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UTILIZING TWO TEMPERATURE ZONES
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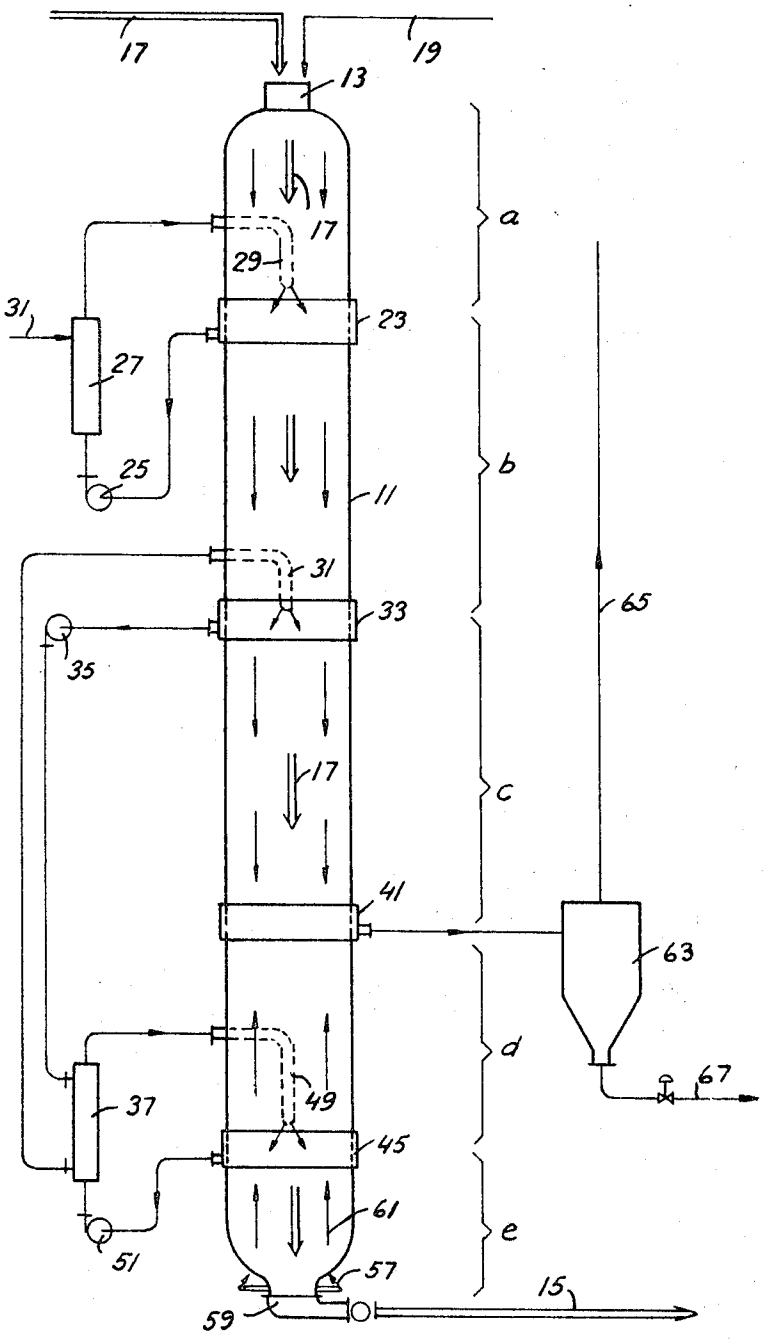

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METHOD FOR CONTINUOUS CELLULOSE DIGESTION UTILIZING TWO TEMPERATURE ZONES

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ABSTRACT OF THE DISCLOSURE

By performing the digestion in two stages using the same digesting liquor but different temperatures in these stages, the digesting temperature of the latter stage is reduced in comparison to that of the former. In the first stage, the high temperature stage, the fibrous material is in a condition thoroughly impregnated with digesting liquor and the reaction starts at once in full force. However, the diffusion of digesting liquor into the interior of the fibrous material cannot follow step. Consequently, in the interior of the fibrous material the content of digesting liquor is depleted and the content of dissolved substances increases considerably more rapidly than in the surface layer of the chip particles. In the second stage, the lower temperature stage, the digesting reaction takes place less rapidly and there the diffusion has comparatively more time to be effective. Consequently, the concentrations of digesting liquor and dissolved substances are better equalized over the surface layers and the interior of the fibrous material with the result that the material is more uniformly digested.

The present invention relates to a method and apparatus for continuously digesting cellulosic material. More particularly, the invention relates to certain improvements in cellulose digestion wherein cellulosic fibrous material is charged continuously in known manner into one end of a longitudinal cylindrical digester, fed together with a digesting liquid, such as sulphate liquor, in the longitudinal direction of the digester through a digesting zone, and possibly a washing zone, and then discharged at the opposite end of the digester.

The invention is based upon the fact that at certain moderate temperatures, penetration of digesting liquor into the interior of the fibrous material due to diffusion, etc., is relatively rapid in comparison to the rate of the digesting reaction whereas, at higher temperatures, the digesting reaction is much more rapid in comparison to penetration of the digesting liquor with the result that the digestion or chemical attack is concentrated upon the surface layers of the fibrous material. The latter is disadvantageous because it may cause overdigestion to give an unevenly digested pulp and a decrease in the yield of cellulose.

The principal object of the present invention is to provide a digestion process and apparatus of the type indicated which make it possible to eliminate the abovementioned disadvantages while at the same time using a temperature sufficiently high to effect rapid digestion. Other objects will also be hereinafter apparent.

The objects of the invention are realized by preforming the digestion in two stages using the same digesting liquor but different temperatures in these stages, the digesting temperature of the latter stage being reduced in comparison to that of the former. In the first stage, the high temperature stage, the fibrous material is in a condition thoroughly impregnated with digesting liquor and the reaction starts at once in full force. However, the diffusion of digesting liquor into the interior of the fibrous material cannot follow step. Consequently in the interior of the fibrous material, the content of digesting liquor is depleted and the content of dissolved substances increases considerably more rapidly than in the surface layer of the chip particles. In the second stage, the lower temperature stage, the digesting reaction takes place less rapidly and there the diffusion has comparatively more time to be effective. Consequently, the concentrations of digesting liquor and dissolved substances are better equalized over the surface layers and the interior of the fibrous material with the result that the material is more uniformly digested.

The invention also relates to a continuous cellulose digester adapted for carrying out the two-temperature digestion referred to above. An essential feature of this apparatus is the provision of cooling means in a circulation conduit or system located externally of the digester and connecting appropriate separating means, e.g. a sieve located in the digester shell, for separating digesting liquor from fibrous material, with an inlet for digesting liquor.

The invention is more fully described below in conjunction with the accompanying diagrammatic drawing wherein the numeral **11** represents an upright cylindrical digester of an essentially uniform cross-sectional area and a length of the order of 10 times the diameter. Provided at the upper end of the digester are charging devices **13**, the detailed construction of which is not described or necessary because they are known from earlier patents. By said charging means a comminuted cellulosic fibrous material, such as wood chips, is charged into the digester fully continuously or as small successive batches. The material moves vertically downwards through the digester and is discharged at the lower end thereof into a conduit **15** by means of discharging devices which are also known and therefore not shown. The direction of motion of material is indicated by double arrows **17**. During its passage through the digester, the fibrous material is subjected to various treatments which are connected each to a separate zone *a*, *b*, *c*, *d* and *e*, respectively.

In the first, comparatively short zone *a*, impregnation of the chips or other fibrous material takes place with the digesting liquor charged together with the chips, as indicated by the arrow **19**. For purposes of illustration, it is assumed that the digesting liquor consists of sulphate liquor comprising 110 grams active alkali (counted as Na_2O) per liter. During the time period of 30 to 60 minutes required for the fibrous material to pass through the zone *a*, the alkali penetrates into the interior of the chip particles mainly by diffusion, with the result that the concentration of the chemicals becomes practically uniform throughout. As the fibrous material, thus thoroughly impregnated with digesting liquor moves downward through the digester, it arrives opposite to a sieve girdle **23** inserted in the digester shell. At this point, heat is applied by withdrawing digesting liquor through the sieve girdle **23** by means of a pump **25**, the withdrawn liquor being circulated through an exterior conduit including a heating device **27**. The conduit is connected to a tube **29** positioned within the digester and extending along the axis thereof with an orifice located approximately at the level of the sieve girdle **23**. The withdrawn liquor heated in the heating device **27** by means of steam **31** supplied thereto, is discharged from the orifice of the tube **29** radially outwards and causes the chips column to assume digesting temperature. As an alternative, the heating may take place by injection of the steam into the circulation conduit or directly into the digester at essentially the same point in the digester.

The first stage of delignifying digestion takes place in the zone *b*. Due to the heating just described, the temperature of chips and liquor is raised from about 105–110° C. to 175–185° C., preferably approximately 181° C. This temperature is maintained during the time interval

of 15–45 minutes, preferably about 30 minutes, required for the chips column to pass through the zone *b*. Of course, the temperature may be affected to some extent by heat losses to the surrounding and in the other direction by the reaction heat. At the high temperature, the digesting liquor is highly active for the dissolution of lignin out of the fibrous material. Spent liquor within the fibrous material is only partly replaced by fresh liquor due to the fact that the diffusion rate in said temperature range is not sufficiently high in comparison to the reaction rate. Therefore, at the end of zone *b*, the strength of the liquor within the chip particles may have dropped to 16 grams Na_2O per liter, whereas the liquor contained in the spaces between the chip particles may contain 55 grams Na_2O per liter. In case the digestion were to continue at said high temperature, the reaction would be too heavily concentrated upon the surface layers with the result that the interior of the chip particles would be insufficiently digested or the surface layers would be overdigested.

Therefore, according to the invention, means are provided to effect a temperature drop of the order of 10 to 20° C. at this point in the digestion. To this end, digesting liquor of a lower temperature than the abovementioned temperature of zone *b*, is charged into the digester and is spread over its cross-sectional area. This digesting liquor of lower temperature is of the same chemical content as the liquor of zone *b* and preferably consists of the digesting liquor that has already been used in the first stage and that is extracted, cooled and returned to the digester.

The digesting liquor of lower temperature is introduced through an interior conduit **31** extending along the axis of the digester and having an orifice located at the level of a second sieve girdle **33** inserted in the digester shell, or somewhat above said level. Connected to the conduit **31** and the sieve girdle **33** is an exterior circulation conduit in which are inserted a pump **35** and a heat exchanger **37**, the latter serving as a cooler for the circulating digesting liquor. The cooled digesting liquor is spread from the orifice of the tube **31** radially outwards while displacing the warmer digesting liquid towards and out through the sieve girdle **33**, so that the temperature of the entire cross-section of the chips column is lowered when it passes this level. The cooling effect is such that the temperature is lowered to 155 to 170° C., preferably to about 160° C. This lower temperature is substantially maintained during the time period of 60 to 120 minutes, preferably about 90 minutes, required for the chips column to pass through the zone *c*, the low temperature digesting zone. In this lower temperature range, the diffusion rate is somewhat reduced as compared to the diffusion rate at the high-temperature range, but the digestion reaction rate is even more greatly reduced. As a result, a better balance is obtained between reaction and diffusion, so that fresh liquor to the required extent can penetrate into the interior of the fibrous material and react there to give a thorough and uniform digestion.

In the zone *c*, the digesting liquor moves cocurrently to the fibrous material and might be discharged together with digested material through the outlet **15** at the lower end of the digester immediately after the completed digestion. However, according to the invention, it is preferred that the cellulosic pulp be prewashed in the digester and this particular embodiment is shown in the drawing. Thus, as shown, the spent digesting liquor is withdrawn through a third sieve gridle **41** located at a considerable distance from the lower end of the digester, and the part of the digester situated below the sieve girdle **41** is used for washing the completely digested pulp. The washing liquid used may consist either of water or of filtrate emanating from a following wash filter and containing residues of digesting liquor. This washing liquid is supplied at a comparatively low temperature through nozzles **57** distributed around the pulp outlet **59** of the digester. A certain portion of this liquid which performs a final cooling of the pulp to approximately 90 to 95° C. and also a dilution thereof, accompanies the same out through the outlet **59**, whereas another portion is forced upwards through the pulp column countercurrently to the direction of its feed, as indicated by the arrows **61**.

Between the sieve girdle **41**, through which the digesting liquor is driven out by the encountering wash liquid, and the lower end of the digester, there is inserted a fourth sieve girdle **45** which divides the lower end part of the digester provided for washing, into two zones *d* and *e*. As mentioned, in zone *e*, counter-current wash by means of cold washing liquid is performed. This washing liquid is extracted through the sieve girdle **45** by a pump **51** and is circulated in an exterior circulation conduit connected to an interior conduit **49** which extends axially in the digester and has an orifice located approximately at the level of the sieve girdle **45**. Inserted in the circulation conduit is the heat exchanger **37** wherein the wash liquid is heated by heat-exchange with the digesting liquor which is cooled in the above-described manner. The wash liquid supplied through the conduit **49** is spread radially outwards and displaces the colder wash liquid towards and out through the sieve girdle **45**. In this manner, the temperature of the wash liquid is raised so that the average temperature of the high temperature wash zone *d* is maintained at about 150° C. The wash liquid together with liquor washed out of the pulp moves upwardly and departs through the sieve girdle **41** together with undiluted spent digesting liquor coming from above. From the sieve **41**, the mixture flows to a container **63**, which may be a cyclone separator in which a pressure is maintained which is considerably reduced in comparison to the pressure of the digester. From container **63**, released steam and gas are led off through the conduit **65** for recovery of heat content while the spent liquor is carried through the conduit **67** to an appropriate chemical recovery plant.

It will be appreciated that the above described embodiment of the invention is given only as an example and may be modified in various respects. Thus, for example, different digesting liquors may be used which require other temperatures and/or temperature differentials for the two digesting stages than those mentioned above. Furthermore, the heat obtained by cooling the digesting liquor may be used for some other purpose than the above mentioned, e.g., for a first heating of the liquor supplied at the top of the digester. If desired, the cooling may also be obtained by supplying cool fresh liquor or possibly cool spent liquor to the circulation loop having its inlet at **31**. Finally, the invention may also be used in the case where impregnation of the fibrous material with digesting liquor takes place in a separate vessel outside the digester.

The scope of the invention is defined in the following claims wherein.

What is claimed is:

1. In a method for digesting cellulose wherein cellulosic fibrous material is supplied continuously to one end of a longitudinal digester, fed together with a digesting liquor in the longitudinal direction of the digester through a digesting zone, and discharged at the other end of the digester, the improvement which comprises carrying out the digestion in two stages including: diffusing the digesting liquor at least part-way into the cellulosic fibrous material and at least partly digesting the cellulosic fibrous material at a temperature maintained within the range of 175° C.—185° C. in longitudinally upstream part of the digesting zone as the first stage; within the remainder of said zone, maintaining the digesting temperature within the range of 155°—170° C to decrease the rate of digestion of the cellulosic fibrous material relative to the rate of diffusion of the digesting liquor into the cellulosic fibrous material as the second stage.

2. The method of claim **1** including: introducing into the digesting zone intermediate the first and second stages

digesting liquor having lower temperature than the digesting temperature of the first stage and spreading out the digesting liquor over the cross section of the digesting zone for providing reduction of the digesting temperature of the second stage respecting the digesting temperature of the first stage.

3. The method of claim 1 including removing the digesting liquor used in the first stage from the digester; cooling the removed digesting liquor; and returning the cooled digesting liquor to the digester as digesting liquor for said second stage.

4. The method of claim 3 comprising: exchanging heat between said removed digesting liquor and a cooler washing liquid, thereby heating said washing liquid and providing said cooling of the removed digesting liquor; and washing the digested cellulosic fibrous material in the digester with said heated washing liquid.

5. The method of claim 1 further comprising: washing the cellulosic fibrous material within said digester downstream of said second stage.

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