June 2, 1953 J. H. ROSS ET AL 2,640,774

PRODUCTION OF CELLULOSE PULP

Filed July 16, 1949 2 Sheets-Sheet 1

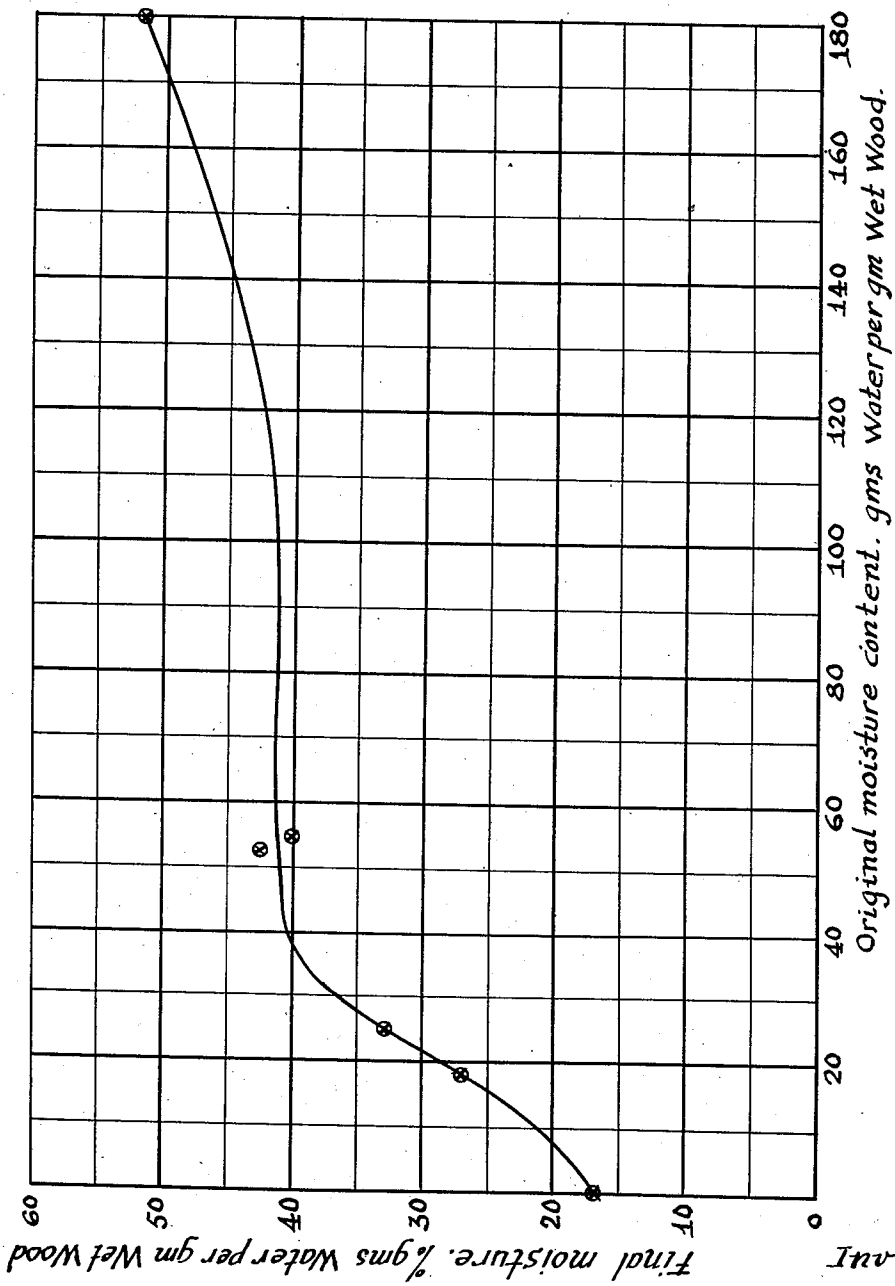

FIG. 1

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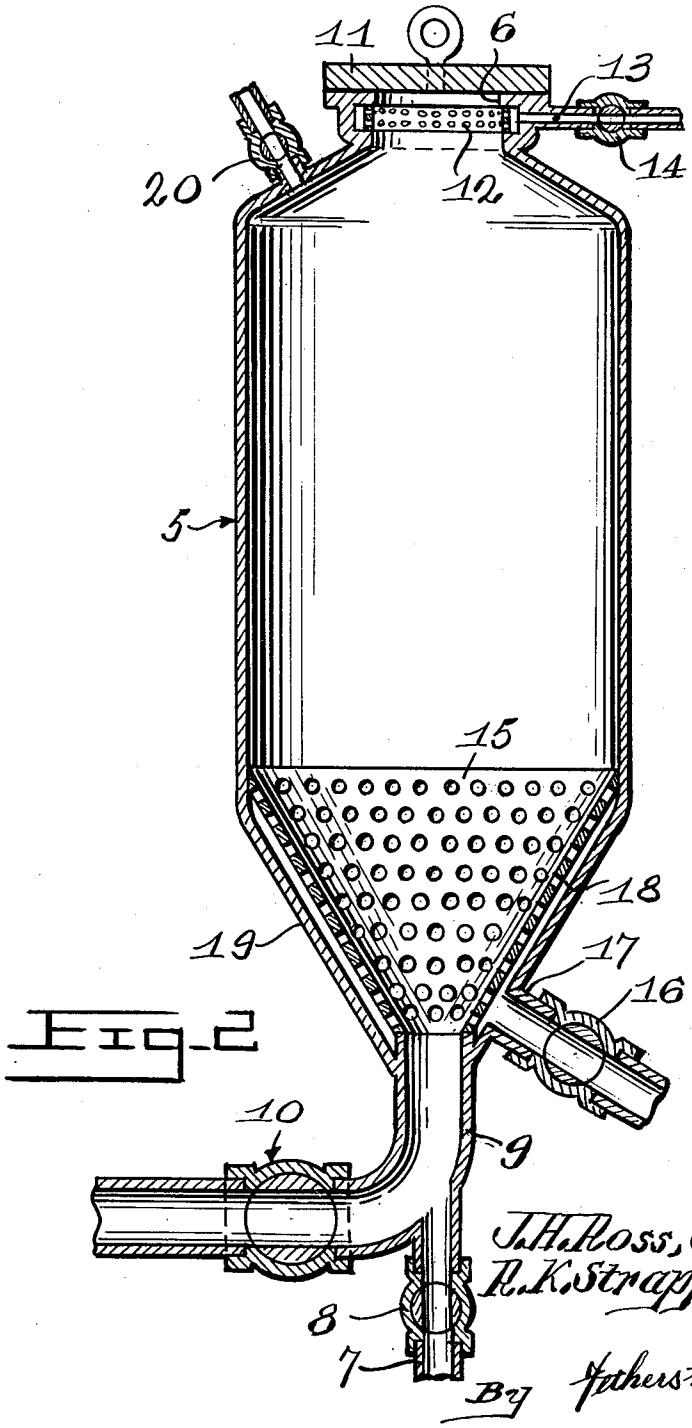

Fig-2

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PRODUCTION OF CELLULOSE PULP

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8 Claims. (Cl. 92—6)

1

This invention relates to the production of cellulose pulp from plant materials.

The invention is herein described as applied to the chemical pulping of wood chips but the principles and procedures involved are applicable, in whole or in part, to the pulping of straw, bamboo and other ligno-cellulosic material by the sulphate, sulphite and other known chemical pulping processes.

A salient feature of the invention consists in the provision of a pretreatment procedure whereby wood chips of widely varying original moisture content, preferably within the commercial range of 25% to 50% original moisture content, are brought to a substantially uniform moisture content, corresponding to or closely approaching the fibre saturation point for wood and are otherwise conditioned to facilitate the rapid and uniform penetration thereof by an aqueous solution of defibrating reagents commonly referred to as the cooking liquor. In an article published in Industrial and Engineering Chemistry, vol. 1, No. 2, April 15, 1929, A. J. Stamm has pointed out that the term "fibre saturation point" was first used in connection with wood to designate the moisture content below which further reduction of moisture caused changes in the strength of the wood. In this same article Stamm also points out that the absorption of water by wood belongs to the same general class of phenomena as the absorption of various liquids by different fibrous material and very closely resembles the absorption of water by other cellulosic fibres. Water contained in wood fibre is in two forms, i. e., free water and absorbed water and, according to Stamm, the saturation point may be defined as that state in which the cavity of the fibre is entirely free from liquid moisture and its wall is saturated throughout. It is at this saturation point that a wood fibre commences to shrink on drying and exhibits its maximum ability for absorption and diffusion of defibrating reagents in aqueous solution.

In the pretreatment procedure afforded by the present invention the wood chips of varying original moisture content are brought to a substantially uniform moisture content, closely approaching the fibre saturation point by packing the chips into a pressure vessel, introducing steam into the vessel to expel air therefrom through a suitable vent opening, closing the vent opening when the vessel is cleared of air and continuing the introduction of steam until the vessel is filled with steam at a predetermined superatmospheric pressure, and then rapidly re-

2

ducing the steam pressure to a predetermined lower value by discontinuing the supply of steam and venting the vessel through one or more steam outlets of sufficient capacity to enable reduction of the steam pressure to the lower limit to be accomplished in a brief period of time such, for example, as 5 or 6 minutes. In this pretreatment procedure the optimum results are attained by raising the steam pressure to the upper limit as rapidly as possible consistent with uniform heating of the chips to the temperature of the surrounding steam and by discontinuing the introduction of steam and initiating the rapid pressure reducing withdrawal of steam from the vessel as soon as the upper limit of steam pressure is attained. When the raising and lowering of the steam pressure is carried out in this preferred manner, the total time required for the pretreatment procedure is reduced to a minimum which is desirable both from the standpoint of economy of operation and reduction of the length of time the wood chips are exposed to the action of the steam, the latter consideration being important to ensure conditioning of the chips for rapid and uniform impregnation thereof by defibrating reagents with the least possible danger of impairing the paper making properties on the chips. In this connection, it is important to note that the desired conditioning of the chips by the pretreatment procedure of the present invention is not dependent on the use of high maximum steam pressures or on prolonged exposure of the wood chips to the action of the steam. On the contrary, the maximum steam pressure employed in the pretreatment procedure may be a relatively low superatmospheric pressure and there is no necessity of maintaining the maximum steam pressure for any appreciable period following attainment thereof.

In practice it has been found that there is a wide range within which the values to which the steam pressure and temperature are raised during the pretreatment procedure may be varied depending on the nature and condition of the wood and compliance with specific requirements concerning yield and quality of the pulp to be produced from the pretreated chips.

The important factors governing the selection of the upper and lower limits of steam pressure employed in the pretreatment procedure are time and minimum impairment of the pulp making properties of the wood. The results of numerous experiments and commercial applications of the invention indicate that the use of maximum

steam pressures substantially higher than 50 lbs. per square inch is not commercially economical because of the length of time required to attain such higher pressures in commercial digesters. Moreover, the use of such higher pressures prolongs the time of exposure of the wood chips to the steam and thereby increases the hazard of impairing the pulp making properties of the chips by hydrolysis, distillation and other adverse effects of superatmospheric steam. Hence while usable pulp may be produced by pretreatment of the wood chips at maximum steam pressures exceeding 50 lbs. per sq. in., the operating time is not economical and the yield and quality of the pulp produced from the pretreated chips is inferior to that obtained from chips pretreated at maximum temperatures below or not exceeding 50 lbs. per sq. in. The optimum maximum pressure recommended for the pretreatment procedure is approximately 20 lbs. per sq. in. This pressure can be reached in a very few minutes in a commercial digester and if not maintained for an excessive period of time before being reduced to the lower limit, gives entirely satisfactory conditioning results with a wide margin of safety as regards avoidance of any appreciable impairment of the pulp making properties of the wood by the action of the steam. High maximum pretreatment pressures ranging from 20 lbs. to 50 lbs. per sq. in. have also been used in procedures which gave an increased yield of uniformly cooked good quality pulp representing a definite improvement over the yield and quality of pulp obtained by conventional pulping procedures not employing the pretreatment prescribed by the present invention. When pretreating wood chips at maximum pretreatment pressures of the order of 40 to 50 lbs. per sq. in. or higher, it is especially desirable that the steam pressure be maintained at this upper limit only momentarily in order to reduce to a minimum adverse effects of this high pressure steaming on the structure of the cellulose in the wood and on the solubility of the lignin and other binding substances in normal pulping liquors.

The lower limit to which the pressure in the pressure vessel is reduced during pretreatment of the chips may be any pressure which can conveniently be arrived at within an allotted period of time suitable for economical commercial operation and which will give the required differential between the upper and lower limits of pressure. At this point, it may be noted that the efficiency of the pretreatment procedure increases with an increase in the rate at which the pressure is dropped from the upper to the lower limit. The lower limit of pressure may be superatmospheric, zero or subatmospheric.

The mechanism of the pretreatment procedure may be explained as follows: During filling of the pressure vessel with steam to establish therein the selected upper limit of steam pressure and temperature, the wood chips are heated to the temperature of the surrounding steam which penetrates the chips to some extent. During the ensuing rapid reduction of the steam pressure to the selected lower limit, the water within the wood chips is flashed into steam and flows out of the chips with considerable velocity. This high velocity outflow of steam from within the wood chips serves to efficiently purge the latter of air, free water and certain penetration-retarding solids which are entrained and removed by the outflowing steam.

In addition to efficiently purging the wood chips of air, free water and other penetration retarding substances, the pretreatment procedure has the peculiar characteristic that it results in the moisture content of the chips being brought to or very close to the fibre saturation point by either increasing or decreasing the original moisture content of the chips. When the original moisture content of the chips is below the fibre saturation point the pretreatment adds the required amount of moisture in the form of absorbed water. When the original moisture content of the chips is above the fibre saturation point, the pretreatment brings the moisture content close to the fibre saturation point by removing free water.

Repetition of the pretreatment procedure is desirable and, in many cases, necessary to bring the moisture content of the pretreated chips sufficiently close to the fibre saturation point and to effect substantially complete purging of the chips of air, free water, and certain other penetration-retarding substances. Under especially favourable conditions a single application of the pretreatment procedure may give commercially satisfactory results but, as a general rule, two or more applications of the pretreatment procedure will be found necessary to obtain the optimum results. On the other hand excessive repetition of the pretreatment procedure may have detrimental effects on the cellulose and should be avoided.

From the foregoing discussion it will be seen that the predetermined procedure which constitutes the basic novel feature of the invention serves, by its unique moisture-content regulating effect and its efficient removal of penetration-retarding substances, to place the chips in the optimum condition for rapidly absorbing and uniformly distributing throughout their structure or tissue the defibrating reagents contained in the cooking or pulping liquor. It is also important to note that these results are obtained without in any way adversely affecting the pulp making qualities of the chips.

After being pretreated in accordance with the present invention the wood chips are rapidly and uniformly impregnated with the cooking liquor and heated to a pulping reaction temperature by one of several alternative procedures, the selection of which is dependent on such factors as the nature or species of the pretreated chips, the kind of pulp desired, and the type of cooking liquor used. These various impregnating and pulping procedures and the basis on which they are selected in accordance with the nature and condition of the raw material and the kind of pulp desired are hereinafter fully described with the aid of suitable examples and with reference to the accompanying drawings, in which:

Figure 1 is a graph showing the moisture content regulating effect of a typical pretreatment procedure to which the raw material is subjected in accordance with the invention prior to being impregnated with the cooking liquor and heated to a pulping reaction temperature; and

Fig. 2 is a sectional view of a typical digester or pressure vessel which may be employed in the commercial application of the invention.

The graph (Fig. 1) shows the moisture regulating effect obtained in a laboratory experiment by subjecting Douglas fir chips of widely varying original moisture content to four successive applications of the pretreatment purging procedure.

In each application of the pretreatment procedure the cycle of raising the steam pressure in the pressure vessel to the upper limit (40 lbs. per square inch) and quickly reducing it to the lower limit (0 lbs. per square inch) was completed in approximately three minutes. It will be noted that this pretreatment increased the moisture contents of chips having an original content of from 0% to 25% and reduced to 40% the moisture content of chips having an original moisture content of approximately 55%. It will also be seen that in the very extreme case of chips having an original moisture content of 185%, the pretreatment reduced the moisture content to 54%. The original moisure content of wood chips originally employed in the production of cellulose pulp lies within the range of 25% to 55% and, in this range, the pretreatment procedure is effective to bring all the chips to a uniform moisture content of approximately 40% which is very close to the fibre saturation point at which the chips exhibit their maximum ability to absorb and uniformly distribute throughout their structure defibrating reagents which are brought in contact with the chips in aqueous solution.

Commercial applications of the invention have been carried out in a digester of the type indicated at 5 in Fig. 2. The raw wood chips are introduced into the digester through the top filling opening 6 with or without the aid of conventional chip packing equipment. At the same time, or at any other suitable time, steam is admitted to the bottom of the digester by steam supply line 7, steam valve 8 and the digester blowdown outlet 9 which is controlled by a normally closed blowdown valve 10. When the digester has been sufficiently packed with chips, the filling opening 6 is closed by a cover 11 and the introduction of steam is continued until the air in the digester has been expelled through a strainer 12, a vent passage 13 and an open vent valve 14 provided at the top of the digester. When all the air has been expelled from the digester, steam is discharged through vent valve 14 which is then closed and steaming continued to attain, as quickly as possible, the selected upper limit of steam pressure and temperature. The steam is then immediately shut off and rapid reduction of the steam pressure to the lower limit is initiated with the least possible delay by exhausting steam from the digester through a bottom strainer 15 and a drain valve 16 which controls a drain conduit 17 communicating with a space 18 reserved between strainer 15 and the lower conical bottom portion 19 of the digester. When drain valve 16 is opened, vent valve 14 is also preferably opened to facilitate the desired rapid reduction of the steam pressure within the digester.

It is important that the digester have adequate provision for rapid reduction in steam pressure. Many digesters now in use do not have adequate provision for this purpose, and if it is desired to practice the present invention in such digesters it is recommended that they be altered, preferably along the lines of the digester described herein. Thus in some instances it may be necessary to install a strainer such as the bottom strainer 15, and a drain valve and conduit of large capacity such as the valve 16 and the conduit 17 shown in the drawings.

In cases where it is necessary to repeat the pretreatment procedure to bring the wood chips to the fibre saturation point and to efficiently purge them of air, free water and certain other penetration-retarding substances the expulsion of air and the heating of the chips during the initial application of the pretreatment procedure enables the desired raising and lowering of the steam pressure in succeeding applications of such procedure to be appreciably shortened as compared with the time required by the initial pretreatment of the chips.

The steam which is discharged through vent valve 14 during the chip heating and air-expelling stage of the pretreatment procedure is at a temperature of approximately 212° F. The introduction of steam into the digester following the closure of vent valve 14 is discontinued as soon as the desired upper limit of steam pressure and temperature is reached and this upper limit should not exceed a steam pressure of 40 lbs. per square inch with a corresponding temperature of 140° C. and should not be held at this upper limit for any appreciable length of time sufficient to impair the paper-making qualities of the pretreated chips.

While the upper and lower limits of steam pressure employed in the pretreatment procedure may be widely varied within the prescribed range, the selection of these limits and the extent, if any, to which the pretreatment procedure is repeated, will obviously be based on the attainment of commercially satisfactory results in the shortest possible time, having regard to the nature and condition of the raw material. Various trials have established the fact that, in a large number of cases, commercially satisfactory results can be obtained, in the pretreatment of the chips, by varying the steam pressure from an upper limit of 20 lbs. per sq. in. to a lower limit of 10 lbs. per sq. in.

With reference to repetition of the pretreatment procedure, it has also been established that wood with moisture contents normally encountered as well as water soaked woods may be efficiently purged of penetration-retarding substances and brought to a uniform moisture content closely approaching the fibre saturation point by from two to four applications of the pretreatment procedure.

When the pretreatment procedure is completed, valves 14 and 16 are closed and cooking liquor is introduced into the digester through a valve 20 to commence the impregnation and pulping-reaction stages of the complete process for the production of cellulose pulp.

The impregnation and pulping of the wood chips may be carried out as a single stage operation in which impregnation takes place while the cooking liquor in the digester is being gradually heated up to attain pulping-reaction temperatures and pressures. In this case, the pretreatment of the chips ensures that, by the time pulping reaction conditions are obtained in the digester, the chips will be uniformly penetrated by the pulping or chemical reagents of the cooking liquor to a much greater degree than heretofore with the result that the pulp produced will be of a more uniform character in that it will contain smaller percentages of overcooked and undercooked fibres. The rapidity and degree of uniformity with which the pretreated chips are impregnated also offers the possibility of safely shortening the cooking cycle by increasing the rapidity with which the cooking liquor is heated up to a pulping reaction temperature and by decreasing the length of time during which the chips are left in contact with the cooking liquor

after pulping-reaction conditions have been attained.

The impregnation and pulping of the chips may also be carried out in such manner as to constitute essentially a two-stage operation. Precautions are taken to maintain the temperature of the cooking liquor below the pulping-reaction temperature until it has been determined that the chips have absorbed and uniformly distributed throughout their structure the full amount of defibrating chemicals of the cooking liquor which the chips are capable of absorbing and distributing throughout their structure. The contents of the digester are then heated up to attain pulping reaction conditions of temperature and pressure. This two-stage procedure gives a greater margin of safety with reference to ensuring that all the chips are uniformly impregnated to the fullest possible extent before being subjected to pulping-reaction conditions of temperature and pressure. It also lends itself to withdrawal of a substantial proportion of the cooking liquor following complete impregnation of the chips and thus enables the heating of the contents of the digester to attain pulping reaction conditions to be carried out with greater rapidity, thus contributing to the saving of both heat and time.

When the impregnation and pulping of the chips is carried out as a two-stage process, as above described, the partially exhausted liquor which is withdrawn from the digester when the chips are completely impregnated is fortified and brought back to its original strength by the addition of white liquor.

When impregnation and pulping of the chips is carried out as a two-stage process, it has been found that pressure impregnation of the chips serves, in conjunction with the pretreatment procedure, to provide the optimum conditions for the most complete and uniform impregnation of the chips in the shortest possible time preceding heating of the impregnated chips to pulping reaction temperatures. When pressure impregnation is resorted to, the cooking liquor is pumped into the digester **5** through valve **20** and is placed under the required pressure either by means of the liquor pump or by injecting steam into the top of the digester in any suitable manner and preferably through the top strainer **12**. The pressure on the cooking liquor is maintained for a suitable period of time to ensure the best possible penetration results. Part of the cooking liquor is then preferably withdrawn from the digester through the bottom strainer **15** and valve **16** before heating up the contents of the digester to attain pulping reaction temperatures and pressures. The volume of liquor withdrawn from the digester following the impregnation of the chips may be any desired proportion of the total volume of liquor introduced into the digester. In this connection, it may be noted that since the chips have been fully impregnated, there is no necessity for retaining a large volume of excess liquor in the digester during the heating of the digester content to pulping reaction temperatures and considerable time and heat may therefore be saved by withdrawing from the digester, following impregnation of the chips, all but a very small amount of the excess liquor. The small amount of excess liquor retained in the digester is substantially uniformly distributed among the chips during the actual cooking operation by steam distribution and by conventional liquor circulating methods.

The pressure employed in the pressure impregnation of the chips may be varied within wide limits ranging, for example, from about 20 lbs. per square inch to 100 lbs. per square inch or higher. In a number of instances the chips were impregnated at a pressure of 100 lbs. per square inch and results were entirely satisfactory. However, in other instances, commercially satisfactory results were also obtained by impregnating the chips at an impregnating pressure of 20 lbs. per square inch. So far as can be determined from the results of numerous experimental and commercial applications of the invention, there appears to be no particular advantage in using impregnating pressures above 100 lbs. per square inch but it is possible that extended applications of the invention may disclose instances in which use of higher pressures may develop some advantages. The ratio of the strength of the partially exhausted liquor withdrawn from the digester upon completion of impregnation appears to vary according to the original strength of the liquor and the temperature at which the impregnation takes place and this consideration should be borne in mind in determining the strength of the original cooking liquor.

Another advantage of the present invention is that it lends itself to the uniform pulping of a mixture of woods of different species which cannot be uniformly pulped by conventional pulping procedures. By carrying out the pretreatment, impregnation and pulping reaction procedures as prescribed by this invention, it has been found possible to produce a uniform pulp of commercially satisfactory quality from a mixture of jack pine and poplar wood chips mixed together in equal proportion by weight.

The invention is further illustrated by the following examples:

EXAMPLE I

Production of kraft pulp from jack pine chips having an original moisture content within the normal commercial range

The chips were packed into the digester through opening **6** by a conventional steam packer (not shown), aided by introduction of steam into the bottom of the digester through steam valve **8**. The introduction of steam into the bottom of the digester through valve **8** was effected at the maximum rate consistent with prevention of the steam breaking through the chip charge. When the digester was sufficiently packed with chips, the charging opening **6** was closed by cover **11** with vent valve **14** open. The supply of steam through valve **8** was continued until a steam discharge temperature of 212° F. was registered at vent valve **14**. The valve **14** was then closed and the introduction of steam through valve **8** continued until the steam pressure in the digester was raised to 20 lbs. per sq. in. This required approximately 7 minutes. The supply of steam through valve **8** was then immediately discontinued and valves **14** and **16** were immediately opened to reduce the steam pressure in the digester to 10 lbs. per sq. in. as rapidly as possible. This reduction of steam pressure required approximately 6 minutes. When the lower limit of pressure was reached, the valves **14** and **16** were closed and steam valve **8** again opened to again raise the steam pressure in the digester to 20 lbs. per sq. in. This second raising of the steam pressure to the specified upper limit re-

quired approximately 5 minutes. The valve 16 was then immediately reclosed and the relief valves 14 and 16 quickly opened to again reduce the steam pressure in the digester to 10 lbs. per sq. in. This second reduction of the steam pressure to the lower limit required about 4 minutes. In this case no further repetition of the pretreatment procedure was found necessary to bring the chips to the fibre saturation point and to effect a satisfactory purging of the chips of air, free water and other penetration-resisting substances.

When the pretreatment procedure was completed, the cooking liquor was pumped into the digester to completely fill the same and the liquor pump was continued in operation for a further period of two to three minutes. At the end of this time, the level recorder on the liquor tank showed no further decrease in volume and the liquor supply pump was shut off.

Following the shutting off of the liquor supply pump, the cooking liquor in the digester was subjected to mechanical pressure by means of steam introduced into the top of the digester. This pressure applying steam acted as a piston on top of the liquor and served to raise the pressure in the digester to approximately 100 lbs. per sq. in. in a few seconds. When the pressure impregnation of the chips was completed, a large proportion of the surplus liquor was withdrawn from the digester and returned to the liquor tank. The digester was equipped with a circulating line including a pump (not shown) and this pump was used for withdrawing the surplus liquor from the digester and returning it to the liquor tank at the end of the pressure impregnation of the chips. The total period of time required for filling the digester with the cooking liquor and effecting the pressure impregnation of the chips was approximately 12 minutes and the temperature of impregnation was below the pulping reaction temperature.

When the cooking liquor in the digester was reduced to the selected level, following completion of the pressure impregnation of the chips, steam was introduced into the digester to bring the contents thereof to a maximum temperature of approximately 259° F. This required approximately 45 minutes and the pulping reaction temperature thus established was maintained for a further period of approximately two hours to complete the cook.

The cooking liquor used was a regular kraft cooking liquor of approximately 30% sulphidity and containing approximately 16.5% active alkali.

This operation produced a good quality of uniformly cooked pulp with an increased yield of from 2% to 3.2%. The pulp was easily washed with less water than is usually required and contained a reduced amount of knotter rejects. The steam consumption and the time required to complete the cook was appreciably reduced due to the low ratio of cooking liquor to wood employed in the defibrating reaction stage of the process. The pretreatment of the chips, plus the low liquor to wood ratio employed in the defibrating reaction stage enabled the temperature of the digester contents to be raised to the pulping reaction temperature as rapidly as the system would permit and this makes it possible to increase the digester turnover, that is to say, in the number of cooks completed in each digester over a period of time, such as 24 hours.

EXAMPLE II

Production of sulphite pulp with low liquor to wood ratio during the defibrating reaction stage of the process

The chips were packed into the digester and were subjected to four applications of the pretreatment procedure carried out as described in Example I. The digester was then filled with an amount of sulphite cooking liquor sufficient to completely submerge the chips and the liquor was then subjected, for a period of ten minutes, to a pressure of 100 lbs. per square inch at a temperature below the defibrating reaction temperature. A sufficient amount of the surplus cooking liquor was then immediately withdrawn from the digester to reduce the liquor to wood ratio to about 2.3 to 1, calculated on the basis of the bone dry weight of the wood. The contents of the digester were then heated to 135° C. in 15 minutes and this temperature was maintained for 2½ hours. This operation produced a total yield of 53.2% of good quality uniformly cooked pulp with a screen yield of approximately 50%. The pulp was quite soft with no evidence of burning.

EXAMPLE III

Production of sulphite pulp from western hemlock chips

In this case the digester was packed with wood chips in the same manner as described in Example I, namely, with the aid of a chip packer and the admission of steam to the bottom of the digester through the steam valve 8. This required a period of approximately 23 minutes.

When the packing of the digester with chips was completed, the charging opening 6 was closed by cover 11; vent valve 14 was opened; and the introduction of steam was continued through valve 8 until steam was discharged through vent valve 14 at a temperature of 212° F. This required a period of approximately 8 minutes.

As soon as the temperature of the steam discharged through vent valve 14 was registered at 212° F., the valve 14 was closed and the introduction of steam through valve 8 continued until the steam pressure in the digester registered 8 lbs. per sq. in. This required approximately 10 minutes. The introduction of steam into the digester was then discontinued and the steam pressure in the digester reduced as rapidly as possible to 3 lbs. per sq. in. by withdrawing steam therefrom. This reduction of pressure required approximately 5 minutes and the pretreatment procedure was not repeated.

Following the reduction of steam pressure in the digester to 3 lbs. per sq. in. at the end of the pretreatment procedure, cooking acid from a suitable accumulator was pumped into the digester and the acid supply pump was continued in operation until the level in the accumulator had ceased to fall. The pump pressure thus established in the digester after the latter was filled with acid was approximately 75 lbs. per sq. in. and was arrived at in an acid charging period of approximately 30 minutes. By this time, the chips had taken up the maximum amount of acid which they were capable of absorbing and side relief of the digester was resorted to for a period of 15 minutes. The temperature of the digester contents was then raised to approximately 140° C. in the shortest possible time that the system would permit by introduction of steam. This required about 105 minutes and the temperature was maintained at the level of 140° C. for a further period of 20

minutes. A further period of 30 minutes was used up in reducing the pressure in the digester.

The digester used in Example III was a conventional sulphite digester of approximately ten tons accepted pulp capacity and was provided with a conventional hot acid cooking system. With a digester of this type the normal time required for completion of a cook, as measured from the commencement of steaming until the blowdown, was 7 hours.

The yield and quality of pulp produced by this operation was substantially the same as that obtained by the procedure described in Example II.

EXAMPLE IV

Production of uniformly cooked kraft pulp from jack pine and poplar wood chips mixed together in equal proportions

In this case the procedure followed, except as regards the use of a mixture of wood chips of different species, was exactly as described in Example I.

In the pulping of mixed species of wood in accordance with the procedure prescribed in Example IV, it appears that the uniform pulping results obtained are due to the fact that each chip is made to take up a miximum amount of liquid which is constant or approximately so for each species. The amount of chemical taken up, by regulating the concentration of the solution, can be made sufficient for the pulping reaction and therefore each chip is, in fact, its own digester. Thus the species more easily pulped does not have access, after delignification, to a continuing supply of chemical and so further degrading of the pulp does not take place. The result is, therefore, a uniform product from a mixture of species. It may be again emphasized that the conditioning of the chip to its constant moisture saturation value, coupled with its ability to subsequently receive an adequate amount of chemical in solution is an essential feature of this process.

This operation produced a good quality of uniformly cooked pulp of mixed species with the increased yield and other advantages pointed out in connection with Example I. The poplar was not overcooked and the rejects were normal.

Having thus described the principles of our invention and several applications thereof, it will be understood that various modifications may be resorted to within the scope and spirit of the invention as defined by the appended claims.

We claim:

1. In the production of cellulose pulp from fibrous plant material, the process which consists of the steps of introducing plant material in subdivided condition into a pressure vessel; displacing air in said pressure vessel with steam; subjecting said plant material within said pressure vessel to a pre-treating operation which compries introducing steam under pressure to establish within the capillary interstices of the plant material a mixture of air and steam until a pressure of from about five to about fifty pounds per square inch gage pressure is reached, then discontinuing the introduction of steam, and while excluding additional air from said pressure vessel forthwith rapidly withdrawing said mixture of air and steam from said pressure vessel and from the interstices of said plant material until a pressure is reached within the range of from atmospheric pressure to a gage pressure half that which existed when the introduction of steam was discontinued; thereafter immersing said pre-treated plant material in cooking liquor while continuing to exclude air from said plant material; and then cooking said pre-treated plant material.

2. The process of claim 1 in which the pre-treating operation is carried out a plurality of times before the plant material is immersed in cooking liquor.

3. In the production of cellulose pulp from fibrous plant material, the process which consists of the steps of introducing plant material in subdivided condition into a pressure vessel; displacing air in said pressure vessel with steam; subjecting said plant material within said pressure vessel to a pre-treating operation which comprises introducing steam under pressure to establish within the capillary interstices of the plant material a mixture of air and steam until a pressure of from about five to about fifty pounds per square inch gage pressure is reached, then discontinuing the introduction of steam, and while excluding additional air from said pressure vessel forthwith rapidly withdrawing said mixture of air and steam from said pressure vessel and from the interstices of said plant material until a pressure is reached within the range of from atmospheric pressure to a gage pressure half that which existed when the introduction of steam was discontinued; thereafter immersing said pre-treated plant material in cooking liquor at a temperature below that of defibration reaction while continuing to exclude air from said plant material; subjecting said plant material and cooking liquor to a substantial hydrostatic pressure to force said cooking liquor into the interstices of said plant material; and then heating said impregnated plant material to defibration reaction temperature.

4. The process of claim 3 in which the pre-treating operation is carried out a plurality of times before the plant material is immersed in cooking liquor.

5. In the production of cellulose pulp from fibrous plant material, the process which consists of the steps of introducing plant material in subdivided condition into a pressure vessel; displacing air in said pressure vessel with steam; subjecting said plant material within said pressure vessel to a pre-treating operation which comprises introducing steam under pressure to establish within the capilliary interstices of the plant material a mixture of air and steam until a pressure of from about five to about fifty pounds per square inch gage pressure is reached, then discontinuing the introduction of steam, and while excluding additional air from said pressure vessel forthwith rapidly withdrawing said mixture of air and steam from said pressure vessel and from the interstices of said plant material until a pressure is reached within the range of from atmospheric pressure to a gage pressure half that which existed when the introduction of steam was discontinued; thereafter immersing said pre-treated plant material in cooking liquor while continuing to exclude air from said plant material, the quantity of cooking liquor being sufficient to completely submerge said pre-treated plant material; withdrawing a substantial portion of the cooking liquor surrounding said plant material; and then cooking said pre-treated plant material.

6. The process of claim 5 in which the pre-treating operation is carried out a plurality of times before the plant material is immersed in cooking liquor.

7. In the production of cellulose pulp from fibrous plant material, the process which con-

sists of the steps of introducing plant material in subdivided condition into a pressure vessel; displacing air in said pressure vessel with steam; subjecting said plant material within said pressure vessel to a pre-treating operation which comprises introducing steam under pressure to establish within the capillary interstices of the plant material a mixture of air and steam until a pressure of from about five to about fifty pounds per square inch gage pressure is reached, then discontinuing the introduction of steam, and while excluding additional air from said pressure vessel forthwith rapidly withdrawing said mixture of air and steam from said pressure vessel and from the interstices of said plant material until a pressure is reached within the range of from atmospheric pressure to a gage pressure half that which existed when the introduction of steam was discontinued; thereafter immersing said pre-treated plant material in cooking liquor while continuing to exclude air from said plant material, the quantity of cooking liquor being sufficient to completely submerge said pre-treated plant material; and then cooking said pre-treated plant material while completely submerged in cooking liquor.

8. The process of claim 2 in which the pre-treating operation is carried out a plurality of

times before the plant material is immersed in cooking liquor.

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