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PAPER MANUFACTURE

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This invention relates to the manufacture of paper. It more particularly concerns the manufacture of paper filled with alkaline filler.

The principal object of this invention is to prevent the deterioration or destruction of the sizing in paper filled with alkaline filler by regulating the temperature to which the web is raised in drying.

An important object is to accomplish this by drying the web on paper machine driers, the surface of said driers having a relatively low temperature.

A further object is to prevent this deterioration or destruction by drying with a heated gas such as air.

A further object is to prevent this deterioration or destruction by means of drying in a vacuum.

A further object is to prevent this deterioration or destruction by prevention of contact of the paper web with the surface of the steam drying cylinders.

Other objects and advantages of this invention will become apparent during the course of the following description.

In the manufacture of paper filled with alkaline filler, as is well known, the sizing, for example, size precipitate such as rosin size precipitated by alum, is deteriorated in the mix by contact with alkaline filler even to the point of destruction. As is well known from the disclosures of my prior patents, this deterioration by alkaline filler is not confined to rosin sizing of any definite composition but is a reaction characteristic of rosin sizings in general. This deterioration may be prevented by various techniques such for example, as those described in a number of my already issued patents and copending applications. For example, it may be substantially prevented by minimizing the time and/or intimacy of contact of the constituents of the mix, suitably by adding one or more of the chemically incompatible materials at the dilute stage in the paper-making process. It may also be substantially lessened by lowering the temperature of the paper mix. Likewise, it may be avoided or prevented, for example, by the application, precipitation or regeneration of the sizing in the web. Moreover, it may in certain cases be substantially lessened by suitably treating the alkaline filler, as with paraffin emulsion, for example.

Paper is customarily dried on the steam drying cylinders, i. e. driers, of a paper machine and although satisfactory sizing results may be obtained by my previously described processes when the paper made thereby is thus dried, nevertheless an investigation of the effects of drying temperatures has shown that in many cases the optimum results from these processes are not obtained at the temperatures ordinarily employed on the paper machine in drying.

I have found that if the temperature of the wet paper web during drying is kept at or below a critical temperature, which is approximately 75° C., much better results are obtained than if higher temperatures are employed; and apparently the lower the temperature used within certain limits the better the results. For example, in certain cases I have found that a temperature of the web of approximately 65° C. gives substantially improved results over 75° C. and in many instances a temperature of approximately 45° C. seems to give the optimum sizing effect.

I have found that drying at such temperatures in certain cases not only gives much better sizing when the minimizing, web treatment, or other of the above mentioned techniques is employed, but also in many cases gives a fair degree of sizing without the employment of such techniques; and in certain cases where, if the regular drying procedure were employed, the sizing effect would have been substantially completely destroyed by the alkaline filler, by using the present drying procedure a moderate degree of sizing is obtained.

The theory I have evolved to explain these findings is this: the contact of alkaline filler with the sizing in the wet web has a slow deteriorating effect at room temperature, but this effect is substantially enhanced by an increase in temperature of the web. Sizing, which for example has been precipitated in the beater, and which, without the employment of minimizing or other special technique, has apparently been deteriorated by the alkaline filler in the mix even to the point of destruction, in many instances has not been completely destroyed before the web contacts with the driers, and the deterioration reaction is completed at the elevated temperature of the driers. By holding the paper web at or below the critical temperature during drying, this final action of the alkaline filler on the sizing is substantially lessened if not in many cases substantially eliminated.

Thus, better sizing is obtained in the case where a sizing effect would otherwise exist, but which might be somewhat deteriorated on the driers, and a moderate degree of sizing is in many instances obtained where no sizing effect would otherwise exist owing to its destruction being completed on the driers. This theory would appear to be substantiated by the fact that if an alkaline filler paper mix is allowed to remain long enough and in sufficiently intimate contact actually to complete the destruction of the sizing before the web is formed, the drying at a lowered temperature is not effective in producing a sizing effect. It is only when there is some actual residual effective sizing left in the mix, or when the sizing has been substantially unattacked, or has been restored, or produced by the application of the minimizing or other technique, that a sizing effect

or an enhancement of a sizing effect can be obtained in the web by the conducting of the drying at or below the critical temperature.

As the ordinary paper machines operate with steam drying cylinders at least some of which are usually above 100° C., it is apparent that it is necessary to operate such machines somewhat differently in order to carry out the present invention.

One satisfactory method is to utilize exhaust steam under a considerable vacuum in the driers (i. e. drying cylinders) whereby the surface temperature thereof is kept at substantially 75° C. or below. Another method is by passing water or other fluid at suitable temperature, rather than steam, through the driers. Of course it will be apparent that in either of these cases, a vacuum drier (i. e. a chamber under vacuum in which paper machine driers are enclosed) may be used rather than paper machine driers operating in the open air, which will serve to hasten in a marked degree the drying of the paper which is otherwise slowed down materially by the lower temperatures employed in my process.

I have also found that instead of drying the paper web in contact with a substantially smooth surface, such as a paper machine drier, which imparts its heat to the paper by direct contact therewith, if the web be dried by contact with a hot gas such as air, in most cases the sizing effect obtained is substantially enhanced over that obtained when the paper is dried by contact with a substantially smooth solid surface.

For example, I have found that although a satisfactorily sized paper may be obtained by the use of heated air below 75° C., for instance at 45° C. or higher; nevertheless it is possible with heated air drying to have the temperature of the air which is drying the paper considerably higher than 75° C., for example up to 105° C., or even higher up to that temperature where the cellulose would be substantially injured by the heat employed. I have also found that in many cases when heat is imparted by hot air the higher the temperature of the air, the better the sizing.

I do not believe, however, that these findings conflict with my previous findings relative to drying in contact with solid surfaces such as paper machine driers, as the theory which I have evolved relative to hot air drying harmonizes the two sets of observations.

My theory in this connection is that paper dried in hot air does not reach a substantially higher temperature than, if as high as, the wet bulb temperature corresponding to the relative humidity of the air in which it is dried. Thus, even though the paper be dried with air heated to 75° C. or above, the actual temperature of the web, owing to the absorption from the web itself of part of the latent heat required in the evaporation of its water content, is substantially less than the temperature of the air employed and does not rise as high as or higher than the critical temperature of 75° C. while any substantial quantity of moisture still remains in the paper. Of course it will be understood that if air saturated or substantially saturated with moisture is employed for drying, and said air is at a temperature above 75° C., the temperature of the web will then rise to substantially the temperature of the air (but not above 100° C. while it still contains any substantial degree of moisture): thus such saturated or substantially saturated air employed at above 75° C. is not suit-

able for carrying out my invention, and hot air should be employed in the carrying out of my invention only under conditions such that the temperature of the web is not raised thereby above 75° C., which is only possible, if air above 75° C. be used, when such air is not substantially saturated with moisture. The theory further postulates that the destruction of the sizing is a function both of the temperature and time, and that the speeding up of the time may so shorten the period during which destruction can take place as to compensate for the greater rate of destruction at the somewhat higher temperature employed providing the temperature of the paper does not rise too high; and likewise the lower rate of destruction at a lower temperature may result in actually greater sizing destruction by the prolonged time of drying required at that lower temperature.

Drying at a higher temperature is very much more rapid than drying at a lower temperature, and thus when heated air is used for drying, the higher temperature employed so speeds up the rate of drying that the increase in the rate of destruction due to rise in temperature is substantially counteracted and the net result may even be a lessening in the destruction taking place. When using high temperature air for drying, the temperature of the paper itself is kept reasonably low by the extremely rapid evaporation of the water with its consequent cooling effect on the paper itself.

On the other hand, where a contact surface is used for conveying the heat for drying, such as in a steam drying cylinder, the temperature of the paper itself is actually raised above the wet bulb temperature which would exist at the humidity of the surrounding air, because the water in the paper itself is directly heated by contact with the drier surface. Thus, paper dried on a drier is in many cases actually heated to the vicinity of the surface temperature of the drier itself, although if the temperature of the drier is above 100° C., of course, the wet paper itself will not be raised above that point but will approach very close to it.

It will thus be seen that the drying at a higher temperature on paper machine driers increases the deteriorating effect of alkaline filler on the sizing for which the lessening time fails to compensate, owing to the high temperature to which the paper itself is raised; whereas, when paper is dried in heated air out of contact with drying cylinders, the temperature of the air, although much higher than the paper, does not actually raise the temperature of the paper very high and thus the increased rapidity of drying at the higher temperatures so diminishes the time that the slight rise, if any, in the actual temperature of the paper is much more than compensated for, with the result that a satisfactory sizing effect is obtained even at air temperatures up to 105° C. and above.

The evidence indicates that the destructive action of the alkaline filler on the sizing takes place primarily in the presence of a substantial quantity of water, and that the rate of reaction diminishes with the reduction in the amount of water or moisture present, becoming substantially negligible when most of the water has been eliminated from the sheet. It will thus be apparent that in drying, even if the paper at the end of the drying operation is somewhat raised in temperature, nevertheless the rise of the temperature of the paper at such time is of

little significance because the rate of reaction is then so retarded.

In order to carry out that modification of my invention where the paper is dried by heated air, I may employ for drying the paper a festooning system such as is used in certain paper coating machines. This, however, is expensive and also has the disadvantage that the paper with certain fibrous finishes has a tendency to cockle and wrinkle on drying. Therefore, I prefer to dry the paper under tension and for this purpose may provide a chamber in which the paper is passed over a series of guide rolls, so that it travels under tension in vertical or in horizontal loops as may be desired. It has been found that contact with any hot surface has some deteriorating effect on the sizing of the sheet at a high temperature owing to the direct heating of the water in the paper itself, even though the surface be non-metallic and a relatively poor conductor of heat such as glass or wood. It is thus better, if it is feasible mechanically, to have the tension rolls over which the paper passes situated outside of the chamber into which the heated air or other gas is admitted and have the paper pass out of the chamber to the points where it passes over these rolls so that the rolls themselves may be kept substantially cool. Or the rolls if desired may be placed within the chamber and be cooled by a suitable fluid such as water.

I have disclosed above two means I may employ by which the temperature of the web in drying is not raised up to or substantially above the critical point of 75° C. These means are firstly paper machine driers in which the drying cylinder surface temperature is not substantially above 75° C., and secondly heated air at any temperature, preferably higher than 75° C.

There is a third means by which my invention may be carried out, namely, drying on paper machine driers which have a surface temperature above 75° C., but under conditions such that the temperature of the web is not raised above 75° C. In this instance means are adopted so that although the surface temperature of the driers is higher than 75° C., the actual temperature of the web is not raised higher than 75° C., and in many cases is substantially lower.

There are two modifications by which this third means of carrying out my invention may be practiced. The first modification is by the use of a vacuum drier. Mention has been made above of the use of a vacuum dryer with drying cylinders heated up to 75° C. In the present instance, however, I use drying cylinders heated up to higher temperatures, which may be any temperature such as may be employed in drying paper, that is, up to 100° C., and higher if desired. The vacuum drier is then operated under a vacuum such that water will boil thereunder at a temperature of 75° C. or below, and preferably considerably below 75° C. Under such a vacuum the water will evaporate from the web at or below its boiling point, and thus the temperature of the web will not rise higher than the boiling point of water at the vacuum employed. Under these conditions, therefore, the temperature of the web is maintained at 75° C. or below and a satisfactorily sized paper results. For example, the vacuum drier may operate at a vacuum of about 28" of mercury or thereabouts at which vacuum water boils at substantially 33° C., so that regardless of the temperature of the drying cylinders actually employed, the temperature of the web will

not rise above that point. It should be stated that to obtain well sized paper in a vacuum drier without raising the web temperature higher than 75° C. is contrary to results previously obtained in a vacuum drier with rosin sized papers not containing alkaline filler, where it has been found necessary to heat the still moist web to 80° C. or thereabouts in order to obtain satisfactory sizing.

The second modification of my third means is not so efficient as vacuum drying, but under certain circumstances is a convenient method to use. This method is to employ the ordinary paper machine driers and to provide a felt contacting with the surface of the driers, using in addition if desired the ordinary paper machine drier felt. The paper to be dried thus contacts with the single felt or passes between the two felts and is never in contact with the surface of the driers. In this case the driers may be run at the usual temperature of substantially 100° C. or higher, but owing to the interposition of a felt between the driers and the paper web, the paper web does not reach this advanced temperature but is kept down to substantially 75° C. or lower, and of course by controlling the temperature of the driers, the temperature of the web can be suitably regulated. Another adaptation of this method is to provide the paper machine driers with a slat surface, such as one made of wood, which will hold the paper away from the surface of the paper machine driers; or to use a textile or other relatively non-conducting jacket for the driers, and thus effect drying without substantially contacting the paper with the surface of the driers.

As will be apparent, other expedients analogous to these may be utilized, but it should be remembered that the optimum results are obtainable when the web is not contacted at atmospheric pressure above the critical temperature with any hot solid object, although wood or textile surfaces because of their relatively poor heat conducting qualities are better than the surface of paper machine driers and can be used at a higher temperature with better results than can the driers.

As has been stated above, the action of alkaline filler on sizing slows down appreciably when the percentage of moisture in the sheet has been considerably lowered and it is thus sometimes feasible to conduct only a substantial, for instance the major, part of the drying according to the methods disclosed herein. For example, it is sometimes feasible to use higher drying temperatures at atmospheric pressure on those driers which expel the final portions of moisture from the paper than on the driers removing the first portions of the moisture, and thus to speed up the drying operation without deteriorating the sizing to any considerable extent, although the web in its latter stages of drying may be raised to a temperature above 75° C.

Where paraffin or other thermoplastic material is used as sizing, or in conjunction with other sizing material, it is in many cases desirable to pass the dry or almost dry paper over a drier or driers or the like heated to at least as high a temperature as the softening or in some cases the melting point of the thermoplastic material in question.

In the prior art the expression "air dried" when applied to rosin sized papers has meant that the paper has been dried in the air at low temperature, i. e. at substantially room temperature. It will be understood that the present invention is not concerned with air drying as thus

used, but rather with drying with heated air. As a matter of fact, when rosin sized paper filled with alkaline filler is dried in the air at room temperature in certain cases a moderate degree of sizing may be obtained, but as explained above, drying with heated air greatly enhances the sizing effect, even up to an air temperature of 105° C. or higher, and it is to drying with heated air that this modification of my invention is directed.

10 The sizing I prefer to employ is rosin size precipitated by a suitable precipitant such, for example, as alum. Such sizing when used in sufficient quantity renders the paper substantially water resistant so that it may be written upon 15 with aqueous writing ink, and when used in lesser quantity imparts a lesser degree of water resistance, which, other things being equal, corresponds in general roughly to the quantity of sizing employed. Other sizes may be used, however, such as are employed in the paper industry 20 in place of rosin size, such for example as other saponifiable materials such as waxes, fatty acids and the like, either in saponified condition, or in emulsion in substantially unsaponified condition, 25 as well as emulsions of various thermoplastic materials such as paraffin, all of which may be used in many cases in conjunction with rosin size. It is to be understood, however, that in respect to the sizes mentioned, sizings containing 30 paraffin or the like are much more resistant to the action of alkaline filler than is rosin sizing and the like, owing to the presence of the inert paraffin or the like, but what deterioration these sizings containing paraffin or the like do suffer from alkaline filler in the ordinary drying practice is materially reduced by the present invention. 35 Where I employ the term "rosin sizing" in the claims hereof I employ it in a generic sense to mean any of the sizings mentioned above in this paragraph, or their equivalents. The sizing mentioned above in this paragraph is not to be confused with the sizing which is known as animal or tub sizing, i. e. glue or materials used in place thereof, the purpose of which is to impart 45 a stiffening or strengthening or the like to the paper surface, and thus where I speak of sizing or sized paper in the claims I refer exclusively to the type of sizing described in the previous sentences, and to the paper in which it is used.

50 In the practice of my invention if the size I use is to be precipitated I may for example precipitate it in the beater, or may utilize the minimizing technique, (i. e. adding material to the mix under conditions favoring the minimizing of the time and/or intimacy of contact of the constituents of the mix), in connection with the size precipitation or restoration; or I may apply the size to, or precipitate it or restore it in, the web, 55 or I may add previously precipitated sizing to the paper mix or the web, or the like. In any and all of these cases the deteriorating effect on the sizing of paper machine driers as ordinarily operated is lessened or substantially eliminated by the practice of my process.

60 The alkaline filler may be added to the mix in the beater, and/or under minimizing conditions, and/or to the web, as desired.

While I have proposed above a theory which appears to explain the facts surrounding the present invention, it is to be distinctly understood that my invention is not limited in any way by this or any other theory, as regardless of theory, my invention is operable under the conditions disclosed.

75 Instead of using air as a heating medium, I

may employ other heated gas, preferably one which is non-inflammable and which may occur in industry in heated form, such as flue gas, preferably suitably purified. Thus, where in the claims I use the words "heated air", I mean to include any such suitable heated gas as an equivalent.

In some paper machines only one large steam drying cylinder is used in the place of the usual bank of driers. Of course, my invention may be suitably carried out on such a machine if desired, and thus in the claims where I speak of drying paper on driers I mean to include the case where only one drier is used.

By the term "alkaline filler", I mean substantially water insoluble filler which when agitated in contact with freshly boiled distilled water, say for an hour, will impart a pH value to such water greater than 7.0, that is, which will be on the alkaline side of the neutral point. Among fillers included in this group may be mentioned calcium carbonate, of which lime mud from the causticizing process is one form; calcium carbonate magnesium basic carbonate employed in the paper disclosed in my United States Patent No. 1,595,416, issued August 10, 1926; calcium carbonate magnesium hydroxide disclosed in my United States Patent No. 1,415,391, issued May 9, 1922; and other substantially water insoluble normal or basic carbonates of alkaline earth metals, (which expression is herein intended to include magnesium), or compounds, double salts, or physically associated mixtures of these with one or more other acid soluble materials of a substantially water insoluble nature.

By the term "alkaline filler" I also intend to include fibrous material and/or other material such as paper coating constituents or the like containing one or more compounds of the character referred to, such as "old papers" or similar papers, "broke", or the like.

The term "drying" when employed herein in connection with a paper web is used in its ordinarily accepted meaning in the art as referring to such drying as takes place subsequent to the passage of such web through the customary press section of the paper machine.

Where in the claims the expression "major part of the drying" is used, it means the removal by evaporation of more than half of the weight of water remaining in the web after the web has passed through the customary press section of the paper machine.

When I use the word "paper" herein, I use it in the broad sense to include products of manufacture of all types and of all weights and thicknesses, which contain as an essential constituent a considerable amount of prepared fibre and which are capable of being produced on a Fourdrinier, cylinder, or other forming, felting, shaping or molding machine.

Of course it is to be understood that a combination of one or more of the three drying methods disclosed herein may be employed in drying the paper instead of using only one of the methods alone.

By "room temperature" as specifically used in the claims I mean the ordinary temperature of the air in the paper machine room which surrounds the point of delivery of the wet web from the web-forming device and the customary press part of the paper machine.

Where in the claims, I speak of the temperature of paper machine driers, I refer to their surface temperature.

In certain of the claims I have stated that the paper may be dried "under conditions such that the temperature of the web is not raised above 75° C., by supplying heat to said web from a heat source above room temperature"; in certain other of the claims I have stated that the drying is accomplished "by heating the paper web to an extent sufficient to elevate the temperature thereof but insufficient to raise the temperature of the web substantially in excess of 75° C."; and in certain other of the claims I have stated that the drying operation is conducted by "evaporating at least the major part of the water in the paper web by heating the web to an extent sufficient to elevate the temperature thereof but insufficient to raise the temperature of the web substantially in excess of 75° C., and thereafter heating the partially dried web at a higher temperature." It is of course obvious that in the drying of paper at atmospheric pressure in the ordinary manner on the usual steam heated paper machine driers, that, at the initial stage of the drying operation, the web will not necessarily be raised immediately to a temperature higher than 75° C. However, as the web continues to contact with the steam heated drying surface, the web soon attains a temperature higher than 75° C. It will of course be understood that in the several expressions referred to above or in any other similar expression which may be used in the claims, I do not mean to include such condition which may take place in ordinary paper machine drying as described above, and therefore I specifically exclude from such expressions the condition which exists at the initial part of the drying of a paper web at substantially atmospheric pressure with ordinary steam heated paper machine driers.

While I have described in detail the preferred embodiments of my invention, it is to be understood that the details of procedure, ingredients, methods of operation, apparatus, and arrangement of steps may be widely varied without departing from the spirit of the invention or the scope of the subjoined claims.

I claim:

1. In a process of manufacturing paper filled with alkaline filler wherein there is provided a water-containing paper web which contains alkaline filler comprising calcium carbonate and rosin sizing, and wherein heat from a heat source above room temperature is supplied to said water-containing web to effect drying thereof, the improvement which comprises maintaining said web, from the time of formation thereof until at least the major part of the drying thereof has been effected, at a temperature not exceeding 75° C.

2. A process according to claim 1 wherein said web is maintained at a temperature not exceeding 75° C. throughout substantially the entire drying thereof.

3. A process according to claim 1 wherein said web contains thermoplastic material and wherein the temperature of the web which has been subjected to drying until at least the major part of the water has been evaporated is subsequently raised sufficiently to cause fluxing of said thermoplastic material.

4. A process according to claim 1 wherein at least the major part of the drying is effected by contacting the water-containing paper web with

heated paper machine driers at a temperature not substantially exceeding 75° C.

5. A process according to claim 1 wherein at least the major part of the drying is effected by exposing the water-containing paper web to heated air.

6. A process according to claim 1 wherein at least the major part of the drying is effected by contacting the water-containing paper web with heated paper machine driers in a chamber under a vacuum such that the boiling point of water thereunder does not exceed a temperature of 75° C.

7. A process according to claim 1 wherein at least the major part of the drying is effected by contacting the water-containing paper web with paper machine driers heated to a temperature above 75° C. in a chamber under a vacuum such that the boiling point of water thereunder does not exceed a temperature of 75° C.

8. A process according to claim 1 wherein at least the major part of the drying is effected by contacting the water-containing paper web with paper machine driers heated to a temperature above 75° C. in a chamber under a vacuum such that the boiling point of water thereunder does not exceed a temperature of 65° C.

9. A process according to claim 1 wherein at least the major part of the drying is effected by contacting the water-containing paper web with paper machine driers heated to a temperature above 75° C. in a chamber under a vacuum such that the boiling point of water thereunder does not exceed a temperature of 45° C.

10. A process according to claim 1 wherein at least the major part of the drying is effected on paper machine driers having a surface temperature above 75° C. but not substantially in direct contact therewith.

11. In the manufacture of paper filled with alkaline filler wherein there is provided a water-containing paper web containing alkaline filler comprising calcium carbonate and rosin sizing and wherein the water-containing web is subsequently dried, the improvement which comprises maintaining said water-containing web at a temperature not exceeding 75° C. from the time of the formation of said web up to the drying thereof, and effecting the drying of said water-containing web by heating the same to an extent sufficient to elevate the temperature thereof but insufficient to raise the temperature of the web above 75° C.

12. In the manufacture of paper filled with alkaline filler wherein there is provided a water-containing paper web containing alkaline filler comprising calcium carbonate and rosin sizing and wherein the water-containing web is subsequently dried, the improvement which comprises maintaining said water-containing web at a temperature not exceeding 75° C. from the time of formation of said web up to the drying thereof, and subjecting said water-containing web to a drying operation comprising evaporating at least the major part of the water in said water-containing web by heating the same to an extent sufficient to elevate the temperature thereof but insufficient to raise the temperature of the web above 75° C., and thereafter heating the said web from which part of the water has been thus removed at a higher temperature.

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CERTIFICATE OF CORRECTION.

Patent No. 2,115,747.

May 3, 1938.

HAROLD ROBERT RAFTON.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 3, first column, line 9, for the word "finishes" read furnishes; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 19th day of July, A. D. 1938.

(Seal)

Henry Van Arsedale,
Acting Commissioner of Patents.