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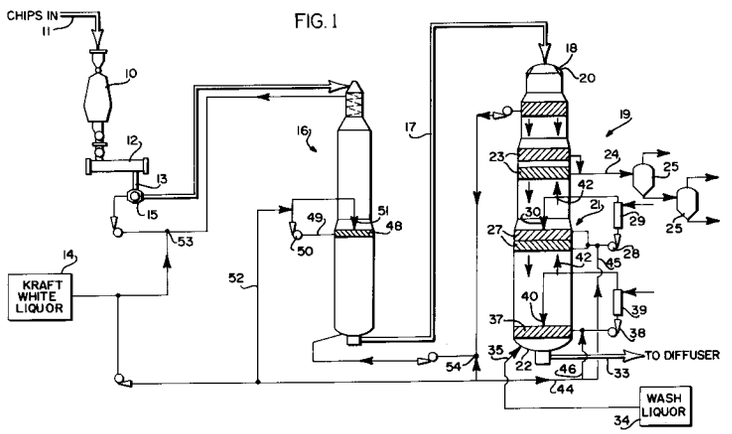
(54) Extended kraft cooking with white liquor added to wash circulation.

(57) In the continuous kraft pulping of comminuted cellulosic fibrous material (e.g. wood chips) to produce paper pulp, viscosity for a given Kappa Number is significantly increased (e.g. at least about 20%) by adding kraft white liquor to the wash recirculation loop (38-40) in a continuous digester (19). Optimum results are obtained when kraft white liquor is also added to a recirculation loop (28-30) at a central portion of the digester, so that the majority of the digester has countercurrent flow between white liquor and cellulosic material. About 5-20% of the total white liquor necessary to effect kraft cooking is introduced in the wash circulation, and about 10-20% is introduced into the central portion recirculation. The temperature in the wash zone is maintained at about 140-175 ° C.

FIG. 1



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BACKGROUND AND SUMMARY OF THE INVENTION

In recent years, great strides have been made in improving the continuous kraft pulping of comminuted cellulosic fibrous material (e.g. wood chips) to produce kraft pulp. In conventional continuous digestion systems, the white liquor was added only to the recirculation loop between the digester and other components, and/or into an impregnation vessel. However, in about 1983, it was recognized the increased bleach brightness potential and savings in bleaching chemicals could be utilized if kraft white liquor were added in a number of places in the process, including (and most importantly) in a central recirculation loop within the continuous upright digester. Black liquor was withdrawn from screens between the top and central portion of the digester, meaning that for a part of the cooking zone the kraft white liquor flowed countercurrently to the cellulosic material.

While the improved process and system as described above -- marketed commercially by Kaymr, Inc. of Glens Falls, New York and Kaymr AB of Karlstad, Sweden under the trademark "MCC" -- has resulted in vast improvements in the many commercial installations in which it has been used since its commercial introduction in 1985, it is desirable to effect still further improvements in continuous kraft pulping.

According to the present invention, further significant improvements to continuous kraft pulping have been made by adding a portion of the kraft white liquor to the wash recirculation loop at the bottom of the digester, so that the kraft white liquor flows countercurrent to the material through a longer part of the digester vessel. Typically, the temperature in the wash zone also is maintained at about 140-165° C. Not only does the invention result in an improved pulp viscosity for a given Kappa Number (improvements of at least about 20% are achieved, and normally at least about 30%), the digester becomes easier to operate (the chip and liquor levels being easier to control, and the entire process flowing more smoothly). While the desirable results according to the invention are achieved merely by adding kraft liquor to the wash recirculation, for the most effective results it is still desirable to add the kraft liquor to the central recirculation loop (and at other conventional locations in the process).

According to one aspect of the present invention, a method of continuously kraft pulping comminuted cellulosic fibrous materials utilizing an upright digester having a top, bottom, and central portions is provided. That method comprises the following steps: (a) passing comminuted cellulosic fibrous material entrained in kraft white liquor into the top of the digester; (b) extracting black liquor from at least one screen between the top and bottom of the digester; (c) at a first portion of the digester withdrawing and recirculating liquid in a first recirculation loop; (d) adding wash liquid at the bottom of the digester; (e) adjacent to the bottom of the digester withdrawing and recirculating liquid in a second, wash, recirculation loop; (f) adding kraft white liquor to the second recirculation loop, the liquor recirculated into the digester in part passing upwardly therein countercurrent to the material flow; and the amount of white liquor added in this second recirculation loop being sufficient to increase the viscosity and strength properties of the pulp produced compared to the practice of the same method with the same material and Kappa Number, and other parameters only without step (f); and (g) withdrawing kraft pulp from the bottom of the digester. Preferably, step (b) is practiced between the top and central portion of the digester, and step (c) at the central portion, and there is the further step (h) of adding kraft white liquor into the first circulation loop. The amount of kraft white liquor added in the second recirculation loop is at least about 5%, and preferably about 10-20% (e.g. 15%) of the total white liquor necessary to effect kraft pulping. The amount of kraft white liquor added in step (h) is preferably at least about 10% of the total amount of kraft white liquor necessary to effect kraft pulping, preferably about 10-20%.

According to another aspect of the present invention, an apparatus for continuously kraft pulping comminute cellulosic fibrous material is provided. The apparatus comprises: an upright digester vessel, having a top, bottom, and central portion; means for introducing comminuted cellulosic fibrous material entrained in white liquor into the top of the digester; means for extracting black liquor from at lest one screen between the top of the digester and the central portion thereof; at the central portion of the digester, means for withdrawing and recirculating liquid in a first circulation loop; means for adding wash liquid to the bottom of the digester; adjacent the bottom of the digester, means for withdrawing and recirculating liquid in a second, wash, recirculation loop; means for withdrawing kraft pulp from the bottom of the digester; and means for introducing white liquor into said second recirculation loop. Means are also preferably provided for introducing white liquor into the first recirculation loop. Each recirculation loop comprises a withdrawal conduit, pump, heater, and re-introduction conduit. The means for introducing white liquor into each recirculation loop comprises means for introducing the liquor into the withdrawal conduit before the pump and heater

According to still another aspect of the present invention, another method of continuously kraft pulping cellulosic material is provided. This method comprises all the steps of: (a) passing comminuted cellulosic

fibrous material entrained in kraft white liquor into the top of the digester; (b) extracting black liquor from at least one screen between the top and central portion of the digester; (c) at the central portion of the digester withdrawing and recirculating liquid in a first circulation loop; (d) adding kraft white liquor to the liquid in the first recirculation loop; (e) adding wash liquid at the bottom of the digester; (f) adjacent the bottom of the digester withdrawing and recirculating liquid in a second, wash, recirculation loop; (g) withdrawing kraft pulp from the bottom of the digester; and (h) increasing the viscosity of the kraft pulp produced, at a given Kappa Number, by at least about 20% compared to pulp produced by the practice of only the steps (a) - (g), by adding kraft white liquor to the second recirculation loop.

It is the primary object of the present invention to improve conventional continuous kraft pulping processes. This and other aspects of the invention will become clear from an inspection of the detailed description of the invention and from the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a side schematic view showing an exemplary kraft pulping apparatus according to the present invention;

FIGURE 2 is a graphical representation plotting viscosity versus Kappa Number when comparing the invention to prior art continuous kraft pulping procedures; and

FIGURE 3 is a representation like that of Figure 2 plotting the viscosity/Kappa Number ratio versus Kappa Number.

DETAILED DESCRIPTION OF THE DRAWINGS

An exemplary apparatus for kraft pulping according to the invention is illustrated in Figure 1. Entirely standard components include a chips bin 10 for receiving a feed of chips 11 or like cellulosic comminuted fibrous material. From the chips bin 10, the material goes to a horizontal steaming vessel 12, and a vertical conduit 13, kraft white liquor from the source 14 being added to the material in the conduit 13 to slurry the material as it is fed to the high pressure feeder 15. From the high pressure feeder 15 the material entrained in kraft white liquor passes to an optional impregnation vessel 16, and then in line 17 to the top 18 of a continuous digester 19. At the top of the digester 19 there is a liquid/material separation device 20, which preferably comprises a plurality of bull screens with switching withdrawal from the screens, or the like. The digester 19 also includes a central portion 21 and a bottom 22.

At a portion of the digester 19 between the top 18 and the central portion 21 thereof one or more screens 23, and conduit 24, are provided as means for extracting black liquor from the digester 19. The black liquor is typically passed in conduit 24 to a series of flash tanks 25, as is conventional. At the central portion 21 of the digester 19, withdrawal screens 27 are also provided, being connected by a withdrawal conduit to a pump 28 and a heater 29 for re-introduction of the withdrawn liquid at point 30 of a re-introduction conduit, the point 30 typically being slightly above the screens 27. At the bottom 22 of the digester, kraft pulp is withdrawn in conduit 33 (a scraper or like conventional components can also be utilized), and wash liquor from source 34 is added in introduction conduit 35.

Adjacent the bottom of the digester 19 a wash screen (one or more rows) 37 is provided, liquid being withdrawn therethrough in a withdrawal conduit under the influence of pump 38, and then passing through heater 39 into a re-introduction conduit to be introduced at point 40 just above the screen 37. From the point 40 up to the screens 23, liquid flows countercurrently to the material -- as designated by arrows 42 -- while above the screens 23 it flows cocurrently.

What has been described so far, and including a main conduit 44 for adding kraft white liquor in conduit 45 to the first recirculation loop at digester central portion 21, is conventional in the Kamyr MCC™ system. According to the present invention, a conduit 46 is provided for interconnecting the main conduit 44 to the withdrawal conduit in the second, wash, recirculation loop provided by elements 37 through 40.

In the practice of the present invention, sufficient kraft white liquor is added in conduit 46 so as to achieve significantly enhanced viscosity and strength properties of the pulp produced compared to the practice of the same method without the introduction of kraft white liquor in conduit 46. For example, the amount of kraft white liquor added in conduit 46 is at least about 5% of the total amount of kraft liquor utilized to effect kraft pulping, and typically is about 10-20% (e.g. about 15%). Kraft white liquor preferably is also added -- as is known per se -- in conduit 45 in addition to conduit 46, the amount added in conduit 45 being at least about 10%, and preferably about 10-20%.

The apparatus of Figure 1 also includes a recirculation loop at a central portion of the impregnation vessel 16, including screen 48, withdrawal conduit 49, pump 50, and re-introduction conduit/point 51. Kraft

white liquor from source 14 also is preferably added as indicated by lines or points 52, 53, 54 to the recirculation loop in the impregnation vessel 16, and to the recirculation conduits from the digester to the impregnation vessel 16, and from the impregnation vessel 16 to the high pressure feeder 15. Normally the majority of the white liquor used in the conventional continuous kraft pulping process is added at the points or conduits 52 - 54.

Graphical representations of some of the improved results achieved according to the present invention are illustrated in Figures 2 and 3. As can be seen in Figure 2, viscosity is plotted against Kappa Number for three major different processes. The first procedure -- illustrated by line 55 -- is conventional continuous kraft cooking. The second procedure -- illustrated by line 56 -- is for the Kamyr MCC™ system and process. The data points 57 illustrate results achieved by practicing the present invention. In the practice of the procedures resulting in the data plotted in Figure 2, all parameters were maintained essentially the same except for the addition of kraft white liquor, and the temperature in the wash zone according to the invention was raised to about 140-175 °C, compared to about 125-130 °C for conventional kraft cooking and Kamyr's MCC™ process. The conditions resulting in the plots in Figures 2 and 3 are set forth in the following table:

TABLE I

Cook Type	Conventional	MCC™	Invention
Presteaming			
Time, min	5	5	5
Temp., °C	110	110	110
Impregnation, L/W = 4			
WL to feed, % as NaOH on wood (% of total WL used)	16.2 (90%)	11.7 (65%)	10.8 (60%)
Time, min	30	30	30
Temp., °C	120	120	120
Co-Current Stage			
WL to BC, % as NaOH on wood (% of total WL used)	1.8 (10%)	3.6 (20%)	2.7 (15%)
Max. temp., °C	170	170	165
Total time, min.	90	45	45
Central Stage			
WL, % as NaOH on wood (% of total WL used)	-	2.7 (15%)	1.8 (10%)
Max. temp., °C	-	170	165
Time, min.	-	60	60
Wash Stage			
WL, % as NaOH on wood (% of total WL used)	-	-	2.7 (15%)
Max. temp., °C	135	135	165
Time, min.	180	180	180

Conditions for all cooks were targeted at total EA (WL) addition of 18% NaOH based on wood.

In tests of the conventional kraft process which resulted in graph line 55, white liquor was added only at points 53 and 54. In the testing that resulted in graph line 56, white liquor was also added in conduit 45. In the practice of the present invention -- resulting in data points 57 -- about 15% of the kraft white liquor necessary to effect kraft pulping was added in conduit 46, with about 10% in conduit 45, and the rest in 53 and 54.

In the practice of the invention, the addition of white liquor at 53 is normally about 50-60% of the total white liquor added, and about 10-20% at 54 (with about 10-20% at 45, and 5-20% at 46).

Figure 3 graphically illustrates the same test results as Figure 2, only the viscosity/Kappa Number ratio is plotted against Kappa Number. The graphical representation 60 is attained during conventional kraft cooking, the graphical representation 61 during the practice of the Kamyr MCC™ process and system, and the data points 62 in the practice of the present invention.

As can be seen from both Figures 2 and 3, the viscosity of the plots produced according to the

invention is at least 30% greater than for the best prior art system (MCC™), and can under almost all circumstances be expected to be at least 20% greater.

According to the present invention not only does the viscosity of the final pulp produced increase, the strength properties (tear, tensile, and burst) are also increased for a given Kappa Number. Further, unexpectedly, the entire digester becomes easier to operate. The easier operation of the digester alone is enough to warrant utilization of the method according to the invention.

Advantageous results are achieved according to the invention whether or not an impregnation vessel 16 is provided, and most of the advantageous results according to the invention are achieved whether or not white liquor is added in conduit 45. However, optimum results are obtained when utilizing an impregnation vessel 16, and also adding white liquor in conduit 45.

It will thus be seen that according to the present invention an improved method and apparatus for the continuous kraft pulping of cellulosic material is provided. While the invention has been herein shown and described in what is presently conceived to be the most practical and preferred embodiment thereof, the same principles can be applied to a single vessel hydraulic digester and either one or two vessel steam/liquor phase digesters, and thus it will be apparent to those of ordinary skill in the art that many modifications may be made thereof within the scope of the invention, which scope is to be accorded the broadest interpretation of the appended claims so as to encompass all equivalent structures and procedures.

Claims

1. A method of continuously kraft pulping comminuted cellulosic fibrous material using an upright digester (19) having top (18), bottom (22), and central (21) portions, comprising the step of:

(a) passing comminuted cellulosic fibrous material entrained in kraft white liquor into the top of the digester; (b) extracting black liquor from at least one screen (23) between the top and bottom of the digester; (c) at a first portion of the digester withdrawing and recirculating liquid in a first recirculation loop (28, 29); (d) adding wash liquid (34) at the bottom of the digester; (e) withdrawing kraft pulp from the bottom of the digester;

characterized by: (f) adjacent the bottom of the digester withdrawing and recirculating liquid in a second, wash, recirculation loop (38, 39); and (g) adding kraft white liquor (14) to said second recirculation loop, the liquor recirculated into the digester in part passing upwardly therein countercurrent to the material flow; and the amount of white liquor added in the second recirculation loop being sufficient to increase the viscosity and strength properties of the pulp produced compared to the practice of the same method with the same material, Kappa Number, and other parameters only without step (g).

2. A method as recited in claim 1 further characterized in that step (b) is practiced between the top and central portion of the digester, and step (c) is practiced at the central portion of the digester; and characterized by the further step (h) of adding kraft white liquor (14) to the first recirculation loop (38, 39), the liquor recirculated into the digester in part passing upwardly therein countercurrent to the material flow.

3. A method as recited in claim 2 further characterized in that step (g) is practiced so that about 5-20% of the total amount of kraft white liquor utilized to effect kraft pulping is added during the practice of step (g).

4. A method as recited in claim 1 further characterized in that steps (a) - (f) are practiced so that the majority of kraft white liquor is added in step (a) and at least 5% of the total kraft liquor utilized for kraft cooking as added in step (g), and the temperature in step (g) is about 140-175 ° C.

5. A method as recited in claim 2 further utilizing an impregnation vessel (16), and a conduit (17) connected between the impregnation vessel and the digester, and further characterized in that step (a) is practiced by adding kraft white liquor (14) to the conduit and impregnation vessel, and so that the majority of the kraft white liquor added is added in the conduit and the impregnation vessel, about 5-20% of the kraft white liquor utilized to effect kraft cooking is added in step (g), and about 10-20% of the kraft white liquor utilized is added in step (h).

6. A method as recited in claim 2 further characterized in that in both the first and second circulation

loops the liquid is pumped (via 28, 38) and heated (via 29, 39) before being reintroduced into the digester, and further characterized in that steps (g) and (h) are practiced by introducing the kraft white liquor prior to (at 45, 46) the pumping and heating of the recirculated liquid in the recirculation loop.

7. Apparatus for continuously kraft pulping comminuted cellulosic fibrous material comprising:

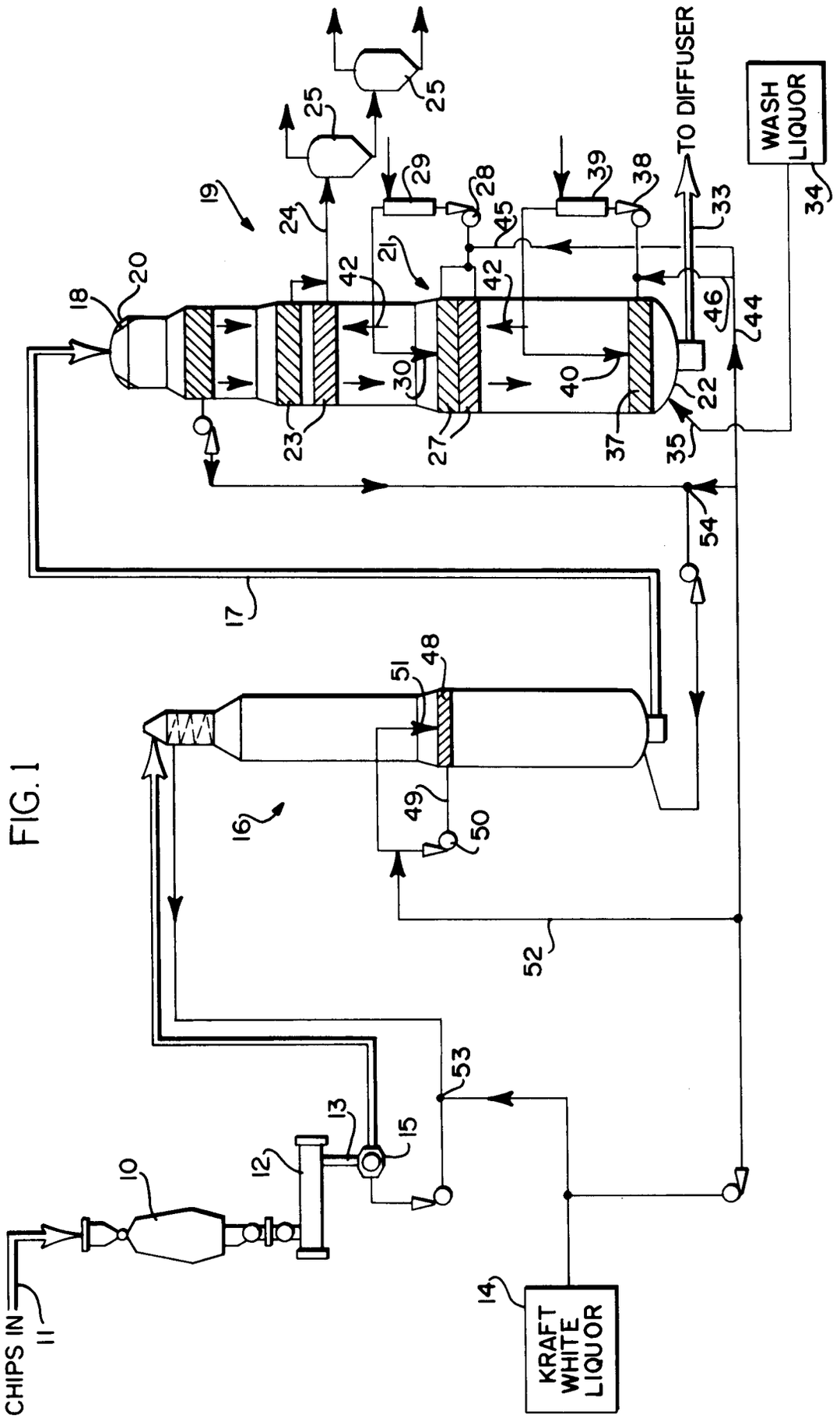
an upright digester vessel (19), having top (18), bottom (22), and central (21) portions; means (17) for introducing comminuted cellulosic fibrous material entrained in white liquor into the top of the digester; means (23, 24) for extracting black liquor from at least one screen (23) between the top of the digester and the central portion thereof; at the central portion of the digester, means (27, 28) for withdrawing and recirculating liquid in a first circulation loop; means (34, 35) for adding wash liquid to the bottom of the digester; means (33) for withdrawing kraft pulp from the bottom of the digester; and

characterized by means (37, 38) adjacent the bottom of the digester, for withdrawing and recirculating liquid in a second, wash, recirculation loop; and means (14, 44, 46) for introducing white liquor into said second recirculation loop.

8. Apparatus as recited in claim 7 further characterized by means (14, 44, 45) for introducing white liquor into said first recirculation loop.

9. Apparatus as recited in claim 8 further characterized in that each recirculation loop comprises a withdrawal conduit, pump (28, 38), heater (39, 29) and re-introduction conduit (30, 40), and said means for introducing white liquor into each recirculation loop comprises means (45, 46) for introducing the liquor in said withdrawal conduit before the pump and heater.

10. Apparatus as recited in claim 7 further comprising an upright impregnation vessel (16) having a top and a bottom, and a conduit (17) for interconnecting the bottom of the impregnation vessel to the top of the digester and a recirculation loop (54) for recirculating liquid from the top of the digester to the bottom of the impregnation vessel, and at a central portion of the impregnation vessel, means (48-51) for withdrawing and recirculating liquid in a third circulation loop, and means (14, 52) for introducing white liquor into said third recirculation loop.


CHIPS IN
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TO DIFFUSER
WASH LIQUOR

FIG. 1

FIG. 2 VISCOSITY VS. KAPPA NUMBER

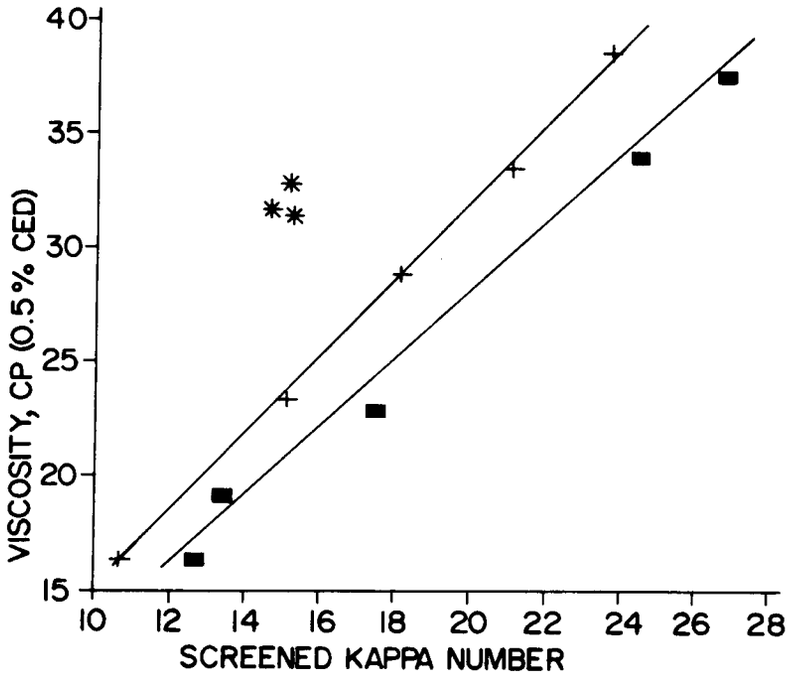

FIG. 3 V/K RATIO VS. KAPPA NUMBER