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(54) Title: APPARATUS AND METHOD FOR DEWATERING A PAPER WEB

(57) Abstract

An apparatus and method is disclosed for dewatering a paper web. The apparatus includes a head box (12) capable of emitting a continuous, wet paper web (14). The wet paper web has an upper surface and a lower surface. A movable, closed loop forming fabric (16) contacts the lower surface of the wet paper web and conveys the paper web away from the head box. A movable, closed loop transfer fabric (28) contacts the upper surface of the wet paper web and cooperates with the forming fabric (16) to sandwich the paper web therebetween. The wet paper web, forming fabric and transfer fabric are passed through a first dewatering mechanism (34) to remove water therefrom. The wet paper web, forming fabric and transfer fabric are then routed through an air press (36) to remove additional water therefrom. The air press is positioned upstream of a location where the paper web is transferred to the transfer fabric. The method involves the steps of conveying the wet paper web, forming fabric and transfer fabric through the first dewatering mechanism and then through the air press before transferring the paper web onto the transfer fabric.
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APPARATUS AND METHOD FOR DEWATERING A PAPER WEB

FIELD OF THE INVENTION

This invention relates to an apparatus and method for dewatering a paper web. More specifically, this invention relates to an apparatus and method for dewatering a paper web using a combination of first dewatering mechanism and an air press to simultaneously dewater a paper web, forming fabric and transfer fabric.

BACKGROUND OF THE INVENTION

There are many characteristics of tissue products, such as bath and facial tissue, that must be considered in producing a finished product having the desirable attributes that make it suitable and preferred for its intended purpose. Improved softness of a product has long been one major objective which tends to separate premium products from generic products. In general, the two major components of softness include "high bulk", which is equated with low density, and a "lack of stiffness." As the bulk increases and the stiffness decreases, the product is perceived by the consumer as having improving softness.

In conventional paper making technology, a paper web emanating from a head box is generally supported and conveyed by a forming fabric and is then transferred to a movable, water attracting felt. The felt is capable of receiving water from the wet paper web as the web and felt are routed through a nip formed by a pressure roll and a Yankee dryer. At this nip, a substantial amount of the water present in the wet paper web is squeezed out and transferred to the felt. One disadvantage with this process is that the paper web is compressed at the nip and looses some of its bulk. In order to retain bulk, one can replace the felt with a transfer fabric. The transfer fabric will not acquire water from the paper web to the same extent as the felt, and therefore, the paper web will not be compressed as much. However, the transfer fabric will be wetted and will have to be dewatered at some point in the process.

Now an apparatus and method have been invented which allows for a wet paper web, forming fabric and transfer fabric to be dewatered simultaneously and in an economical manner.
SUMMARY OF THE INVENTION

Briefly, this invention relates to an apparatus and method for dewatering a paper web. The apparatus includes a head box capable of emitting a continuous wet paper web. The wet paper web has an upper surface and a lower surface. A movable, closed loop forming fabric contacts the lower surface of the wet paper web and conveys the wet paper web away from the head box. A movable, closed loop transfer fabric contacts the upper surface of the wet paper web and cooperates with the forming fabric to sandwich the wet paper web therebetween. The wet paper web, forming fabric and transfer fabric are passed through a first dewatering mechanism to remove water therefrom. The wet paper web, forming fabric and transfer fabric are then routed through an air press to remove additional water therefrom. The air press is positioned upstream of a location where the paper web is transferred to the transfer fabric.

The method of dewatering the wet paper web includes the step of emitting a continuous wet paper web from a head box. The wet paper web has an upper surface and a lower surface. The lower surface of the wet paper web is contacted by a movable, closed loop forming fabric and the wet paper web is conveyed away from the head box. The upper surface of the wet paper web is contacted by a movable, closed loop transfer fabric which cooperates with the forming fabric to sandwich the wet paper web therebetween. The wet paper web, forming fabric and transfer fabric are then passed through a first dewatering mechanism to remove water therefrom. The wet paper web, forming fabric and transfer fabric are then routed through an air press to remove additional water therefrom. The air press is positioned upstream of a location where the paper web is transferred to the transfer fabric.

The general object of this invention is to provide an apparatus and method for dewatering a paper web. A more specific object of this invention is to provide an apparatus and method for dewatering a paper web using a first dewatering mechanism and an air press and routing a wet paper web, forming fabric and transfer fabric sequentially through the first dewatering mechanism and air press.

Another object of this invention is to provide an apparatus and method for dewatering a paper web wherein the paper web, forming fabric and transfer fabric are all dewatered simultaneously.

A further object of this invention is to provide an efficient and economical way to dewater a paper web, forming fabric and transfer fabric at the same time.
Still another object of this invention is to provide an apparatus and method for dewatering a paper web which utilizes an air press and which substitutes a transfer fabric for the felt.

Still further, an object of this invention is to provide an apparatus and method for dewatering a paper web and a transfer fabric together which can be carried out with minimal changes to existing equipment.

Other objects and advantages of the present invention will become more apparent to those skilled in the art in view of the following description and the accompanying drawing.

**BRIEF DESCRIPTION OF THE DRAWINGS**

Fig. 1 is a schematic view of the apparatus and paper making process of this invention.

**DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT**

Referring to Fig. 1, a paper making schematic 10 is shown depicting the apparatus and method of this invention. The apparatus includes a head box 12 which delivers or emits a dilute slurry of fibers in the form of a continuous wet paper web 14 to a forming fabric 16. The wet paper web 14 is made up of cellulose fibers and water and has a ratio of about 100 pounds of water per pound of fibers when exiting the head box 12. The paper web 14 has an upper surface 18 and a lower surface 20. A forming zone 22 is positioned immediately downstream of the head box 12 and functions to reduce the water content of the wet paper web 14. The water content of the paper web 14 is reduced to less than about 15 pounds of water per pound of fiber, and preferably, to approximately 10 pounds of water per pound of fiber. In Fig. 1, the forming zone is depicted as including a suction breast roll 24.

The forming fabric 16 is movable and is configured as a closed loop which moves around the breast roll 24 as well as around a plurality of guide rolls 26, two of which are shown. One skilled in the paper making art will know that many guide rolls 26 are normally utilized in the loop of the forming fabric 16. The forming fabric 16 is positioned adjacent to the head box 12 and is designed to contact and support the lower surface 20 of the wet paper web 14. The forming fabric 16 also functions to convey the wet paper web 14 away from the head box 12. The apparatus further includes a transfer fabric 28
which contacts the upper surface 18 of the wet paper web 14 and cooperates with the forming fabric 16 to sandwich the wet paper web 14 therebetween. The transfer fabric 28 is also movable and is configured as a closed loop which moves around a pressure roll 30 and a plurality of guide rolls 32, six of which are shown. Again, one skilled in the paper making art will normally utilize more than six guide rolls 32 in the loop of the transfer fabric 28. The transfer roll 28 can be constructed of synthetic material such as thermoplastics. A preferred thermoplastic material is hydrolysis-resistant polyester. For enhanced fabric life, wear resistant materials such as nylon can be incorporated into the fabric. Other materials can also be used, such as polyphenylene sulfide and poly ether ether ketone, especially when extreme operating conditions (for example, high temperature) are encountered.

Various types of transfer fabrics each having different structures, weave and mesh patterns, hole geometry, etc. are commercially available today. One company which sells transfer fabrics which are suitable to practice this invention is Albany International Corporation having an office at P.O. Box 1907, Albany, New York 12201. A suitable forming fabric 16 is Albany International 94 M.

The apparatus 10 also includes a first dewatering mechanism 34 and a second dewatering mechanism 36. The first dewatering mechanism 34 is a non-compressive dewatering means and can consist of one or more steam boxes, one or more vacuum boxes, or a combination of at least one steam box and at least one vacuum box. In addition, the first dewatering mechanism 34 can be an air knife or a thermal device. Thermal devices include a conventional dryer, an infra-red dryer, one or more through dryers, a sonic dryer, a microwave oven, a superheated steam device, a saturated steam dewatering device, a supercritical fluid dewatering device, a displacement dewatering device, etc. The combination of two or more different kinds of devices, for example a thermal device and a mechanical device is anticipated by this invention as well as the combination of two or more different thermal devices.

It has been found that a steam box 38 aligned above one or more, and preferably two, vacuum boxes 40, works well. In Fig. 1, a single steam box 38 is shown being vertically arranged and slightly laterally offset from two vacuum boxes 40. The steam box 38 and the two vacuum boxes 40 cooperate to form a pathway 42 through which the wet paper web 14, the forming fabric 16 and the transfer fabric 28 pass. The first dewatering mechanism 34 is designed to reduce the amount of water in the wet paper web 16 from between about 10 to about 15 pounds of water per pound of fiber down to a range of about 2 to about 5 pounds of water per pound of fibers. This equates to a range
of consistency of from between about 9% to about 6% down to a range of consistency of from between about 33% to about 16%. Consistency is defined herein as "100 times (the pounds of fiber) divided by (the number of pounds of fiber plus pounds of water)". It should be noted that as the consistency value (percentage) decreases the ratio of "pounds of water per pound of fiber" increases.

Preferably, the first dewatering mechanism 34 will reduce the amount of water in the wet paper web 16 to a range of between from about 3 to about 4 pounds of water per pound of fiber. This equates to a range of consistency of from between about 25% to about 20%. More preferably, the first dewatering mechanism 34 will reduce the amount of water in the wet paper web 16 to a ratio of approximately 3.5 pounds of water per pound of fiber. This equates to a consistency value of about 22%. It should be noted that in the first dewatering mechanism 34, the wet paper web 14, the forming fabric 16 and the transfer fabric 28 are simultaneously dewatered. The action of the steam box 38 causes the water which is present on the transfer fabric 28 and in the wet paper web 16 to be more easily removed by increasing the temperature of the water. The action of the steam box 38 together with the suction force of the vacuum boxes 40 causes the water in the wet paper web 16 to be displaced or withdrawn into and through the forming fabric 16. The forming fabric 16 is a fine fabric compared to the transfer fabric 28 and is constructed of a material which is more acceptable to receiving water from the wet paper web 14 then is the transfer fabric 28.

One unique feature of the present invention is that all three layers, that is the wet paper web 16, the forming fabric 16 and the transfer fabric 28, are dewatered at the same time in a very efficient and economical manner. This simultaneous dewatering feature eliminates the need to separately dewater the transfer fabric 28 upstream of the first dewatering mechanism 34. However, if one wanted to use a preliminary dewatering mechanism, one could certainly do so but such is not necessary for carrying out this invention.

Immediately downstream of the first dewatering mechanism 34 is the second dewatering mechanism 36. The second dewatering mechanism 36 is a non-compressive dewatering means, for example, an air press 44 having a passageway 46 formed therethrough. The construction and function of an air press is taught in United States patent application having Serial Number 08/961,915 which was filed on October 31, 1997. This patent application is entitled: "AIR PRESS FOR DEWATERING A WET WEB" and is incorporated by reference and made a part hereof. A second United States patent application which also teaches an air press is Serial Number 08/647,508 which was filed
on May 14, 1998. This second patent application is entitled: "METHOD AND APPARATUS FOR MAKING SOFT TISSUE" and is also incorporated by reference and made a part hereof.

An air press 44 generally comprises an upper air plenum in combination with a lower collection device in the form of one or more vacuum or suction boxes. The wet paper web 14, the forming fabric 16 and the transfer fabric 28 form a sandwich which passes between the air plenum and the vacuum box. Pressurized air is supplied to the air plenum through air manifolds operatively connected to a pressurized fluid source such as a compressor or blower. The air plenum is fitted with a plenum cover which has a bottom surface that resides during use in close proximity to the vacuum box and in very close proximity to or in contact with the forming fabric 16. The plenum cover is formed with slots extending perpendicular to the machine direction across substantially the entire width of the wet paper web 14 but desirably slightly less than the width of the forming and transfer fabrics, 16 and 28 respectively, to permit passage of pressurized fluid from the air plenum through the two fabrics, 16 and 28, and through the wet paper web 14.

The vacuum box of the air press 44 is operatively connected to a vacuum source and fixedly mounted to a support structure. The vacuum box includes a cover having a top surface over which the forming fabric 16 travels. The vacuum box cover is formed with a pair of slots that correspond to the location of the slots formed in the plenum cover. The pressurized fluid dewater the wet paper web 14 as the pressurized fluid is drawn from the air plenum into and through the vacuum box.

The fluid pressure within the air plenum is desirably maintained at about 5 pounds per square inch (psi) (about 0.35 bar) or greater, preferably within the range of from between about 5 psi to about 30 psi (about 0.35 bar to about 2.07 bar), and more preferably, about 15 psi (about 1.03 bar). The fluid pressure within the air plenum is desirably monitored and controlled to a predetermined level. The temperature of the air is from between about 70°F (about 21°C) to about 200°F (about 93°C), preferably from between about 100°F (about 38°C) to about 200°F (about 93°C), and most preferably, from between about 140°F (about 60°C) to about 200°F (about 93°C). Depending on the equipment used to compress the air, the elevated temperature can be caused by the heat of compression or, alternately, the air can be heated as desired. However, the heated air does not need to be heated to an elevated temperature as is common in a thermal dryer, such as a Yankee dryer or a throughdrier, where the temperatures normally exceeds 300°F. Instead, the air press 44 can use room
temperature air of about 70°F (about 21°C) or, alternatively, hotter air that is first cooled down to approximately room temperature can be used.

The bottom surface of the plenum cover is desirably gently curved to facilitate control of the wet paper web 14. The surface is curved toward the vacuum box and curved about an axis disposed on the vacuum box side of the wet paper web 14. The curvature of the bottom surface allows a change in angle of the combination of the forming fabric 16, the wet paper web 14 and the transfer fabric 28 resulting in a net downward force that seals the vacuum box against the entry of outside air and supports the wet paper web 14 during the dewatering process. The angle of curvature allows the loading and unloading of the air press as required from time to time, based on process conditions. The change in angle necessary is dependent on the pressure differential between the pressure and vacuum sides and is desirably above about 5 degrees, and particularly within the range of about 5 to about 30 degrees, typically about 7.5 degrees.

The top and bottom surfaces of the air press 44 desirably have differing radii of curvature. In particular, the radius of curvature of the bottom surface is desirably larger than the radius of curvature of the top surface so as form contact lines between the air plenum and the vacuum box at the leading and trailing edges of the air press 44. With proper attention to the position of the forming fabric 16 and the transfer fabric 28 sandwich and loading and unloading mechanisms, the radii of curvature of these surfaces may be reversed.

The leading and trailing edges of the air press 44 may also be provided with end seals that are maintained in very close proximity to or in contact with the transfer fabric 28 at all times. The end seals minimize the escape of pressurized fluid between the air plenum and the vacuum box in the machine direction. Suitable end seals may be formed of low friction materials such as resilient plastic compounds. The materials forming the end seals preferentially wear relative to the two fabrics 16 and 28. The end seals desirably have curved edges to prevent snagging the fabrics.

The air press 44 is desirably provided with side seals to prevent the loss of pressurized fluid along the side edges of the air press 44. The side seals can include a semi-rigid material that is adapted to deform or flex slightly when exposed to the pressurized fluid of the air plenum. The side seals can define a slot for attachment to the vacuum box cover using a clamping bar and fastener or other suitable means. In cross-section, each side seal can be L-shaped with a leg projecting upward from the vacuum box cover into a side seal slot formed in the plenum cover. Pressurized fluid from the air plenum causes the legs to bend outward into sealing contact with the outward surface of
the side seal slot of the plenum cover. Alternatively, the position of the side seals could be reversed, such that they are fixedly attached to the plenum cover and make sealing contact with contact surfaces defined by the vacuum box cover. In any such alternative designs, it is desirable for the side seals to be urged into engagement with the sealing contact surface by the pressurized fluid.

The term "seal" is used herein to refer to the relationship between the air plenum and the wet web. The air plenum is operatively associated with and is in indirect contact with the web such that at least about 85 percent or more of the air fed to the air plenum flows through the web when the air plenum is operated at a pressure differential across the web of about 30 inches of mercury or greater.

Prior dewatering devices that merely positioned a steam blowing tube, a blowing nozzle or the like opposite a vacuum or suction box are not integrally sealed and are either unable to obtain comparable dewatering consistencies when operated at the same energy input, or require a significantly greater energy input to obtain the same dewatering consistency.

The air press is able to dewater cellulosic webs to very high consistencies due in large part to the high pressure differential established across the web and the resulting air flow through the web. In particular embodiments, for example, the air press can increase the consistency of the wet web by about 3 percent or greater, particularly about 5 percent or greater, such as from between about 5 to about 20 percent, more particularly, about 7 percent or greater, and most particularly, from between about 7 to about 20 percent. Thus, the consistency of the wet web upon exiting the air press is at least 33%, preferably at least about 37%, and most preferably, at least about 40%.

The pressure differential across the wet web provided by the air press may be about 25 inches of mercury or greater, such as from between about 25 to about 120 inches of mercury, particularly about 35 inches of mercury or greater, such as from between about 35 to about 60 inches of mercury, and more particularly from between about 40 to about 50 inches of mercury. This may be achieved in part by an air plenum of the air press maintaining a fluid pressure on one side of the wet web of greater than 0 to about 60 pounds per square inch gauge (psig), particularly greater than 0 to about 30 psig, more particularly about 5 psig or greater, such as from between about 5 to about 30 psig, and more particularly still, from between about 5 to about 20 psig. The collection device of the air press desirably functions as a vacuum box operating at 0 to about 29 inches of mercury vacuum, particularly 0 to about 25 inches of mercury vacuum, particularly greater than 0 to about 25 inches of mercury vacuum, and more particularly,
from between about 10 to about 20 inches of mercury vacuum, such as about 15 inches of mercury vacuum. The collection device desirably but not necessarily forms an integral seal with the air plenum and draws a vacuum to facilitate its function as a collection device for air and liquid. Pressure levels within both the air plenum and the collection device are desirably monitored and controlled to predetermined levels.

Significantly, the pressurized fluid used in the air press is sealed from ambient air to create a substantial air flow through the web, which results in the tremendous dewatering capability of the air press. The flow of pressurized fluid through the air press is suitably from between about 5 to about 500 standard cubic feet per minute (SCFM) per square inch of open area, particularly about 10 SCFM per square inch of open area or greater, such as from between about 10 to about 200 SCFM per square inch of open area, and more particularly, about 40 SCFM per square inch of open area or greater, such as from between about 40 to about 120 SCFM per square inch of open area. Desirably, about 95 percent or more of the pressurized fluid supplied to the air plenum is drawn through the wet web into the vacuum box. For purposes of the present invention, the term "standard cubic feet per minute" means cubic feet per minute measured at 14.7 pounds per square inch absolute and 60° F (16°C).

A key characteristic of the air press 44, as defined herein, is that substantially all of the air entering the plenum flows through the web 14. The aforementioned seals serve to prevent leakage to the extent that at least about 85% of the air flowing into the air press 44 actually flows through the web 14. It is this prevention of air leakage that distinguishes the air press 44 from prior art devices and which allows the process to operate economically while maintaining adequate machine speed.

A position control mechanism maintains the air plenum in very close proximity to the vacuum box and in contact with the transfer fabric 28. The position control mechanism can include a pair of levers connected by crosspieces and fixedly attached to the air plenum by suitable fasteners. The ends of the levers opposite the air plenum are rotatably mounted on a shaft. The position control mechanism also includes a counterbalance cylinder operably connecting a fixed structural support and one of the crosspieces. The counterbalance cylinder is adapted to extend or retract and thereby cause the levers to rotate about the shaft, which causes the air plenum to move closer to or further away from the vacuum box.

In use, a control system causes the counterbalance cylinder to extend sufficiently for the end seals to contact the transfer fabric 28 and the side seals to be positioned within the side seal slots. The air press 44 is activated such that pressurized fluid fills the
air plenum and the semi-rigid side seals are forced into sealing engagement with the plenum cover. The pressurized fluid also creates an upward force tending to move the air plenum away from the transfer fabric 28. The control system directs operation of the counterbalance cylinder to offset this upward force based on continuous measurements of the fluid pressure within the air plenum by the pressure monitoring system. The end seals are thereby maintained in very close proximity to or in contact with the transfer fabric 28 at all times. The control system counters random pressure drops or peaks within the air plenum by proportionately decreasing or increasing the force applied by the counterbalance cylinder. The air flow within the air press 44 may also be monitored.

Consequently, the end seals do not clamp the forming and transfer fabrics, 16 and 28 respectively, which would otherwise lead to excessive wear of the fabrics.

The above-identified air plenum and vacuum box can be mounted within a suitable frame structure. The frame structure can include upper and lower support plates separated by a plurality of vertically oriented support bars. The air plenum defines a chamber that is adapted to receive a supply of pressurized fluid through one or more suitable air conduits operatively connected to a pressurized fluid source. Correspondingly, the vacuum box defines a plurality of vacuum chambers that are desirably operatively connected to low and high vacuum sources by suitable fluid conduits. The water removed from the wet paper web 14 is thereafter separated from the air streams and removed.

It should be noted that the pressurized air stream in the air press 44 will force the water in the transfer fabric 28 downward into the wet paper web 14. This water is then withdrawn or removed from the wet paper web 14 and enters the forming fabric 16 by the combination of pressurized air and vacuum. From the forming fabric 16, the water is removed and withdrawn from the air press 44. The dewatering or drying of the transfer fabric 28, the paper web 14 and the forming fabric 16 occur simultaneously.

As mentioned earlier, the wet paper web 14 will enter the second dewatering mechanism 36 with a ratio of from between about 2 to about 5 pounds of water per pound of fiber. This equates to a consistency of from between about 33% to about 16%. Upon leaving the second dewatering mechanism 36, the wet paper web 14 will have a ratio of from between about 1.5 to about 2 pounds of water per pound of fiber. This equates to a consistency of from between about 40% to about 33%. Preferably, the wet paper web 14 will have a ratio of about 1.8 pounds of water per pound of fiber or a consistency of about 36%. Most preferably, the wet paper web 14 will have a ratio of about 1.7 pounds of water per pound of fiber or a consistency of about 37%. Even more preferably, the wet
paper web 14 will have a ratio of less than about 1.5 pounds of water per pound of fiber or a consistency of about 40%.

As previously mentioned, it is the integral sealing of the air press 44, wherein substantially all of the air fed to the pressure plenum flows through the web 14, that allows the consistency of the web 14 leaving the air press 44 to have a value of from between about 33% to about 40% when the equipment is run at commercial speed with acceptable energy consumption. Commercial speed are normally in the range of from about 2,000 to about 10,000 feet per minute (ft/min), preferably from between about 3,000 to about 7,000 ft/min, and most preferably, greater than about 3,500 ft/min.

Maintenance of this consistency allows commercial operation of the tissue machine as it is well-known that a strong relationship exists between the consistency of the web as it is transferred to the Yankee dryer and the machine speed that can be maintained. Many tissue machines are "dryer limited" in that the ability to dry the web 14 to the required dryness at the creping blade determines the speed of the machine. When using non-thermal, non-compressive dewatering technologies, it is very difficult to maintain machine speed while controlling energy cost. The integrally sealed air press 44, as described herein, allows essentially the same machine speed as achievable with standard wet-pressed machine (with a given Yankee dryer system) while operating at a cost that is offset by the achievable basis weight reduction associated with the use of non-compressive dewatering rather than the traditional pressure roll.

A major constraint to maximizing the consistency after the second dewatering mechanism 36 (i.e. the air press 44) is the water carried back by the transfer fabric 28. The transfer fabric 28 carries the web 14 to the Yankee dryer 52 and goes through the pressure roll nip 50. As a result, the transfer fabric 28 becomes contaminated with fiber and any chemicals added to the fiber such as wet or dry strength chemicals, and needs to be cleaned, generally on a continuous basis.

To clean the transfer fabric 28, showers, including flooded nip, scarfing and/or high pressure cleaning showers are used. This showering technique, well known in the industry, is effective in removing the fiber and chemicals from the transfer fabric 28, but leaves the transfer fabric 28 carrying significant amounts of water in the interstices of the transfer fabric 28. The amount of water carried in the transfer fabric 28 varies tremendously with the fabric type, but can easily exceed 100 grams per square meter (gsm) of fabric area. If not removed, this water will transfer back into the wet web 14 via capillary forces when the transfer fabric 28 and the wet web 14 come into contact at or before the pick-up shoe (or roll).
To solve this problem, a transfer fabric dewatering system can be installed (a means for blowing air through the fabric such as an air knife as described in U. S. patent 5,230,776 entitled: "PAPER MACHINE FOR MANUFACTURING A SOFT CREPE PAPER WEB" which issued on July 27, 1993 and is assigned to Valmet Paper Machinery, Inc. and European Patent Application 0,526,592 B1 entitled: "PAPER MACHINE FOR THE MANUFACTURE OF HIGH BULK SOFT CREPE PAPER" which published April 5, 1995 and is assigned to Valmet-Karlstad AB. These systems can be used to remove some of the water from the transfer fabric 28 prior to contact with the wet web 14. In general, despite the expenditure of considerable energy to dewater the transfer fabric 28, 10 gsm of water or more can remains in the transfer fabric 28. It is highly improbable that either of the two above-identified patented systems can operate at speeds in excess of about 3,000 ft/min and at a consistency of greater than about 30%.

However, by having the transfer fabric 28 run through the first dewatering means 34 and the air press 44, the first dewatering means 34 and the air press 44 can simultaneously dewater the transfer fabric 28 as well as the wet web 14. This will save energy and/or increase the speed of the machine if it is dryer limited. In this manner, the transfer fabric dewatering system can be minimized, and/or eliminated, so that the energy used to dewater the transfer fabric 28 can be saved.

Referring again to Figure 1, the apparatus 10 includes a transfer shoe 48 positioned downstream of the second dewatering mechanism 36. The transfer shoe 48 functions to separate the paper web 14 from the forming fabric 16. Another way of stating this is to say that the transfer shoe 48 transfers the paper web 14 onto the transfer fabric 28 such that it is free of the forming fabric 16. The construction and operation of the transfer shoe 48 is known to those skilled in the paper making art.

After leaving the transfer shoe 48, the paper web 14 and the transfer fabric 28 are guided around the rotatable pressure roll 30 and through a nip 50 formed by the contact of the pressure roll 30 against a Yankee dryer 52. Since the paper web 14 preferentially contains less than about 2 pounds of water per pound of fibers and since the paper web 14 has a low density and a low basis weight, no additional dewatering is necessary at the nip 50. This means that the paper web 14 will have sufficient bulk so as to exhibit superior softness and can be sold as a preferred product, be it toilet tissue, facial tissue, etc. The paper web 14 will pass around the outer circumference of the Yankee dryer 52 after leaving the nip 50 and will be dried in the conventional fashion using thermal energy.
Referring again to Figure 1, one will notice a cleaning mechanism 54 is present in the closed loop of the transfer fabric 28. The cleaning mechanism 54 is designed to be positioned adjacent to the moving transfer fabric 28 and functions to remove contaminants therefrom. A high pressure shower of water can be directed to impinge upon the transfer fabric 28 and loosen and remove contamination. Preferably, pressurized water is sprayed onto and through the transfer fabric 28 so as to remove any fibers or cellulose particles that may be present. The type of spray nozzles, nozzle tips, pressure levels, etc., as well as the use of high pressure needle showers with oscillating spray patterns, are well known in the paper making art. After using pressurized water to remove the contaminants, an air knife or some similar type of equipment can be used to partially dewater or partially dry the transfer fabric 28. As stated earlier, this is not necessary but can be employed depending upon the type of fabric one uses and the efficiency of the first and second dewatering mechanisms, 34 and 36, respectively.

It should also be mentioned that the multiple guide rolls 32 present in the closed loop of the transfer fabric 28 aid in routing the transfer fabric 28 pass the cleaning mechanism 54 and through the first and second dewatering mechanisms, 34 and 36 respectively. The placement and position of the various guide rolls 32 will be decided by the length of the loop of the transfer fabric 28, the amount of equipment cooperating with the loop of the transfer fabric 28, the speed of the overall paper making machine, as well as other variables known to those skilled in the paper making art.

METHOD

Referring again to Figure 1, the method of dewatering the wet paper web 14 is easily understood by following the progression of the wet paper web 14 through the paper making apparatus 10. Starting at the left of the diagram, one will notice that a continuous wet paper web 14 is emitted from the head box 12. The wet paper web 14 has an upper surface 18 and a lower surface 20. Immediately downstream of the head box 12 is a suction breast roll 24 which serves to remove a large quantity of water from the wet paper web 14. This water removal occurs when the lower surface 20 of the wet paper web 14 contacts the movable, closed loop forming fabric 16. The forming fabric 16 also functions to convey the wet paper web 14 away from the head box 12. Within a short distance of the exit of the head box 12, the upper surface 18 of the wet paper web 14 is contacted by the movable, closed loop transfer fabric 28. The transfer fabric 28 cooperates with the forming fabric 16 to sandwich the wet paper web 14 therebetween.
The three layer sandwich consisting of, from top to bottom, the transfer fabric 28, the wet paper web 14 and the forming fabric 16 are routed through the first dewatering mechanism 34. The first dewatering mechanism 34 can consist of a steam box 38 vertically arranged relative to one or more vacuum boxes 40. A pathway 42 passes between the steam box 38 and the vacuum box 40 and provides the opening through which the three layer sandwich can be routed. In the first dewatering mechanism 34, water is simultaneously removed or withdrawn from the transfer fabric 28 and passes into the wet paper web 14. Likewise, the water in the wet paper web 14 is removed or withdrawn into the forming fabric 16 and then out of the forming fabric 16. Gravity, along with the pressurized air and suction keep the water flowing downward and out of the three layers. The wet paper web 14 along with the two fabrics, 16 and 28, are immediately passed into a second dewatering mechanism 36. The second dewatering mechanism 36 is preferably an air press 44 which functions to remove or withdraw additional water from the wet paper web 14 as well as from the two fabrics 16 and 28. In the air press 44, water is again simultaneously removed or withdrawn from the transfer fabric 28 and passes into the wet paper web 14. Likewise, the water in the wet paper web 14 is removed or withdrawn and passes into the forming fabric 16 and then out of the forming fabric 16.

After exiting the air press 44, the paper web 14 and the two fabrics 16 and 28 are directed past the transfer shoe 48 wherein the paper web 14 is separated from the forming fabric 16. The paper web 14 and the transfer fabric 28 are then guided around the rotatable pressure roll 30 which is positioned downstream of the transfer shoe 48. The paper web 14 and the transfer fabric 16 are then passed through the nip 50 formed by the rotatable Yankee dryer 52 and the pressure roll 30. At this point, the paper web 14 is transferred onto the Yankee dryer 52 and is thermally dried while the transfer fabric 28 is routed to a cleaning mechanism 54 where contamination is removed. Since no appreciable compression occurs at the nip between the pressure roll 30 and the Yankee dryer 50, the paper web 14 does not loose it's bulk. This increased bulk gives the finished product a greater softness than can be achieved using a conventional process wherein a paper web would be compressed between the pressure roll 30 and the Yankee dryer 50 using a felt instead of a transfer fabric.

While the invention has been described in conjunction with a specific embodiment, it is to be understood that many alternatives, modifications and variations will be apparent to those skilled in the art in light of the foregoing description. Accordingly, this invention is intended to embrace all such alternatives, modifications and variations which fall within the spirit and scope of the appended claims.
We claim:

1. An apparatus for dewatering of a paper web comprising:
   a) a head box capable of emitting a continuous paper web, said paper web having an upper surface and a lower surface;
   b) a movable, closed loop forming fabric contacting said lower surface of said paper web and conveying said paper web away from said head box;
   c) a movable, closed loop transfer fabric contacting said upper surface of said paper web and cooperating with said forming fabric to sandwich said paper web therebetween;
   d) first dewatering means for removing water from said paper web, from said forming fabric and from said transfer fabric; and
   e) an air press capable of removing water from said paper web, from said forming fabric and from said transfer fabric, said air press positioned upstream of a location where said paper web is transferred to said transfer fabric.

2. The apparatus of claim 1 wherein said air press is integrally sealed such that at least about 85% of the air flowing into said air press flows through said web.

3. The apparatus of claim 1 wherein said web exiting said air press has a consistency of at least about 33%.

4. The apparatus of claim 3 wherein said web exiting said air press has a consistency of at least about 37%.

5. The apparatus of claim 4 wherein said web exiting said air press has a consistency of at least about 40%.

6. The apparatus of claim 1 wherein said first dewatering means and said air press function to displace water from said transfer fabric to said paper web, from said paper web to said forming fabric and then out of said forming fabric.

7. The apparatus of claim 1 wherein the ratio of pounds of water to pounds of fibers in said web existing said air press is from between about 1.5:1 to about 2:1.
8. The apparatus of claim 7 wherein said web existing said air press has a ratio of pounds of water to pounds of fibers of about 1.7:1.

9. The apparatus of claim 8 wherein said web existing said air press has a ratio of pounds of water to pounds of fibers of about 1.5:1.

10. An apparatus for dewatering of a paper web comprising:
    a) a head box capable of emitting a continuous paper web, said paper web having an upper surface and a lower surface;
    b) a movable, closed loop forming fabric positioned adjacent to said head box, said forming fabric contacting and supporting said lower surface of said paper web and conveying said paper web away from said head box;
    c) a movable, closed loop polyester transfer fabric contacting said upper surface of said paper web and cooperating with said forming fabric to sandwich said paper web therebetween;
    d) first dewatering means for removing water from said paper web, from said forming fabric and from said transfer fabric; and
    e) an air press capable of removing water from said paper web, from said forming fabric and from said transfer fabric, said air press positioned upstream of a location where said paper web is transferred to said transfer fabric, and said air press being integrally sealed such that at least 85% of the air flowing into said air press flows through said web.

11. The apparatus of claim 10 wherein said air press has an air flow therethrough which is at a temperature of from between about 70°F to about 200°F.

12. The apparatus of claim 11 wherein said air press has an air flow therethrough which is at a temperature of from between about 100°F to about 200°F.

13. The apparatus of claim 12 wherein said air press has an air flow therethrough which is at a temperature of from between about 140°F to about 200°F.

14. The apparatus of claim 10 wherein said forming fabric, said transfer fabric and said web are all routed through said first dewatering means and then through said air
press to cause both to be simultaneously dewatered while using a minimum amount of energy.

15. An apparatus for dewatering of a paper web comprising:
   a) a head box capable of emitting a continuous paper web, said paper web having an upper surface and a lower surface;
   b) a movable, closed loop forming fabric contacting said lower surface of said paper web and conveying said paper web away from said head box;
   c) a movable, closed loop transfer fabric contacting said upper surface of said paper and cooperating with said forming fabric to sandwich said paper web therebetween;
   d) a steam box and at least one vacuum box cooperating to form a pathway through which said paper web, forming fabric and transfer fabric pass, said steam box and said at least one vacuum box withdrawing water from said paper web, forming fabric and transfer fabric;
   e) an air press positioned downstream of said steam box and at least one vacuum box and having a passageway formed therein through which said paper web, forming fabric and transfer fabric pass, said air press withdrawing additional water out of said paper web, forming fabric and transfer fabric;
   f) a transfer shoe positioned downstream of said air press which transfers said paper web onto said transfer fabric;
   g) a rotatable pressure roll positioned downstream of said air press and around which said transfer fabric and paper web is guided; and
   h) a rotatable Yankee dryer cooperating with said pressure roll to form a nip therebetween through which said transfer fabric and said paper web pass.

16. A method of dewatering of a paper web, said method comprising the steps of:
   a) emitting a continuous paper web from a head box, said paper web having an upper surface and a lower surface;
   b) contacting said lower surface of said paper web with a movable, closed loop forming fabric and conveying said paper web away from said head box;
   c) contacting said upper surface of said paper web with a movable, closed loop transfer fabric which cooperates with said forming fabric to sandwich said paper web therebetween;
   d) passing said paper web, forming fabric and transfer fabric through a first dewatering means to remove water therefrom; and
e) routing said paper web, forming fabric and transfer fabric through an air press to remove additional water therefrom, said air press positioned upstream of a location where said paper web is transferred to said transfer fabric.

17. The method of claim 16 wherein said water is simultaneously removed from said paper web, forming fabric and transfer fabric at said first dewatering means.

18. The method of claim 16 wherein said water is simultaneously removed from said paper web, forming fabric and transfer fabric at said air press.

19. A method of dewatering of a paper web, said method comprising the steps of:
   a) emitting a continuous paper web from a head box, said paper web having an upper surface and a lower surface;
   b) contacting said lower surface of said paper web with a movable, closed loop forming fabric and conveying said paper web away from said head box;
   c) contacting said upper surface of said paper web with a movable, closed loop polyester transfer fabric which cooperates with said forming fabric to sandwich said paper web therebetween;
   d) passing said paper web, forming fabric and transfer fabric through a first dewatering means to remove water therefrom; and
   e) routing said paper web, forming fabric and transfer fabric through an air press to remove additional water therefrom, said air press positioned upstream of a location where said paper web is transferred to said transfer fabric, and said air press being integrally sealed such that at least 85% of the air flowing into said air press flows through said web.

20. A method of dewatering of a paper web, said method comprising the steps of:
   a) emitting a continuous paper web from a head box, said paper web having an upper surface and a lower surface;
   b) contacting said lower surface of said paper web with a movable, closed loop forming fabric and conveying said paper web away from said head box;
   c) contacting said upper surface of said paper web with a movable, closed loop transfer fabric which cooperates with said forming fabric to sandwich said paper web therebetween;
d) routing said paper web, forming fabric and transfer fabric between a steam
box and at least one vacuum box to withdraw water from said paper web, forming fabric
and transfer fabric;

e) passing said paper web, forming fabric and transfer fabric through an air
press to withdraw additional water out of said paper web, forming fabric and transfer
fabric;

f) using a transfer shoe positioned downstream of said air press to transfers
said paper web onto said transfer fabric;

g) guiding said transfer fabric and paper web around a rotatable pressure roll
positioned downstream of said transfer shoe; and

h) passing said transfer fabric and said paper web through a nip formed by a
rotatable Yankee dryer and said pressure roll.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7  D21F11/14

B. FIELDS SEARCHED
Minimum documentation searched (classification system followed by classification symbols)
IPC 7  D21F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic database consulted during the international search (name of database and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
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<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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<td>A</td>
<td>WO 97 43484 A (KIMBERLY-CLARK WORLDWIDE INC.) 20 November 1997 (1997-11-20)</td>
<td>1,2, 15-20</td>
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Further documents are listed in the continuation of box C. Patent family members are listed in annex.

Date of the actual completion of the international search
3 May 2000

Date of mailing of the international search report
15/05/2000

Name and mailing address of the ISA
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