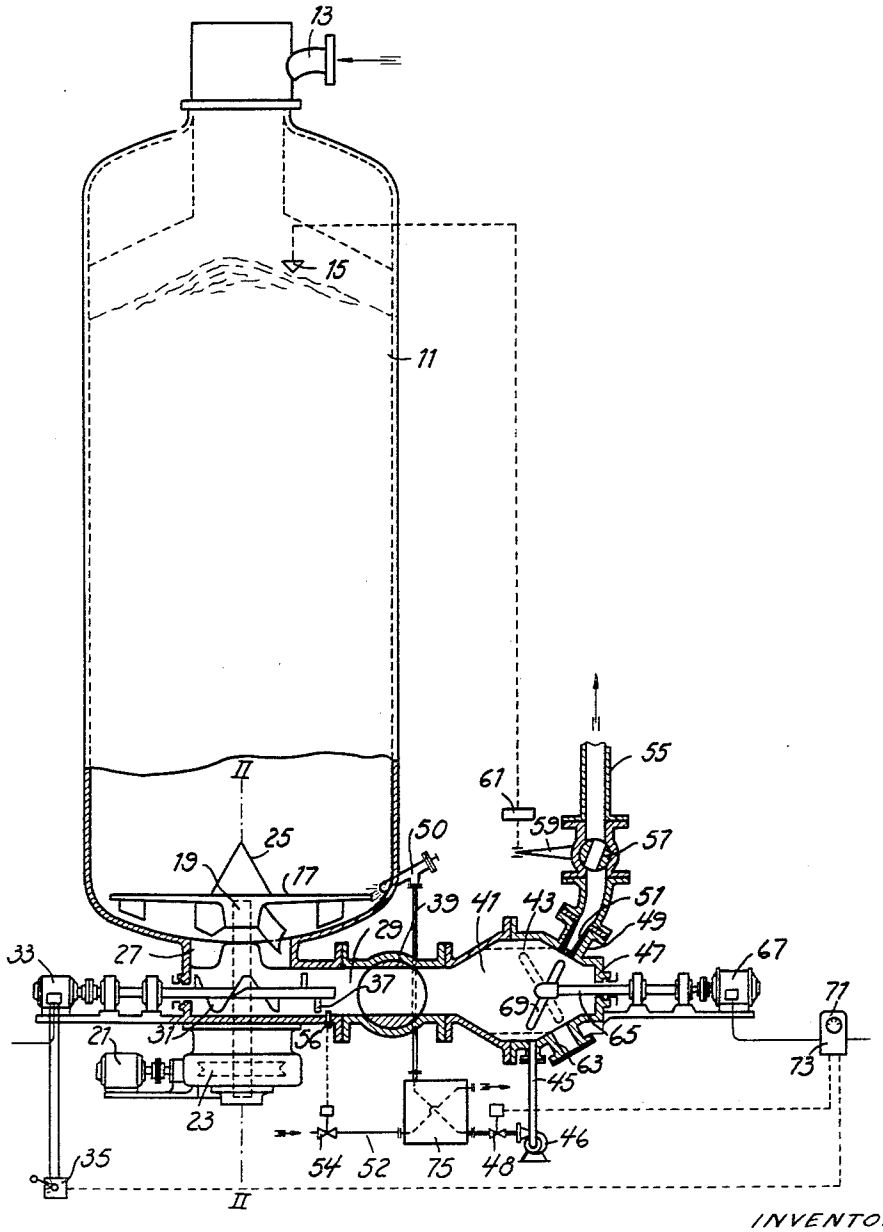
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DIGESTION APPARATUS AND METHOD

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DIGESTION APPARATUS AND METHOD

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The invention relates to the digestion of fibrous materials and particularly to apparatus and method for the continuous digestion of cellulose.

Apparatus has heretofore been proposed to transfer digested pulp from the pulp outlet of a digester to a device for separating off used digesting liquor from the fiber material of the pulp wherein there is substantially no pressure difference between the digester and said device and wherein means are provided for returning used digesting liquor to the digester in the vicinity of its outlet in order to dilute the pulp and facilitate its discharge. In such apparatus, the return digesting liquor has been delivered directly back to the digester at high temperature and therefore the pulp discharging from the digester is practically at cooking temperature. This may be disadvantageous for the reason that at the temperature prevailing in the digester, the pulp cannot always withstand the mechanical stresses involved in its discharge from the digester without deteriorating or having its quality impaired. It is possible to avoid such disadvantages by returning to the digester adjacent its outlet, relatively cool digesting liquor which has been recovered from the discharged pulp after the pressure has been relieved; but then it is necessary to use an expensive high pressure pump for pumping the digesting liquor at its reduced pressure, to the digester at a much higher pressure, thus increasing the cost of operation.

Accordingly, it is an important objet of the invention to overcome the foregoing and other disadvantages by providing a novel apparatus and method of the character referred to for separating pulp and used liquor in a separating device operating under substantially the same pressure as the digester, and also for returning used digesting liquor from the separating device to the digester adjacent its pulp outlet and at a reduced temperature whereby the pulp will be diluted and its temperature decreased to a safe value. In one embodiment of the apparatus of the invention, this reduced temperature is effected by providing a cooling means, preferably constituting a heat exchanger, in heat transfer relation with a return conduit for the used digesting liquor separated off in the aforesaid device. Thus, the desired discharge circulation can be maintained by means of a relatively inexpensive, low pressure pump. And, since it has been found that the aforementioned deterioration in the quality of the pulp can be satisfactorily avoided by a comparatively small temperature drop at the discharge end of the digester, for example, a drop of approximately only 10 or 20 degrees centigrade, the advantage realized by separating off the used digesting liquor while at a high temperature and still highly fluent can be conveniently retained and yet not result in large demands being imposed on the aforesaid cooling means in effecting the desired temperature drop of the returning liquor.

It is a further object of the invention that the cooling effect of the aforesaid cooling means be adjustable. Although this may be done manually, preferably it is achieved by providing a controller automatically operative in response to the temperature of the diluted pulp adjacent to or downstream from the digester outlet.

A still further object resides in the provision of means in apparatus of the type referred to, for controlling the amount of digesting liquor returned to the digester. Although this control can also be effected manually, preferably it is performed by a controller automatically operative in response to a condition of the digested pulp in or close to the separating device.

Other objects and advantages of the invention will become apparent from the following description and drawings in which a continuous cellulose digestion apparatus, embodying the invention, is shown in a side elevational and partially sectioned view.

In the drawing, **11** designates an upright cylindrical digester, the upper end of which is fed by conventional means (not shown) with the usual mixture of wood chips, straw or similar fibrous material and a suitable digesting liquor, such as sodium lye. The mixture is supplied through a conduit **13** and drops into the digester, so that a level is formed therein which is detected by level feeling means **15**. The material, which may be preheated if desired, is heated to digesting temperature either indirectly by circulating the liquor and heating the same outside of the digester in a known manner by suitable means (not shown), or by means of steam directly supplied to the digester. In the upper end of the digester a steam pressure corresponding to the temperature required for the digestion is maintained in any appropriate manner. The digested fiber material is discharged at the bottom of the digester by means of devices to be described in detail hereinbelow, at an average rate substantially equal to the supply rate, so that the level **15** is held essentially constant. The material slowly sinks through the digester and is completely digested when reaching the bottom thereof. As an example of the conditions existing in the digester, the temperature may be around 170–200° C. and the pressure may be around 8–10 atmospheres gauge.

The discharging device at the botom of the digester comprises, in the illustrative embodiment shown, a rotary scraper **17** appropriately attached to and driven by a vertical shaft **19** centrally located in the digester. Shaft **19** passes through the digester bottom and is sealed thereto by suitable stuffing boxes or the like, as indicated in the drawing, being driven by the motor **21** in any suitable manner as by the worm gear **23** driven by a worm (not shown) associated with the motor shaft. The scraper **17** preferably extends substantially over the whole cross-sectional area of the digester and scrapes off the column of material underneath, so that the column of material will descend uniformly. A conical member **25** may be centrally located on the scraper, as shown, and has a braking action upon the material at the center. By means of the scraper **17** the material is fed into an outlet **27** arranged in the digester bottom near its center and at the side of the shaft **19**. Connected to the outlet is a horizontal passage **29**, which below the outlet **27** is shaped as an open flute and the rest of which is tubular. Suitably arranged in the passage **29** is a feeding screw **31**, connected to be driven by a motor **33**, the speed of which preferably is controlled by a device **35** to be referred to again hereinbelow.

The free or right hand end of the shaft of the feeding screw **31** may be provided with pins **37** adapted to break up the material fed out of the screw thread. Inserted in the passage **29** after the feeding screw is a valve. This valve may be of the rotary type having a movable body **39** shaped like a ball having a through cylindrical bore preferably of the same diameter as the tubular passage adjoining it on both sides. In this manner, when the valve is open, its bore is flush with the passage and the latter is thereby completely unrestricted.

Chamber 41 is connected to passage 29 downstream of valve body 39, as shown, and preferably includes an enlarged central portion concentric to and arranged as an axial extension of the passage 29. Inserted in the widened part is a cylindrical sieve 43, through which digesting liquor can be separated-off. The end of chamber 41 remote from the passage 29 may be closed by a planar wall 47.

A conduit 49, having a throttling-out device therein connects into chamber 41. Said device preferably includes a fixed throttle point in series with a variable throttle point. In the illustrative embodiment, the fixed throttle point is formed by a narrow nozzle 51 of wear-resistant material, and the variable throttle point is defined by a rotatable valve 57 inserted in the conduit 55. The rotatable valve body of the valve 57 can be turned by a lever 59 attached thereto and driven by suitable means such as servo motor 61. The latter motor preferably is controlled by the pulp level feeling means 15 in the digester in such a manner that when the pulp level drops, the lever 59 is raised, whereby the effective cross-sectional area or opening of the valve 57 is decreased to decrease flow therethrough. On the other hand, when the pulp level rises, the valve is turned toward its fully opened position. The conduit 55 may be connected to an appropriate blow tank (not shown) which is under a considerably reduced pressure.

Opposite to the connecting sleeve 49, the wall of chamber 41 may have a similar sleeve 63 connected thereto as shown, and to which a further throttling-out device can be attached, when required. Normally the open lower end of sleeve 63 will be covered or closed by a removable plate.

Preferably arranged in the chamber 41 is a stirrer including a shaft 65 passing through or journalled and sealed in the wall 47, a driving motor 67 therefor, and a number of pins 69 attached to the inner end of the shaft. Alternatively, said pins may be given the shape of blades, scrapers or similar suitable structure. Also, some of the pins may be so placed that they pass close to the nozzle 51 whereby they will function to clean the same in the event larger particles tend to stick thereto. Other stirring means (not shown) may be arranged to clean the sieve 43, if desired. The stirrer 65, 67, 69 forms a pulp consistency feeling means including an instrument 71 connected into the electric line supplying the motor 67, as shown, and this instrument is adapted to measure the force required to turn the stirrer, thereby giving an indication of the consistency of the pulp in the chamber 41.

The present invention contemplates that the space between the sieve 43 and the wall of the chamber 41 be in communication with the digester 11 adjacent outlet 27 for the return flow of used digesting liquor from chamber 41 to the digester, with means being provided to desirably reduce the temperature of this returning liquor for purposes indicated heretofore. Referring now to the illustrative embodiment, a return conduit 45 connects into the space between sieve 43 and the wall of chamber 41, as shown, with a low pressure pump 46 and control valve 48 arranged in series therein on one side of or upstream from a cooling means 75. The return conduit 45 then leads to one or more spray nozzles 50 inserted through the digester wall in the vicinity of scraper 17, as shown.

The cooling means 75 is shown in the form of a fluid-to-fluid heat exchanger, through which return conduit 45 and cooling medium conduit 52 extend. As indicated, this heat exchanger is of the closed type wherein the fluids passing through conduits 45, 52 do not come in contact with each other. Any suitable cooling medium may be used, for example water, and a control valve 54 is arranged in line 52, as shown, to regulate the flow of cooling medium therethrough, thereby varying the cooling effect of the heat exchanger. The position of valve 54 preferably is automatically controlled by a temperature responsive device 56 operatively connected thereto and

positioned to be influenced by the temperature of the pulp either at or downstream from the digester outlet 27 and after the pulp has been diluted by and mixed with the relatively cool digesting liquor supplied by nozzle or nozzles 50. As shown, this temperature responsive means may be positioned in the wall of passage 29 adjacent digester outlet 27. However, other positions for this means will be evident.

The instrument 71 for indicating the consistency of the pulp in chamber 41 preferably forms part of an automatic controller 73 operatively connected to the device 35 and valve 48 for respectively and appropriately varying the speed of the motor 33 and the position of valve 48 in response to variation in the consistency of the pulp in chamber 41 in order to maintain the pulp consistency constant. As is evident, if the pulp gets too thick controller 73 will operate valve 48 and motor 33 so that more liquor will be returned through line 45 with the angular velocity of screw 31 decreased; and if the pulp gets too thin the opposite will take place.

A description of the operation of the apparatus follows: Pulp diluted with returning digesting liquor supplied through the spray nozzle or nozzles 50 is fed by scraper 17 through the outlet 27, from which it immediately enters the thread of the feeding screw 31 and is forced thereby through the passage 29 and into the chamber 41 through the opened valve 39. In chamber 41, a part of the used digesting liquor is separated-off and passes through sieve 43, while the pulp consisting of the solid fiber material and the main part of the digesting liquor is discharged through the nozzle 51. Within the chamber 41 the pressure is very nearly equal to the pressure of the digester, i.e. the pressure is of the order of 8 to 10 atmospheres and therefore a great pressure drop takes place when the pulp passes the nozzles 51.

The digesting liquor separated-off by the sieve 43 is pumped by the pump 46 through the heat exchanger 75 to the spray nozzles 50 and thus is returned to the digester in the circuit of circulating liquor formed at the discharge end of the digester. The returned liquor having been cooled in the heat exchanger 75 operates to lower the temperature of the pulp discharged through the digester outlet 27, so that even if the pulp at that point still contains some aggressive alkali, the reaction rate is so slow that the fibers will not be noticeably damaged by the mechanical action of the scrapers and the feeding screw. It has been found that lowering of the pulp temperature say from about 170° C. to about 160° is fully sufficient for eliminating this danger. And if the digested pulp at the digester outlet is diluted to twice its volume, the returned liquor need be cooled by the heat exchanger 75 only from say about 160° C. to about 150° C. Consequently, the heat exchanger 75 can conveniently and desirably have a comparatively small capacity and for the cooling, cold water or even luke-warm water or other suitable medium having a temperature of about 50 to 70° C. can be used.

The controlling device 73 varies the speed of the feeding screw 31 and the opening of the valve 48 in such a manner that an approximately constant consistency of the pulp in the chamber 41 is desirably maintained. The quantity of the returned liquor will also vary due to said control, which to a certain degree can also influence the cooling effect of the cooler. However, in such a case the control initiated by the means 56 will step in and automatically vary the quantity of cooling water passing through the heat exchanger in accordance with the digested pulp temperature.

The above-described embodiment can be modified in various respects without departing from the scope of the invention. For instance, sieves for separating-off digesting liquor may be arranged also in the wall of the passage 29, and said passage together with the feeding screw 31 can be designed to form a screw press for separating-off as much liquor from the pulp as possible. The inven-

tion can be applied also to other press or sieve devices of the kind operating under a pressure at least roughly equal to the digester pressure and in which, therefore, the liquor separated-off is obtained at a high temperature corresponding to pressure in the digester.

It will thus be seen that the objects of this invention have been fully and effectively carried out. It will be realized, however, that the embodiments described and illustrated for the purpose of disclosing the principles of the invention may be changed without departing from such principles. Therefore, this invention embraces all modification encompassed by the spirit and scope of the following claims.

I claim:

1. Apparatus for the continuous digestion of fibrous materials, such as cellulose, said apparatus comprising: a longitudinal digester having an inlet end and an outlet end, means for continuously discharging a mixture of pulp and digesting liquor through said outlet end; a device communicating with said outlet end and adapted to separate digesting liquor from pulp flowing from said digester, said device operating under substantially the same pressure as said digester; return conduit means establishing fluid communication between said device and said digester adjacent said outlet end and distant from said inlet end for return flow to said digester of digesting liquor separated off in said device; and cooling means disposed in heat transfer relation with said return conduit means to reduce the temperature of the digesting liquor being returned to said digester.

2. The apparatus defined in claim 1 wherein said cooling means is a heat exchanger having means for passing a cooling medium in heat transfer relation to the digesting liquor flowing in said return conduit means.

3. The apparatus as defined in claim 1 and further comprising: control means responsive to the temperature of the pulp adjacent said outlet and operative to regulate the cooling effect of said cooling means.

4. The apparatus as defined in claim 3 and further comprising: control means responsive to the consistency of the pulp after it has left the digester and operative to regulate the quantity of digesting liquor returned to said digester.

5. The apparatus defined in claim 1 and further comprising: control means responsive to the consistency of the pulp after it has left the digester and operative to regulate the quantity of digesting liquor returned to said digester.

6. In a continuous cellulose digester having: an inlet and an outlet; means under substantially the same pressure as said digester and located downstream from said outlet for separating digesting liquor from pulp; and a conduit connecting said means to said digester adjacent said outlet and distant from said inlet for return flow to said digester of digesting liquor separated off in said means; the improvement which comprises: cooling means disposed in heat transfer relation with said conduit for lowering the temperature of the returning digesting liquor to a value below the temperature in said outlet.

7. The structure defined in claim 6 wherein a further improvement comprises: control means responsive to the temperature of the pulp adjacent said outlet and operative to regulate the cooling effect of said cooling means.

8. The structure defined in claim 6 wherein a further improvement comprises: control means responsive to the consistency of the pulp after it has left the digester and operative to regulate the quantity of digesting liquor returned to said digester.

9. In the process of continuously digesting cellulose wherein digesting liquor and pulp are discharged from a point in a digesting chamber to a separating chamber wherein the digesting liquor is separated from the pulp at substantially the same pressure as that which exists in the digesting chamber, said process including the steps of: returning digesting liquor, separated off in said separating chamber, to the digesting chamber adjacent the discharge point and at substantially the same pressure as that which exists in the digesting chamber; and cooling the digesting liquor returned to the digesting chamber to a temperature below that which exists in the discharge point therein.

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