding of metal cations present with complexing agents.

12. Process of chemical treatment with sulfonating agents in order to introduce hydrophilic sulfonated group on wood residue.

13. Process of chemical treatment with oxidized agents in order to form hydrophilic groups like hydroxide groups, carboxylic groups, hydroperoxide groups, aldehyde groups on wood residue surface.

14. Process of residues compression, decompression and process of alternating compression, decompression in order to assure air removal and subsequent chemical penetration of chemicals into wood residue.

15. Process of complementary chemical treatment of wood residues when introducing the residues into a steam pressure vessel.


17. Process of defibration in a decompression chamber.

18. Process of displacement and washing of chemicals from defibrated products.

19. Process of complexing wood residues by DTPA Sodiumdithethystamminopentaacetate in concentration from 0.1% to 5% based on dry weight of residue.

20. Process of complexing wood residues by Sodiumtripolyposphate in concentration from 0.1 % to 5%.

21. Process of complexing wood residues by EDTA Ethylenediaminetetraacetic acid in concentration from 0.1% to 5%.
22. Process of complexing wood residues by Nitriloacetic acid in concentration from 0.1% to 5%.
23. Process of sulfonation, concentration of NaSO₃, sodium sulphite from 0.5% to 15% based on dry weight of residues of conifers.
24. Process of sulfonation, concentration of NaSO₃, sodium sulphite from 0.5% to 15% plus NaOH sodium hydroxide in concentration from .5% to 5% in case of broad leaf species based on dry weight basis.
25. Process of oxidation, concentration of hydrogen peroxide from 1% to 20%; sodium silicate 5%, magnesium sulphate .5%. All percentages based on dry weight basis, pH 10.5 adjusted by the presence from .5% to 5% of sodium hydroxide.
26. Process of refined pulp brightening includes the step wherein bleaching of refined pulp is carried out employing one or more of the bleaching agents: Hydrogen Peroxyde H₂O₂, in a concentration range of 0.5% to 10%; Sodium Peroxyde Na₂O₂, in a concentration range of 0.5% to 10%; Magnesium Sulphate MgSO₄, in a concentration range of 0.1% to 2%; Sodium Silicate Na₂SiO₃, in a concentration range of 0.1% to 3%; DTPA in a concentration range of 0.1% to 5%; Sodium Hydroxide NaOH in a concentration range of 1.0% to 5% in a range of pH 9-11 adjustment, at temperature range of 40°C to 70°C, at retention time of 60 to 120 minutes, at consistency range of pulp 0.5% to 7% of dry fibre weight basis, Oxygen O₂, at pressure range of 2 to 6 atmospheres, at temperature range of 80°C to 140°C, at retention time range of 45 minutes to 120 minutes, Ozone O₃, at pressure range of 1 to 3 atmospheres at temperature range of 70°C to 150°C, at retention time range of 40 minutes to 120 minutes, at pulp consistency range of 12% to 20%, includes the step wherein brightness reversion protection is achieved by sulfur dioxide SO₂ treatment in a concentration range of 0.1% to 1.0% and retention time range of 5 minutes to 60 minutes, includes the step, wherein non-compulsory water washing is carried out after each bleaching agent reaction, all percentages being based upon the dry weight of said vegetable fibres.
Figure 3
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<td>A</td>
<td>ABSTRACT BULLETIN OF THE INSTITUTE OF PAPER CHEMISTRY,</td>
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The present search report has been drawn up for all claims.

The place of search: THE HAGUE. The date of completion of the search: 11-10-1985. The examiner: NESTBY K.

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## DOCUMENTS CONSIDERED TO BE RELEVANT

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