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PROCESS OF PRODUCING CELLULOSE FROM WOOD AND OTHER CELLULOSE CONTAINING MATERIAL AND APPARATUS THEREFOR

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Fig. 2

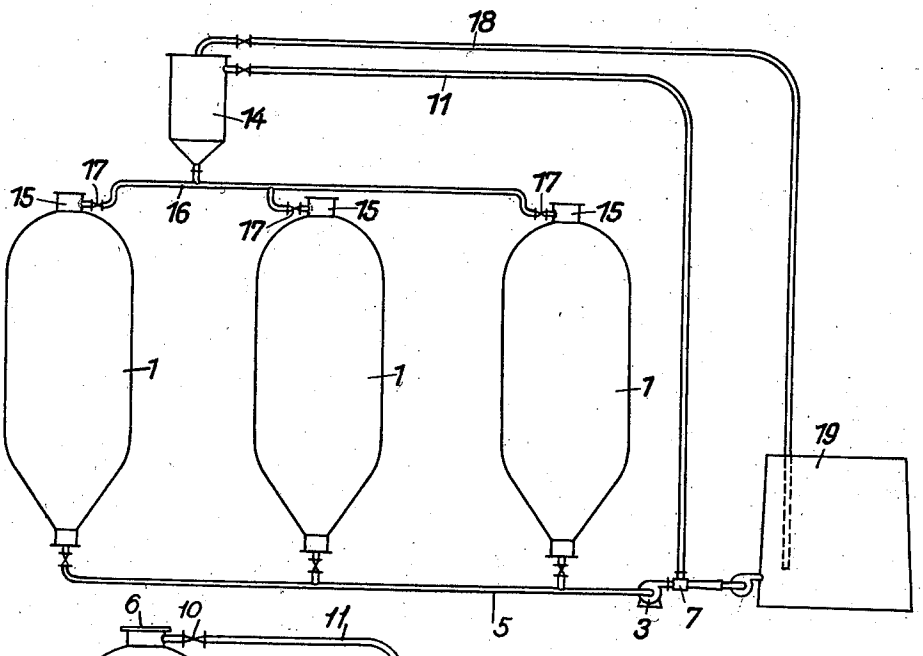
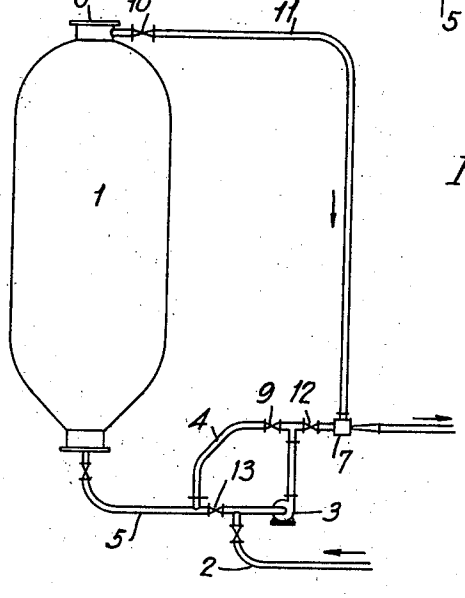


Fig. 1



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PROCESS OF PRODUCING CELLULOSE FROM WOOD AND OTHER CELLULOSE CONTAINING MATERIAL AND APPARATUS THEREFOR

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11 Claims. (Cl. 92—7)

This invention relates to a process for decomposing wood and other cellulose-containing fibrous material and an apparatus therefor.

It is well known that in the production of cellulose from wood or other cellulose-containing fibrous material, that a great variety of attempts have been made to improve the digestion process and the product resulting therefrom. In connection with these various proposals, very little consideration has been given thus far to rapid and uniform impregnation of the wood chips, or the like. In one proposal, an attempt was made to assist the penetration of the digestion liquor by cutting the wood into extremely small pieces, for instance, pieces having a length of about 25 to 40 millimeters, a width of 20 to 35 millimeters and a thickness from 4 to 6 millimeters were used. These small wood pieces were digested in the usual way and the liquor had to penetrate slowly from the edges of the chips. In connection with these tests, it was found that of the usual cooking time of about 12 to 15 hours, about 70% to 80% (9 or 10 hours) were required for the impregnation of the wood chips and the remaining time was required for the digestion of the wood into cellulose. When these prior procedures were carried into practice, the digestion liquor reached the middle of each wood chip at approximately the end of the cooking period. Thus, the cellulose fibers are digested on the outside of the chips and as impregnation proceeds towards the middle of the chip, the digestion progresses approximately proportionally to the speed of impregnation. The digested cellulose fibers, therefore, remain for many hours in the hot digestion liquor until the last cellulose fibers remaining in the inside of the wood chips have been decomposed. It has been established that the longer the retention of the digested cellulose fibers in hot liquor under pressure, the more fibers are attacked, weakened and their physical properties are changed. Various other attempts have been made to provide an improved process. Among these attempts may be mentioned the complete covering of wood to be digested with cold or hot liquor with vacuum or with pressure and draining the excess liquor and then cooking in the usual way. It has also been attempted to suck the air from the digester and the wood contained therein before introducing the digesting liquor into the digester. Then again, a procedure has been proposed which involves lixiviating the fibrous material in the digester and after increasing the cooking pressure by the addition of steam to draw off a part of the liquor for the purpose of decreasing pressure. The top valve of the digester sometimes was open in order to let out the air present at the top of the digester. The various proposals and attempts which have been made possessed disadvantages and shortcomings of one sort or another. As far as I am aware the art has not been provided with a process whereby uniform impregnation has been obtained and uniform cellulose has been produced.

I have discovered a process which avoids the disadvantages and shortcomings of the prior art and which provides the art with the process for effecting relatively uniform and rapid impregnation of the wood chips and the production of relatively uniform cellulose.

It is an object of the present invention to provide a process of digesting wood and other cellulose-containing fibrous material in an efficient, practical and economical manner.

It is another object of the invention to provide a process of digesting wood and the like in a shorter time and with the consumption of a smaller amount of steam and digesting liquor than was necessary heretofore.

It is also within the contemplation of the invention to provide an apparatus for carrying the improved process into practice on a commercial and industrial scale.

A further object of the invention is the provision of the process for the digestion of wood and other cellulose-containing fibrous material in which the impregnation of the individual wood chips is accomplished in a relatively rapid manner and the digestion of the cellulose fibers is effected in practically the same period of time to give improved and uniform results.

Other objects and advantages of the invention will become apparent from the following description taken in conjunction with the drawing in which:

Fig. 1 is an elevational view somewhat diagrammatic of an embodiment for carrying the present invention into practice; and

Fig. 2 is a modified embodiment of the apparatus shown in Fig. 1 to carry a modified procedure of the present invention into practice.

Generally speaking, the largest part of the volume within a pulp digester, or the like, is occupied by air and the smallest volume is occupied by the cellulose fibers proper. The air occupies the space between the wood chips and occupies the space between the fibers within the wood chips. Furthermore, the moisture in the wood chips occupies a volume in each chip and the space occupied by the air depends upon the moisture con-

tent of the wood. For instance, wood having a moisture content of about 20% consists of about 10% of actual wood pulp or cellulose fibers, about 20% of moisture and about 70% of air.

In carrying the present process into practice, the air which occupies a large volume within the wood chips (for instance about 70% in the illustrative example) must be withdrawn and replaced with digesting liquor which occupies the space of the withdrawn intra-cellular air. It is also necessary to withdraw the air occupying the space between the adjacent wood chips. When all of the foregoing air has been removed, I have found that impregnation proceeds with greater rapidity than heretofore known. With rapid impregnation, the digestion proceeds quicker and more uniformly than was possible with prior procedures. The amount of steam and of digesting liquor required for effecting the digestion of the wood chips or other cellulose-containing fibrous material has been found less than formerly required. Due to the fact that practically all of the fibers within each individual chip is cooked or digested at approximately the same time, practically no decomposition of cellulose fibers occurs due to the finished fibers remaining in the hot liquor. In other words, when carrying the present invention into practice, the impregnation of the wood is effected so completely and rapidly that it is possible to start almost immediately with the digesting temperature required for dissolving the lignin without endangering the resulting fibers.

Broadly stated, the invention contemplates filling a closable digester with fibrous material such as wood chips and then with digesting liquor such as sulfite liquor. After closing the digester completely, the digesting liquor is completely withdrawn and the air occupying the space between the adjacent chips and the intra-cellulose space is withdrawn with the creation of a vacuum in the digester. After the withdrawal of the digesting liquor and practically all of the air, the digesting liquor is introduced and the digestion is carried out to the desired extent. It has been found that in this process the liquor immediately penetrates into the interior of the deaerated and de-gassed wood chips when the digester is refilled. In this manner, practically an instantaneous impregnation of the wood chips and wood fibrous material with digesting liquor is accomplished.

According to the present invention, a digester may be used alone in conjunction with the digesting liquor to perform the function of a vacuum-producing pump. In other words, the shell of the digester may be compared with a cylinder of a pump and the digesting liquor which is withdrawn from the digester may be compared with the piston of a pump. It will readily be appreciated that the lowering of the level of liquor in the digester creates a vacuum and causes the escape of air and gas from the digester and the wood chips in a safe manner. The digestion process is thus accelerated. If desired, a further acceleration of the impregnation process may be effected by reintroducing the digesting liquor into the digester at higher temperatures, for example, temperatures in the zone of about 100° C. or so.

In carrying out the present process in practice, the cover on the top of the digester may be held open while the digesting liquor is reintroduced. In this manner, the reintroduced liquor acts as a piston and pushes air and gas from the digester. In some instances, it may be desirable to conduct the mixture of air and gas withdrawn from the top of the digester to a recovery system for absorption of gases, particularly sulfur dioxide.

In conducting the process, the top of the digester may be subjected to vacuum in order to facilitate the sucking off of the air and gas. For instance, an ejector or other appropriate vacuum-producing apparatus may be connected with the top part of the digester by means of a pipe or other suitable conduit to suck the air and gas therefrom. For instance, the liquor which is withdrawn from the bottom of the digester may be caused to flow through an ejector which is connected to the top of the digester. In this manner, you produce a double vacuum effect.

As a result of extensive tests, it has been demonstrated that a higher concentration of digesting liquor may be employed. When a higher concentration is used, it has been found that only a smaller quantity of digesting liquor is needed than in the case of conventional digesting processes. In this manner, a saving of digesting liquor is effected in addition to heat. It is believed that the relatively rapid impregnation and the uniform digestion of the fibers which are completely protected by the impregnating liquor makes this possible.

Experiments have shown that it is possible after the impregnation of the fibrous material to immediately start the cooking or digestion at about 100° C. or so. It is believed that this is possible because the impregnation is so complete that endangering the cellulose fibers does not occur. As the digestion of the fibrous material takes place in almost all parts of the wood chips at the same time, a real shortening of cooking or digesting may be effected. The process produces uniform cellulose with an extraordinary saving of cellulose fibers and with the use of a relatively small quantity of digesting liquor and with a relatively small consumption of heat.

For best results, it is essential that the digesting liquor is drained completely from the digester in order that practically every part of the fibrous material is exposed to a vacuum. The subsequent impregnation occurs uniformly throughout practically every part of the wood chips. In withdrawing the liquor from the closed digester it is preferred to effect the withdrawal in such a manner that the withdrawn liquor can run from the digester under the influence of its own weight. Under these conditions, an absorbing container or storage reservoir is used into which the withdrawn liquor is conducted. The storage tank is located at a point lower than the bottom of the digester. Of course, the withdrawal of liquor may be effected by the use of pumps or other improved apparatus.

Although a rather constant vacuum is produced in the digester by the withdrawal of liquor itself, means may be employed for controlling, regulating or equalizing the vacuum. These modifications and variations, of course, are to be considered within the purview and scope of the present invention, as those skilled in the art will readily understand.

Referring to Fig. 1, the reference character 1 designates a pulp digester or a container. An inlet line 2 is provided for conducting digesting liquor to the digester. A pump 3 is connected to pipe 2 and to the digester by means of a connecting pipe 4 and a pipe 5 leading to the bottom of the digester. At the top of the digester a cover 6 is provided. For effecting a vacuum in the top of the digester an ejector 7 is located

at a point where the liquor which is withdrawn from the digester 1 may pass through to create a vacuum. In the various lines valves 8, 9, 10, 12 and 13 are provided. A pipe line 11 connects the top of the digester with the ejector 7.

The operation of the foregoing apparatus is obvious to those skilled in the art. It will be sufficient to point out that digester 1 is charged with wood chips or other fibrous material and then is filled with digesting liquor such as sulfide liquor. In filling the digester, of course, valves 8 and 9 are opened so that liquor may pass from pipe 2 to pump 3 and thence to the digester 1 through pipes 4 and 5. After filling the digester, valves 8 and 9 are closed and valves 12 and 13 are opened as well as valve 10. The liquor withdrawn from digester 1 is passed through ejector 7 and is conducted to a storage tank (not shown). In emptying the digester, the liquor creates a vacuum and withdraws air and gas from between the wood chips and between the cells within the chips. In addition, the operation of ejector 7 effects a vacuum in pipe 11 and the top of digester and withdraws further amounts of air and gas. When the air and gas has been practically completely removed from the digester and from the intracellulose space, the liquor is introduced into the digester and the cooking process is started. As pointed out hereinbefore, the cooking process may be started at a relatively high temperature, say about 100° C. or so.

In some instances, it may be desirable to use a modified apparatus shown in Fig. 2. In this modified arrangement, many pieces of apparatus are the same as in Fig. 1 and, consequently, the same reference characters will be used in referring to the same pieces of apparatus.

It will be observed that a plurality of digesters are connected in parallel. Pipe line 5 is connected to the bottom of each digester 1 and then to pump 3 and ejector 7. The filling mouths or openings 15 at the tops of the digesters are connected together by means of a pipe line or conduit 16. A valve 17 is provided at the junction where pipe line 16 is connected to the filling mouths 15. Above pipe line 16 is an auxiliary container 14. This container is connected by pipe 11 to ejector 7 in the same manner as the top of digester 1 in Fig. 1 was connected to the ejector. A pipe line 18 extends from the top auxiliary container 14 into a storage reservoir 19.

The arrangement shown in Fig. 2 is operated in accordance with the same principle underlying the operation of the apparatus illustrated in Fig. 1. Thus, the digester is completely filled with chips in the usual way. This may be accomplished in any suitable manner but is preferably effected with a mechanical filling apparatus so that the highest compactness of the charge may be reached. After filling the digester with chips ordinary cooking liquor is introduced into the digester. In mills where the cooking liquor is preheated, it is advisable to take for the first charge cold liquor having a temperature of about 25° C. to about 35° C. Not only are all of the digesters filled with liquor but the auxiliary container 14 is filled to overflowing. Any surplus liquor is carried to the storage tank 19 by means of pipe line 18. The valve in pipe line 18 adjacent to the auxiliary container is shut off and all of the digesters are closed. The first digester is then emptied through pipe line 5, pump 3 and ejector 7 into storage tank 19. In emptying the digester the auxiliary container 14 is emptied and a vacuum is created. This assists in obtaining a higher vacuum in the digester. The emptying of the digester creates a vacuum and causes the withdrawal of air and gas between the wood chips and between the wood fibers. The other digesters may be emptied with the creation of a vacuum. It is to be noted that these other digesters may be filled with wood chips or may just be filled with liquor alone.

The liquor withdrawn from the digester and the auxiliary container is forced by means of pump 3 through ejector 7. As the suction side of this ejector is connected to the top of auxiliary container 14 by means of pipe line 11, air and gas are removed from the top of the auxiliary container simultaneously with the discharge of liquor and the removal of air and gas from the digester. In carrying out this process, it has been observed that SO_2 gases escape with the air and due to the fact that the SO_2 gases are heavier than air they tend to settle to the bottom, whereas the air floats to the top. In consequence, the air tends to rise into auxiliary container 14 and the SO_2 gases tend to sink in the digesters.

When the digesters are emptied, the cooking liquor is forced into them again. Either the same liquor which was withdrawn may be used or preheated liquor may be used if the mill is equipped with a preheating apparatus. In the latter case the efficiency of the impregnation is considerably increased. The second feed of liquor to the digester is carried out under a high vacuum and, consequently, the operation is achieved rapidly. The digester is preferably filled to such an extent with liquor that the quantity fed is about 16 to about 18% less than the total liquor capacity of the digester. The liquor level gauge on the digester permits an exact regulation of the liquor level.

It has been found that an auxiliary container 14 having a capacity of about 4 to about 6 cubic meters gave satisfactory results. It is preferred to make the auxiliary container 14 essentially in the form of a cylinder in which the height is several times the diameter. Of course, the bottom of the auxiliary container may be shaped in any suitable manner for connecting pipe 16. When an apparatus of the foregoing construction is used, a relatively high vacuum may be produced in the auxiliary container (for example 500 millimeters of mercury). The auxiliary container may be made of any appropriate material. For instance, the vessel or container may be made of a relatively thin sheet iron provided with a brick lining. Ordinarily, the auxiliary container is only exposed to relatively low pressures such as 1.5 atmospheres gauge pressure.

In discharging the digesters, the liquor which sucks the air and gas is conducted to storage tank 19. In this storage tank, the SO_2 gases are absorbed in the liquor. The undissolved air, etc., bubbles through the liquor and is released at the top of storage tank 19. If desired, another pump may be interposed between ejector 7 and the storage tank in order to force the liquor and gases into the storage tank. By using the foregoing procedure still greater uniformity of impregnation of the wood chips or cellulose-containing fibrous material is accomplished in all parts of the digesters. It will be observed that the present invention provides a process in which both the preliminary cooking and the cooking time proper can be considerably shortened. In addition, a completely uniform digestion of the wood chips is accomplished while at the same time re-

taining the fibers in a condition of maximum solidity. When applying the process to a digester having a net capacity, for example, of about 225 cubic meters, about 30 meters were required for drawing off the liquor for evacuating purposes. The filling of the second batch of liquor into the digester required about 20 minutes. The impregnation took about one hour while the shortening of the cooking cycle amounted from about 3 to about 5 hours. In certain test, a cooking cycle of about 6½ hours was realized, whereas the cooking cycle in the same mill before the introduction of the present process amounted to about 13 to 14 hours. In other words, by the use of the present invention the time of the cooking cycle is reduced one-half.

It is also to be observed that in the old impregnating processes the impregnation of the chips proceeded very slowly. When the cellulose fibers were not soaked with liquor they were discolored brown at a temperature of about 105° C. It was, therefore, necessary to extend the preliminary cooking period a comparatively long time, for instance, from about 5 to about 6 hours. In view of the fact that during the preliminary cooking period the liquor penetrates very slowly into the wood chips, there was, of course, an uneven attack of the wood, inasmuch as the fibers on the front sides were attacked before the ones at the middle of the chip. There has been found a marked difference between the solidity of the fibers first attacked in comparison with those which were last attacked. Moreover, the uneven attack of digestion further entails a partial destruction or deterioration of the fibers first attacked due to the fact that they cannot be discharged from the digester immediately after the attack and have been exposed to the cooking liquor for too long a period of time. In contrast to the old process, the present invention provides a process which considerably accelerates the impregnation of the chips and causes the uniform impregnation thereof with the constant uniform or even attack of the fibers. Due to the shortening by the present process of the preliminary cooking period, the total cooking period is considerably shortened and the fibers are exposed to the mordant liquor for a much shorter time. A much better strength or solidity in the fibers is obtained.

Furthermore, it is to be noted that the present invention may be used for other materials than wood. These other materials may be deaerated and degasified in the same manner, as described heretofore in connection with wood and cellulose-containing fibrous material.

I claim:—

1. The process of digesting wood and other cellulose-containing fibrous material in a closable digester which comprises introducing fibrous material into the digester, completely filling the digester with liquor, discharging the liquor from the bottom of the digester to create a vacuum and to withdraw air and gas between the pieces of the fibrous material and within the fibrous material, reintroducing liquor into said digester, and effecting digestion of the fibrous material.

2. The process of digesting wood and other cellulose-containing fibrous material in a closable digester which comprises introducing fibrous material into the digester, completely filling the digester with liquor, discharging the liquor from the bottom of the digester to create a vacuum and to withdraw air and gas between the pieces of the fibrous material and within the fibrous material while sucking air and gas simultaneously from the top of the digester, reintroducing liquor into said digester, and effecting digestion of the fibrous material.

3. The process of digesting wood and other cellulose-containing fibrous material in a closable digester which comprises introducing fibrous material into the digester, completely filling the digester with liquor, discharging the liquor from the bottom of the digester to create a vacuum and to withdraw air and gas between the pieces of the fibrous material and within the fibrous material, passing the withdrawn liquor through an ejector connected to the top of the digester for sucking off air and gas, re-introducing liquor into said digester, and effecting digestion of the fibrous material.

4. The process of digesting wood and other cellulose-containing fibrous material in a closable digester which comprises introducing fibrous material into the digester, completely filling the digester with liquor, discharging the liquor from the bottom of the digester to create a vacuum and to withdraw air and gas between the pieces of the fibrous material and within the fibrous material, re-introducing liquor into said digester, opening the top of the digester while re-introducing the liquor, and effecting digestion of the fibrous material.

5. An apparatus for deaerating and degasifying material especially of a fibrous nature which comprises a digester, a discharge pipe connected to the bottom thereof, an ejector connected to said discharge pipe and a pipe connecting the suction port of said ejector with the top of said digester.

6. An apparatus for deaerating and degasifying material especially of a fibrous nature which comprises a digester, a discharge pipe connected to the bottom thereof, a pump for withdrawing and reintroducing liquor from said digester, an ejector connected to said discharge pipe of said pump, and a pipe connecting the suction port of said ejector with the top of said digester.

7. An apparatus for deaerating and degasifying material especially of a fibrous nature which comprises a digester, an auxiliary container connected to the top of said digester, a discharge pipe connected to the bottom thereof, an ejector connected to said discharge pipe, a pipe connecting the suction port of said ejector with the top of said auxiliary container, a storage tank connected to said ejector for receiving the withdrawn liquor, air and gas, and a pipe line connecting the top of said auxiliary container with said storage tank.

8. An apparatus for deaerating and degasifying material especially of a fibrous nature which comprises a digester, an auxiliary container connected to the top of said digester, a discharge pipe connected to the bottom thereof, a pump for withdrawing and reintroducing liquor from said digester, an ejector connected to said discharge pipe, a pipe connecting the suction port of said ejector with the top of said auxiliary container, a storage tank connected to said ejector for receiving the withdrawn liquor, air and gas, and a pipe line connecting the top of said auxiliary container with said storage tank.

9. The apparatus set forth in claim 7 in which the auxiliary container has the form of a cylinder having a height several times the diameter thereof.

10. The apparatus set forth in claim 8 in which a second liquor pump is located between the ejector and the storage tank.

11. An apparatus for deaerating and degasifying material especially of a fibrous nature which comprises a plurality of digesters connected in parallel, a discharge pipe connecting to the bottom of each digester, a connecting pipe associated with the top of each digester, an auxiliary tank connected to said pipe line associated with the tops of the digesters, a pump in said discharge pipe, an ejector operatively associated with said pump, a pipe line connecting the suction port of said adjuster with the top of the auxiliary container, a storage tank for receiving liquor, air and gas from the ejector, and a pipe line connecting the top of the auxiliary container with said storage tank.

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