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(54) **Method and apparatus for efficiently producing cellulosic pulp by the thermo-mechanical pulping method.**

(57) Method and apparatus for producing cellulosic pulp by the thermo-mechanical pulping method wherein wood chips are contacted with gaseous steam at a temperature and for a time sufficient to bring the temperature of the chips close to that of the steam, compacting the resulting steam treated chips while mechanically conveying the same to reduce the moisture content and produce a compacted moist mass, shredding the compacted mass while further conveying the same under more severe conditions than the original conveying and then passing the shredded mass into a refiner.

The apparatus of the present invention preferably takes the form of a pair of coaxially operating worm-type conveyors with the end of one conveyor being journalled in the end of the other, and operating under conditions such that the second conveyor tends to pull the compacted mass faster than it is being delivered and thereby provides a shredding action to maintain a fairly uniform input into the refiner stage.

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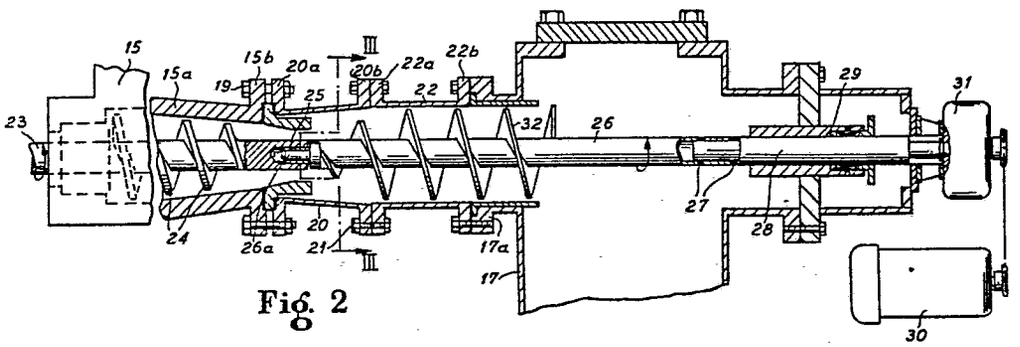
15
15a
15b
19
20a
III
20b
22a
22b
22
25
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32
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29
31
27
28
24
26a
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21
III
17a
17
30

Fig. 2

METHOD AND APPARATUS FOR EFFICIENTLY PRODUCING CELLULOSIC PULP BY THE THERMO-MECHANICAL PULPING METHOD

This invention is in the field of thermo-mechanical pulping methods and apparatus wherein wood chips are steamed and then compacted before delivery to a refiner. The specific improvement of the present invention centers around a conveyor stage which receives the steamed and compressed wood chips in the form of a compacted mass and shreds the same while delivering it to the input of a refiner, thereby providing a more uniform feed into the refiner stage.

The two most common methods of pulping until recent times have been the mechanical pulping operation in which wood chips are mechanically abraded, usually by means of a stone wheel, and a chemical treatment wherein the wood chips are processed with sulfate or sulfite baths. The mechanical system is less expensive but results in fibers which are shorter than would be optimum for use in various types of paper making. The chemical process, on the other hand, requires the use of large amounts of equipment such as high pressure tanks and the like which are quite expensive. The high initial cost of installation and the cost of operation of the chemical processes are not always justified.

In more recent times, a new technique known as thermo-mechanical pulping and refining has become commercially accepted. In a typical thermo-mechanical pulping operation, wood chips from a chip bin are fed through a chip washing system and then by means of a screw feed are fed into a rotary feeder valve which feeds the chips to a steaming tube operating at superatmospheric pressures. The material is introduced into one end of the tube and is conveyed by means of a screw type conveyor to the outlet end. During their travel through the tube, the wood chips are contacted with steam from multiple steam jets which maintain

a uniform steam pressure throughout the length of the tube. Following the treatment in the steaming tube wherein the temperature of the material is brought above the lignin softening temperature, the material passes through a first stage pressurized refiner to which there is coupled a blow valve. The mixture of steam and pulp is then passed to a cyclone separator and a conveyor system delivers the pulp freed from the steam in the separator to a second stage refiner which is non-pressurized. The pulp produced in the second stage refiner is then passed into a stock chest and then goes through the various other stages which are common to any procedure for making up a suspension of fibers suitable for use in a headbox.

U.S. Patent No. 3,921,918 describes a method for mechanically refining which involves pretreating fibrous material with steam in a preheater followed by refining the steam treated material in a disc refiner under conditions which generate steam, with at least a part of the developed steam being directed back to the preheater.

U.S. Patent No. 3,661,328 describes a pulp refining system using a multi-stage disc refining. In the first stage, the refining is carried out in a pressurized environment under moderately elevated temperatures. Subsequent disc refining steps are carried out under atmospheric pressure conditions. The multi-stage refining process is said to result in a reduction in the bulk of the fiber furnished.

There is also a study entitled "Mechanical Pulp From Chips" appearing in Tappi, Vol. 45, April, 1962 at page 257.

U.S. Patents Nos. 2,935,931 and 2,975,096 both assigned to The Bauer Bros. Company deal with fiberizing presses and the like using screw type conveyors.

In a typical commercial embodiment of the thermo-mechanical pulping process, a plug screw feeder feeds compacted, macreated chips to a first-stage refiner. Difficulties

have arisen because of the uneven feed presented to the refiner, since the compacted material tends to remain in the form of lumps of various sizes. When the compacted chips are forced along the horizontal inlet pipe by material behind them, the chips tend to drop spasmodically out of the end of the pipe where the pipe meets the vertical steam separation chamber. This causes large fluctuations in the rate at which chips reach the refiner and consequently causes substantial fluctuation in refiner loading. The net result is that pulp quality is not uniform and this uneven type of operation is generally considered to be unsatisfactory.

The present invention provides a method and apparatus for correcting the difficulties encountered in the feeding of thermo-mechanical pulp to a refiner. Specifically, the present invention provides a method wherein the wood chips are contacted with gaseous steam at a temperature and for a time sufficient to bring the temperature of the chips close to that of the steam, the resulting steam treated chips are compacted while being mechanically conveyed to reduce the moisture content thereof and produce a compacted moist mass. The compacted mass is then shredded by means of further conveying under more severe conditions than the original conveying and thereafter the shredded mass of fairly uniform size is introduced into the inlet of a refiner.

A number of other features are present in the method and apparatus of the present invention. For one, the chips are preferably compacted at compaction ratios of at least 2.5 to 1 during the original conveying. The contacting with gaseous steam preferably occurs at ambient pressure conditions, and the initial compaction of the steam treated chips is carried out until the moisture content is at least as low as 30%.

Features of the apparatus of the present invention include the use of first and second conveyor means which each take

the form of worm-type conveyors coaxially mounted with respect to each other, with the second conveyor means having one end received in the end of the first conveyor means. In order to provide the shredding action, the second conveyor may be provided with flights which have a larger pitch than the flights of the first conveyor. Alternatively, or in addition to this feature, the second conveyor can be driven at a higher rate of speed. As a further embodiment of the invention, the first and second conveyors may each have oppositely oriented flights, and have drive means which drive the two conveyors in opposite directions. The objective to be achieved by the second conveyor is to tend to pull the compacted mass from the first conveyor at a rate which is faster than it is being delivered by the first conveyor thereby breaking up the compacted mass and feeding the chips to the refiner at a more or less uniform rate.

A further description of the present invention will be made in connection with the attached sheet of drawings which illustrate several embodiments thereof, and in which:

Fig. 1 is a partly schematic view of an overall system for treating wood chips by the method and apparatus of the present invention, from the time the chips are steamed to the time they are passed to the refiner;

Fig. 2 is a view partly in cross section on an enlarged scale illustrating the manner in which the two conveyor means cooperate to feed the steamed and compacted pulp into the refiner;

Fig. 3 is a cross-sectional view taken substantially along the line III-III of Fig. 2; and

Fig. 4 is a schematic view of a modified form of the invention illustrating oppositely rotating conveyor means.

Referring to Fig. 1, reference numeral 10 indicates generally a chip bin which is open to the ambient atmosphere and into which there extends a manifold 11 carrying a plurality of steam jet lines 12. Steam at substantially

atmospheric pressure is received into the manifold 11 from a line 13 under the control of a gate valve 14. Additional sources of steam can be used if necessary or desired.

The residence time of the wood chips in the chip bin during steaming is typically on the order of 1 to 5 minutes, or at least sufficient to bring the chips to a temperature approximating the temperature of the steam (212°F, 100°C). After steaming under atmospheric conditions, the chips are delivered to a plug screw feeder 15 driven by a motor 16. In the plug screw feeder 15, the atmospheric pressure of the chip bin 10 is isolated from the superatmospheric pressure existing in a first refiner stage 16. The plug screw feeder 15 delivers the chip through a vertical steam separating tube 17 into an inlet conveyor 18 of the first refiner stage 16.

In the plug screw feeder 15, the steamed chips are subjected to substantial compression whereby the moisture content is reduced to as low as 30% or preferably as low as 25%, in contrast to conventional plug feeder operation which reduces the moisture to about 50%. The higher compaction ratios used, being on the order of at least 2.5 to 1 or preferably 2.7 to 1 as compared with a normal compression ratio of 1.9 to 1 in these devices, fractures bonds between fibers in the chips to a greater extent than normal, enabling the first stage of refining to be operated at a reduced power level.

Under normal operating conditions in the plug screw feeder 15, compacted, macerated chips are fed to the first stage refiner 16. Difficulties have arisen with uneven feed, however, because the compacted material tends to remain in lumps of various sizes. When the compacted chips are forced into the tube 17, the chips tend to drop at irregular intervals into the inlet of the first refiner stage, and this results in large fluctuations in the rate at which the chips reach the refiner. Consequently, there are corresponding fluctuations in refiner loading. The net

result is that pulp quality is not as uniform as would be desired.

To compensate for this irregular feeding, the mass of swollen, steamed wood chips is further broken up before the wood chips enter the tube 17. To accomplish this, an assembly of the type shown in Figs. 2 and 3 of the drawings may be used. The end of the plug screw feeder 15 terminates in a hollow frusto-conical portion 15a and an annular flange 15b. The flange 15b is connected by means of bolts 19 to a flange 20a of a hollow frusto-conical coupling section 20. This section has a marginal annular flange 20b which is secured by means of bolts 21 to a uniform diameter coupling section 22 having an annular flange 22a at one end abutting the flange 20b, and an annular flange 22b at the opposite end which is secured to an annular flange 17a of the tube 17.

In the plug screw feeder 15 there is a shaft 23 having screw conveyor flights 24 which move the steamed chips after rather severe compaction toward the tube 17 and ultimately into the first refiner stage 16.

The end of the shaft 23 is suitably recessed to provide space for accepting a sleeve type bearing 25 which receives a reduced diameter end portion 26a of a stub shaft which is positioned within a hollow extractor screw shaft 26. The opposite end of the hollow shaft 26 is secured by means of weld deposits 27 to a drive shaft 28 journaled for rotation within a bearing 29 and driven by a motor 30 through a speed reducer 31.

The hollow shaft 26 carries flights 32 of progressively increasing radius as shown in Figs. 2 and 3. In one preferred form of the present invention, the pitch of the screw flights 32 is larger than the pitch of the screw flights 24 of the feeding screws. Consequently, if the shafts 23 and 26 are rotated at the same speed, the flights 32 will tend to pull away the compacted material being delivered by the flights 24 at a greater rate of speed

than it is being delivered. This action tends to break up the mass of steamed wood chips into smaller particles which uniformly fall by means of gravity through the tube 17 and end up in the inlet conveyor 18 feeding the first refiner stage 16.

It is also possible to drive the shaft 26 at a greater speed than the shaft 23 in which case the pitch of the flights 32 and 24, respectively, can be the same. As a further alternative, the speed of the shaft 26 can be greater than the rotational speed of the shaft 23 and the flights 32 also have a longer pitch than the flights 24. The important thing is that the flights 32 provide a shredding action to break up the compressed mass being delivered by means of the plug screw feeder 15 into relatively small pieces.

The first stage refiner 16 operates at a pressure of about 20 to 30 psi gauge (138 to 552 KPa). The refiner itself is preferably a horizontal single disc refiner of the type available commercially from the Beloit Corporation under their trademark "Uni-Mount". Basically, this type of refiner has a single dynamically balanced disc driven by a synchronous or induction motor. During operation of the refiner, steam is generated and this steam can be conveniently used as a source for the steam in the line 13 by providing a conduit 34 extending from the pressurized tube 17 into the gate valve 14. The refined material leaves through a line 40.

The embodiment of the invention shown in Fig. 4 can also be employed satisfactorily. In this form of the invention, there is shown a shaft 35 forming part of the plug screw feeder and having flights 36 forcing the compacted mass to the right as shown in Fig. 4. The extractor screw makes use of a hollow shaft 37 which is coupled to the plug screw shaft 35 in the same manner as illustrated in Fig. 2. The flights 38 in the extractor screw, however, are oppositely oriented with respect to the flights 36, and the shaft 37

is driven in the opposite direction from the shaft 35. The shredding action still occurs as the material is delivered from the flights 36 into the flights 38.

With the system of the present invention, there are no stationary obstructions which would otherwise inhibit the movement of the compacted chip mass. The end of the extractor screw conveyor is supported by the end of the plug screw feeder. The lateral load on the extractor screw is not great and since the plug screw is of rigid construction and cantilevered into the compaction zone with a rigid bearing, it is possible for the extractor screw to be thus supported by the end of the plug screw.

In transferring the compacted steamed material from the plug screw into the tube, it is important that there be no abrupt changes in cross-sectional area through which the chip mass must pass. The beginning of the flights on the conveyor screw must have essentially a zero radial dimension at the transition with the feeding screw, as best illustrated in Fig. 3. Without this type of configuration on the end of the shaft, the leading edge of the flight on the extractor screw would be required to shear off a portion of the compacted mass which will require much more power to drive the extractor screw as well as subject it to much greater lateral loads.

It should be evident that various modifications can be made to the described embodiments without departing from the scope of the present invention.

CLAIMS:

1. The method of producing cellulosic pulp by the thermo-mechanical pulping method characterized in that it comprises:

contacting wood chips with gaseous steam at a temperature and for a time sufficient to bring the temperature of said chips close to that of said steam,

compacting the resulting steam treated chips while mechanically conveying the same to reduce the moisture content and produce a compacted moist mass,

shredding said compacted mass while further conveying the same under more severe conditions than the original conveying, and

passing the shredded mass into a refiner.

2. A method according to claim 1 characterized in that said chips are compacted at compaction ratios of at least 2.5 to 1 during the original conveying.

3. A method according to claim 1 characterized in that said shredded mass is subjected to free fall between the shredding and passing the shredded mass into a refiner.

4. A method according to claim 1 characterized in that said compacting occurs in the presence of pressurized steam and for a time sufficient to raise the temperature of said chips to at least the lignin softening point.

5. A method according to claim 1 characterized in that said contacting with gaseous steam occurs at ambient pressure conditions.

6. A method according to claim 1 characterized in that said steam treated chips are compacted to a moisture content at least as low as 30%.

7. An apparatus for compacting steam treated chips characterized in that it comprises:

first conveyor means receiving said chips and arranged to compress the same and reduce the moisture content of said chips as they are being conveyed,

a second conveyor means receiving the compressed

mass from said first conveyor means, said second conveyor means being arranged to shred said compressed mass into relatively small pieces, and

refiner means receiving said small pieces resulting from the shredding action of said second conveyor means.

8. An apparatus according to claim 7 characterized in that said first and second conveyor means are each worm-type conveyors which are coaxially mounted with said second conveyor means having one end received in the end of said first conveyor means.

9. An apparatus according to claim 7 characterized in that said first and second conveyor means are each worm-type conveyors operating coaxially with respect to each other, said second conveyor means having flights with a larger pitch than the flights of said first conveyor means.

10. An apparatus according to claim 7 characterized in that it includes means for driving said second conveyor means at a faster speed than said first conveyor means.

11. An apparatus according to claim 7 characterized in that it includes:

a tube receiving the discharge from said second conveyor means, and

means connecting said tube to said refiner means.

12. An apparatus according to claim 7 characterized in that said first and second conveyor means are each worm-type conveyors having oppositely oriented flights, and

means for driving said first conveyor means and said second conveyor means in opposite directions.

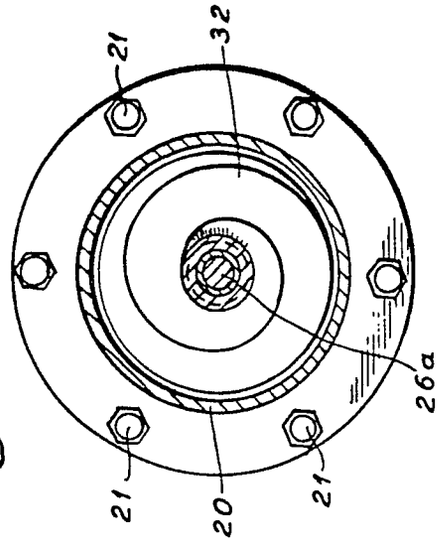

Fig. 3

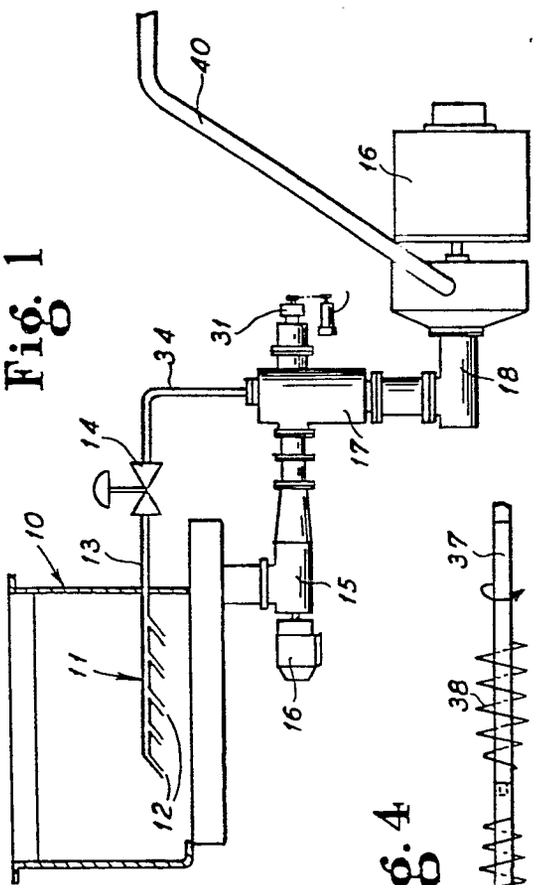

Fig. 1

Fig. 4

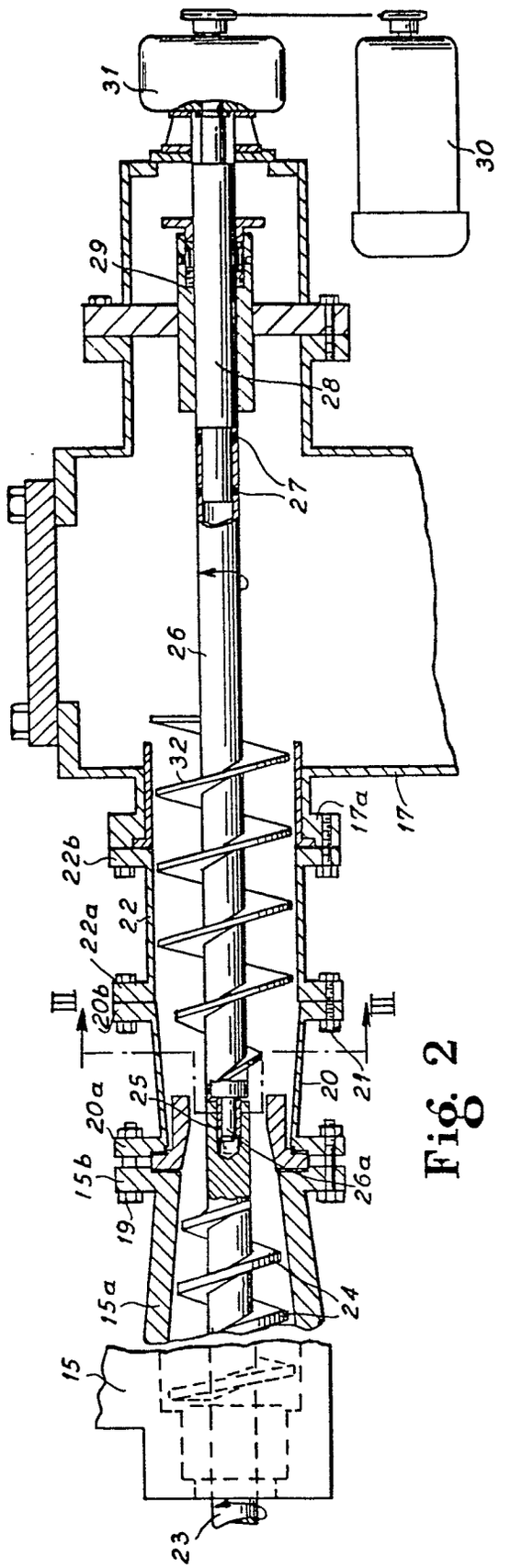

Fig. 2