United States Patent

Kamio

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[54] CONTINUOUSLY DETECTING THE DEGREE OF DELIGNIFICATION OF PULP

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[52] **U.S. Cl.**.....**162/49,** 162/238, 162/263

[51] **Int. Cl.**.....**D21c 7/12**

[58] **Field of Search** 162/49, 242, 263, 238; 137/92, 137/467.5

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[57] **ABSTRACT**

A process for continuously detecting the degree of delignification of pulp in a continuous digester wherein pressure drop in a length of pipe located downstream of the digester, between a blow tank and an accumulator, is measured and used to compute the degree of delignification of the pulp. Pulp flow through the pipe and consistency of the pulp leaving the digester can also be used in obtaining a more accurate determination of the degree of delignification.

5 Claims, 5 Drawing Figures

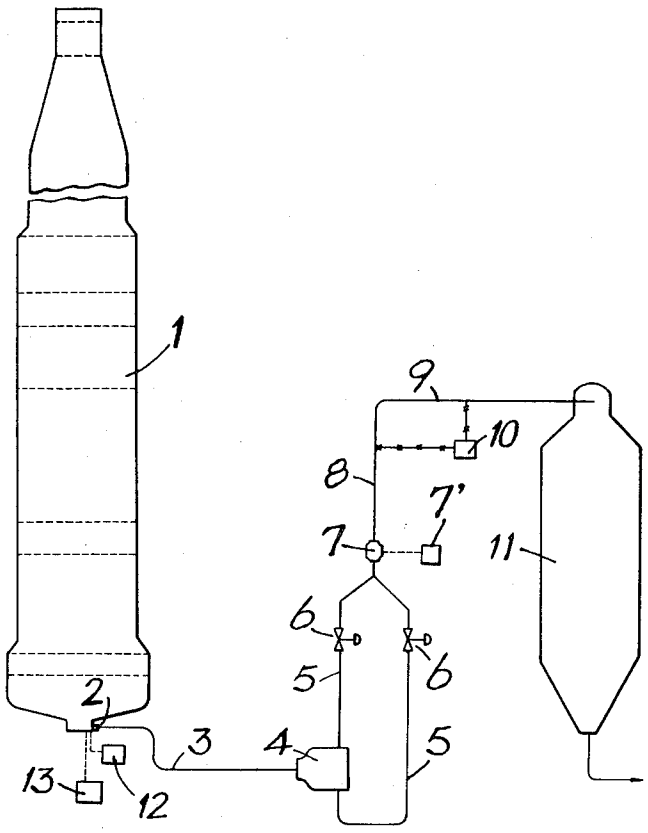


FIG. 1

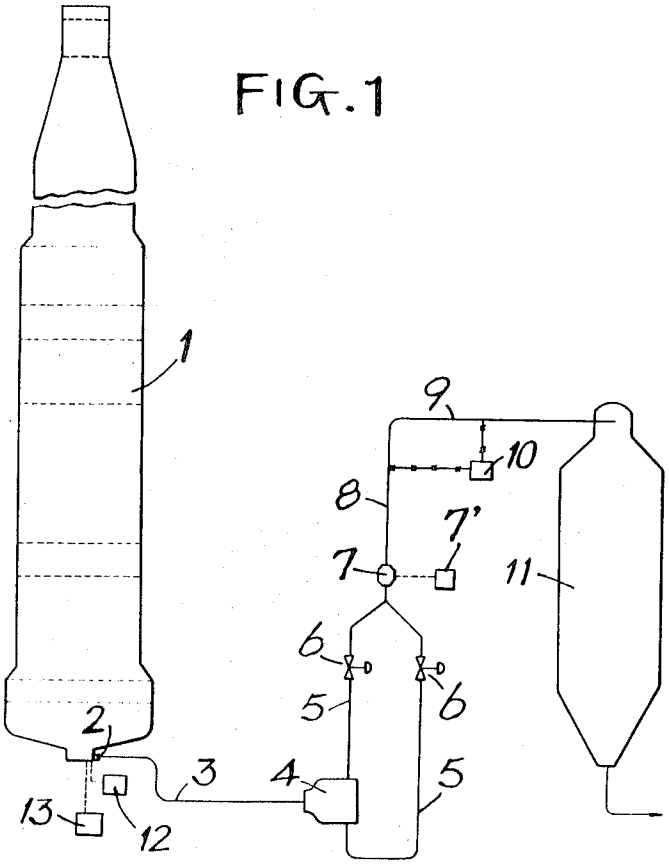
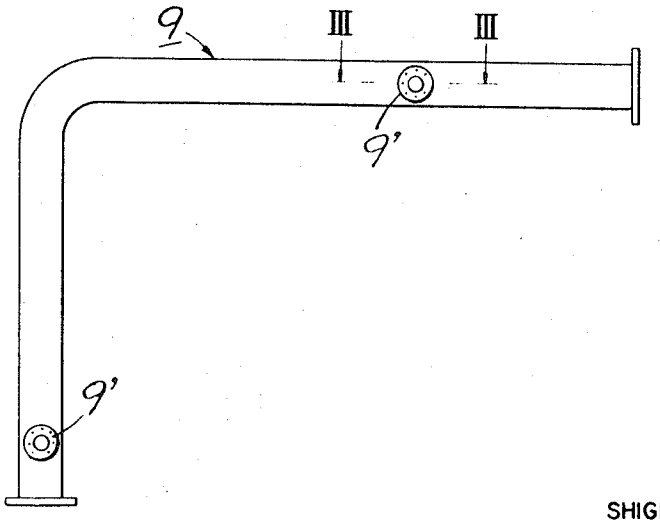


FIG. 2



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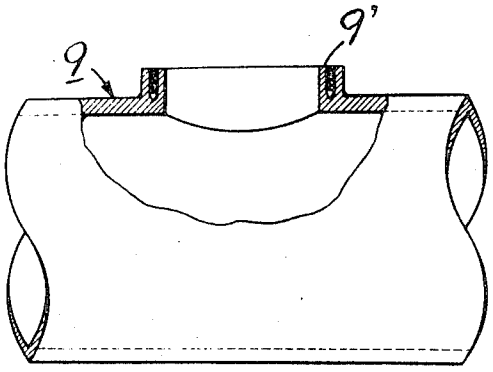
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FIG. 3



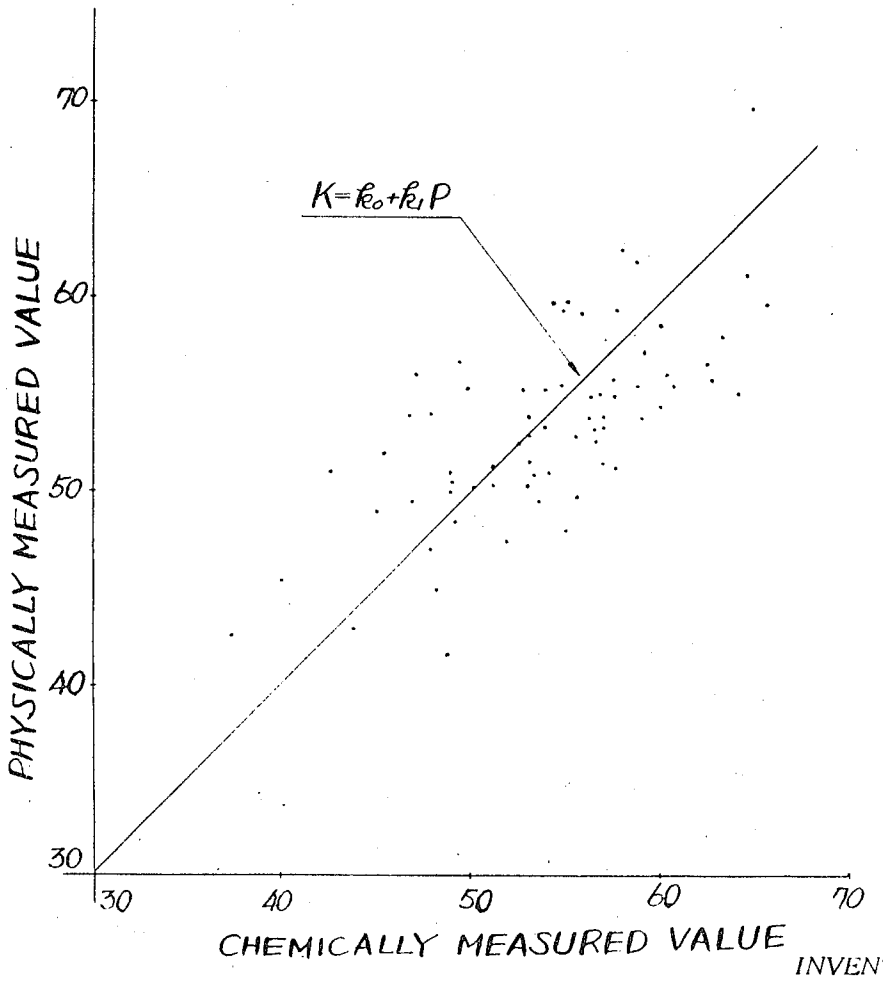


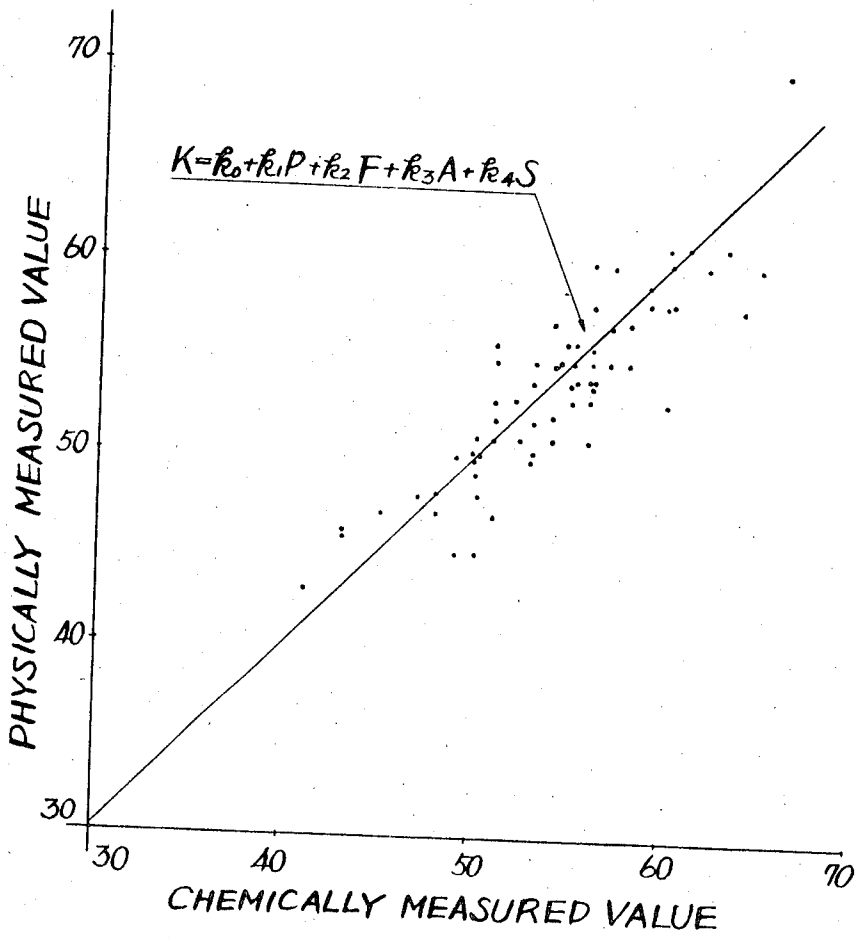
FIG. 4

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FIG. 5



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CONTINUOUSLY DETECTING THE DEGREE OF DELIGNIFICATION OF PULP

This invention relates to the process and means of detecting the degree of delignification of a pulp material at a pulp mill, and has particular reference to a process of this character which permits of continuously monitoring delignification of the pulp so as to control the digester operation.

Due to increased consumption of paper, the pulp industry will eventually suffer the scarcity of suitable raw materials for pulp and will have to live with whatever type of wood available which may be possibly processed into pulp. At the same time, the industry is called upon to assure improved yields and quality of pulp from less suitable wood. One practical approach to accomplish this end would be to maintain the best cooking conditions for a pulp material in the digester of the pulp mill on the basis of such information of how well the pulp has been cooked as may be available at a suitable point downstream of the digester. Since the main constituent to be removed from the pulp in the digester is lignin, the general process according to the invention will be referred to herein as related to "Degree of Delignification" which is to be continuously measured by means hereinafter described. A knowledge of the degree of delignification of a particular pulp specie of the digester also greatly facilitates the washing, bleaching and other treatments of the pulp that follow the stage of digestion in the pulping process.

There have hitherto been proposed many methods for measuring the cooking values, but they are not satisfactory in that they require sampling of the cooked material from time to time for chemical analysis. Such known methods also have a limitation on sampling location due to the fact that since the pulp liquor is not yet homogeneously mixed immediately at the outlet of the digester, where it is supposed to be most ideally sampled, sampling in most pulp mills would have to take place as far apart from the digester as downstream of the washer past the blow tank. This would entail considerable time lag and make it not feasible to adjust the cooking conditions with such untimely information of spot sampling. In addition, such sampling analysis would not be entirely satisfactory because it is local by nature and cannot accurately forecast the degree of delignification of the voluminous pulp mass present in the digester.

Whereas, it is an object for this invention to provide a novel, useful process and means of continuously measuring and monitoring the degree of delignification of the pulp to ensure that the best cooking conditions are maintained throughout operation of the system.

The inventive concept of the present invention owes its merits to the discovery that the degree to which the pulp is cooked and delignified in the digester is substantially proportional to a pressure drop encountered in the flow of the pulp liquor through a transport pipe downstream of the digester. The process according to the invention may thus be represented by the following simple equation of multiple regression:

$$K = K_o + K_1 P \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

where K is a dependent variable standing for the degree of delignification, and P is an independent variable for the pressure drop which may be encountered in the flowing cooked pulp.

In order to obtain a more accurate and extensive degree of delignification, there may be considered flow F and consistency C of the pulp to add to the above basic formula, thus:

$$K = K_o + K_1 P + K_2 F + K_3 C \ldots\ldots\ldots\ldots 2$$

Consistency C of the pulp may be obtained by the use of a costly instrument such as a gamma-ray consistency meter which may be connected to a conduit through which the pulp liquor is passed. Alternatively, it will be possible to measure the pulp consistency C by detecting load current A through and r.p.m. values of the agitator at the bottom of the digester in the usual pulp mill. With these factors taken into account, the regression formula for cooking value may appear as follows:

$$K = K_o + K_1 P + K_2 F + K_3 A + K_4 S \ldots\ldots\ldots 3$$

It will be understood that K_o, K_1 ..... and so on are coefficients which may be statistically ascertained according to the rule of multiple regression on the basis of a sufficient number of test data as exemplified in Table 1 below.

As already stated, the process of the invention is based on the discovery of the fact that pressure drop P corresponds to delignification K whereby it is made possible to obtain continuously the degree to which the pulp material is cooked and delignified in the digester.

It is generally known (for instance, as reported by TAPPI in its periodical publication Vol., 35, No. 12, Dec. 1952) that the pressure drop P referred to above is variable with freeness, consistency and velocity of the pulp liquor. Experience has indicated, however, that the pressure drop P would not be for all practical purposes affected by changes in the velocity of the pulp flow providing that such changes occurred on the order of 50 percent. As regards consistency C, it would be absolutely unlikely to have to change it as much as 1 percent under normal operating conditions, and hence this parameter may be considered practically negligible. Furthermore, the pulp liquor when flowing through a pipe exhibits a non-Newtonian flow characteristic, viz the pulp tends to flow with relatively large amounts of water distributed over the inner wall of the pipe so as to least affect the pressure of the pulp flow. Having thus considered the possible effects of consistency and velocity of the pulp liquor, it will be appreciated that freeness alone would be the last parameter that may affect the pressure drop P. Here, the term "freeness" represents a value far greater than measurable by ordinary freeness tester.

There may be considered many ways of detecting pressure drop P of the pulp across a transport piping between two optional points. One convenient means would be to use an elbow or otherwise specifically bent tube of relatively small length and check the pressure drop P across the same. While it is possible to obtain the pressure drop P by checking the pressure of the pulp flow at two extreme ends of a straight pipe about 10 to 20 meters long, this may be more conveniently accomplished with use of a bent tube measuring 3 meters long, 150 millimeters in diameter and 1.5 R in curvature.

The object and features of the invention will be more apparent from the following description taken in conjunction with the accompanying drawings in which:

FIG. 1 is a flow diagram illustrating an arrangement embodying the invention;

FIG. 2 is an enlarged front-elevational view of a pressure detection device incorporated in the arrangement of FIG. 1;

FIG. 3 is a cross-sectional view on enlarged scale taken on the line III—III of FIG. 2; and

FIGS. 4 and 5 each graphically display the degree of delignification physically measured according to the invention as plotted against those chemically measured by conventional process.

Referring to FIG. 1, there is shown Kamyr digester 1 having a bottom outlet 2 for discharge of the cooked pulp liquor. To this outlet is connected a pipe member 3 for transporting the cooked pulp liquor to a blow tank unit 4. Designated at 5 is a pair of pipes shunting from the blow tank unit 4 and extending past flow control valves 6 until they tie into each other just before an electromagnetic flow meter/transmitter 7 which is coupled with a signal transducer 7'. Designated at 8 is a flow pipe connected at one end with the flow meter 7 and at the other with an elbow 9. The pipe 8 may suitably be of steel and 150A in diameter.

The elbow 9 is provided with a flanged port 9' (see FIG. 2) near each end thereof for sampling the pressure of the cooked pulp and is connected via these flanged ports 9' to a pressure drop detector/transducer 10 which may be capable of translating the pressure drop P into electrical signal. A downstream end of the elbow 9 is connected to the overhead of an accumulator tank 11 which holds and stores the cooked pulp liquor.

Designated at 12 is a thermal converter connected to an agitator (not shown) of the digester and adapted to measure load current through the agitator. Also connected to the agita-

tor is a tachometer **13** adapted to measure the revolutions per minute of the agitator.

The apparatus thus arranged for detecting and monitoring the degree of delignification of the pulp according to the invention may be operated with the following particulars:

Digester:	Kamyr digester (350 T/D)
Pulp:	Unbleached sulfate pulp (LUKP)
Cooking value:	41.1 to 63.6 (TAPPI Standard T236)
Pulp consistency:	Approx. 10%
Pulp flow:	111 to 210 m³/min.
Agitator load current:	43.0 to 75.0 amperes
Agitator revolution:	3.11 to 4.26 r.p.m.
Pressure detector:	Diaphragm type transducer
Agitator load current meter:	Thermal converter
Agitator tachometer:	Rotary generator
Pressure drop section:	SGP elbow 3 meters long, 150A in diameter and 1.5R in curvature.

The results of measuring the degrees of delignification under the foregoing conditions are tabulated below in comparison with the corresponding values obtained by conventional chemical process (potassium permanganate titration). These are also graphically shown in FIGS. **4** and **5**.

TABLE 1

Test No.	K	P (%)	S (r.p.m.)	A (amp.)	F(m³/h.)	K'
1	60.6	17.4	4.20	70.0	197.0	59.5
2	59.1	19.2	4.20	71.0	177.0	59.3
3	50.9	28.2	4.26	58.0	171.0	56.2
4	54.5	25.6	4.22	68.0	160.0	56.7
5	47.0	34.8	4.26	59.0	145.0	45.3
6	50.7	28.1	4.26	61.0	146.0	54.2
7	54.7	27.1	4.19	73.0	147.0	54.1
8	53.6	21.8	3.63	66.0	146.0	51.3
9	50.2	26.1	3.64	61.0	146.0	50.4
10	50.7	24.0	3.65	57.0	161.0	51.4
11	49.5	19.7	3.71	42.0	189.0	49.7
12	60.8	10.6	3.60	69.0	173.0	61.4
13	49.8	26.8	3.66	54.0	188.0	45.0
14	57.6	11.8	3.11	60.0	198.0	57.5
15	54.5	15.5	3.12	56.0	192.0	54.0
16	55.2	15.9	3.12	58.0	197.0	53.9
17	49.7	21.3	3.15	48.0	196.0	49.5
18	55.5	18.7	3.14	64.0	190.0	52.7
19	54.2	20.3	3.14	64.0	179.0	55.7
20	53.0	20.2	3.72	56.0	178.0	59.5
21	59.1	10.6	3.70	61.0	184.0	55.5
22	52.3	21.8	3.68	64.0	129.0	50.7
23	55.6	17.5	3.66	62.0	172.0	55.7
24	56.9	18.1	4.19	63.0	174.0	53.3
25	57.3	15.2	4.20	59.0	179.0	54.6
26	52.9	154 27.5	4.18	63.0	178.0	50.0
27	54.4	19.7	4.22	55.0	185.0	52.7
28	52.0	22.1	4.24	52.0	176.0	50.3
29	47.3	32.4	4.24	51.0	180.0	51.0
30	48.3	27.2	3.62	51.0	181.0	47.0
31	52.5	26.1	3.58	63.0	183.0	51.0
32	59.7	12.6	3.56	66.0	190.0	56.6
33	51.0	21.0	3.56	66.0	190.0	51.1
34	54.9	18.5	3.58	59.0	189.0	53.2
35	55.9	16.2	3.60	58.0	194.0	62.2
36	48.0	25.9	3.64	47.0	186.0	41.1
37	58.3	18.2	4.16	67.0	179.0	51.7
38	52.4	22.2	4.21	54.0	173.0	53.8
39	45.5	40.5	4.19	58.0	175.0	43.4
40	51.1	23.8	4.22	52.0	173.0	50.3
41	48.2	27.9	4.23	49.0	170.0	40.6
42	46.2	37.4	4.20	56.0	174.0	42.5
43	47.7	22.9	3.76	41.0	186.0	47.4
44	56.2	17.4	3.67	62.0	183.0	55.1
45	52.8	21.2	3.70	56.0	184.0	55.5
46	59.1	22.5	3.73	49.0	183.0	52.7
47	58.0	16.4	4.30	62.0	182.0	55.5
48	53.6	14.8	3.11	62.0	130.0	55.8
49	48.3	20.0	3.13	55.0	111.0	47.9
50	40.5	32.2	3.16	46.0	118.0	42.7
51	60.0	9.3	3.63	71.0	131.0	59.9
52	57.0	11.9	3.65	62.0	149.0	58.4
53	55.6	12.4	3.66	58.0	149.0	56.0
54	54.8	16.5	4.20	52.0	185.0	54.0
55	55.5	17.0	4.18	55.0	185.0	55.1
56	60.3	17.1	4.01	73.0	179.0	64.5
57	57.1	16.0	4.07	62.0	170.0	57.2
58	57.6	20.0	4.24	67.0	178.0	59.9
59	50.9	29.4	4.19	57.0	192.0	51.9
60	57.8	21.1	4.14	68.0	191.0	63.6
61	57.7	20.5	4.14	68.0	182.0	59.9
62	55.0	18.1	3.68	59.0	182.0	54.1
63	51.0	25.3	3.70	53.0	203.0	55.5
64	54.1	22.3	3.65	60.0	197.0	55.5
65	55.7	18.7	3.65	60.0	197.0	53.8
66	57.9	15.0	3.12	66.0	195.0	58.8
67	52.2	22.0	3.16	57.0	196.0	52.8
68	54.8	17.4	3.16	58.0	202.0	51.1
69	44.6	30.0	3.22	43.0	198.0	49.2
70	49.6	26.0	3.18	54.0	197.0	48.5
71	49.1	25.0	3.19	51.0	197.0	50.4
72	52.5	18.3	3.18	52.0	199.0	51.7
73	64.4	10.3	3.66	75.0	204.0	69.9
74	56.1	14.5	3.69	53.0	210.0	55.6
75	53.0	18.3	3.71	48.0	210.0	55.2
76	54.9	18.6	3.69	55.0	210.0	55.0
77	61.0	12.0	3.63	67.0	201.0	63.1

Note:-

K ... Degree of delignification obtained according to the invention

K' ... Degree of delignification obtained according to conventional chemical sampling method

P ... Pressure drop

S ... Revolutions per minute of agitator

A ... Load current of agitator

F ... Flow of cooked pulp

It will be understood that the degrees of delignification K appearing in the above table were obtained by Formula 3 wherein the regression coefficients K_0, K_1, K_2, K_3, and K_4 had been previously determined to be 28, −0.45, 0.048, 0.31 and 2.2, respectively, according to the rule of multiple regression as applied to the data K', P, S, A and F *shown in Table 1. The delignification values* K obtained according to Formula 3 are graphically shown in FIG. **5** as plotted against those obtained by the conventional chemical analysis, while FIG. **4** shows the case where the values K obtained according to Formula 1 are compared with the corresponding values resulting from the conventional process. The coefficients K_0 and K_1 in Formula 1 are 75 and −1.0, respectively, as having previously been sought from the multiple regression as applied to the data of K' and P alone.

The invention may be most advantageously applied to a computer of a conventional type whereby decisions can be made more rapidly to correct for charges, for instance, in the pressure of the flowing pulp past the digester.

Having thus described the invention, it will be understood that the invention is not to be limited to the precise arrangement of apparatus illustrated, but many modifications may be made therein without departing from the scope of the appended claims.

What is claimed is:

1. In a pulping operation having a continuous type digester wherein the pulp is cooked and delignified, the invention comprising a process of continuously detecting the degree of delignification of said pulp in said digester comprising conducting cooked flowing pulp from a digester to a blow tank unit, directing said flowing pulp through a flow control valve to a flow pipe and thence to the overhead of an accumulator tank, measuring the pressure drop in a length of said flow pipe of said flowing pulp downstream of said digester between said blow tank unit and the overhead of said accumulator tank, and computing values from said measurement to determine the degree of delignification of the pulp and using said values received from said measurement to control the conditions of delignification in said digester.

2. The process as claimed in claim **1** and further including modifying said values received by detecting load current and number of revolutions of an agitator located within said digester to determine the consistency of the pulp flowing out of said digester and using said consistency in said computing step.

3. The process as claimed in claim 2 and further including modifying said values received by detecting the pulp flow across the flow pipe of the digester for the cooked pulp ejected therefrom and using said pulp flow in said computing step.

4. In pulping operations at a pulp mill equipped with a continuous-type digester wherein the pulp is cooked and delignified, the process of continuously detecting the degree of delignification of the pulp being cooked in the digester which comprises measuring the pressure drop of the cooked pulp withdrawn from and flowing downstream of the digester between said blow tank unit and the overhead of said accumulator tank, and computing the degree of delignification of said pulp in accordance with the equation of $K = K_o + K_1P$ wherein K is a dependent variable standing for the degree of delignification and P is an independent variable for said pressure drop and K_o and K_1 are multiple regression coefficients having values 28 and −0.45 respectively.

5. In pulping operations at a pulp mill equipped with a continuous-type digester wherein the pulp is cooked and delignified, the process of continuously detecting the degree of delignification of the pulp being cooked in the digester which comprises measuring the load current of the digester agitator, measuring the number of revolutions of said agitator, measuring the pressure drop and flow of the cooked pulp withdrawn from and flowing downstream of the digester between said blow tank unit and the overhead of said accumulator tank, and computing the degree of delignification of said pulp in accordance with the equation $K = K_o + K_1P + K_2F + K_3A + K_4S$ wherein K is the degree of delignification obtained according to the invention, P is the pressure drop, S is revolutions per minute of the agitator, A is the load current of the agitator and F is the flow of cooked pulp and K_o, K_1, K_2, K_3 and K_4 are multiple regression coefficients having values 28, −0.45, 0.048, 0.31 and 2.2 respectively.

* * * * *