March 29, 1966 D. L. CALKINS 3,242,583

METHOD OF DRYING A RUNNING WEB OF SHEET MATERIAL

Filed Nov. 6, 1963 2 Sheets-Sheet 1

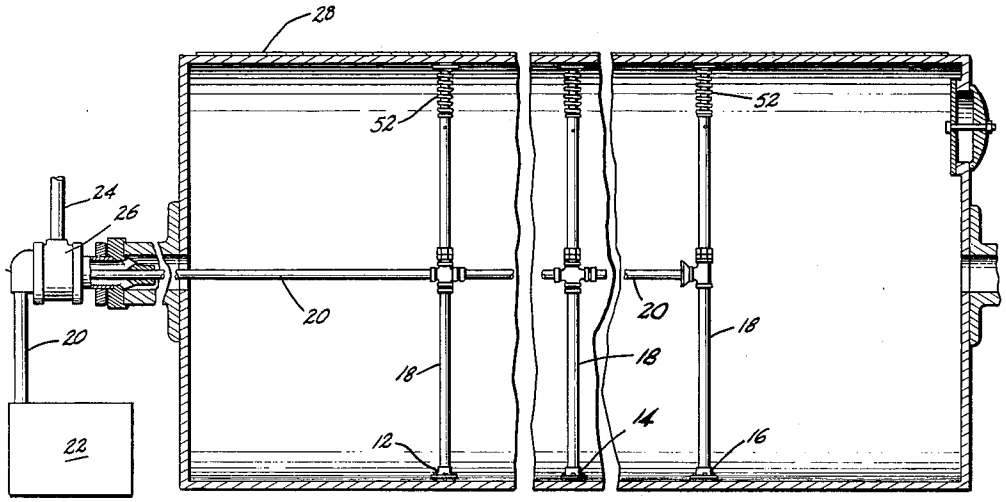


FIG. 1

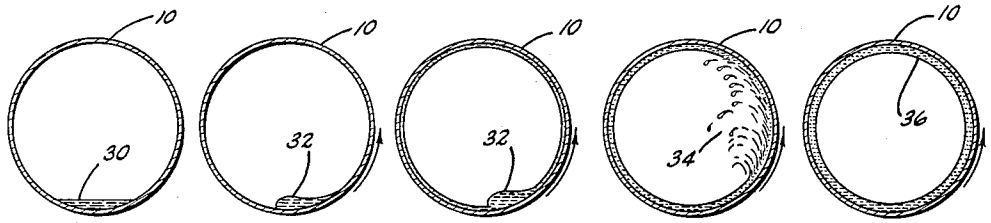


FIG. 2 FIG. 3 FIG. 4 FIG. 5 FIG. 6

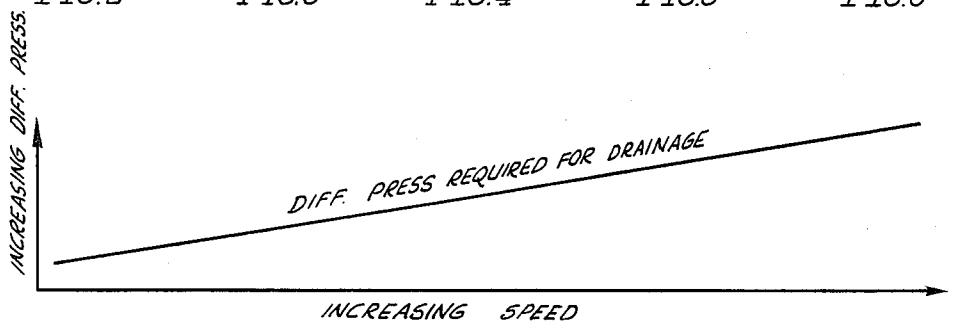


FIG. 8

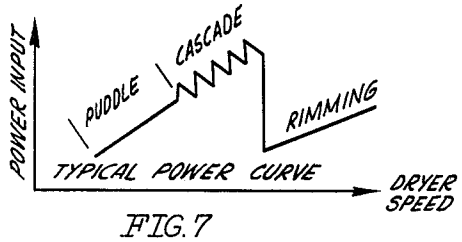


FIG. 7

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METHOD OF DRYING A RUNNING WEB OF SHEET MATERIAL

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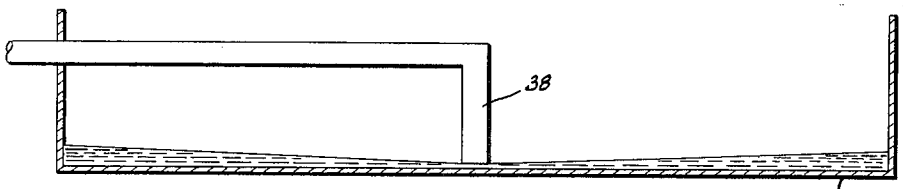


FIG. 9

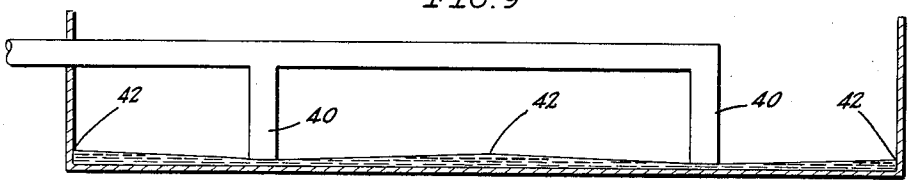


FIG. 10

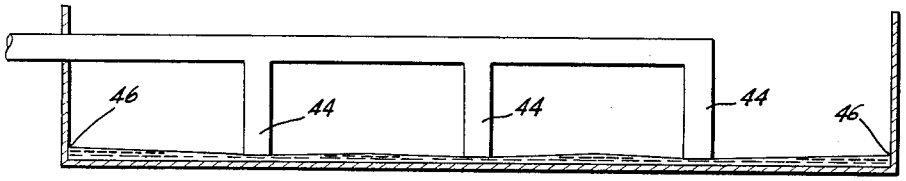


FIG. 11

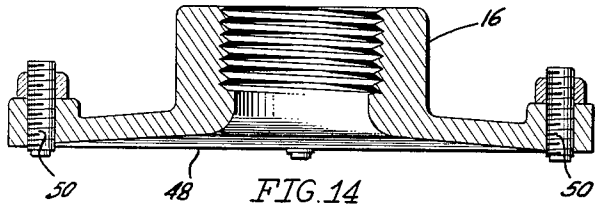


FIG. 14

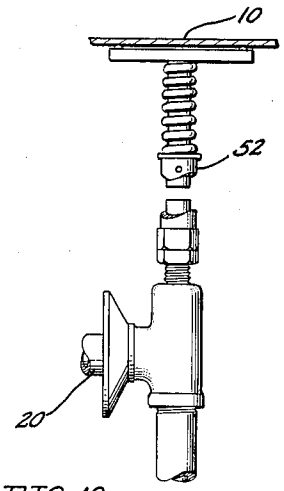
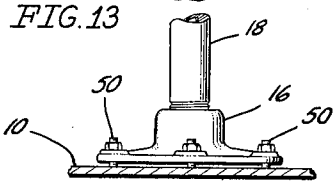


FIG. 13



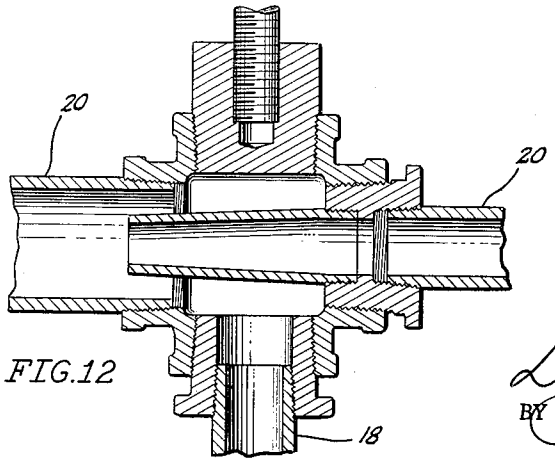


FIG. 12

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3,242,583

METHOD OF DRYING A RUNNING WEB OF SHEET MATERIAL

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Filed Nov. 6, 1963, Ser. No. 321,923
4 Claims. (Cl. 34—18)

The present invention relates to improvements in the drying of a running web of sheet material by surface contact with a steam heated, horizontally disposed rotated drum or cylinder, being particularly concerned with paper machines and textile dryers, but having application to textile machines and the like, as well.

With regard to the particular product being manufactured, it is an object of the invention to provide a method of drying paper which will produce a sheet material of substantially uniform widthwise moisture content.

In addition to better control of the moisture content and quality of the product being dried, another object of the invention is to provide a method which will reduce the power input to the dryer and minimize bearing problems.

Another object of the invention is to provide an improved method and apparatus for handling condensate in a steam heated cylinder in which the relationship of the condensate to the interior surface of the cylinder, its depth and state of movement (rimming, puddling or cascading) is such as to enable the cylinder to be efficiently and uniformly heated so as to effect a uniform transfer of heat between the exterior surface of the cylinder and the sheet material across the full width of the latter.

A further object of the invention is to provide an improved dryer of the type described in which the condensate is withdrawn from the interior surface of the dryer at a point or points substantially removed from the opposite ends of the cylinder.

A still further object of the invention is to provide an improved system for condensate removal from the interior of the dryer cylinder in which a plurality of rotated syphons are axially spaced along the interior surface of the cylinder.

These and other objects and advantages of the present invention will more fully appear from the following specification and the appended claims.

In the drawings,

FIG. 1 is a diagrammatic view of a dryer drum or cylinder illustrating the novel condensate handling system,

FIGS. 2 through 6 are diagrammatic illustrations of the state of the condensate under conditions ranging from no rotation to rimming,

FIG. 7 is a diagrammatic illustration of the effect the state of the condensate has upon power input to the dryer,

FIG. 8 is a diagram showing relation between different pressure and rate of rotation of dryer required for drainage,

FIGS. 9, 10 and 11 are diagrammatic showings of different locations of the syphon structure and illustrate the effect upon condensate gradient,

FIG. 12 is a vertical section through the condensate orifice and brace and syphon assembly,

FIG. 13 is a side elevational view of the syphon structure as positioned within the dryer, and

FIG. 14 is an enlarged fragmentary vertical section of the pickup fitting of the syphon structure.

In the operation of a paper making machine, for example, a slurry of water and fibrous material, such as wood pulp, cotton fiber, bagasse, flax, etc., is spread upon wire mesh and then it is transferred to a felt belt. The felt absorbs enough of the water to provide a thin sheet

of paper with sufficient strength to thereafter be conveyed in contact with dryers in the form of large drums or cylinders rotated about their horizontal axis and heated by steam.

The full width of the sheet is contacted by the cylindrical exterior surface of the drums in heat-exchange relation, the sheet, in practice, being passed under some drums and over others in making some products, and only over the drums in making other products as, for example, tissue paper.

During the first part of the drying operation, the moist paper sheet will maintain a temperautre of approximately 185° F. regardless of its moisture content. This temperature of 185° F. will exist widthwise of the running sheet irrespective of commercial variations in sheet thickness or variations in the widthwise moisture content of the sheet.

In general, the rate of condensation of steam within the interior of a drying drum is dependent upon the temperature of the sheet in contact with the exterior surface of the drying drum. Thus (1) if the moisture content, during the period the temperature of the sheet is substantially the same widthwise, is not uniform widthwise of the sheet, or (2) if the moisture content is uniform and the sheet is not of uniform thickness widthwise, the areas of the sheet of less moisture content, as well as the thinner areas, will dry out before other areas of the sheet are dried out, assuming there is a relatively uniform exchange of heat between the steam and all areas of the cylindrical wall of the drum. This will produce a sheet of varying moisture content across its width.

In commercial practice, to produce a sheet of paper of a maximum allowable moisture content in any area of the sheet, the areas of varying moisture content mentioned above have resulted in the production of sheets having areas of lesser moisture content than the permitted maximum. These "dried out" areas may cause trouble in the use of the paper in box making, for example, the "dried out" areas being objectionably brittle. Also, over drying of areas of the sheet penalizes the paper manufacturer as most paper is sold by the weight and the more moisture in the paper within the maximum permitted limits, the higher the compensation to the paper manufacturer for his product and the fibrous material contained therein.

As the exchange of heat between the steam and drum, at a relatively uniform rate lengthwise of the drum has not been possible heretofore in commercial practice because of unsolved condensate problems, improvements in uniformity of sheet thickness and widthwise moisture content prior to contacting the dryers has not resulted in an end product of uniform widthwise moisture content.

According to the present invention, overdrying of the paper sheet has been substantially reduced and a sheet of more uniform moisture content across the width of the sheet has been produced by improving the handling of condensate within the interior of the dryer drum.

In general, the present invention involves the following steps for the removal of moisture from a continuous running web of sheet material by surface contact with a heated, horizontally disposed, rotated cylinder for the purpose of producing a sheet material of reduced, substantially uniform widthwise moisture content: (a) Heating cylinder by the interior admission of steam distributed relatively uniformly throughout the length of the cylinder to provide a relatively uniform supply of uncondensed steam in intimate reltion to substantially the entire interior surface of the cylinder, (b) withdrawing the condensate from the cylinder at a plurality of points spaced lengthwise of the cylinder and located directly adjacent the interior surface of the cylinder, (c) rotating the cyl-

inder at a speed which will provide relatively uniform distribution of the condensate lengthwise of the cylinder, and (d) withdrawing the condensate at said points by differential pressure at a rate which will substantially maintain a film of condensate of uniform depth lengthwise of the cylinder whereby the rate of condensation of steam may vary throughout the length of the cylinder depending upon the widthwise variation in the moisture content of the sheet material contacting the exterior surface of the cylinder.

By following the steps outlined in the preceding paragraph it becomes possible in the drying of a running web of sheet mateiral to correct and make substantially uniform the widthwise moisture content of the sheet material with an accompanying avoidance of "dried out" or overdried areas. It also becomes possible to reduce to moisture content uniformly widthwise of the sheet material when the moisture content of the sheet material at the initial contact of the exterior surface of the cylinder, is substantially uniform widthwise thereof.

The condensate within the dryer cylinder **10** of FIG. 1 is preferably removed by a syphon system which rotates with the dryer cylinder as a unit. In such a system the condensate flows along the interior surface of the cylinder to the syphon heads, hence radially inward to the center of the cylinder and then axially along the center line of the cylinder to a condensate receiver located exteriorly of the cylinder. This movement of the condensate with the cylinder rotating at rimming speeds is accomplished by a suitable differential in pressure existing between the steam pressure within the dryer cylinder and the pressure in the condensate receiver. This differential must be sufficient to overcome the centrifugal forces acting upon the condensate as well as the gravitational forces which must be overcome to elevate the condensate to the center line of the cylinder. As the speed of the cylinder **10** is increased, the differential pressure required to obtain sufficient drainage must be increased. When the steam pressure is increased within the cylinder **10**, the differential pressure required for proper drainage becomes less.

The dryer cylinder **10** is shown equipped with three rotary syphon heads **12, 14** and **16** each radially connected by a pipe **18** to a drainage system comprising a pipe **20** located at the center line of the cylinder **10** and extending exterioraly of the cylinder for connection to a suitable condensate receiver **22**. Standard controls regulate the steam pressure within the cylinder **10** and the differential pressure between the cylinder **10** and the condensate receiver **22**.

Steam under pressure is conducted through the pipe **24** into the rotary joint **26** and discharged into the interior of the cylinder **10** to uniformly flood the interior of the cylinder **10** with an adequate supply of live uncondensed steam capable of fully satisfying the rate of condensation that may develop under all conditions of heat exchange taking place between the surface of the cylinder **10** and the contacting running web **28** of the sheet material.

In FIGS. 2 through 6 is illustrated the various states of the condensate within the cylinder **10** at different speeds of rotation. When the cylinder **10** is stationary or rotated very slowly the condensate rests in a pool **30** at the bottom of the cylinder **10**. As the speed of the cylinder **10** is increased, pool **30** is displaced in the direction of rotation to form a puddle **32** in which the condensate most removed from the interior surface of the cylinder **10** is flowing counter to the direction of rotation. In FIG. 4, the speed of rotation has been further increased and the puddle **32** is shown as moving to a higher position with a portion of the condensate in rimming relation to the interior surface of the cylinder. A further increase in speed of rotation results in the cascading of the condensate at **34** with an increased amount of rimming. FIG. 6 illustrates the state of the condensate with the cylinder **10** being rotated sufficiently to place all the condensate **36** in rimming relation and uniformly distributed about the interior surface of the cylinder for removal by differential pressure by a rotary syphon system.

FIG. 7 illustrates the improvements in power consumption which results when the speed of rotation of the cylinder **10** is sufficient to cause all the condensate **36** to be disposed in rimming relationship with the interior surface of the cylinder **10**. The detrimental effects of cascading upon bearing structure is illustrated by that portion of the power curve which corresponds to the power consumption with the action of the condensate cascading as shown in FIG. 5.

In FIG. 8 the increase in differential pressure between the condensate receiver **22** and the cylinder **10** as the speed of rotation of the cylinder **10** is increased has been illustrated. With complete rimming of the condensate as illustrated in FIG. 6, the centrifugal forces are the greatest and the differential pressure must be increased over that, for example, when the speed of rotation provides cacading as shown in FIG. 5.

Assuming the cylinder **10** to be of uniform inside diameter and being rotated about a horizontal axis located at the center line at the speed of rotation of FIG. 6 which will place all the condensate in a rimming condition and no differential in pressure between the cylinder **10** and the receiver **22**, the depth of the film of condensate will be substantially uniform throughout the length of the cylinder **10**. With a differential in pressure that is sufficient to cause the flow of condensate through the heads **12, 14** and **16** of FIG. 1, into pipes **18** and to the receiver **22** through the pipes **20**, such a flow will result in a slight gradient being imparted to the surface of the rimming condensate.

With a single syphon head **38** located at the center of the cylinder **10** as shown in FIG. 9, the depth of rimming condensate will be greatest at the ends of the cylinder **10** and the depth will decrease toward the center.

Through the use of two syphon heads **40** as shown in FIG. 10, with the cylinder **10** being rotated under the same conditions as illustrated in FIG. 9, the rimming condensate will be of maximum depth at the points **42**, but the depth of the condensate will be substantially less than the maximum depth illustrated in FIG. 9.

In FIG. 11, three syphon heads **44** are shown in such an arrangement with regard to their longitudinal spacing within the cylinder **10** that the depth of the rimming condensate between the heads **44** will be substantially less than at the points **42** of FIG. 10 with the maximum depth of condensate being at **46** and corresponding to the depth at points **42** of FIG. 10. As the amount of heat exchange between the exterior surface of the cylinder **10** and the sheet material **28** is affected by the depth of the rimming condensate, by reducing the exchange of heat adjacent the ends of the cylinder **10** by increasing the depth of the condensate at the ends, the tendency to overdry the sheet material **28** at the ends of the cylinder **10** due to exposure to ambient heat, a more uniform widthwise moisture content of the sheet material **28** may be obtained.

FIGS. 12, 13 and 14 disclose in detail the construction of the syphon structure shown in FIG. 1. The heads **12, 14** and **16** may be identical. As shown in FIG. 14, the head **16** has an inlet **48** which is disposed and spaced at adjustable relation to the interior surface of the cylinder **10** by screws **50** spring clamping structure **52** more fully described in United States Patent No. 3,034,225 holds the heads **12, 14** and **16** in affixed relation to the interior surface of the cylinder **10**.

I claim:

1. A method of drying a running web of sheet material by surface contact with a steam heated, horizontally disposed, rotated cylinder, comprising the steps of:

(a) heating the cylinder by the interior admission of steam distributed relatively uniformly through-

out the length of the cylinder to provide a relatively uniform supply of uncondensed steam in intimate relation to substantially the entire interior surface of the cylinder,

(b) withdrawing the condensate from the cylinder at a plurality of discrete points separated from each other by a substantial distance and spaced lengthwise of the cylinder and located directly adjacent the interior surface of the cylinder,

(c) rotating the cylinder at a speed which will provide relatively uniform distribution of the condensate lengthwise of the cylinder, and

(d) withdrawing the condensate at said points by differential pressure at a rate which will substantially maintain a film of condensate of uniform depth lengthwise of the cylinder whereby the rate of condensation of steam may vary throughout the length of the cylinder depending upon the widthwise variation in the moisture content of the sheet material contacting the exterior surface of the cylinder.

2. A method of drying a running web of sheet material by surface contact with a steam heated, horizontal disposed, rotated cylinder, comprising the steps of:

(a) heating the cylinder by the interior admission of steam distributed relatively uniformly throughout the length of the cylinder to provide a relatively uniform supply of uncondensed steam in intimate relation to substantially the entire interior surface of the cylinder,

(b) withdrawing the condensate from the cylinder at a plurality of discrete points separated from each other by a substantial distance and spaced lengthwise of the cylinder and located directly adjacent the interior surface of the cylinder,

(c) rotating the cylinder at a speed which will dispose the condensate in a rimming state and provide relatively uniform circumferential distribution of the condensate lengthwise of the cylinder, and

(d) withdrawing the condensate at said points by differential pressure at a rate which will substantially maintain a film of condensate of uniform depth lengthwise of the cylinder whereby the rate of condensation of steam may vary throughout the length of the cylinder depending upon the widthwise variation in the moisture content of the sheet material contacting the exterior surface of the cylinder.

3. In the making of paper, a method of removal of moisture from a continuous running web of sheet material by surface contact with a heated, horizontally disposed, rotated cylinder for the purpose of producing paper stock of reduced, substantially uniform widthwise moisture content, comprising the steps of:

(a) heating the cylinder by the interior admission of steam distributed relatively uniformly throughout the length of the cylinder to provide a relaitvely uniform supply of uncondensed steam in intimate relation to substantially the entire interior surface of the cylinder,

(b) withdrawing the condensate from the cylinder at a plurality of discrete points spaced from each other by a substantial distance and spaced lengthwise of the cylinder and located directly adjacent the interior surface of the cylinder,

(c) rotating the cylinder at a speed which will provide relatively uniform distribution of the condensate lengthwise of the cylinder, and

(d) withdrawing the condensate at said points by differential pressure at a rate which will substantially maintain a film of condensate of uniform depth lengthwise of the cylinder whereby the rate of condensation of steam may vary throughout the length of the cylinder depending upon the widthwise variation in the moisture content of the sheet material contacting the exterior surface of the cylinder.

4. In the making of paper, a method of removal of moisture from a continuous running web of sheet material by surface contact with a heated, horizontally disposed, rotated cylinder for the purpose of producing paper stock of reduced, substantially uniform widthwise moisture content, comprising the steps of:

(a) heating the cylinder by the interior admission of steam distributed relatively uniformly throughout the length of the cylinder to provide a relatively uniform supply of uncondensed steam in intimate relation of substantially the entire interior surface of the cylinder,

(b) withdrawing the condensate from the cylinder at a plurality of discrete points spaced from each other by a substantial distance and spaced lengthwise of the cylinder and located directly adjacent the interior surface of the cylinder,

(c) rotating the cylinder at a speed which will dispose the condensate in a rimming state and provide relatively uniform circumferential distribution of the condensate lengthwise of the cylinder, and

(d) withdrawing the condensate at said points by differential pressure at a rate which will substantially maintain a film of condensate of uniform depth lengthwise of the cylinder whereby the rate of condensation of steam may vary throughout the length of the cylinder depending upon the widthwise variation in the moisture content of the sheet material contacting the exterior surface of the cylinder.

References Cited by the Examiner

UNITED STATES PATENTS

3,034,225 5/1962 Hieronymus ..... 34—125

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A. D. HERRMANN, *Assistant Examiner.*