CURTAIN COATING PROCESS AND APPARATUS

Filed March 31, 1966

FIG. 1

FIG. 2

FIG. 3

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Filed Mar. 11, 1966, Serial No. 539,046
Int. Cl. 44g 1/40, 1/44
U.S. Cl. 117—65.2
9 Claims

ABSTRACT OF THE DISCLOSURE
In a curtain coater, a resilient roller is placed against the uncoated side of coated substrate as said substrate passes over a chill roller, which is spaced downstream from the falling curtain of coating material.

This invention relates to applying a hot melt coating to at least one surface of a substrate. In one aspect, this invention relates to curtain coaters. In another aspect, this invention relates to an improved method of applying a hot melt to a substrate.

When applied to the coating of certain solid substrate materials with hot viscous liquids, such as molten wax, molten synthetic resins, and blends of wax with synthetic resins (generally referred to as hot melts), most coating procedures are characterized in varying degree by a number of disadvantages. Among such disadvantages there may be mentioned: waste or uneconomical use of the coating material, decrease in flexibility of the substrate as a result of coating, and failure of the coating technique to successfully apply a smooth continuous coating which is free from cracks, bubbles, pinholes, blisters and the like.

In recent years, the curtain coater process has been developed to applying such hot melt coatings to substrates. In curtain coating, the stock to be coated is passed through a gravitating or falling curtain or film of the coating medium so that the coating medium impinges upon the exposed surface of the stock and is deposited thereon as a thin, relatively uniform film. The excess coating material which is not deposited on the stock is collected in a suitable receiving container and, preferably, degassed and cycled to the point of origin of the gravitating curtain for reuse. Preferably, the stock is preheated prior to coating; however, with relatively thin stocks such as celophane, and similar thin plastic sheets, this is generally not required. In any case, the hot melt must be cooled below the tacky point prior to rolling the stock to prevent sticking. This is generally accomplished by passing the freshly coated stock around a chill roll. The conventional curtain coater has been very effective in coating porous substrates; however, when semi-porous substrates such as plastic film, glassine paper, paper, grease-proof paper and the like are coated with a curtain coater; bubbles, pinholes or small areas of non-adhered coatings frequently result. These problems are largely eliminated by the process disclosed in the copending application of Pollitzer, Kresse, Wong and Cordy, filed Sept. 13, 1965, and having Ser. No. 486,787 and now abandoned. According to the method disclosed by Pollitzer et al., the hot melt is subjected to a degassing step prior to application. However, the stock itself can be the source of the gas bubbles, e.g., a small amount of moisture; also, a small amount of air can be entrapped at the point of impingement. While the degassed hot melt may give an apparently uniform, hole-free coating, the coating may not actually adhere uniformly and thus the coating will break subsequent to the coating. With porous substrates, steam formed by moisture or other gas will pass through the substrate, whereas with semi-porous substrates, the gas flow meets with sufficient pressure to be a source of potential difficulty. This is illustrated by clay-backed substrates. It has been found that little or no trouble is encountered when using the degassed hot melt to the coated side of the substrate. On the other hand, considerable difficulty is encountered on coating the untreated side. This is probably due to the fact that the paper stock contains some moisture and when the hot melt is applied to the substrate, the steam produced passes readily through the substrate. However, when applying the coating to the untreated side, the steam does not readily pass through the clay and forms small bubbles in the film. On the chill roll, the steam is condensed and reabsorbed by the substrate; however, the hot melt film does not adhere to the substrate.

It is an object of this invention to provide methods of coating substrates. Another object of this invention is to provide a method for improving the adhesion of coatings to substrates. Another object of this invention is to provide a method for maintaining the flatness of thin substrates after applying hot melts to the surface thereof. It is still another object of this invention to provide a method for improving the gloss and surface smoothness to surfaces applied to substrates. Still another object of this invention is to improve heat transfer at the chill roll following application of hot melt to substrates, and still other objects, features and advantages of this invention will be apparent to those skilled in the art having been given this disclosure and the appended claims.

These objects are accomplished according to this invention by passing a substrate which has been coated with a hot melt by means of a curtain coater over a chill roll and between said chill roll and a pressure roll. As has been indicated, the substrates to which this invention is of particular usefulness are impervious substrates such as metallic foils, i.e., aluminum foil, etc., plastic sheets such as celophane, polyethylene and other polymer and copolymer flexible sheeting materials and semi-porous sheets such as clay-backed and lacquer-backed papers, paper, greaseproof paper, glassine paper and the like.

The coating materials to which this invention is particularly useful are hot melts which are subject to applying to substrates, e.g., a falling curtain as utilized in a curtain coater. These materials are waxes, wax-copolymer blends and the like. In general, these materials have an inherent viscosity at 250° F. in the range of 15,000 to 100,000 cps. A typical wax-copolymer blend would be a hydrocarbon high melting wax with butyl rubber, or ethylene-vinylacetate copolymer. Such melts are known in the art, and are not a part of this invention.

The apparatus by which the present invention is practiced in one embodiment comprises a curtain coating device which can be of conventional type and which functions to provide a gravitating or downwardly propelled curtain or film of the coating composition; a conveyor system or means for moving the substrate to be coated through the gravitating curtain of the coating composition and a means for cooling the stock after coating. Preferably, the curtain coater will have conduit means for collecting and recycling to the curtain coating device all the excess coating composition which is not deposited upon the stock; means for preheating the stock when so desired and means for removing gas from the coating composition. An important feature of a preferred...
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3. An embodiment of the apparatus used in the practice of the present invention is a pressure roll in cooperation with the means for cooling so as to press the film against the stock as it passes over the cooling means. In a typical installation wherein a sheet of stock is continuously unrolled, passed through the curtain coater and is subsequently rerolled, the cooling means intermediate the curtain coater and the reroller will comprise a chill roll and a pressure roll so arranged that the falling pressure roll is held in contact with the stock as it passes over the cooling roll. Preferably, the pressure roll will have a resilient surface such as rubber or high melting plastic, e.g., butadiene, styrene copolymers, high melting point polyethylene and acrylic copolymer, which hot melt of these variably polymerizable monomers or polyvinylfluorides such as "Teflon." For some stocks it is desirable to include in the apparatus used in practicing the invention, humidifying means for adding sufficient moisture to the stock to be coated to prevent excessive dehydration of the stock and fiber embrittlement in those cases where the stock is preheated prior to the application of the coating thereto.

The coating material useful in this invention is any hot melt suitable for use in a falling film or curtain coater. In general, these materials are mixtures of paraffin and/or polyethylene and polyvinylacetate copolymer, e.g., 30% wax and 70% copolymer of 80% ethylene with 20% vinylacetate. Other polymers and copolymers are sometimes used such as polystyrene, polyethylene, polybutadiene, butadiene-styrene copolymer, vinylacetate and polyvinylacetate. The only limitation being that the blend or melt will form a free-flowing film at the extrusion temperature which should be low enough so that the substrate is not damaged at the point of contact. Thus, any melt having a viscosity in the range of 15,000 to 100,000 ccs./250°F. can be used. Although 250°F. is the reference temperature, the coater reservoir or extrusion temperature will generally be higher than this, e.g., 270 to 400°F. As a rule of thumb, it can be said that for each 5°F. raise in temperature, the actual viscosity will be halved. Thus, if a blend having a reference viscosity of 100,000 ccs./250°F. were heated to 300°F., the film viscosity would be about 25,000 centipoises.

The pressure in a curtain coater extruder or film former ranges generally from 5 to 20 psi.g. as compared to 100 to 500 psi.g. in the conventional extruder coater. The falling film flows upon the substrate to be coated, and the excess runs off, is collected, degassed and returned to the film former where the temperature and pressure desired for the particular melt is maintained. The substrate then passes over a chill roll wherein the coated material is cooled to a temperature wherein it is no longer tacky, and the coated substrate can then be rerolled on the reroller. The chiller is ordinarily cooled with refrigerated water; however, with some hot melts, a lower temperature may be required and some other cooling medium such as alcohol or ethylene glycol can be employed. The amount of cooling required is such that the coated material can be rerolled without sticking. Thus, the temperature of the chill roll will be dependent upon the nature of the melt, the speed of the substrate, the surface area (heat transfer surface) of the chill roll and the like. In general, this temperature varies from 5 to 150°F. All of the above is known in the art as used in the coating industry not only with curtain coaters, but coaters in general, and no detailed description is deemed necessary in this specification.

As far as the present invention is concerned, the temperature of the coating as it enters the nip between the pressure roll and the chill roll should be such that the coating material has set sufficiently that it will not rupture as the gas bubbles are compressed and yet retain sufficient additional properties to adhere to the substrate when bubbles and the like are forced by the pressure roll against the substrate. As will be understood by those skilled in the art, this temperature will be dependent upon the nature of the coating and the substrate, and each individual case will have its own range which can readily be determined by the skilled operator. This temperature will generally range from about 100 to 150°F., but is not necessarily limited thereto. This temperature can be regulated by controlling the temperature of the substrate and the falling film coating and the feed rate of the substrate. This feed rate generally will vary from about 200 ft. per minute to 1000 ft. per minute or more. The film thickness will also affect the required temperature, and in turn the film thickness is affected by the rate at which hot melt is supplied to the nip of the substrate feed rate. In general, a thickness from about 0.1 mil to 10 mils is desired. In some applications, a prechill roll can be used to control the temperature of the coating at the nip. The prechill roll also serves a useful purpose where the substrate has been previously coated on the reverse side, e.g., with thermoplastic lacquer or hot melt, in that the hot curtain can soften the underside of the substrate and the prechill roll serves to resolidify this reverse side coating and prevent its being marred by the pressure roll.

The invention will be further described with reference to the accompanying drawings.

FIGURE 1 is a schematic illustration of a conventional curtain coater incorporating a resilient pressure roll and FIGURE 2 is a schematic illustration of such a curtain coater utilizing a prechill roll.

Referring now to the drawings, substrate 2 from supply roll 1 is passed over rollers 3, 4 and 5 under coating head 6 which has an elongated nozzle at its lower end so as to provide a falling film or curtain which impinges on the substrate 2 thus coating same. Excess coating material from curtain 7 falls over the sides of the substrate into overflow collector 8 and is passed via conduit 9 back through a degasser (not shown) to the melt reservoir (not shown). This reservoir is equipped with suitable means for maintaining the desired temperature, e.g., internal heating coils or jacket, and a pump for delivering coating material to the coating head 6 at a controlled rate. If desired, an agitator can be provided as is known in the art. The coated substrate then passes through the nip 15 between a previously having a resilient surface) and chill roller 11 and over rollers 12 and 13 to rewind, not shown. In FIGURE 2, a prechill roll 14 is put ahead of the substrate feed rate. In general, the operation and description is the same as FIGURE 1, and the same numbers are used to illustrate the corresponding parts. The pressure between the pressure roll and chill roll can vary over a wide range, say from 10 lbs./in. of nip to 500 lbs./in. of nip and preferably from 25 to 150 lbs. per inch of nip.

Referring to FIGURE 3, the substrate after passing over the gravitating film passes over roller 16 and back around chill roll 11 and then between the nip formed by chill roll 11 and resilient pressure roll 10. In this case, the chill roll serves as prechill as well as final chill. The remaining rollers are numbered as in FIGURE 1 and only so much of this embodiment is shown as to illustrate the modification.

A number of runs were made using the equipment of FIGURE 1. The pressure between the rubber roll 10 and chill roll 11 was 30 pounds per inch of nip. The resilient or rubber roll 10 had a rubber surface of 70 Shore "A" hardness. The chill roll was of metallic finish. In all of the runs, the coating composition was a mixture of paraffin wax and ethylene-vinyl-acetate copolymer. The mixture was varied to obtain the desired viscosity at 250°F.
EXAMPLE I
Wax blend: Viscosity at 250° F. = 42,750 c.p.s.
Substrate: Aluminum foil-pouch stock laminate, coating foil side.
Melt temperature: 370° F.
Web feed rate: 800 f.p.m. (feet per minute).
Coating weight: 22.3 lbs./3000 ft².

With no pressure roll, the coating contained visible bubbles. With the pressure roll at 50 lbs./inch, the bubbles were flattened and the general appearance of the coating was much improved. The flattened portions appeared to have adhered to the substrate.

EXAMPLE II
Wax blend: Viscosity at 250° F. = 57,250 c.p.s.
Substrate: 30# blassine paper.
Coating temperature: 360° F.
Web speed: 1100 f.p.m.
Coating weight: 10.5 lbs./3000 ft².

With no pressure roll, the coating was rough and had many air inclusions between the film and substrate. The coating was easily abraded over the air inclusions.

When the pressure roll was used, the coating was smooth and of good appearance. Adhesion and resistance to abrasion was greatly improved.

EXAMPLE III
Wax blend: Viscosity at 250° F. = 3,000 c.p.s.
Substrate: 30# clay-coated bleached kraft, coating non-clay side.
Coating temperature: 285° F.
Web speed: 1000 f.p.m.
Coating weight: 9.9 lbs./3000 ft².

In the absence of the pressure roll, the coating was rough and contained many pinholes.

With pressure roll, the coating was smooth, of good appearance and apparently free of pinholes.

EXAMPLE IV
Wax blend: Viscosity at 250° F. = 1280 c.p.s.
Substrate: 1 mil thick cellophane.
Coating temperature: 255° F.
Web speed: 275 f.p.m.
Coating weight: 38.7 lbs./3000 ft².

In the absence of the pressure roll, the coated sheet was ridged and corrugated.

With the pressure roll, the coated sheet was smooth and flat.

In the case of the curtain coater being of substantial distance from the chill and pressure roll, or where the film has a tendency to set prior to reaching the nip 15, it is often desirable to pass the moving substrate through a reflective or insulated tunnel or additional heat can be supplied such as by infrared lights or the like to keep the coating soft prior to the substrate contacting the chill roll. In case of glassine paper, wax paper or the like being coated on the opposite side, it will be found advantageous to use the prechill roll of FIGURE 2. In case of heavy substrate, it is sometimes desirable to preheat the substrate prior to coating. Here the use of heated rolls, infrared heating, or the like would be used prior to applying the coating composition. It should also be obvious to those skilled in the art that the number of rollers shown can vary and that the passage of the coated substrate between the nip of the resilient and chill roll can vary from that shown, e.g., the substrate need not pass over the rill of the roll on top of the nip 15. Other changes can be made by those skilled in the art without departing from the scope and spirit of the invention. While all of the cylindrical surfaces have been described as rollers, it is obvious that low friction stationary bars can also be used.

Having thus described the invention, we claim:
1. In a curtain coater wherein a hot melt is gravitated as a film upon a substrate to be coated and said substrate is continuously passed beneath the gravitating film and over a chill roll spaced downstream from said gravitating film, the improvement comprising a pressure roll in alignment with said chill roll and adjacent said roll and exerting a pressure upon said chill roll and so aligned that said substrate with the resulting film passes between the nip formed between said chill roll and said pressure roll with the coated side of said substrate in contact with said chill roll and the underside of said substrate is in contact with said pressure roll.
2. In the process of coating a substrate with a hot melt coating composition by passing the substrate continuously through a gravitating liquid curtain of said hot melt and setting the melt by passing the coated substrate over a cooling cylinder being spaced downstream from said gravitating liquid curtain, the improvement comprising applying a pressure by means of a resilient roll against the uncoated side of said substrate as it passes over said cooling cylinder.
3. The improvement of claim 2 wherein the temperature of the coating is controlled so as to be only partially set when said pressure is applied.
4. The improvement of claim 3 wherein said pressure is at least 10 pounds per inch of nip between said cooling cylinder and said resilient roll.
5. The improvement of claim 3 wherein the temperature is controlled by precooling the film prior to applying said pressure.
6. In the process of coating a substrate by continuously passing said substrate through a gravitating hot curtain of the coating material and downstream from said gravitating hot curtain setting said coating by passing the coated substrate over a first rotating cylinder having means for regulating the temperature of said rotating cylinder to a temperature wherein said film is set, the improvement comprising passing said coated substrate between the nip formed by said rotating cylinder and a second rotating cylinder having a resilient surface and co-acting with said first rotating cylinder so as to apply a pressure to the backside of said substrate.
7. The improvement of claim 6 wherein said coating material is only partially set where said substrate coated with coating material enters said nip.
8. The improvement of claim 7 wherein the pressure in the nip between said first rotating cylinder and said second rotating cylinder is at least 10 pounds per inch of nip.
9. The improvement of claim 7 wherein said pressure is in the range 25 to 150 pounds per inch of nip.

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U.S. Cl. X.R.
117—158, 168, 155; 118—117; 161—234; 156—244