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DRYING OF FIBROUS, POROUS COATING BASE WET MATERIAL BY PERCOLATION OF HOT GAS THERETHROUGH

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ABSTRACT OF THE DISCLOSURE

Improved quality is imparted to fibrous web materials used as base stock for saturating and coating applications by employing production conditions that eliminate nonuniform and preferential shrinkage and the tendency of the open fibrous webs to develop discrete stress areas in the form of cockles and puckers. The process has particular advantage for base stock of low densimeter value, such as a value of less than 1 sec./100 ml. and preferably less than 0.1 sec./100 ml., as measured by TAPPI test method T 460 os–68 and involves the percolation of gases through the wet web material as it is held by the gases in a restrained condition on a single foraminous support during drying until its moisture content is reduced to a level of about 8 percent by weight and less.

BACKGROUND AND SUMMARY OF THE INVENTION

The present invention relates generally to open or porous fibrous web materials. More particularly, it is concerned with new and improved saturating and coating base materials having improved appearance and performance characteristics and with a new and improved method for their manufacture.

Heretofore it has been the practice in the paper industry to produce continuous nonwoven webs of open or porous paper stock for subsequent conversion to mimeograph stencil, food casing, packaging tape and similar products by saturating or coating the upper stock with aqueous or non-aqueous treating materials. Such paper stock or base web materials have been produced in a conventional papermaking manner by forming continuous fibrous webs from dilute aqueous dispersions of the fibers, that is, by using a wet or water-laid process. The wet webs formed in this manner conventionally have a water content exceeding 65 percent by weight and are dried (to a water content of less than about ten percent by weight) on a series of drying cans or drums prior to the subsequent coating operation required to form the desired end product.

Although visual inspection of the dried base webs generally fails to detect any surface imperfections, it has been found that these webs exhibit numerous surface defects such as cockles, puckers or ripples which appear in varying degrees and exhibit irregular and nonuniform acceptance of the treating or coating material when this base or stock material is subsequently used as a saturation or coating base. The cockles and puckers are considerably more pronounced in the open or highly porous, lightweight or tissue web materials of low densimeter value and consequently cause considerable concern within the coating industry, especially when used for mimeograph stencil and other multi-coated products. These irregularities become particularly objectionable where different colors are used for each coating of a multiple coating operation.

Since the irregularities are not readily apparent in the base stock material upon manufacture but only become prominent when the stock material is saturated

or subjected to the coating operations, it is difficult to determine whether a commercial run of continuous base stock material will produce the desired end results without extensive testing of each individual machine run.

It has also been known heretofore that variations in a web's degree of elongation can undesirably affect certain applications, such as food casing and the like. Casings are made by multiple saturation or coating operations and generally are produced by slicing the long base web materials into longitudinal strips that are then formed into long cylinders and coated with viscose. As will be appreciated, some cylinders are formed from edge portions of the base web while others are formed from the center or intermediate portions thereof. Consequently, unless the base web possesses a substantially uniform or nonvarying transverse elongation profile across the width of the web, tubes or cylinders made from the center portions will vary substantially from those taken from the edge portions. As a result of this variation it has frequently been the practice to use only the center portion of the base web, discarding the edge portions and thereby increasing the ultimate cost of the product.

Accordingly, it is a primary object of the present invention to provide a new and improved coating base or stock material having improved product quality particularly in its appearance and performance characteristics when subjected to saturation and coating operations thereby resulting in an improved appearance in the end product and the ability to utilize a larger proportion of the coating base or stock material produced.

Another object of the present invention is to provide a coating base of the type described that provides uniform acceptance of the treating material, and does not exhibit puckers or cockles, does not promote streaking upon saturation or coating with aqueous or nonaqueous s turants or coatings and exhibits an improved transverse elongation profile, that is, greater uniformity of elongation as measured at transversely spaced locations across the water-laid web.

A further object of the present invention is to provide a new and improved method of producing open web materials of the type described by the use of processing conditions that obviate the development of stress areas in the web and the resultant irregularities heretofore evidenced upon saturation or coating.

A still further object of the present invention is to provide a new and improved method for producing continuous webs of the type described utilizing a wet papermaking process that assures complete drying of the web material in an uninterrupted restrained condition thereby imparting to the web material improved appearance and performance characteristics. Included in this object is the provision for a method of drying porous tissue web material of low densimeter value to a water content of about 8 percent by weight and less by means of a single through drying unit capable of restrainably holding the web material during its entire drying cycle.

Other objects will be in part obvious and in part pointed out in more detail hereinafter.

These and related objects are accomplished in accordance with the present invention by utilizing operating conditions that eliminate web stress areas susceptible of evidencing cockle and pucker surface defects before or after impregnation. Since, in accordance with the present invention, these stress areas are believed to be caused by nonuniform and preferential shrinkage during drying, a procedure is employed for drying the base stock material to a moisture content of about 8 percent by weight and less in a continuous uninterrupted manner under restrained conditions, preferably by means of the percolation of gases through the web material as it is held in its restrained condition. The process has particular advantage for coat-

ing base stock of high porosity and low densimeter value, such as a value of less than 1 sec./100 ml. and preferably less than 0.1 sec./100 ml., as measured by TAPPI test method T 460 os–68, since the irregularities evidenced heretofore are far more pronounced on such base stock material.

A better understanding of the objects, advantages, features, properties and relationships of the invention will be obtained from the following detailed description which sets forth certain illustrative embodiments and is indicative of the way in which the principles of the invention are employed.

DESCRIPTION OF PREFERRED EMBODIMENT

For ease of illustration and clarity of understanding the present invention will be described in connection with stencil tissue. However, it will be appreciated that other high porosity paper webs such as base paper for casing, tape and the like can also be advantageously produced in accordance with the present invention and are included within the principles and concepts described herein.

Briefly described, the end product, such as a stencil tissue, is comprised of a fibrous base stock material of light weight, porous, substantially lintless and highly absorbent character. The stock is preferably fabricated of extremely long, nonhydrated, natural fibers from a highly dilute aqueous suspension or dispersion of such fibers and is formed into a lightweight web on a papermaking machine such as the inclined wire type apparatus described in Osborne U.S. Pat. No. 2,045,095. The base tissue, having the requisite characteristics, is dried and then coated by a suitable method such as, for example, roller coating, fountain coating, spray coating or the like, with a composition that is displaceable when acted upon by a typewriter, stylus or the like to form openings or passages in the coating through which ink may be transmitted. The base tissue web must not only exhibit excellent flexibility and strength but should provide a stencil sheet having ease and cleanliness of stencilization coupled with resistance to fiber rupture by the typewriter key or stylus and resistance to reaction with the particular ink employed.

Typical of the stencil base tissue produced heretofore are the papers described in Osborne U.S. Pat. No. 2,045,096. However, as will be appreciated, the particular web material will vary in physical characteristics and in composition depending on its ultimate intended use. For the purposes of this invention, only those fibrous web materials having a densimeter value of less than 1 sec./100 ml. as measured by TAPPI test method T 460 os–68 will be considered.

The stencil papers of the aforementioned Osborne patent, U.S. 2,045,096, exhibit this low densimeter value and are comprised of vegetable fibers of the Musa family such as abaca or Manila hemp fibers. These fibers are substantially uniform in length and of greater length than many other conventionally employed papermaking fibers, varying from about 4 to 7 mm. in length and being substantially free of the minute fibers which tend to produce lint in the finished tissue paper. The fibers are relatively cylindrical, are slightly tapered and have little tendency to curl or twist when suspended in a highly dilute fiber dispersion. These "low fluidity" fibers have a fiber diameter of less than about 30 microns and a length to diameter ratio between about 300 and 400. The maximum fiber diameter is about 30 microns and may be as low as 5 to 7 microns. The preferred fiber length is about 5 mm. for a fiber having a diameter of about 18 microns.

Although the preferred fiber content for stencil base webs is 100% abaca fibers, these fibers can be admixed with various proportions of other natural or man-made fibers, the fiber selection depending only on the desired end use. For example natural fibers including but not limited to jute, caroa, sisal or various wood pulps such as bleached or unbleached kraft may be used, as may synthetics such as rayon, nylon, polyester or vinyl copolymers and the like.

The fiber content of other coating base materials includes not only those fibers mentioned hereinbefore but also other suitable natural or synthetic fibers either alone or in admixture. In fact the teachings of the present invention can be beneficially employed with fibrous webs containing up to 100 percent synthetic fibers such as rayon.

Although the materials produced from the aforementioned fibers are generally of high permeability, it is the open fibrous structure and particularly the low densimeter value of the web materials that is of principal importance for optimum utilization of the beneficial properties of the present invention. Typical examples of the properties of various base webs for stencil, casing, tape and cushioning media are set forth below.

	Stencil	Casing	Tape	Cushioning
Basis wt. (grams/sq. meter)	11.7	25.0	35.8	258
Gurley permeability (c.f.m./ft.² at ½" water pressure drop)	601	266	7.6	92.4
Densimeter * (sec./100 ml.)	.06	.08	.60	.11

* Using no sheet, the time required to push 100 ml. of air through 1 square inch orifice is 0.05 sec.

The fibers employed in making the web material are dispersed in conventional fashion in a highly dilute aqueous solution. The extremely large proportion of water in the dispersion facilitates free and rapid flow through the moving inclined screen of the papermaking machine leaving the fibers deposited on the screen in the form of an extremely wet, fibrous paper web, that is, a web having a water content substantially higher than about 65 percent by weight. Alternatively, the fibers might be dry laid to form webs that are subsequently treated in a "wet back" fashion to obtain the desired web strength when dried. In such instances the amount of water in the web is generally below that amount normally present in water laid webs as formed prior to being dried.

As mentioned, when the wet web was dried on standard steam-heated dryer cans to reduce the water content to about five percent by weight and less, the dried web frequently possessed randomly distributed surface defects that usually went undetected until the subsequent coating operation used in forming the stencil sheets. These defects have been termed "cockles" and "puckers." The cockles generally take the form of uniform closely spaced undulations or ripples disposed along the machine direction of the web. The ripples are of varying length but usually average about ½ inch in length and occur in randomly distributed groups, primarily near the edges of the web material, but at times covering the entire cross dimension of the web. The puckers can be generally categorized as large cockles randomly spaced throughout the sheets, yet they still are difficult to detect as the material comes directly from the dryer section of the conventional papermaking machine. As can be appreciated, these defects or imperfections in the web material have constituted an almost constant customer complaint over the years.

It has been speculated heretofore that the cockles and ripples result from the use of excessive and/or variable heat in the drying operation and some reduction in their quantity has been achieved by closely controlling the temperature in the dryer section of the papermaking machine. However, the use of heated drums having a lower temperature necessarily requires an excessively long drying section and drying time and tends to render impractical the use of such techniques.

In accordance with the present invention it is believed that the imperfections result from nonuniform and preferential shrinkage of the web during the drying operation, and that the maintenance of the web in a continuously restrained condition during a through drying operation will eliminate these undesirable stress areas. The uninterrupted drying involves subjecting the wet web to a percolating or

through drying technique whereby air is passed through the web as it is continuously held against a foraminous support. The process utilized for accomplishing this restrained and uninterrupted drying condition preferably is applied to the wet web material as it comes from the wet end of the papermaking machine before the water content of the web has been reduced to a level below about 65 percent by weight. However, utilization of this technique on webs rewet to a moisture content of about 50 percent by weight has also proved beneficial.

It is believed that two major effects take place during the drying operation and are optimized in through drying. These effects are the transfer of heat to the substance being dried and the mass transfer of the evaporated vapors away from the substance being dried. As discussed in U.S. Pat. No. 3,345,756, these are accomplished in through drying by subjecting the material to the percolation of hot gasses therethrough by means of a difference in pressure between the two surfaces of the material while simultaneously heating the material by radiation of convection means. This through drying technique has been used heretofore on fibrous web materials such as kraft paper, toweling, newsprint and board corrugated stock. However, its advantageous features have gone unrecognized with respect to open fibrous web materials used as coating base stock and having the extremely low densimeter values mentioned hereinbefore. Additionally, prior published reports have failed to indicate a necessity for maintaining the web materials in an uninterrupted and continuously restrained condition during the entire drying operation until the web had become stabilized, i.e., during the reduction in moisture content of the web from a level of at least about 50 percent down to about 8 percent and less by weight.

It is essential in accordance with the present invention that the restrained conditions be maintained in a continuous and uninterrupted manner as the web is dried from a moisture level above which fiber shrinkage is initiated to a moisture content at or below which the web has become stabilized. For water laid web material this range falls between about 50 percent and about 8 percent by weight moisture. Even the passing of a partially dried web from one through dryer to a second through dryer with a minimum distance of travel therebetween would be ineffective in completely eliminating the puckers and cockles from the tissue web materials of low densimeter values if significant drying or fiber shrinkage were permitted to occur in an unrestrained condition of the web between the two drying units. Additionally, partial drying of the web, that is drying to a level below about 50 percent but substantially higher than about 10 percent by weight, by means of a thorough drying system followed by conventional drying to completion has also been found inadequate to produce the desired effect of the present invention. As can be appreciated, such partial drying is, in effect, merely a first drying step of an interrupted drying operation.

In recent years many different dryer structures have been proposed for accomplishing the through drying technique. These have all essentially emphasized an improved efficiency of operation in that they occupy less floor space and can reduce the costly capital equipment and maintenance associated with conventional drum drying systems while at the same time providing increased speed of operation and lower cost. These various devices operate under the same basic principle of passing hot or cold air upon or through the web being dried in an attempt to disperse the stagnant layer of moist air believed present in conventional dryer systems. At the same time the kinetic energy of the air is utilized to remove free water from the pores of the paper while opening continuous passages through the thickness or "z" direction of the web material to facilitate removal of water from the interior thereof by percolation and concurrent mass transfer. As can be appreciated, this technique also eliminates localized thermal gradients or hot spots in the web or the formation of gas pockets between the web and the heated drum surface thereby eliminating those conditions believed responsible for forming the undesirable cockle and pucker producing stress areas.

Also characteristic of the material produced in accordance with the present invention is its ability to lie perfectly flat when placed on a table and to exhibit exceptional dimensional stability when exposed to different and changing temperatures and humidity conditions. Further it has been found that low densimeter webs dried in the uninterrupted restrained manner of the present invention accept the saturating or coating solutions in a uniform manner, as contrasted to the slower saturation rate exhibited by conventionally dried papers. As mentioned, the papers of the present invention also are particularly desirable in multi-coating operations since streaking and other mechanical defects are obviated due to the absence of the cockles and puckers.

The specific operating conditions for the through drying operation will vary substantially depending upon the particular end product being made and upon the use thereof. However, as mentioned it is essential that the fibrous web material be thoroughly and completely dried under restraint to a moisture content of about 8 percent by weight and less in a continuous and uninterrupted fashion in order to achieve the new and beneficial results of the present invention. Accordingly, the temperature and flow rate of the drying air, the speed of the web through the drying unit and similar operating conditions cannot be delineated or limited to specific values, although heating to a temperature of 200 to 450° F. is preferred in commercial operation. The restrained condition of the web during the drying process is readily achieved by providing for the flow of gas against the web thereby forcing it into intimate engagement with the foraminous carrier of the dryer unit. This restrained condition can be enhanced not only by applying air pressure to the outer surface of the web material but also by simultaneously creating a vacuum condition on the opposite side of the foraminous surface to positively assure the restrained condition of the fibrous web during the entire drying operation.

The dried web material can be immediately coated or saturated with an appropriate treating material or it can be wound on reels and stored for future coating operations. As will be appreciated, the moisture content of the webs may vary during storage depending on ambient storage conditions and the type and amount of fibers used to make the web.

When employing a stencil coating operation, the dried fibrous material is fed through guide rolls to a coating station provided with, for example, a reverse coating roll and a coating bar to remove all of the excess coating solution from the treated web. The web material is then fed through a tunnel oven where it is dried by a stream of hot air which also is designed to support the sheet during its pass through the oven.

During this coating operation the behavior of the base stock material is observed both prior to its entrance into the coater and subsequent to its emergence from the tunnel dryer. The material treated in accordance with the present invention exhibits a dramatic difference over the base material dried on conventional dryer cans or drums in that it exhibits no puckers or cockles and saturates in an extremly uniform manner as constrasted with the multi-puckered, can dried material that yields non-uniform impregnation. Upon emerging from the drying tunnel the material produced in accordance with the present invention is flat and devoid of surface defects while the cockles and puckers in the can dried material are pronounced and deemed objectionable from an appearance point of view.

The following examples are given in order that the effectiveness of the present invention may be more fully

understood. These examples are set forth for the purpose of illustration only and are not intended to in any way limit the practice of the invention.

EXAMPLES 1–3

Fibrous web materials, having a basis weight of about 11 grams per sq. meter and suited for use as stencil base stock, were made from a 100 percent manila hemp fiber dispersion. One sample designated A was dried on conventional can dryers while the samples labelled Examples 1, 2 and 3 were dried in accordance with the present invention. All samples had an average densimeter value of 0.06 sec./100 ml. At the identical mechine speed and substantially the same drying temperature, a significant quality increase was realized in accordance with the present invention by the elimination of objectionable surface defects such as cockles and puckers. Test data on these samples are set forth below:

	A	Ex. 1	Ex. 2	Ex. 3
Drying temp., ° F	275	220	300	400
Basis wt. (grams/sq. meter)	12.4	11.2	10.7	11.5
Gauge, mils	3.2	2.9	2.9	3.2
Density, grams/cc	.157	.153	.147	.148
Permeability	720	840	880	800
Inlet web moisture, percent	80	80	81	80
Outlet web moisture, percent	5	8	5	1

Samples from the different experiments were subjected to an intense visual inspection. The can dried material did not lie completely flat when placed on a table and exhibited a considerable amount of cockles and puckers. In marked contrast all three examples made according to the present invention lay perfectly flat and no surface defects could be observed. Large sheet samples were also placed successively in a number of different locations where they were exposed to a variety of changing temperatures and humidity conditions. Periodic inspection of these samples revealed no cockle and pucker development in Examples 1, 2 or 3. However, the once flat sheets had lost some of their dimensional stability and some minor buckling had occurred. The surface defects of the can dried samples had become appreciably more pronounced and buckling had reached the state of severity.

Samples of Example A and Example 3 materials were coated in a stencil coater under identical conditions and tested for stencil characteristics. These tests including cut out resistance and number of copies to failure were essentially equal for both samples but the Example 3 material advantageously exhibited no stretch after 3500 copies while the Sample A material exhibited 2.1 percent stretch after 3000 copies and 2.8 percent stretch after 3500 copies.

EXAMPLE 4

Fibrous web materials, having a basis weight of about 25 grams per sq. meter and suited for use as base stock for casing manufacture, were prepared from 100 percent manila hemp fiber dispersion. It was observed that each time the through dryer was used the web exhibited no cockles or puckers even when a previously dried material was treated with a viscose solution to a moisture content above 50 percent and again through dried. However, the elmination of surface defects like cockles and puckers was not realized if can dryers were used in the final drying stage after saturation to a moisture content above 50 percent even though the web may have been through dried during an earlier operation. The densimeter value for all web material treated was 0.08.

EXAMPLE 5

Fibrous web material was made from a fiber dispersion of wood pulp and about 40 percent abaca fibers. After drying in accordance with the present invention, the webs were free of surface defects. Test data on this material is set forth below.

	Ex. 5
Basis Wt. (grams/sq. meter)	49
Inlet Gas Temp., ° F.	340
Air Flow Rate, s.c.f.m./ft.²	112
Permeability	40
Inlet Web Moisture, percent	70
Outlet Web Moisture, percent	4
Densimeter	0.13

EXAMPLES 6–8

Fibrous sheet materials were made from a fiber dispersion of abaca fibers and about 80 percent rayon fibers. The sheet material was dried on through dryers in accordance with the present invention. Typical test data on this material are set forth below:

	Ex. 6	Ex. 7	Ex. 8
Basis wt. (grams/sq. meter)	17	17	17
Inlet gas temp., ° F	360	260	210
Air flow rate, s.c.f.m./ft.²	128	105	112
Inlet web moisture, percent	77	78	79
Outlet web moisture, percent	0	0	0
Densimeter	.05	.05	.05
Permeability	950	944	955

When the same material was can dried, it cockled and wrinkled and, if not dried gradually, holes were "popped" in the sheet. However, when dried in accordance with the present invention, the webs did not cockle or wrinkle, no shrinkage was observed, there were no holes in the web material, the appearance was normal and the web was suitable for impregnation.

As will be apparent to persons skilled in the art, various modifications, adaptations and variations of the foregoing specific disclosure can be made without departing from the teachings of the present invention.

We claim:

1. A method of producing low densimeter, coating base material substantially free of puckers and cockles and exhibiting improved dimensional stability comprising the steps of
   (a) providing a wet fibrous web having a moisture level greater than about 50% by weight, said fibrous web when dry being capable of exhibiting a densimeter value less than 1 sec./100 ml. as measured by TAPPI test method T 460 os–68;
   (b) placing said wet web in intimate, full surface contact with a permeable support and applying a fluid pressure to one side of the web sufficiently to maintain the web in continuous restrainment against the support;
   (c) passing drying gas through said web and said support while continuously holding said web in restrainment against said support to permit percolation of said gas through said web to dry said web to a moisture level below which the web exhibits no further shrinkage; and
   (d) removing the dried web from restrainment after the moisture content thereof reaches said moisture level of no further shrinkage.

2. The process of claim 1 wherein the dried web reaches a level of stabilization at a moisture content of about 8 percent by weight.

3. The process of claim 1 including the heating of the web while it is continuously held against the support.

4. The process of claim 1 wherein the wet fibrous web is formed from an aqueous dispersion of fibers and is placed in contact with said support while having a moisture content of at least about 65 percent by weight.

5. The process of claim 1 wherein the fibers in the fibrous web include manila hemp fibers and the densimeter value of the dried web is less than about 0.1 sec./100 ml.

6. A coating base web material made by the process of claim 1.

References Cited

UNITED STATES PATENTS

2,045,096	6/1936	Osborne	162—100
3,447,247	6/1969	Daane	34—122
2,045,095	6/1936	Osborne	162—13
3,303,576	2/1967	Sisson	34—115
3,284,285	11/1966	Holden	162—297
3,345,756	10/1967	Bryand et al.	34—23

OTHER REFERENCES

Landes: "Testing of Paper and Paper Materials," in Calkin, *Modern Pulp and Paper Making,* Reinhold Publishing Co. (1957), p. 476.

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