

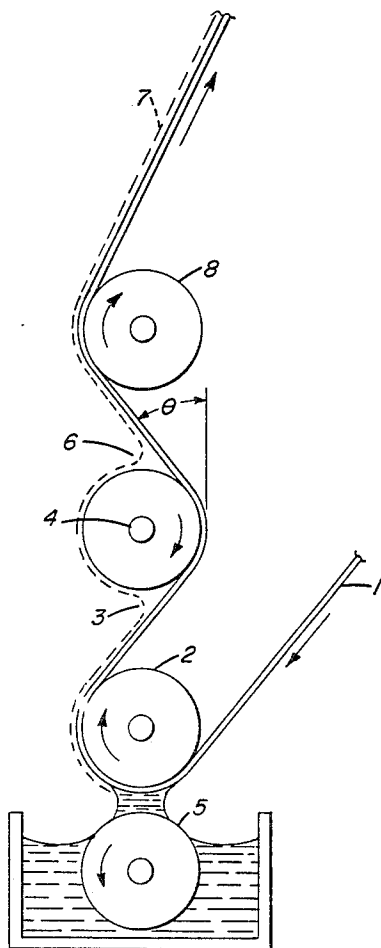
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COATING PROCESS

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COATING PROCESS

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4 Claims 10

ABSTRACT OF THE DISCLOSURE

A thin uniform layer of a liquid coating composition is coated on a web by applying an excess of the coating composition to the web, advancing the web upwardly so that the coated surface engages a meter roll rotating in a direction opposite to the direction of travel of the web and at a peripheral speed of from about 5 to about 50 percent of the linear speed of the web, and then directing the web upwardly away from the meter roll in a direction within 30 degrees of either side of the vertical.

This application is a continuation-in-part of U.S. patent application Ser. No. 294,848, filed July 15, 1963, and now abandoned.

This invention relates to a method of coating traveling webs and more particularly to a method of coating thin fast-moving webs with a fine film of coating fluid.

It is often desirable to supplement or alter the properties of a web material by coating the material with a fluid substance. Many methods of imparting liquid coating to a web have been practiced in the art. The bead or meniscus coating process is one of the more widely used processes which display shortcomings overcome by the present invention. Practice of the bead process consists of passing a web between two rolls having axes in a substantially vertical plane. A clearance of approximately 10–20 mils is set between the rolls and the web conducted therebetween. Fluid is coated onto the web by the bottom immersion roll which is partially immersed in the fluid. It has been found that the popular bead coating process produces less than satisfactory results when web speed exceed 40 feet per minute or when web thickness is less than 3 mils.

Thin webs are of course more easily affected by active coating solutions and require thin coatings thereon. The lower limit in web thickness is attributable to the runout inherent in the rollers due to eccentricity, bearing clearance or other necessary tolerances which preclude satisfactory results with thin coatings. Web speed is limited by the hydrodynamics of the bead. At speeds above 40 feet per minute the bead becomes unstable and deteriorates into a nodal configuration which produces lineyness or a rake pattern on the coated web.

It is therefore an object of this invention to provide a coating process yielding satisfactory results at web speeds greater than 40 feet per minute.

It is another object of this invention to provide a coating process which can be successfully used with webs of less than 3 mils thickness.

Yet a further object of this invention is to provide a coating process which can successfully coat thin webs while the coating thickness is varied several fold by altering operating parameters.

Other objects will be apparent from the drawing and following description.

According to the present invention web materials are coated by first depositing a coating fluid upon the web material in a convenient manner. The web material with the coating fluid deposited thereon is then conducted over a

meter roll rotating counter to the direction of travel of the web with the meter roll contacting the web on the side thereof upon which the coating fluid is spread. Since the periphery direction of travel of the meter roll is opposite the direction of travel of the web over the area of mutual contact, the meter roll picks up a major portion of the coating fluid from the web and thoroughly wets the web with the remaining fluid by smearing it across the web surface. After being removed from the web, the majority of the coating fluid forms a bank of fluid at the line of initial contact between the web and the meter roll. Part of the fluid is picked up on the surface of the meter roll and carried to the terminal line of contact between the meter roll and web where it is collected in the form of a stable meniscus and redeposited therefrom as an even smooth coating upon the web. Thus, by regulating the speed of the meter roll and the speed of the web, not only is the coating deposited upon the web in an even, smooth manner, but also the amount of the coating on the web can be regulated within a fairly wide range.

The invention will be more easily understood with reference to the drawing in which web 1 is drawn from a source (not shown) such as an unwind roll or casting wheel under uniform tension and at a uniform speed. Web 1 passes over spreader roll 2 which flattens web 1 and, in one embodiment of the invention, cooperates with pickup roll 5 to wet web 1 with a coating fluid. Wetting of web 1 may be accomplished in any convenient manner and need not be uniform. Wetted web 1 then passes over oppositely rotating meter roll 4 and a fluid bank 3 is formed ahead of meter roll 4. From the fluid bank 3, meter roll 4 picks up a film of coating fluid and forms a stable meniscus 6 adjacent the line of terminal contact between web 1 and meter roll 4. The actual amount of coating fluid transferred by meter roll 4 from fluid bank 3 to the stable meniscus 6 is determined largely by the speed at which meter roll 4 is revolved. For effective metering, at least some of the coating fluid is drained (by gravity) away from fluid bank 3 in a direction opposite from that of the web. Thus, in the practice of this invention, excess coating fluid is applied initially to web 1; such excess being subsequently determined and removed from web 1 by the action of meter roll 4. Generally the material that is drained in such opposite direction is simply returned to the container from which the coating fluid was originally applied to the web. Web 1 with coating 7 thereon may then be conducted through a drying chamber (not shown) and subsequently wound into rolls (not shown). The angle θ can be controlled by adjustment of roll 8 or meter roll 4 and the process has been successfully operated employing departure angles $\theta \pm 30^\circ$ from the vertical. The angle of entry of web 1 upon meter roll 4 is not as critical as the angle of departure. Successful operation of the process has been attained with the angle of entry varied between $+45^\circ$ above horizontal to -75° below horizontal. The illustrated use of a bead applicator employing rolls 2 and 5 is not critical to the invention and any of the many known methods of dispersing a fluid in order to wet web 1 may be employed.

Meter roll 4 can be constructed of stainless steel, chromeplated steel, aluminum, nylon, Teflon, polyvinyl chloride or a composition of fiber glass-Teflon. Satisfactory performance has been achieved with all of these materials. Chromeplated steel meter rolls 4 having RMS-1½ and RMS-5 finishes operate satisfactorily, but a vapor-blasted finish has scratched the surface of moving web 1 and found not to be entirely satisfactory. Meter rolls 4 of 4.5 mil, 6 mil and 12 mil stainless steel wire wound rolls also produce satisfactory results. Chromeplated steel appears to be the preferable material of construction for meter roll 4, but higher meter roll peripheral

speeds can be attained through use of a nylon roll since it is wet less by the coating composition.

Meter roll 4 is driven with its travel opposite to the direction of travel of web 1. The peripheral speed of meter roll 4 is generally 5-50% of the linear speed of web 1 and preferably 5-20% thereof. While meter roll 4 may be rotated by means separate from that employed to advance web 1, it is sometimes advantageous to interrelate the two drive systems so that the peripheral speed of meter roll 4 changes as a function of the speed of web 1.

Fluid bank 3 prewets web 1 thereby providing a lubricating medium between meter roll 4 and web 1 to prevent abrasion of the web surface. The prewetting of web 1 also contributes to the coating from meniscus 6 in that the initial intimate dispersion of the coating fluid upon web 1 is accomplished before final coating from meniscus 6.

Many parameters influence the quality and quantity of the coating. Basically, the stability of meniscus 6 is the most significant factor in the coating process of the present invention. The following formula indicates the relationship of several important parameters indicated as an empirical flow behavior number indicated hereafter as FBN:

$$\frac{(\mu V)^a}{T} \frac{(R)^b}{ho} \frac{(Fn)^c}{\rho g \cos \theta} = FBN$$

where

μ —viscosity

V —average fluid velocity between wet and coating roll

T —surface tension

R —roller diameter

ho —clearance between web and meter roll

Fn —force normal to web

ρ —specific gravity of coating fluid

g —gravity

θ —departure angle

a, b —constants (approximately $\frac{1}{2}$)

c —constant not known

Any change which increases the value of the FBN tends to decrease the stability of meniscus 6.

The equation is not intended to comprehensively relate the complicated variables which influence the coating process, but rather it is intended to indicate broadly the nature of the relationship between the more obvious of the operating variables and, in an even more general fashion, suggest the order of magnitude of the influence of a given variable. One skilled in the art will find the equation to be helpful in practicing the present invention, but the equation will not supplant the expertise normally expected of one skilled in the art.

Practice of the invention will be more clearly understood with reference to the following examples.

EXAMPLE 1

A 1.0 mil continuous web of cellulose triacetate was coated with a 1.0% by weight solution of cellulose acetate dissolved in methyl alcohol, methyl isobutyl ketone and isopropyl alcohol of about 10 centipoise viscosity. The web was advanced at a rate of 47 feet per minute and the coating fluid used was initially applied to the web by bead applicator. Water jacketing was provided in a 2 inch diameter meter roll to maintain the temperature thereof at 105° F. The chrome plated steel meter roll, which had a 5 RMS finish, was rotated in a direction opposite to that which the web traveled at an angular velocity of 10 r.p.m. A sheet tension on the order of 0.5 pound per linear inch width of web was maintained and the angle of departure of the web from the meter roll was 15° from the vertical. A space of 10 inches existed between the bead applicator and the meter roll. During the operation, a small amount of excess coating fluid was observed returning over the web to the bead

applicator. Under these conditions a uniform coating of satisfactory appearance was obtained. Since the coating fluid often swells the web while forming physical and/or chemical bonds therewith, it is difficult to accurately measure the true thickness of the coating. However, the quality of a given coating will be apparent to one skilled in the art. Unsatisfactory coating is usually a result of uneven coating which unevenly swells or otherwise affects the web to produce a visually apparent lineyness or other pattern upon the web.

EXAMPLE 2

A coating operation was performed with the meter roll rotating at 25 r.p.m. and with the other conditions the same as in Example 1. This change increased three-fold the amount measured on a weight basis, of coating fluid applied to the web while maintaining satisfactory coating appearance. Bead coating processes are limited to web thicknesses of greater than 2.5 mil, but even in the optimum range of web speeds and thicknesses the amount of fluid coated by conventional processes can be altered over only a two-fold range by means of equipment adjustment.

EXAMPLE 3

The operating conditions of Example 1, with the exception of meter roll rotational speed and sheet tension, were again maintained. With a sheet tension of 0.25 pound per linear inch width of web, the meter roll could be rotated at 2-15 r.p.m. with satisfactory coating results. Greater amounts of coating fluid were deposited with the higher meter roll rotational speeds, but the coatings were uniform over the indicated range.

EXAMPLE 4

The coating process of Example 3 was repeated with the sheet tension adjusted to 1.0 pound per linear inch of web and it was found that the meter roll could be rotated at 20-30 r.p.m. with satisfactory coating results. Thus the interdependence of the operating parameters will be readily apparent.

EXAMPLE 5

A polyethylene terephthalate web of 0.5 mil thickness traveling at 80 feet per minute was coated with a 10 centipoise solution of terpolymer latex. A 2.0 inch diameter water-jacketed meter roll maintained at a temperature of 165° F. was rotated contra to the direction of travel of the web at 15 r.p.m. The web was conducted from the meter roll at an angle of 30° to the vertical. The equipment was otherwise the same as in the previous examples. Settings on the bead applicator were adjusted so as to initially apply an excess of the latex onto the web. Thus, during the coating procedure, there was a continuous return of some excess latex from the fluid bank at the entry side of the meter roll to the reservoir of the bead applicator. Under these conditions a satisfactory coating upon the web was obtained.

While this invention is particularly advantageous in the coating of continuous webs of known non-porous polymeric materials with coating fluids of not more than 25 centipoise viscosity, it is to be understood that the process has application to coating other materials with more viscous fluids, though perhaps not with such striking improvement over the prior art as displayed by the preferred embodiments.

The invention has been described in detail with particular reference to preferred embodiments thereof, but it will be understood that variations and modifications can be effected within the spirit and scope of the invention.

I claim:

1. A method of coating a web with a thin uniform layer of a liquid coating composition, comprising the steps of applying to one surface of the web an excess of the coating composition, advancing the web with the excess of coating composition in a generally upward direction, contacting the coated surface of the web with a

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rotatable meter roll to form a bank of the coating composition between the web and the meter roll at the line of engagement, rotating the meter roll in a direction opposite to the direction the web is traveling at the line of engagement with a peripheral speed of from about 5 to about 50 percent of the linear speed of the web to pick up part of the coating composition on the meter roll and then release said part to form a stable meniscus between the web and the meter roll at the terminal line of contact thereof, and directing the web upwardly away from the meter roll in a direction that is within 30 degrees of either side of the vertical; whereby a portion of said coating composition flows downwardly away from said bank as a result of the action of gravity and said coating composition is applied to said web at said meniscus as a uniform layer of the desired thickness.

2. The method of claim 1 wherein the coating composition has a viscosity of up to 25 centipoises.

3. The method of claim 2 wherein the thickness of

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the web is from 0.5 to 2.5 mils and the linear speed of the web is greater than 40 feet per minute.

4. The method of claim 3 wherein the peripheral speed of the meter roll is from about 5 to about 20 percent of the linear speed of the web.

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