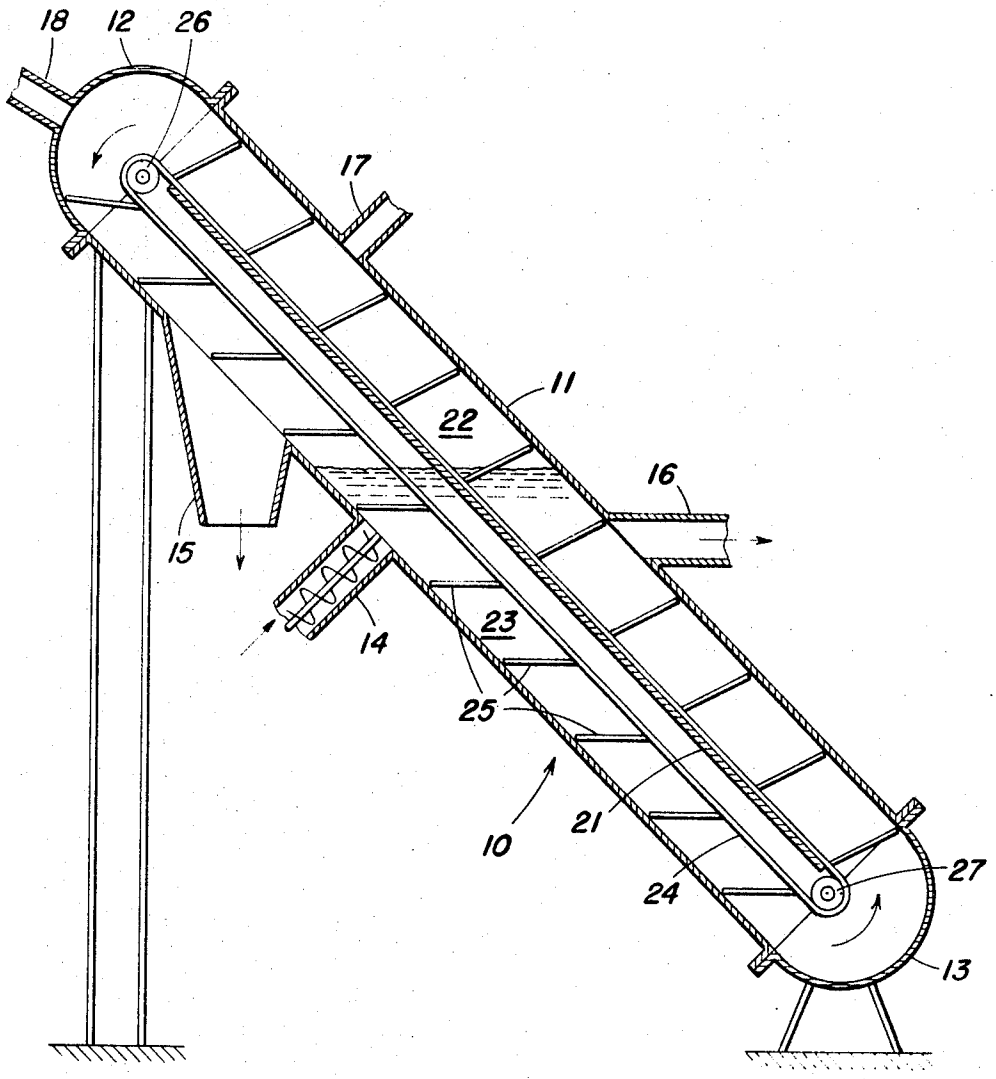
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IMPREGNATION AND DIGESTION OF CELLULOSIC MATERIAL IN A SINGLE VESSEL

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IMPREGNATION AND DIGESTION OF CELLULOSIC MATERIAL IN A SINGLE VESSEL

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ABSTRACT OF THE DISCLOSURE

The impregnation-digestion vessel is inclined and divided into first and second flight passages extending the length of the vessel by a partition, with a sprocket wheel provided at each end. The sprocket wheels support an endless chain which carries perforated flights continuously through both flight passages. The vessel is partially filled with cooking liquor, the level of liquor defining upper and lower portions of the vessel, the upper portion being filled with steam. The liquor is continuously fed into and taken out of the lower portion to maintain a continuous flow of cooking liquor having a quiescent vapor-liquid interface. Cellulosic material is introduced into the lower portion of the vessel, passed through both flight passages of the lower portion, through the vapor-liquid interface and then passed through both flight passages in the upper portion before being removed.

This invention is related to the production of cellulosic pulps, and more particularly to a process and apparatus for impregnating and digesting cellulosic materials.

The chemical processes for treating cellulosic materials to produce cellulosic pulp involve impregnating the material with a liquor that dissolves lignin (hereinafter referred to as a cooking liquor) and digesting (cooking) the impregnated material at an elevated temperature to induce a solvent action on lignin to free cellulosic fibers.

Recently, a process has been developed wherein impregnated cellulosic material is digested in a vapor phase to reduce overall digestion time. In such a process, the cellulosic material is introduced into a first vessel and uniformly impregnated therein with a cooking liquor maintained at a temperature below a value at which the delignification reaction proceeds at a rapid rate, for example, less than about 150° C. The impregnated material is withdrawn from the first vessel and introduced into a vapor phase, in particular steam, maintained in a second vessel. The vapor is at a temperature value at which the delignification reaction proceeds, rapidly, for example, above 175° C., and raises the temperature of the cellulosic material to the digestion temperatures by direct contact therewith. The cellulosic material is maintained in the vapor phase for a time sufficient to complete delignification, generally of from 10 to 20 minutes or less. The material is then introduced into a liquid maintained at a temperature below the delignification temperature to terminate digestion and extract solubilized substances therefrom. Such a process is described in more detail in U.S. Pat. 3,215,588 which is hereby incorporated by reference.

An object of this invention is to provide a new process and apparatus for effecting digestion of a cellulosic material in a vapor phase.

Another object of this invention is to provide an improved process and apparatus for effecting impregnation and digestion of a cellulosic material.

A further object of this invention is to provide a process and apparatus which reduces the overall cost for effecting impregnation and digestion of a cellulosic material.

These and other objects will become more apparent from reading the following detailed description of the invention with reference to the accompanying drawing wherein:

The drawing illustrates an elevated sectional view containing the essential elements of an embodiment of the apparatus of this invention.

The objects of this invention are accomplished by providing a vapor phase maintained at a temperature above which the delignification reaction proceeds rapidly and by providing immediately below the vapor phase, a cooking liquor maintained at a temperature below the value at which the delignification reaction proceeds rapidly. The cellulosic material is introduced into the cooking liquor to effect impregnation thereof and passed from the cooking liquor into the vapor phase to effect delignification thereof. It is to be understood that the cooking liquor may be any of those used for producing pulp from cellulosic materials, including "kraft," sulphite, neutral sulphite, and the like.

More particularly, a suitable cooking liquor is maintained at a temperature up to about 150° C. with the higher temperatures being preferred since they reduce the time for complete penetration, improve chemical distribution within the cellulosic material, and reduce condensation when the material is introduced into the vapor phase. The exact temperature employed is dependent upon the particular cellulosic material to be digested, with lower temperatures; e.g., as low as 110° C. being employed for grasses, stems and the like and higher temperatures; e.g., about 140 to about 150° C., for high density wood chips. In any case, the material should not be subjected to high impregnation temperatures for long periods of time since at such temperatures incipient digestion may occur which reduces yields, inter alia.

A vapor phase is maintained above the cooking liquor, in particular steam, at an elevated temperature, generally above about 150° C., and preferably between about 180° C. and 190° C. As described in U.S. Pat. 3,215,588, such temperatures achieve rapid digestion of the cellulosic material. In order to reduce heat transfer between the hot vapor and cooler cooking liquor and prevent steam condensation, the cooking liquor should be maintained relatively quiescent at the vapor-liquid interface.

In effecting the process of the invention, a cellulosic material, such as wood chips, is introduced into the warm cooking liquor and the material is maintained therein for about 10 to 30 minutes, preferably about 10 to about 15 minutes, to effect impregnation thereof. The material is then passed through the vapor-liquid interface into the vapor phase and maintained therein for about 10 to about 30 minutes, preferably about 10 to 20 minutes or less to effect digestion thereof. The digested material is then withdrawn from the vapor phase for further processing as known in the art, such as cooling, washing, bleaching and the like.

The process of this invention may be effected continuously by passing a cellulosic material either concurrently or countercurrently through a flow of cooking liquor, through the vapor-liquid interface and into the vapor phase, with the cellulosic material being introduced either in solid form or as a slurry with cooking liquor. An apparatus for effecting such a continuous process is illustrated in the drawing but the scope of the invention is not to be limited thereby.

Referring to the drawing, there is provided an inclined impregnating and digestion vessel, generally indicated as **10**, comprised of a cylindrical shell **11** having sealed thereto by a suitable means, such as a weld, a head cap **12**, and a bottom cap **13**. The head and bottom caps **12**

and 13 close the upper and lower ends, respectively, of the shell 11. The underside portion of the shell 11 has mounted thereon an intake 14 for introducing a cellulosic material thereto and an outlet 15 for withdrawing digested cellulosic material therefrom, with the outlet 15 being positioned above the intake 14. The top side of the shell 11 has mounted thereon a liquid outlet 16 for withdrawing cooking liquor from the digester 10 and a vapor inlet 17 for introducing steam into the digester 10, with the vapor inlet 17 being positioned above the liquid outlet 16. The head cap 12 has mounted thereon a vapor outlet 18 for withdrawing steam from the shell 11. The intake 14 and the liquid outlet 16 are positioned on the shell 11 so that the cooking liquor occupies about 60% of the total volume of the vessel 10. The cellulosic material is introduced into the digester 10 and cooking liquor withdrawn from the digester 10 below the vapor-liquid interface maintained therein, thus creating a buffer zone of relatively quiescent liquid between the vapor phase and circulating liquid. The outlet 15 is positioned on the shell 11 so that the treated cellulosic material is withdrawn from the vessel 10 above the vapor-liquid interface maintained within the digester 10.

The interior of the shell contains a partition 21 extending across the entire width, dividing the shell into an upper section 22 and a lower section 23 with the upper and lower portions of the partition 21 terminating short of the head cap 12 and the bottom cap 13 of the shell 11. Adjacent the head cap 12 and the bottom cap 13 and mounted to the shell 11 by suitable means (not shown), there are provided sprocket wheels 26 and 27, respectively. An endless roller chain 24 having a plurality of perforate conveyor flights 25 mounted thereon is positioned on the sprocket wheels 26 and 27. One of the sprocket wheels 26 and 27 engages a suitable drive means (not shown) for moving the chain and the conveyors in the direction indicated by the arrows.

In operation, a slurry of cooking liquor and cellulosic material, such as wood chips, is introduced into the digester 10 through inlet conduit 14. The cellulosic material is first carried downwardly through the liquid phase in lower section 23 and then upwardly through the liquid phase in upper section 22 by the conveyor flights 25 mounted on the endless chain 24. The cooking liquor is withdrawn through outlet 16 at a rate such that the cooking liquor occupies about 60% of the total volume of digester 10. As a result of the contact between the cellulosic material and the cooking liquor in upper and lower sections 22 and 23, respectively, the cellulosic material is uniformly impregnated with the cooking liquor. The temperature of the slurry determines the rate at which the endless conveyor 24 is driven by the sprockets 26 and 27.

The impregnated cellulosic material is carried by the conveyor flights 25 through the liquid-vapor interface into the vapor phase of the upper section 22 maintained at digestion temperatures, by steam introduced thereto through inlet 17, and withdrawn therefrom through outlet 18. The cellulosic material is carried over a reversing point determined by the sprocket 26 into the lower section 23 and withdrawn therefrom through outlet 15 for further processing (not shown). As a result of the passage through the vapor phase maintained in upper and lower sections 22 and 23, respectively, the cellulosic material is rapidly digested.

It is to be understood that only those portions of the apparatus of the invention that are necessary for understanding the manner for effecting impregnation and digestion in a single vessel have been illustrated and described. The use of suitable inlet valves, drive means, etc., are well within the scope of those skilled in the art and thus no further description is deemed necessary.

It is also to be understood that the above apparatus and its operation may be modified in numerous ways without departing from the scope of the invention. Thus, for example, the cellulosic material and cooking liquor

may be introduced separately, with the cellulosic material being introduced, for example, directly from a pressifiner.

In another modification, the flow of cooking liquor may be effected countercurrent to the flow of cellulosic material, for example, by introducing cooking liquor into the upper section 22 and withdrawing the cooking liquor from the lower section 23.

In a further modification, the flow of cooking liquor may be effected cocurrently to the flow of cellulosic material in the lower section 23 and countercurrently to the flow of cellulosic material in the upper section 22, for example, by introducing cooking liquor into both the upper and lower sections 22 and 23, respectively, and withdrawing the cooking liquor from the bottom of the vessel 10. These and other modifications should be readily apparent to those skilled in the art from the teachings of this invention.

The following process conditions are illustrative of the conditions which may be employed in the invention.

Impregnation zone:
- Liquor concentration—10–30 g./l. of effective alkali expressed as Na_2O
- Operating temperature—120–160° C.
- Operating pressure—40–150 p.s.i.g.
- Operating time—10–30 minutes

Steam cooking zone:
- Operating temperature—160–190° C.
- Operating pressure—75–167 p.s.i.g.
- Operating time—10–30 minutes

The process and apparatus of this invention lower overall costs for impregnation and digestion of cellulosic material in that there is a reduction of equipment cost and a simplification of process steps, thereby reducing both the capital and processing cost per ton of final product.

Furthermore, the use of a single vessel makes installation of units for small mills feasible and, in addition, provides needed flexibility. Moreover, the invention results in improved processing of grasses and thin stalks in that such materials may be treated uniformly at low temperatures and liquor concentrations because of intimate and rapid contact.

Obviously, many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood, that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. An apparatus for treating a cellulosic material comprising:
   (a) an elongated vessel holding a liquid, the level of the liquid defining a boundary between a liquid filled first portion of the vessel and a vapor filled second portion of the vessel, said vessel containing means dividing the vessel into first and second flight passages each of which extend through the first and second portion of the vessel;
   (b) means for introducing a cellulosic material below the liquid level in the portion of first flight passage in the first portion of the vessel;
   (c) means for withdrawing a cellulosic material above the liquid level in the portion of the first flight passage in the second portion of the vessel;
   (d) means for withdrawing liquid from below the liquid level in the first portion of the vessel to maintain the liquid level in said vessel;
   (e) means to introduce a vapor into the second portion of the vessel above said liquid level; and
   (f) means extending through the first and second flight passages to transport material introduced through the cellulosic material intake through the portion of the first flight passage in the first portion of the vessel, the portion of the second flight passage in the first portion of the vessel, the portion of the second flight passage in the second portion of the vessel and the

portion of the first flight passage in the second portion of the vessel, in the stated order.

2. The apparatus of claim 1 wherein the means for transporting material comprises an endless chain conveyor having a plurality of perforate conveyor flights mounted thereon.

3. The apparatus as defined in claim 1 wherein the means for withdrawing liquid from the vessel is positioned in the second flight passage to maintain a liquid volume comprising about 60% of the total volume of the vessel.

4. The apparatus as defined in claim 1 wherein the vessel is inclined and the second flight passage is located above the first flight passage.

5. A process for impregnating and digesting a cellulosic material in a single vessel, comprising:

maintaining a cooking liquor in a first portion of the vessel at a temperature up to about 150° C.; introducing steam into a second portion of the vessel to maintain a steam-filled second portion at a temperature above about 150° C.; continuously introducing and withdrawing cooking liquor from the first portion of the vessel below the liquid level to provide continuous circulation of cooking liquor while maintaining a layer of relatively quiescent liquid at the vapor-liquid interface defining the boundary of the first and second portions; continuously introducing cellulosic material into the liquor below the liquid level; transporting the cellulosic material through the liquid to effect impregnation thereof; passing the cellulosic material after impregnation thereof through the vapor-liquid interface into the steam-filled second portion; transporting the cellulosic material through the steam-filled second portion to effect digestion thereof; and withdrawing the digested cellulosic material from the second portion of the vessel.

6. The process as defined in claim 5 wherein the vessel is divided into first and second flight passages each extending through both the first and second portion of the vessel, the cellulosic material being introduced into the portion of the first flight passage in the first portion of the vessel and transported through the portion of the first flight passage in the first portion of the vessel, the portion of the second flight passage in the first portion of the vessel through the vapor-liquid interface, then through the portion of the second flight passage in the second portion of the vessel and the portion of the first flight passage in the second portion of the vessel, said digested cellulosic material being withdrawn from the portion of the first flight passage in the second portion of the vessel.

7. The process of claim 5 wherein the cellulosic material is maintained in the liquid phase for about 10 to about 30 minutes and in the vapor phase for about 10 to about 30 minutes.

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