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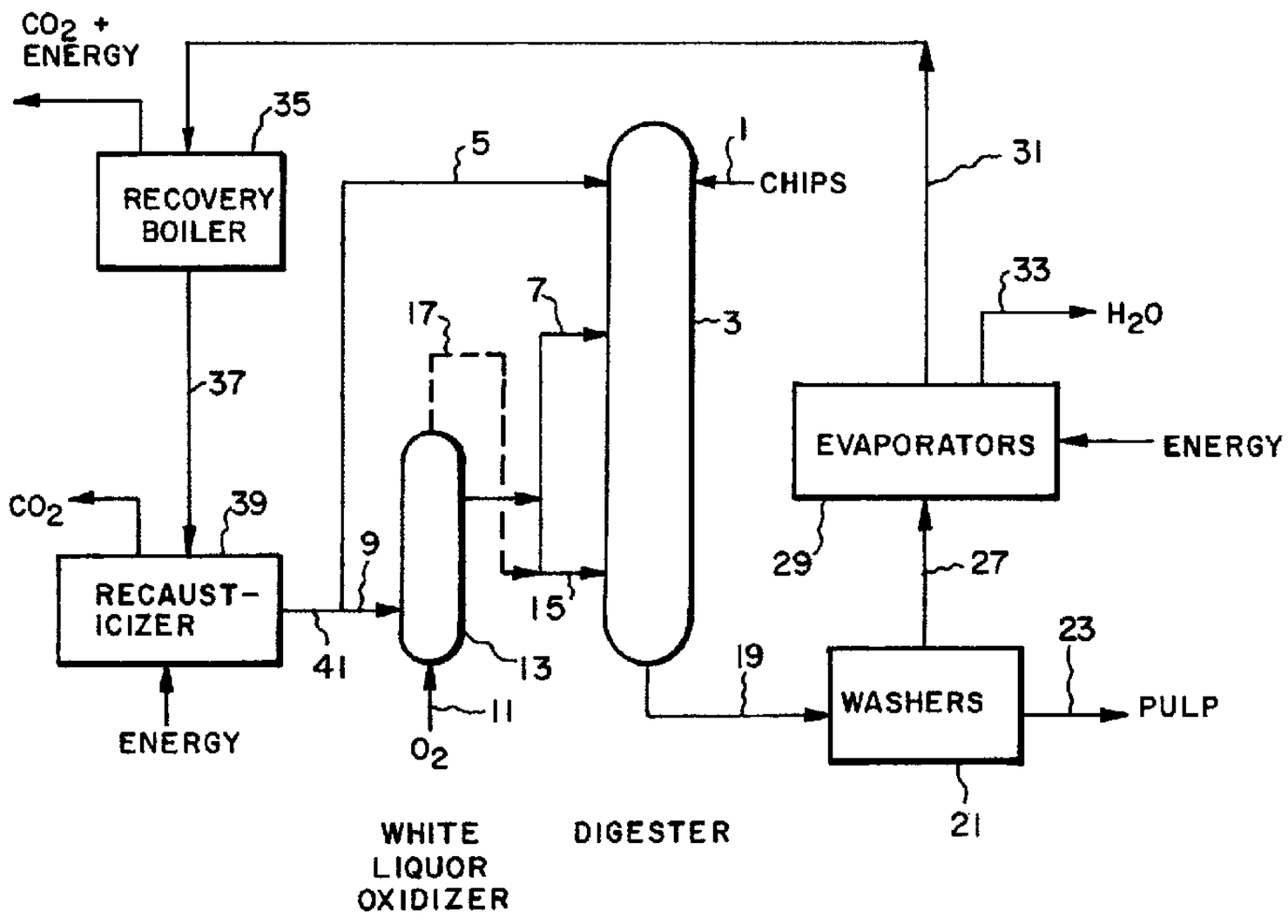
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(54) **UTILISATION DE LESSIVE BLANCHE OXYDEE DANS UN DIGESTEUR POUR PROCEDE KRAFT**

(54) **USE OF OXIDIZED WHITE LIQUOR IN A KRAFT MILL DIGESTER**



(57) Pulp is produced from wood or other lignocellulosic material by an improved kraft process in which the white liquor is introduced into the digester in at least two streams. A portion of the white liquor is used in an initial stage of the pulping process. Another portion of the white liquor is oxidized to convert reduced sulfur compounds in the white liquor to sodium thiosulfate and/or sodium sulfate, and this liquor is used during a later stage of the process. The benefits of using split sulfidity white liquor to produce pulp are realized by using a combination of white liquor and oxidized white liquor in the pulping process.

ABSTRACT OF THE DISCLOSURE

Pulp is produced from wood or other lignocellulosic material by an improved kraft process in which the white liquor is introduced into the digester in at least two streams. A portion of the white liquor is used in an initial stage of the pulping process. Another portion of the white liquor is oxidized to convert reduced sulfur compounds in the white liquor to sodium thiosulfate and/or sodium sulfate, and this liquor is used during a later stage of the process. The benefits of using split sulfidity white liquor to produce pulp are realized by using a combination of white liquor and oxidized white liquor in the pulping process.

221PUS05908

TITLE OF THE INVENTION:

USE OF OXIDIZED WHITE LIQUOR IN A KRAFT MILL DIGESTER

CROSS-REFERENCE TO RELATED APPLICATIONS

Not Applicable

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not applicable

BACKGROUND OF THE INVENTION

The sulfate or kraft process is widely used in the pulp and paper industry to convert wood chips and other lignocellulosic materials into partially delignified cellulose pulp which is used directly for unbleached paper products or which is further delignified and bleached for making high brightness paper products. In this well-known process, chips are converted into partially delignified pulp at elevated temperatures by chemical delignification using an aqueous alkaline solution known as white liquor which chiefly comprises sodium hydroxide, sodium carbonate, and sodium sulfide. The spent liquor from this initial delignification step, known as weak black liquor, contains organic compounds, dissolved lignin, and other wood components. This weak black liquor is concentrated by evaporation, at which point soaps, resins, and fatty acids are recovered.

The resulting strong black liquor is further evaporated, sodium and sulfur in various chemical forms are added as needed to replace losses elsewhere in the process, and the mixture is combusted in a recovery furnace to yield molten sodium sulfide and sodium carbonate. This molten material or smelt is dissolved in water to yield an aqueous liquid known as green liquor. The green liquor is causticized with calcium oxide (lime) to convert the sodium carbonate to sodium hydroxide, which then yields white liquor for use in another pulping cycle.

The pulping step comprises a complex series of reactions and can be carried out in either batch or continuous digester systems. Control of the pulping step is critical to the overall papermaking process and affects key parameters such as pulp yield and the physical properties of the final paper products. Operation of the pulping step also affects the performance of downstream processing steps, and can have a significant impact on the content of sulfur compounds in gaseous and liquid effluent streams from the pulp mill. Accordingly, numerous improvements to the basic pulping step have been developed over the years, and further process modifications are constantly sought to improve mill efficiency and environmental compliance. One area of interest and continuing development is the control of white liquor sulfidity in the digester wherein high sulfidity liquor is used in the earlier portion of the pulping step and low sulfidity liquor is used in the latter portion of the pulping step.

The present invention described herein is an improvement to the kraft pulping process wherein white liquor and oxidized white liquor are used in combination to optimize sulfidity in the digester and reduce the amount of sodium sulfide used in the process, thereby reducing the amount of malodorous sulfur compounds produced in the digester, and reducing the total amount of sodium sulfide used in the digester, which can be beneficial in downstream processing of the black liquor.

BRIEF SUMMARY OF THE INVENTION

The invention is a method to produce lignocellulosic pulp from a lignocellulosic material which comprises providing a comminuted lignocellulosic material; providing a stream of white liquor and at least one stream of oxidized white liquor; contacting the comminuted lignocellulosic material with the white liquor and producing an intermediate mixture containing partially delignified lignocellulosic material; and contacting the intermediate mixture with the oxidized white liquor and producing a further delignified lignocellulosic pulp. The intermediate mixture containing lignocellulosic material can be contacted with one stream of oxidized white liquor, or alternatively can be contacted with two or more streams of oxidized white liquor.

The contacting can be effected in a batch digester vessel. When contacting is effected in a continuous digester vessel, the contacting of the white liquor and with the comminuted lignocellulosic material can be effected in cocurrent or countercurrent flow. The contacting of the oxidized white liquor with the intermediate mixture containing partially delignified lignocellulosic material can be effected in cocurrent or countercurrent flow.

The dosage of white liquor to comminuted lignocellulosic material (dry basis) can be in the range of about 1 to about 25 % as Na_2O. The dosage of oxidized white liquor to comminuted lignocellulosic material (dry basis) can be in the range of about 1 to about 25 % as Na_2O. The sulfidity of the white liquor can be in the range of about 1.0% to about 50%. The sulfidity of the oxidized white liquor can be in the range of 0% to about 49%.

In an alternative embodiment , the invention is a method to produce lignocellulosic pulp from a lignocellulosic material which comprises:

(a) providing a comminuted lignocellulosic material;

(b) providing a stream of white liquor,

(c) providing a first stream of oxidized white and a second stream of oxidized white liquor;

(d) contacting the comminuted lignocellulosic material with the white liquor and producing a first intermediate mixture containing partially delignified lignocellulosic material;

(e) contacting the first intermediate mixture with the first stream of oxidized white liquor and producing a second intermediate mixture containing further delignified lignocellulosic material; and

(f) contacting the second intermediate mixture with the second stream of oxidized white liquor and producing a further delignified lignocellulosic pulp.

The sulfidity of the white liquor can be in the range of about 1.0% to about 50%. The first stream of oxidized white liquor and the second stream of oxidized white liquor each can have a sulfidity in the range of 0% to about 50%, wherein the sulfidity of first stream of oxidized white liquor and the sulfidity of the second stream of oxidized white liquor are essentially equal.

Alternatively, the first stream of oxidized white liquor can have a sulfidity in the range of about 1% to about 50% and the second stream of oxidized white liquor can have a sulfidity in the range of 0% to about 49%, wherein the sulfidity of the first stream of oxidized white liquor is greater than the sulfidity of the second stream of oxidized white liquor.

BRIEF DESCRIPTION OF SEVERAL VIEWS OF THE DRAWINGS

Fig. 1 is a schematic flow diagram of the process of the present invention.

Fig. 2 is a schematic flow diagram of a particular type of continuous digester as an example of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The process of the present invention utilizes a combination of white liquor and oxidized white liquor in the digester to enhance the pulping reactions and minimize the formation of malodorous sulfur compounds in the digester. The degree of white liquor oxidation, the number of oxidized white liquor streams used, and the location of oxidized white liquor introduction into the digester can be tailored to the type of wood or other lignocellulosic material being pulped.

The process is illustrated in the schematic flow diagram of Fig. 1. A flow of comminuted lignocellulosic material 1, typically wood chips, is introduced into digester vessel 3 and typically flows downward through the vessel. White liquor stream 5 is introduced near the top of the digester and is mixed therein with the chips to initiate the first stage of the pulping reactions. During this first pulping period or initial stage, reaction with sodium hydrosulfide [NaHS], which is the predominant and active form of reduced sulfur in the digester, is an important factor in the initial delignification step, and the presence of this form of sulfur in the white liquor ensures that the desired reactions proceed rapidly, preferably in a higher sulfidity range than that used in the usual kraft process. Reduced sulfur also may be present in the liquor as sodium sulfide (Na_2S) depending on the liquor pH.

Sulfidity is the term commonly used to define the reduced sulfur content of white liquor. Sulfidity is defined using the ABC test (CPPA standard method J.12, revision of May 1984) as (all constituents expressed as Na_2O in g/l):

$$\text{Effective Alkali (EA)} = NaOH + \tfrac{1}{2}\, Na_2S \quad (1)$$

$$\text{Active Alkali (AA)} = NaOH + Na_2S \quad (2)$$

$$\text{Total Titratable Alkali (TTA)} = NaOH + Na_2S + Na_2CO_3 \quad (3)$$

$$\text{Sulfide} = 2 \times (AA-EA) \quad (4)$$

$$\text{Sulfidity (\%)} = \text{Sulfide} \times 100/AA \quad (5)$$

In the current practice of kraft pulping, a wide range of white liquor sulfidities are used, but it is generally desirable to keep the white liquor sulfidity in the range of 25-40%.

Contacting of the chips with the white liquor in the initial reaction zone or section of digester 3 yields an intermediate mixture containing partially delignified lignocellulosic material. Oxidized white liquor stream 7 is introduced at an intermediate point in the digester and is mixed with the partially delignified material therein. The delignification reactions continue in a second reaction zone or stage as the pulp flows downward in the digester. The liquor now contains a lower concentration of sodium sulfide/sodium hydrosulfide (lower sulfidity) and a higher concentration of sodium hydroxide than the liquor in the previous pulping stage, which is beneficial as the pulping reactions proceed.

The term "partially delignified lignocellulosic material" means a mixture of pulping liquor, partially pulped chips, and liberated partially delignified fiber, or a mixture of pulping liquor and partially delignified liberated fiber. The term "partially delignified lignocellulosic pulp" or "further delignified lignocellulosic pulp" generally means the pulp withdrawn from the digester vessel.

The terms "white liquor" or "unoxidized white liquor" as used herein mean white liquor which is produced in the recaustization step described earlier. This white liquor

comprises predominantly sodium hydroxide, sodium carbonate, sodium sulfide, sodium hydrosulfide, and water, and may contain minor concentrations of oxidized sulfur species. In addition, other non-process elements (NPEs) such as green liquor dregs are likely to be present due to inherent removal inefficiencies in the recovery area operations. NPEs are introduced with the raw materials (wood, chemicals, and water) and commonly include chloride, potassium, and lesser amounts of other elements. The term "oxidized white liquor" as used herein means any white liquor in which at least a portion of the sodium sulfide/sodium hydrosulfide has been oxidized in a separate white liquor oxidation step to yield sodium thiosulfate and/or sodium sulfate. Oxidized white liquor also may contain small amounts of sodium sulfite and sodium polysulfide. Oxidized white liquor stream 7 is obtained by reacting white liquor stream 9 with oxygen-containing gas stream 11 in white liquor oxidation reactor 13 to obtain the desired degree of oxidation. Oxygen-containing gas stream 11 can be air, oxygen-enriched air, or preferably high purity oxygen containing up to 99.5 vol% oxygen.

Sodium hydrosulfide is oxidized according to the reactions

$$Na_2S + H_2O \text{ -------> } NaSH + NaOH \quad (1)$$

$$2\ NaSH + 2\ O_2 \text{ -------> } Na_2S_2O_3 + H_2O \quad (2)$$

$$Na_2S_2O_3 + 2\ O_2 + 2\ NaOH \text{ -------> } 2\ Na_2SO_4 + H_2O \quad (3)$$

Additional reactions and intermediate sulfur species can occur as well, but equations (1), (2) and (3) describe the overall reactions as generally understood in the art. It is seen from reaction (1) that as sodium sulfide is dissolved, sodium hydroxide is formed, and from reaction (3) that as sodium thiosulfate is consumed sodium hydroxide is consumed. Thus the degree of oxidation can be selected to fix the relative amounts of sodium- and sulfur-containing species as desired to optimize the pulping process in digester 3.

The selected degree of oxidation depends in general on the reaction temperature, the reactor residence time, and the amount of oxygen introduced into reactor 13 relative to the amount of sodium sulfide/sodium hydrosulfide in the unoxidized white liquor. The oxidized white liquor can contain mostly sodium thiosulfate, both sodium thiosulfate and sodium sulfate, or all sodium sulfate as the oxidation products depending on the degree of oxidation. The white liquor can be oxidized to any desired degree by controlling the reaction temperature, reactor residence time, and flow rate of oxygen-containing gas 11. If desired, oxidation reactor 13 can be operated in a stagewise fashion to generate two or more oxidized white liquor streams with differing degrees of oxidation according to reactions (2) and (3), and these streams will have different sulfidity levels.

Oxidized white liquor stream 15, which as shown has the same degree of oxidation as stream 7, can be introduced into the digester at a lower intermediate point as shown. The sulfidity of oxidized white liquor streams 7 and 15 are essentially equal, which means that the sulfidities differ by no more than the reproducibility of the standard sulfidity determination. This liquor is mixed with the partially delignified pulp from the previous reaction zone or stage and the delignification reactions continue in a third reaction zone or stage as the pulp flows downward in the digester. The liquor in contact with the pulp now contains additional sodium hydroxide, which is beneficial as the pulping reactions proceed.

Alternatively, further oxidized white liquor feed stream 17, which has a higher degree of oxidation than stream 7, can be used rather than oxidized white liquor 15 in the lower portion of the digester. In this alternative, the liquor in the lower section of the digester would have a lower sulfidity than if white liquor stream 15 were used as described above.

At the completion of the pulping reactions, further delignified lignocellulosic pulp or treated pulp stream 19 is withdrawn from digester 3, and is washed in washer zone 21 to yield delignified pulp 23. Weak black liquor stream 27, which contains organic compounds, dissolved lignin, and other wood components, flows to evaporator zone 29 in which the weak black liquor is concentrated by multiple stages of evaporation to yield concentrated black liquor 31 and evaporated water 33. Soaps, resins, and fatty acids typically are recovered in evaporator zone 29. Sodium and sulfur in various chemical forms are added to concentrated black liquor 31 as needed (not shown) to replace losses elsewhere in the process, and the mixture is combusted in recovery boiler 35 to yield molten sodium sulfide and sodium carbonate as stream 37. This molten material or smelt is dissolved in water to yield an aqueous liquid known as green liquor (not shown) and the green liquor is recausticized with calcium oxide (lime) in recausticizer 39 to convert the sodium carbonate to sodium hydroxide, which then yields white liquor stream 41 for use in another pulping cycle as described.

The process of Fig. 1 preferably is operated such that the concentration of sodium sulfide/sodium hydrosulfide in the liquor in digester vessel 3, and accordingly the sulfidity of the liquor, are highest in the upper or feed end of the vessel and lowest in the bottom or discharge end of the vessel. Conversely, the concentration of sodium hydroxide in the liquor in digester vessel 3 preferably is lowest in the upper or feed end of the vessel and highest in the bottom or discharge end of the vessel. This satisfies the preferred conditions in the digester in which the initial pulping reactions are carried out in an environment of relatively high sodium sulfide/sodium hydrosulfide concentration and relatively low sodium hydroxide concentration, and in which the later and final pulping reactions are carried out in an environment of relatively low sodium sulfide/sodium hydrosulfide concentration and relatively high sodium hydroxide concentration. This

can be achieved as described earlier by utilizing a portion of the white liquor at the digester inlet and adding another white liquor stream as oxidized white liquor at an intermediate point in the digester. Any number of oxidized white liquor streams can be introduced at intermediate points in the digester, preferably such that the degree of oxidation of each successive oxidized white liquor stream increases (and the sulfidity decreases) as the addition point is located farther from the feed end of the digester.

The dosage of white liquor stream 5 to comminuted lignocellulosic material 1 (dry basis) typically is in the range of about 1 to about 25% and preferably is in the range of about 8 to about 20%. The flow rate of oxidized white liquor stream 7 added to the partially delignified lignocellulosic material at the intermediate point in digester 3 gives a dosage typically in the range of about 1 to about 25% and preferably in the range of about 8 to about 20% based on comminuted lignocellulosic material 1 (dry basis). Dosage as used herein means the weight ratio of liquor to dry lignocellulosic material expressed as %, where the weight of the liquor is expressed as Na_2O.

The sulfidity of white liquor stream 5 typically is in the range of about 0.1% to about 50%, and preferably is in the range of about 8% to about 20%. The sulfidity of oxidized white liquor stream 7 typically is in the range of 0% to about 49%, and preferably is in the range of 0% to about 40%.

White liquor oxidation reactor 13 can be any type of white liquor oxidation system known in the art. It can be a plug flow reactor, a completely mixed gas-liquid reactor, or a series of staged reactors. Oxygen-containing gas stream 11 can be air, enriched air, or preferably high purity oxygen containing up to 99.5 vol% oxygen. If desired, an appropriate catalyst can be used to promote the oxidation reactions.

Digester vessel 3 as shown in Fig. 1 is a continuous digester in which pulp and liquor flow countercurrently through the reaction zones. As discussed later, liquor also

may flow in a direction countercurrent to the pulp flow, and liquor may be withdrawn from and recirculated to sections or zones of the digester. Any of the many types of continuous digesters known in the art can be used to achieve the benefits of the present invention as long as white liquor can be introduced at two or more points in the cooking process. Such a digester can comprise a single vessel, or two or more vessels, such as the Kamyr MCC digester which incorporates an impregnation vessel and a digestion vessel with the liquor addition staged with addition of white liquor in the impregnation vessel and oxidized white liquor at the trim circulation and in the final stage of cooking.

Alternatively, the method of the present invention can be used with batch digesters or pulping reactors in which chips or other lignocellulosic materials are charged to a reactor with white liquor, the charge is cooked or reacted for a defined period of time (during which additional liquor may be introduced and withdrawn from the reactor), and the finished pulp is discharged from the digester. The cycle then is repeated; two or more digesters may be operated in parallel if desired. In the present invention, a batch digester would be operated for an initial period of time using white liquor, followed by one or more additional operating periods using one or more oxidized white liquor streams prepared as earlier described. The present invention also can be used in conjuction with sequencing batch digestion systems known in the art as the Beloit Co. RDH digesters and similar types of liquor displacement processes.

Most of the operating conditions for the process of the present invention as illustrated in Fig. 1 are similar to those of the kraft process. For instance, standard liquor to wood ratios, time to temperature profiles, cooking times, cooking temperatures, cooking additives such as anthraquinone, surfactants, and the like can be optimized in the usual manner (See for example *Pulp and Paper Manufacture*, Vol. 5, Alkaline Pulping, edited by T. M. Grace et al, The Joint Textbook Committee of the Paper

Industry, Atlanta, USA, 1989) and would not be substantially affected by practice of the current invention.

In addition to the digester operation as described above, the method of feeding white liquor and oxidized white liquor of the present invention affects other steps in the kraft process. In the evaporation plant and the recovery boiler, the generation of malodorous gases during the processing of black liquor is critical to the environmental performance of the mill. In simple terms, recovery boiler black liquor water removal systems can be broadly categorized as being of a direct (direct contact evaporator [DCE]) or an indirect (low odor) design. In either case, the emission levels of the two recovery systems are a strong function of the total reduced sulfur (TRS) content of the black liquor being processed.

In DCE boilers, the hot flue gases exiting the recovery boiler are contacted with the partially concentrated black liquor to further increase the solids concentration of the black liquor. This CO_2-containing gas tends to lower the pH of the black liquor at the contacting interface, and this combined with the increase in solids concentration results in the evolution of TRS gases from the black liquor into the flue gases. In contrast, the low odor boiler systems are equipped with indirect heat exchangers (evaporators) and do not contact the black liquor with flue gases. As a result, most mills with low odor boilers are able to operate with atmospheric emission levels of less than 5 ppm TRS when the mill is operated using typical sulfidity white liquors (20-40%).

Mills which operate DCE-equipped recovery boilers typically have difficulty in achieving this level of performance. The emissions from the DCE boilers can originate in two places -- the DCE itself and, to a lesser extent, the recovery boiler. The current invention provides a method of controlling the overall sulfidity of the white liquor and therefore the resulting black liquor. Since at any given operating condition the emission

of TRS from the recovery system is a function of the total amount of reduced sulfur in the black liquor, it is possible to capture the benefits of a high sulfidity white liquor while still meeting the required emission standards for the recovery system by controlling the average sulfidity of the mill's black liquor to the desired level. The operation of a pulp mill in this fashion provides a significant operational advantage.

Because the total load of sulfur to the recovery boiler is either unchanged or increased, additional advantages may be realized in the recovery area operations. Specifically, the increase in sodium sulfide in the smelt produced by the recovery boiler will contribute additional alkalinity in the form of active alkali. This additional capacity can be used by those mills which have an existing bottleneck or to reduce the load in this unit operation, which can result in considerable economic benefits.

Another improvement to the overall recovery operations as a result of the present invention will be realized by the increased load of partially oxidized white liquor introduced into the recovery boiler. Any oxygen carried into the recovery boiler with the black liquor will displace oxygen introduced with the combustion air. This can reduce the total flue gas flow, and hence the flue gas velocity, which results in a decrease in entrained solids and therefore a decrease in the rate of recovery boiler fouling.

The concept also makes it feasible to contemplate the addition of oxygen for delignification of the kraft pulp in the discharge line of the digester, since the sulfide in the white liquor, which must normally be washed from the pulp prior to an oxygen treatment, will not be present. Thus the invention described herein allows the use of residual alkali and elevated process temperatures, and the pulp produced can be delignified further using a combination of oxygen and alkali.

EXAMPLE

A specific example of a digester operating according to the present invention is illustrated in Fig. 2. Digester 201 is a staged pulping reactor vessel designed for the flow of chips and pulp in a downward direction, the flow of liquor in a generally upward direction, and the recirculation of liquor in each of the stages. The digester is nominally 4.98 m diameter by 50 m in height (empty volume is nominally 980 m^3). First stage 203 is defined by the upper portion of the vessel shell and extractor screen 205, which allows the removal of liquor from the vessel via line 207 while allowing downward flow of an intermediate mixture containing lignocellulosic material or partially delignified pulp. Second stage 209 is defined by a middle portion of the vessel shell, extractor screen 205, and extractor screen 211, which allows the removal of liquor from the vessel via line 213 while allowing downward flow of intermediate lignocellulosic pulp or further delignified pulp. Third stage 215 is defined by a lower portion of the vessel shell, extractor screen 211, and extractor screen 217, which allows the removal of liquor from the vessel via line 213 while allowing downward flow of pulp. Final pulp is withdrawn through line 221.

A flow of chips at 2000 m tonne/day is introduced through line 223, mixed with white liquor from line 225 at a flow rate of 1260 liter/min, and the mixture is combined with 600 liter/min of recirculating weak black liquor from line 227 (later defined). The white liquor has a concentration of active alkali 124 g/l as NaOH and a sulfidity of 9 to 17%. The feed mixture flows through line 229 into first stage 203 of digester 201 and the initial pulping reactions occur therein. Dilution liquor comprising either brownstock washer filtrate from a subsequent filtrate tank or fresh hot water or some combination thereof is introduced at a flow rate of 5700 liter/min through line 231. This liquor flows upward through the reactor to effect countercurrent liquor-pulp contacting. Weak black

liquor is withdrawn from extraction screen 205 via line 207 at a flow rate of 6400 liter/min, 600 liter/min is recirculated via line 227 as described above, and a final weak black liquor stream at 5800 liter/min is withdrawn via line 233 at 163°C containing 15 g/l of dissolved solids.

Pulp flows downward though stage 209 of the digester. Liquor is withdrawn from extraction screen 211 via line 213 at 5660 liter/min (representing a volume of 9.7 M^3/air dried ton of wood chips fed in line 223), is combined with 840 liter/min of oxidized white liquor filling in line 235, and the combined recirculation liquor is returned to the digester via line 239 at 6500 liter/min. The oxidized white liquor in line 235 has an active alkali concentration of 124 g/l as NaOH and a sulfidity of 0-8 %. The digester is operated in such a fashion that the net white liquor sulfidity is kept constant at 8.8% by manipulation of the degree of oxidation of the liquor flowing in line 235 and the relative volumetric flows of oxidized white liquor in line 235 and white liquor in line 225. The recirculation liquor in line 237 flows through line 239 to the bottom of stage 209 where it is combined with liquor flowing upward from stage 215.

Pulp flows downward though stage 215 of the digester. Liquor is withdrawn from extraction screen 217 via line 219 at 3000-3300 liter/min min (representing a volume of 4.9 M^3/air dried ton of wood chips fed in line 223), is combined with 0-300 liter/min of oxidized white liquor flowing in line 241, and the combined recirculation liquor is returned to the digester via line 243 at 3300 liter/min. The recirculation liquor in line 243 flows through line 245 to the bottom of stage 215 where it is combined with dilution liquor at 5700 liter/min from line 231. Final pulp is withdrawn through line 221 at a consistency of 11% and a flow rate of 970 air dried ton/day and 86 C. In this example, oxidized white liquor streams in lines 235 and 241 have the same composition.

Thus the present invention provides improved benefits of using white liquor containing sodium sulfide and sodium hydrosulfide for producing kraft pulp by oxidizing a portion of the white liquor and utilizing this oxidized white liquor in combination with unoxided white liquor in the digestion or pulping process. Unoxidized high sulfidity white liquor is used in the early stages of the process and oxidized white liquor with a lower sulfidity is used in the later stages of the process where the sodium sulfide/sodium hydrosulfide in the white liquor is no longer beneficial. This reduces the amount of sodium sulfide/sodium hydrosulfide used in the overall pulping process, thereby reducing the amount of malodorous sulfur compounds produced in the digestion and reducing odor emissions in the downstream processing of the resulting black liquor.

The essential characteristics of the present invention are described completely in the foregoing disclosure. One skilled in the art can understand the invention and make various modifications without departing from the basic spirit of the invention, and without deviating from the scope and equivalents of the claims which follow.

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. A method to produce lignocellulosic pulp from a lignocellulosic material which comprises:

(a) providing a comminuted lignocellulosic material;

(b) providing a stream of white liquor and at least one stream of oxidized white liquor;

(c) contacting the comminuted lignocellulosic material with the white liquor and producing an intermediate mixture containing partially delignified lignocellulosic material; and

(d) contacting the intermediate mixture with the oxidized white liquor and producing a further delignified lignocellulosic pulp.

2. The method of Claim 1 wherein the contacting in (c) and (d) is effected in a batch digester vessel.

3. The method of Claim 1 wherein the contacting in (c) and (d) is effected in a continuous digester vessel.

4. The method of Claim 3 wherein the contacting of the white liquor and with the comminuted lignocellulosic material is effected in cocurrent flow.

5. The method of Claim 3 wherein the contacting of the oxidized white liquor with the Intermediate mixture containing partially delignified lignocellulosic material is effected in cocurrent flow.

6. The method of Claim 3 wherein the contacting of the white liquor with the comminuted lignocellulosic material is effected in countercurrent flow.

7. The method of Claim 3 wherein the contacting of the oxidized white liquor with the intermediate mixture containing partially delignified lignocellulosic material is effected in countercurrent flow.

8. The method of Claim 1 wherein the dosage of white liquor to comminuted lignocellulosic material (dry basis) is in the range of about 1 to about 25 % as Na_2O.

9. The method of Claim 8 wherein the dosage of oxidized white liquor to comminuted lignocellulosic material (dry basis) is in the range of about 1 to about 25 % as Na_2O.

10. The method of Claim 1 wherein the sulfidity of the white liquor is in the range of about 1.0% to about 50%.

11. The method of Claim 10 wherein the sulfidity of the oxidized white liquor liquor is in the range of 0% to about 49%.

12. The method of Claim 1 wherein one stream of oxidized white liquor is contacted with the intermediate mixture containing lignocellulosic material.

13. A method to produce lignocellulosic pulp from a lignocellulosic material which comprises:

(a) providing a comminuted lignocellulosic material;

(b) providing a stream of white liquor,

(c) providing a first stream of oxidized white and a second stream of oxidized white liquor;

(d) contacting the comminuted lignocellulosic material with the white liquor and producing a first intermediate mixture containing partially delignified lignocellulosic material;

(e) contacting the first intermediate mixture with the first stream of oxidized white liquor and producing a second intermediate mixture containing further delignified lignocellulosic material; and

(f) contacting the second intermediate mixture with the second stream of oxidized white liquor and producing a further delignified lignocellulosic pulp.

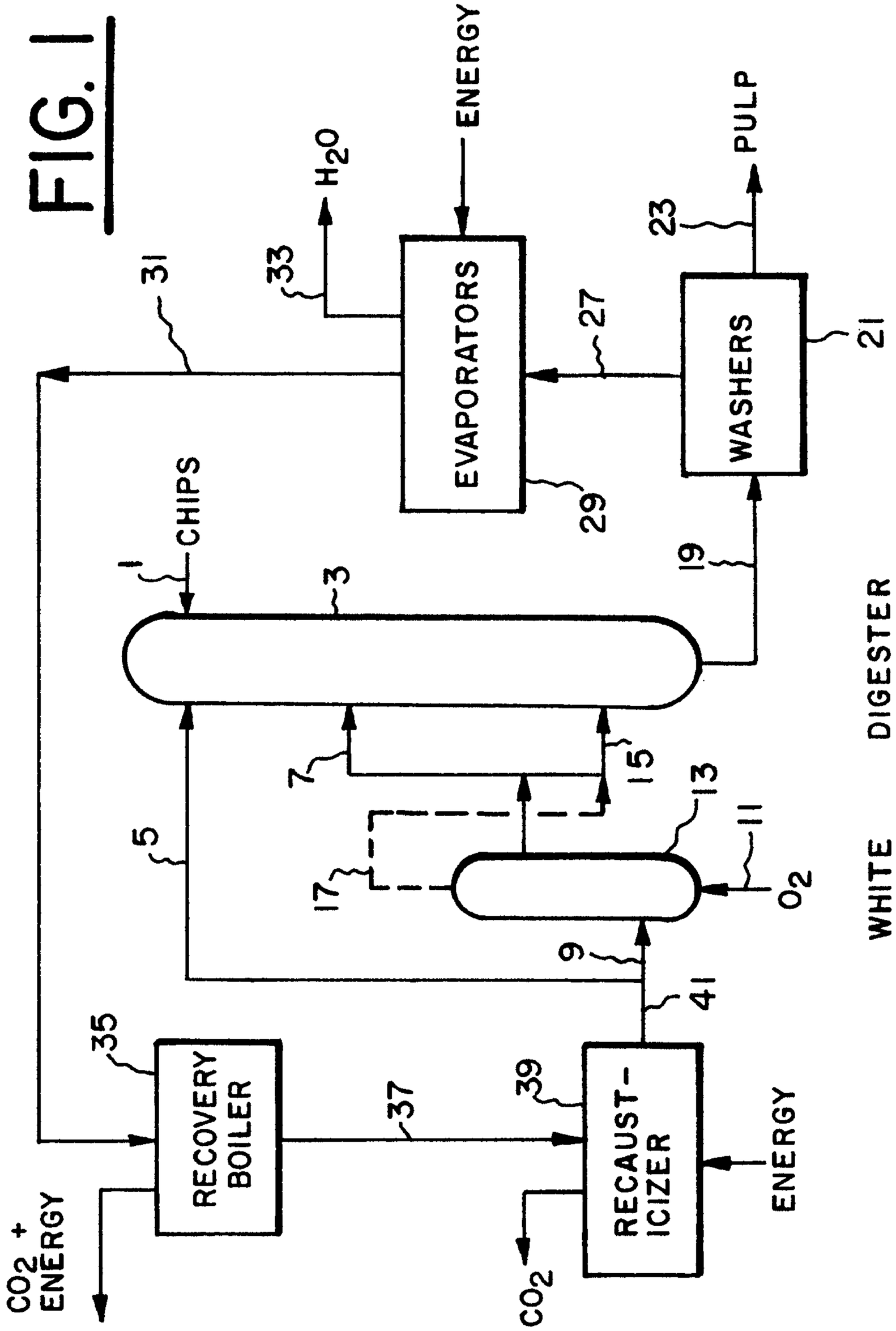
14. The method of Claim 13 wherein the sulfidity of the white liquor is in the range of about 1.0% to about 50%.

15. The method of Claim 13 wherein the first stream of oxidized white liquor and the second stream of oxidized white liquor each have a sulfidity in the range of 0% to about 50%, and wherein the sulfidity of first stream of oxidized white liquor and the sulfidity of the second stream of oxidized white liquor are essentially equal.

16. The method of Claim 13 wherein the first stream of oxidized white liquor has a sulfidity in the range of about 1% to about 50% and the second stream of oxidized white

liquor has a sulfidity in the range of 0% to about 49%, and wherein the sulfidity of the first stream of oxidized white liquor is greater than the sulfidity of the second stream of oxidized white liquor.

FIG. 1



McFadden, Fincham

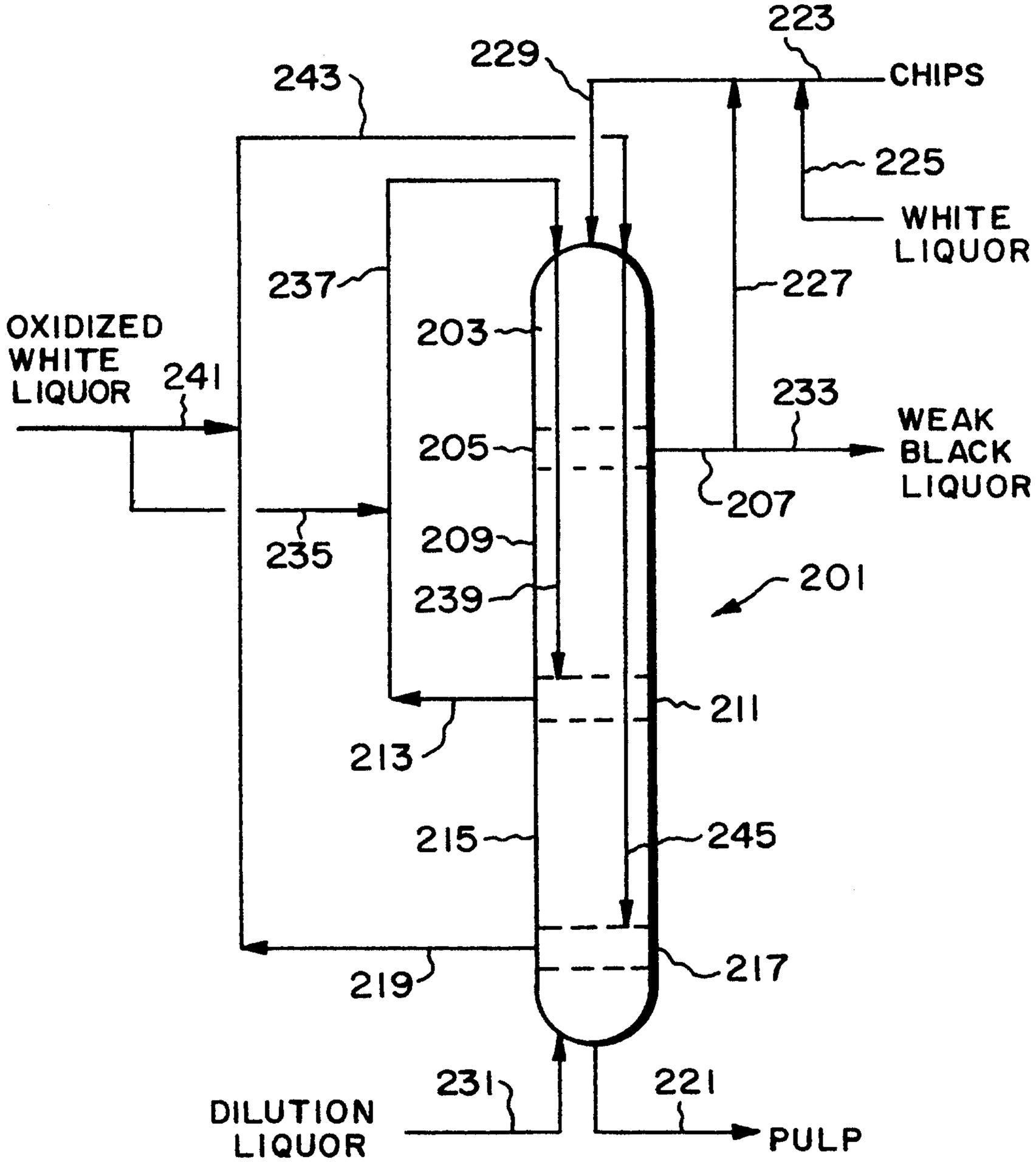
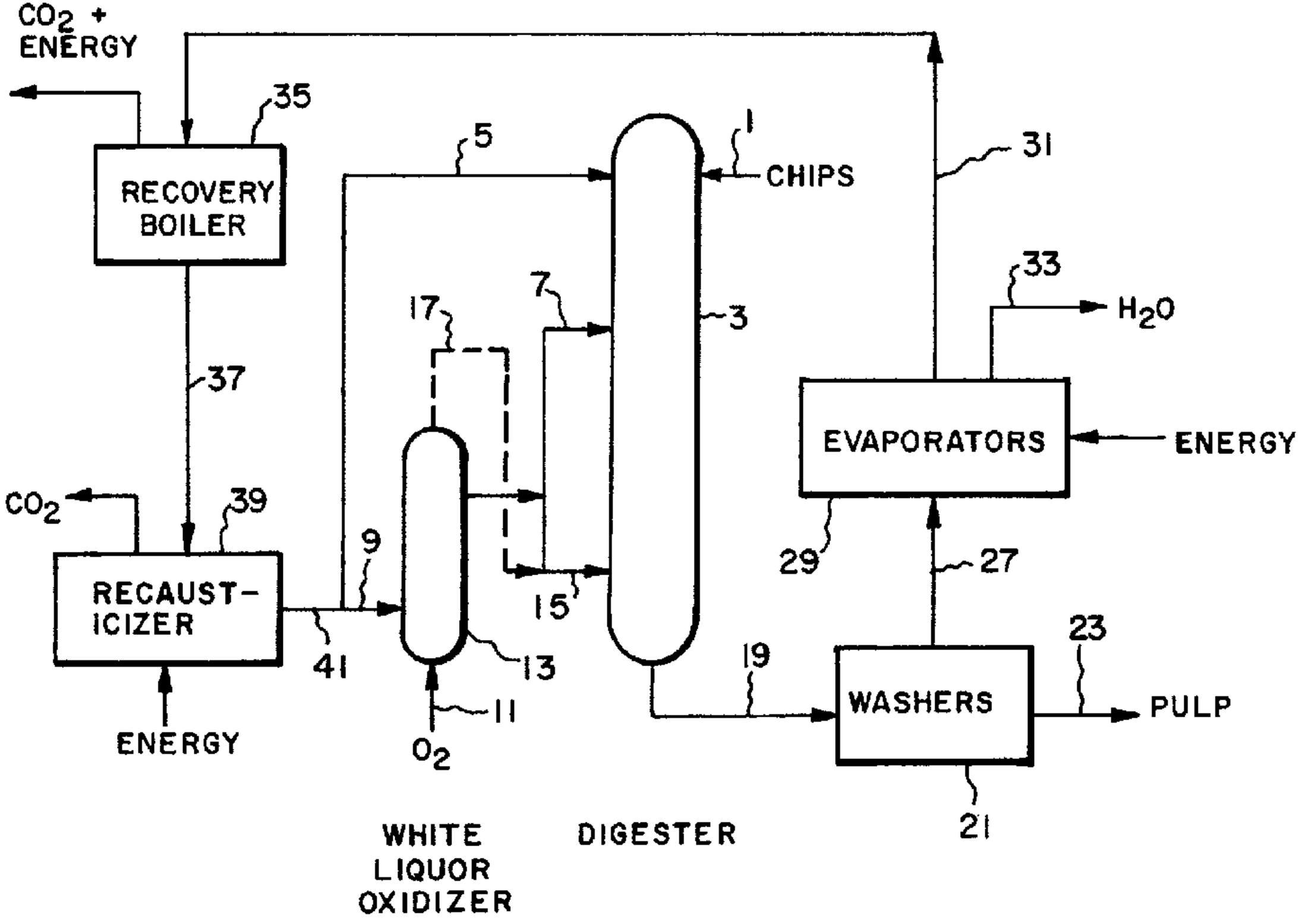


FIG. 2

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CO_2 + ENERGY
35
RECOVERY BOILER
5
1
CHIPS
31
33
H_2O
7
17
3
37
EVAPORATORS
ENERGY
CO_2
39
9
29
27
RECAUST-ICIZER
15
41
13
19
23
WASHERS
PULP
ENERGY
11
O_2
21
WHITE LIQUOR OXIDIZER
DIGESTER