A method is provided in which a small amount of liquid remaining on a non-hygroscopic surface of a sheet material is transferred onto rotating roll surfaces in the form of a thin liquid film while the sheet material passes through plural pairs of squeeze rolls and then the transferred liquid is vaporized by applying hot air upon the squeeze roll surfaces.

8 Claims, 3 Drawing Figures
METHOD AND APPARATUS FOR CONTINUOUSLY DRYING WET NON-HYGROSCOPIC SURFACES OF SHEET MATERIAL

DISCLOSURE

This invention relates to a method and an apparatus for continuously drying wet surfaces of sheet materials made of or coated with non-hygroscopic materials such as for example metal, synthetic resin, or glass.

The most common method of drying wet non-hygroscopic surfaces of sheet materials, which are continuously conveyed, is to directly heat such sheet materials to vaporize liquid deposited on their surfaces. According to such method, however, in order to shorten the drying time, the heating temperature must be raised. Such rise of the heating temperature causes thermal deformation or deterioration of some types of sheet materials to be dried.

Another method is known in which the liquid on the non-hygroscopic surfaces of the sheet material is wiped off by a cloth or the like. Such method, however, has a disadvantage that the liquid adsorptive capacity of the cloth or the like is lowered in a short time. To recover such adsorptive capacity, it is required to vaporize the liquid adsorbed between the entangled fibers or in the capillary fibers with the use of an elaborate apparatus or equipment, involving many problems in practical use.

Accordingly, an object of the present invention is to provide a novel method and an apparatus for easily drying liquid deposited on non-hygroscopic surfaces on sheet materials without thermal deformation or deterioration thereof while they are continuously conveyed.

According to one aspect of the present invention, there is provided a method for continuously drying wet non-hygroscopic surfaces of a sheet material comprising: continuously conveying a sheet material through plural pairs of squeeze rolls juxtaposed in the conveying direction; removing squeezed liquid aggregated and deposited on the surfaces of said sheet material as stemmed or held up by the surfaces of said squeeze rolls; transferring the liquid remaining on said surfaces of said sheet material onto respective rotating squeeze roll surfaces in the form of a thin liquid film while said sheet material passes through the respective pair of said squeeze rolls; and vaporizing said transferred liquid on the surfaces of said respective rotating squeeze rolls by applying hot air upon said squeeze roll surfaces.

When washing water is sprayed on a non-hygroscopic surface of a sheet material such as synthetic resin sheet material, it is dispersed thereon as water drops. Such water drops have small surface area, i.e., small vaporizing areas, so that drying efficiency is bad. Now, if the non-hygroscopic sheet material having the water drops thereon, each of which has a diameter of 5 mm, height of 2 mm and surface area of 19 mm², is conveyed through a pair of squeeze rolls in accordance with the present invention, the water drops are each spread and transferred onto the squeeze roll surfaces with the length of 130 mm and width of 15 mm, so that the surface area becomes 1,950 mm² which is larger more than 100 times of that of the water drop.

In order that the water drops on the non-hygroscopic surface of the sheet material may be effectively transferred on the roll surfaces, that the good contact between the rolls and the sheet material to be dried may be obtained, and that the sheet material may not be injured by the rolls, the squeeze rolls are coated with elastic, liquid non-repellent material such as, for example, synthetic rubber, polyethylene, soft vinyl chloride, soft nylon (6-nylon), or polypropylene. The most preferable coating material is urethane rubber having Shore hardness A 40 – 90.

The first pair of rolls, through which the sheet material is initially subjected to drying treatment of the present invention, mainly act to squeeze the liquid deposited thereon, so that it is preferable to coat the roll with liquid repellent material such as fluorine-contained resin. The squeezed water aggregated on the surface of the sheet material as stemmed or held up by the surfaces of the squeeze rolls drops from both sides of the squeeze rolls or comes down along the surface of the lower squeeze roll and is, thereby, discharged. If it is desired to positively discharge the squeezed water, there may be provided a means for blowing off the squeezed liquid by compressed air or means for sucking it by vacuum.

The water transferred on the rolls can be dried up within a short period of time by applying hot air of relatively low temperature upon the rolls.

For example, when a square shaped synthetic resin sheet of 600 x 600 mm is subjected to the present drying treatment in a housing of 80 cm length and containing eight pairs of squeeze rolls each having a diameter of 44 mm, the sheet was dried up in a little less than four seconds with hot air applied to the rolls at about 40°C.

Thus, according to the present invention, since the sheet material is indirectly dried with the heated squeeze rolls which also function to convey the sheet materials, undesirable thermal influences can be minimized and the drying time period is remarkably shortened.

The hot air applied to the roll surfaces is filled in the housing and then discharged. Accordingly, the hot air filled in the housing will also serve to dry the surfaces of the sheet material and the rolls.

If desired, upper and lower subsidiary rolls may be disposed between the adjacent pairs of the squeeze rolls in contact therewith to form respective closed spaces therebetween. The hot air is applied to the squeeze rolls at the outside of the closed spaces. In such structure, the closed space is effectively isolated from the hot air and the sheet material conveyed through the closed spaces is not affected at all by the hot air, so that this structure is most preferable for drying treatment of sheet materials which are easily deformed or deteriorated by heat.

The present method is most effective when applied to drying treatment of copper plate which has been ground and washed and on which electrical circuit pattern is to be printed.

The objects and advantages of the present invention will become more apparent from the following description when taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a sectional side view showing a drying apparatus according to an embodiment of the present invention which is communicated with a grinding and washing apparatus,

FIG. 2 is a plane view of the apparatus shown in FIG. 1 in which a top cover is removed, and
Fig. 3 is a schematic side view showing a drying apparatus according to another embodiment of the present invention.

Referring to the first embodiment shown in Figs. 1 and 2, a grinding and washing housing is communicated with a drying housing of the present invention.

A pair of feed rollers are disposed adjacent to an inlet, a grinding and washing housing. The housing comprises plurality of pairs of feed rollers, upper and lower spray pipes for washing water disposed between adjacent pairs of feed rollers, a drain pipe connected to the bottom of the housing, a grinding roll, and a roll. A sheet material such as a copper plate is fed in the housing through the inlet thereof by the feed rollers and conveyed by the plural pairs of feed rollers. While conveyed by the feed rollers, the sheet material is subjected to washing, grinding and washing treatments by the spray pipes, grinding roll and spray pipes disposed in that order. Further detailed description relating to the grinding and washing apparatus shall be omitted herein, because this apparatus does not constitute a part of the present invention.

The drying housing has an inlet and an outlet for the sheet material to be treated. The inlet of the drying housing also serves as outlet of the washing and grinding housing. In the drying housing are provided eight pairs of squeeze rolls in which upper and lower rolls of each pair are circumcised with each other. The squeeze rolls are in such a manner that the sheet material can be conveyed along a horizontal plane on which the inlet and the outlet locate. The lower squeeze rolls are positively and simultaneously rotated by a chain sprocket means driven by an electric motor. The upper squeeze rolls are each compressed upon the associated lower squeeze roll by spring force (not shown) or by its weight.

Provided between the paired squeeze rolls are four upper and lower hot air supply pipes which are connected to a duct. The duct is connected to an outlet side of a heater in which air sucked in by a fan is heated. Each of the hot air supply pipes is provided with spouts from which hot air is sprayed over the entire length of the squeeze rolls. The hot air spouts are formed in the pipe in such a manner that the spouts are in opposition to the squeeze rolls at both sides of the hot air supply pipe. The hot air thus sprayed is once stored in the drying housing and is discharged from an exhaust port and through an exhaust duct. The bottom face of the drying housing is inclined so that the squeezed water will be collected into a suitable drain pipe.

In operation, a sheet material to be dried is fed into the drying housing through the inlet opening and is first held between the first pair of squeeze rolls, whereby the liquid deposited on the non-hygroscopic surface of the sheet material is substantially squeezed out and falls down. The remaining liquid on the sheet material is partially transferred onto the squeeze roll surfaces in the form of a thin film, and then the sheet material is further conveyed to the right hand in Figs. 1 and 2 so that it is now held between the second pairs of squeeze rolls, where the same squeezing and transferring of the liquid as set forth above are performed. The similar operations are repeated as the sheet material is conveyed through the pairs of squeeze rolls and thru hot air continuously sprayed from the hot air spouts. The sheet material thus dried in this manner is delivered out from the outlet opening to next printing operations.

In a second embodiment shown in Fig. 3, upper and lower subsidiary rolls are disposed between the adjacent pairs of the squeeze rolls in contact therewith to form respective closed spaces therebetween. Each of the upper and lower subsidiary rolls is separated from each other so as not to contact with the sheet material conveyed through the respective closed spaces. In this embodiment, there is no hot air supply pipe such as provided in the first embodiment. Instead of such hot air supply pipes, the closed drying housing is provided at one end (right end in Fig. 3) of the bottom plate with a hot air intake port communicating with a heater of the type shown in Fig. 1 and at one end (left end in Fig. 3) of the upper plate, which end is remote from the intake port, with a hot air discharge port. Other remaining features are substantially same as those of the first embodiment.

In operation, while the sheet material is conveyed through the squeeze rolls, the liquid deposited on the sheet material is transferred to the squeeze roll surfaces in the form of thin films as disclosed in the first embodiment. The liquid transferred onto the respective squeeze rolls is vaporized by hot air filled in the drying housing outside of the closed spaces. In this embodiment, as the sheet material is to be dried, it is conveyed through the closed spaces which are effectively isolated from the hot air, such structure is most preferable when adapted to drying treatment of sheet materials easily deformed or deteriorated by heat.

Though the present invention has been described with reference to the preferred embodiments thereof, many modifications and alterations may be made within the spirit of the present invention. For example, hot air supply pipes of the type shown in the first embodiment may be provided at the outside of the closed spaces in the housing of the second embodiment.

What is claimed is:

1. An apparatus for continuously drying wet non-hygroscopic surfaces of a sheet material, comprising:
   a. a housing provided with an inlet and an outlet for said sheet material to be dried,
   b. plural pairs of squeeze rolls provided in said housing and juxtaposed in the conveying direction of said sheet material, said squeeze rolls being coated with elastic, liquid non-repellent material, and
   c. hot air supply pipes each being disposed between the adjacent pairs of squeeze rolls with hot air spouts opening in opposition to the respective squeeze rolls along the substantially entire length of the squeeze rolls.

2. An apparatus as claimed in claim 1, further comprising upper and lower subsidiary rolls disposed between the adjacent pairs of said squeeze rolls in contact therewith to form respective closed spaces therebetween; said hot air apply means being disposed outside of said closed spaces.
3. An apparatus as claimed in claim 1, wherein each of said squeeze rolls is coated with synthetic rubber.

4. An apparatus as claimed in claim 1, wherein the first pair of squeeze rolls adjacent to said inlet of said housing is coated with fluorne-contained resin.

5. A method of continuously drying wet non-hygroscopic surfaces of a sheet material comprising:
   a. continuously conveying a sheet material through plural pairs of squeeze rollers juxtaposed in the conveying direction,
   b. removing squeezed liquid transferred onto the surfaces of said squeeze rolls by applying hot air upon said squeeze roll surfaces,
   c. transferring the liquid remaining on said surfaces of said squeeze roll surfaces onto respective rotatin subsidiary roller surfaces which do not contact the sheet material in the form of a thin liquid film, and
   d. vaporizing said transferred liquid on the surfaces of said subsidiary roller surfaces by applying hot air.

6. An apparatus for continuously drying wet non-hygroscopic surfaces of a sheet material, comprising:
   a. a housing provided with an inlet and an outlet for said sheet material to be dried,
   b. plural pairs of squeeze rolls provided in said housing and juxtaposed in the conveying direction of said sheet material, said squeeze rolls being coated with elastic, liquid non-repellent material,
   c. upper and lower subsidiary rolls disposed between the adjacent pairs of said squeeze rolls in contact therewith to form respective closed spaces therebetween; and
   d. means for applying hot air to the squeeze rolls and to the subsidiary rolls, said hot air applying means being outside of said closed spaces.

7. An apparatus as claimed in claim 6 wherein each of said squeeze rolls is coated with synthetic rubber.

8. An apparatus as claimed in claim 6 wherein the first pair of the squeeze rolls adjacent to said inlet of said housing is coated with fluorne-contained resin.

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