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Rose

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[54] **METHOD OF COATING FLEXIBLE SHEET MATERIAL**

[75] Inventor: **Robert Charles Rose,** Atlanta, Ga.

[73] Assignee: **Anglo-American Clays Corporation,** Atlanta, Ga.

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[52] **U.S. Cl.** **427/211;** 118/104; 118/118; 427/361; 427/365

[51] **Int. Cl.**[2] **B05D 1/00;** B05D 5/00; B05D 3/12

[58] **Field of Search** ..... 117/64 R, 65.2, 111 R, 117/155 UA, 156, 68; 118/104, 118

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Primary Examiner—Michael R. Lusignan
Attorney, Agent, or Firm—Browne, Beveridge, DeGrandi & Kline

[57] **ABSTRACT**

A method of applying a high solids coating to a traveling web of flexible sheet material which includes the steps of applying a high solids coating to the web in a quantity in excess of the amount desired to be coated thereon, positioning a wiping roll to engage and wipe and smooth the coating thus applied to the traveling web, rotating the wiping roll in a direction and at a surface speed of rotation sufficient to create a negative hydrodynamic pressure at the nip of engagement of the wiping roll with the coating applied to the traveling web, cleaning the surface of the wiping roll so that it continually presents a clean surface at the nip of engagement of the wiping roll with the coating applied to the traveling web, and drying the coated web. Rotation of the wiping roll in a direction opposed to the direction of movement of the traveling web and at a surface speed of rotation at least equal to the surface speed of movement of the traveling web creates a negative hydrodynamic pressure at the nip of engagement of the wiping roll with the coating applied to the traveling web, the upper limit of the speed of rotation being that which will leave the desired weight of high solids coating on the web.

12 Claims, 6 Drawing Figures

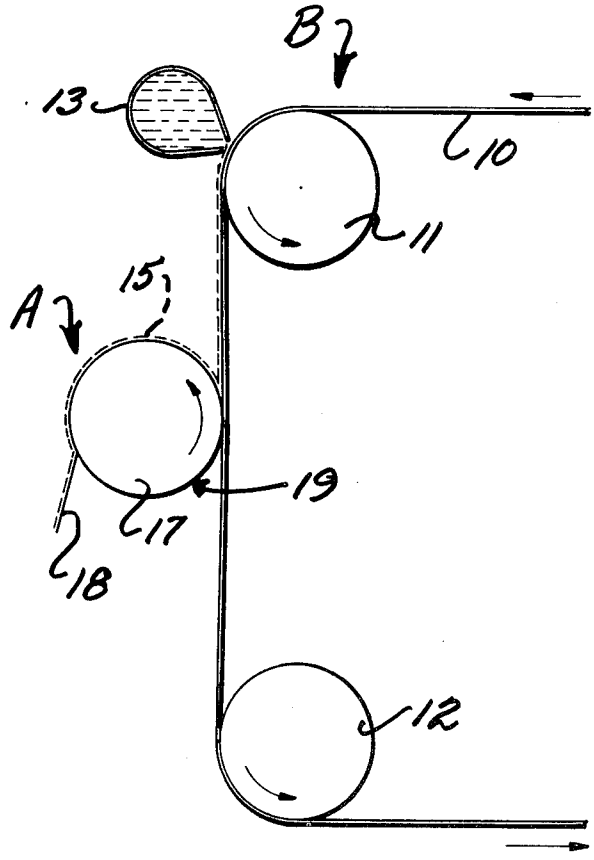


FIG. 1

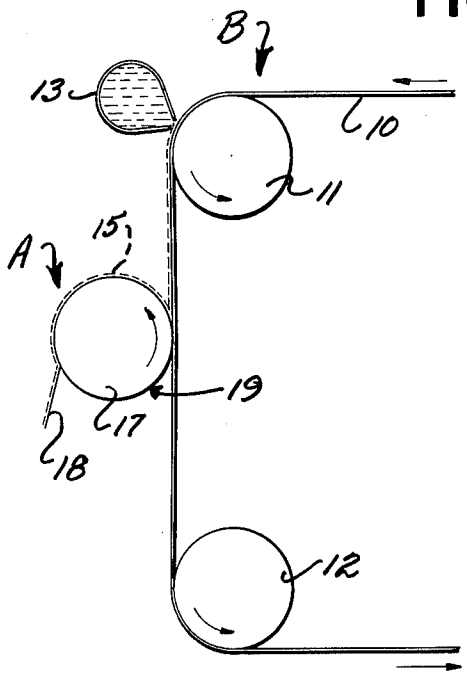


FIG. 2

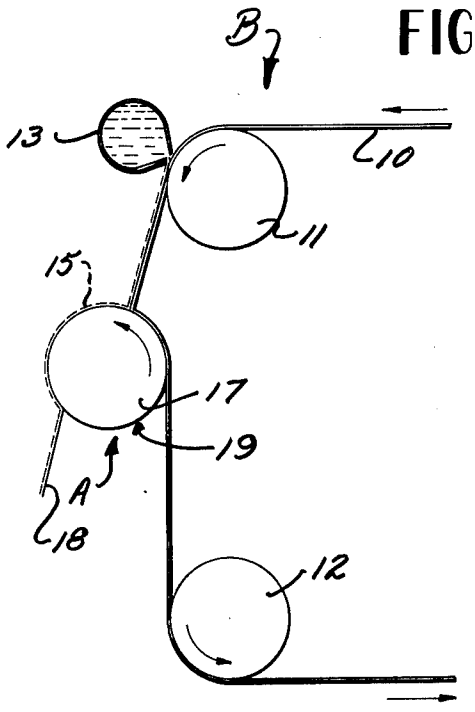
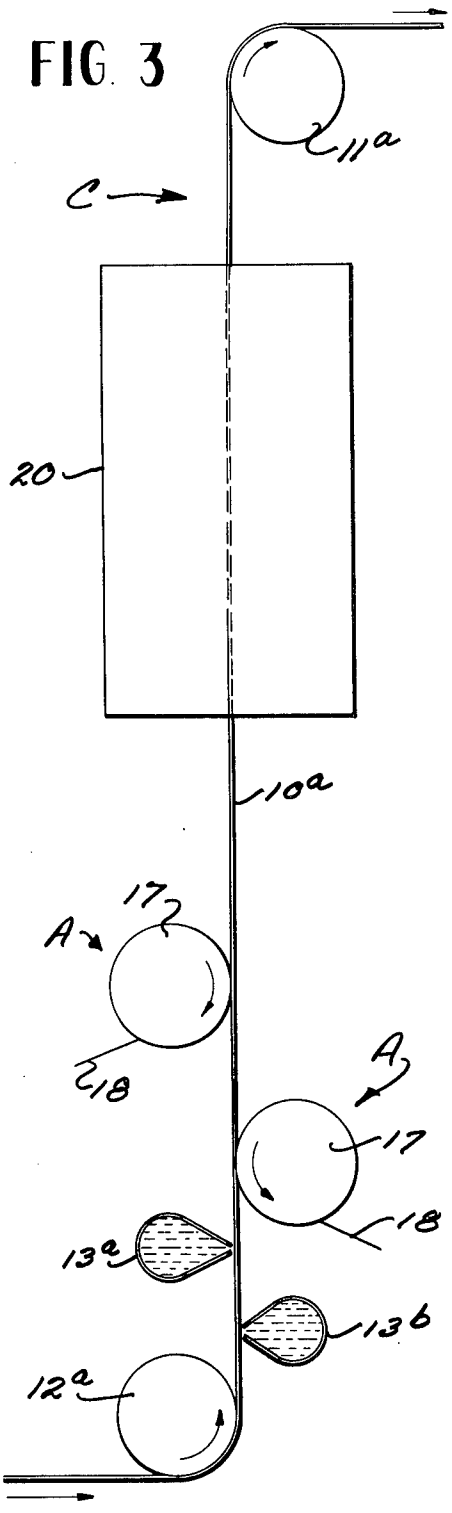


FIG. 3



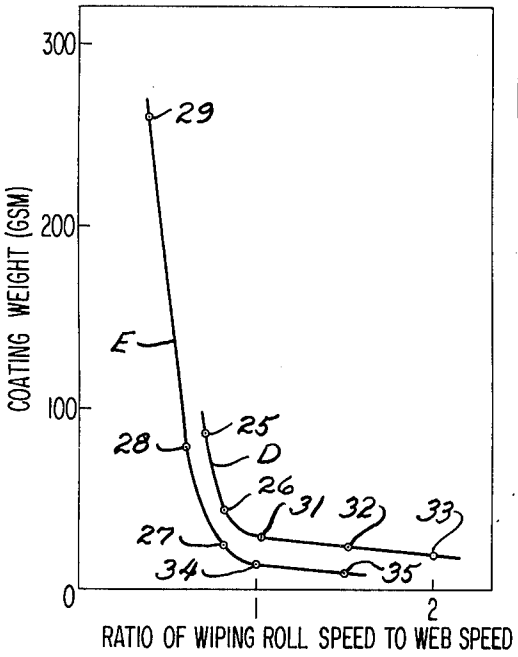


FIG. 4

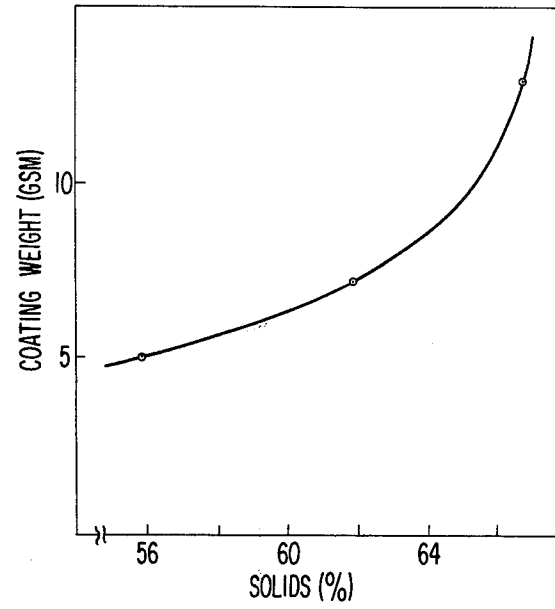


FIG. 5

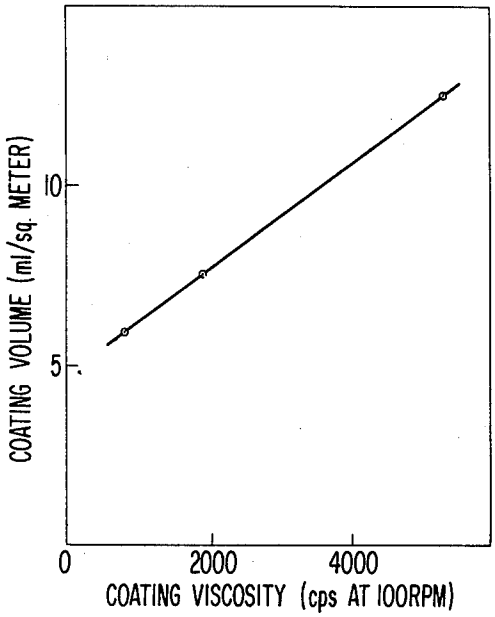


FIG. 6

METHOD OF COATING FLEXIBLE SHEET MATERIAL

BACKGROUND, FIELD, SUMMARY AND OBJECTIVES OF THE INVENTION

This invention generally relates to improvements in methods of coating flexible sheet material. In particular, the same relates to the coating of paper, either on one side or on both sides, with a high solids coating.

A variety of methods have been previously provided for applying a coating to a traveling web of flexible sheet material such as paper. In practice, these methods have employed a variety of different doctoring methods and apparatus, including devices such as an air knife which blows off the excess coating material, trailing blades, doctor bars, rotating doctor rods and reverse rotating doctor rolls. When an air knife, trailing blade, or reverse doctor roll has been utilized, the web is required to be supported at the point of doctoring by some backing means. When doctor bars and doctor rods are employed, the web is usually in the form of a flat inverted V over the bar or rod, being held against the bar or rod by tension applied to the web.

Previously practiced doctoring methods of this type exhibit various advantages and disadvantages in connection with the particular application thereof. Commercially, doctoring methods employing a trailing blade have the advantage of being able to accommodate high speed webs with the capability of applying smooth, almost pattern free coatings. Their disadvantages are that the trailing blade is relatively inflexible with respect to coating weight and is prone to causing scratches on the surface of the coated web. Other previously practiced methods of coating have required operation at lower web speeds and, with the exception of methods using an air knife, produce an undesirable coating pattern in splitting of the coating film. In presently practiced coating methods using a reverse doctor roll, the coat weight left on the web depends on the gap between the roll and the web, and it is difficult to control this accurately, particularly if the thickness of the web varies. A further general limitation in connection with previously employed methods of coating is that they generally require that the coating on one side of the web be dried before the other side of the web can be coated. Thus, in coating on both sides according to previous methods, either two passes of the web through the coater were required, or else two separate coating stations, in tandem, with an intermediate drying station therebetween, were required.

A primary object of the present invention is the provision of a method for applying a high solids coating to a traveling web of flexible sheet material in which a negative hydrodynamic pressure is created at the nip of engagement of the wiping roll with the coating applied to the web, the negative hydrodynamic pressure enabling the coating layer to be sheared off by the wiping roll and carried away from the line of contact of the wiping roll with the coating at a speed greater than that at which the web and coating applied thereto is brought to the line of engagement of the wiping roll with the coating applied to the web, so that no pool of coating composition accumulates in front of or at the line of engagement of the wiping roll with the coating composition.

A further object is the provision of negative hydrodynamic pressure at the nip of engagement of a wiping roll with a coating on a web in a manner to eliminate the necessity of a backing roll for the web, enabling the web to be coated on both sides at the same time.

A further object is the provision of a method of applying a high solids coating, having a solids content in the range of 50–70%, to a traveling web of flexible sheet material in which a wiping roll is provided to engage and wipe and smooth the high solids coating, which wiping roll is rotated in a direction opposed to the direction of movement of the traveling web with respect thereto, at a surface speed of rotation at least equal to the surface speed of movement of the traveling web, and in a range to leave on the web the desired weight of high solids coating.

A further object of the invention is the provision of a method of applying a high solids aqueous mineral coating composition to a traveling web of paper.

My improved method of coating permits high speed coating; with high solids coating; on a wide web; with a wide range of coating weights, the final control of which can be made by adjusting wiping roll speed; without end dams at the nip; providing coatings that are substantially pattern free and substantially free from scratches and streaks.

Other objects and advantages of the invention will become apparent during the following detailed description, taken in connection with the accompanying drawings, and in which drawings:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagrammatic view showing the practice of my invention in application of a high solids coating to one side of a traveling web of flexible sheet material.

FIG. 2 is a view similar to FIG. 1 showing attraction of the traveling web to the wiping roll in the event of a relaxation of tension or break in the traveling web while employing my improved coating method.

FIG. 3 is a diagrammatic view showing the practice of my invention in application of a high solids coating to both sides of a traveling web on a single pass.

FIG. 4 is a graph plotting coating weight with respect to given ratios of reverse wiping roll surface speed to web speed.

FIG. 5 is a graph plotting the effect of coating solids on coating weight at a constant wiping roll speed of twice the web speed.

FIG. 6 is a graph showing the applied volume of wet coating as plotted against a Brookfield viscosity (100 rpm).

DETAILED DESCRIPTION OF THE INVENTION

In the drawings, wherein similar reference characters are used to describe corresponding parts throughout the several views, the letter A may generally designate a reverse wiping roll doctor as it may be employed in the web system B of FIGS. 1 and 2, and the web system C of FIG. 3.

Web system B may include a web **10**, which may be entrained over a pair of spaced apart support rollers **11** and **12**. Conventional means (not shown) may be provided for moving web **10** in the direction indicated and for maintaining appropriate tension thereon for suitable coating thereof. A coating applicator **13** may be provided for applying a coating on web **10**.

It is the general practice to apply an excess of coating to the web in order to insure a complete coverage

thereof on the web. This excess, subsequently removed by wiper A, is shown by dotted line **15.**

Wiper A preferably includes a wiping roll **17** and wiper means **18.**

Wiping roll **17** may comprise a cylindrical roller mounted adjacent web **10** and having an outer periphery disposed tangentially to web **10** to engage and wipe and smooth the coating on web **10.** As shown, wiping roll **17** is rotated at a given speed in a direction opposed to the direction of movement of web **10,** which also moves at a given speed. Wiper means **18** may comprise a doctor blade which engages wiping roll **17** for removal therefrom of any coating material which may have been collected thereby, so that wiping roll **17** presents a continually cleaned wiping surface **19** to web **10.**

Web system C may include a web **10"** which is entrained over a pair of spaced apart support rollers **11"** and **12".** Conventional means (not shown) may be provided for moving web **10"** in the direction indicated and for applying a coating to both sides of web **10".** A conventional drying unit **20** may be provided for drying the coatings before web **10"** is entrained over roller **11".**

As shown in FIG. **3,** a pair of wipers A may be provided to remove excess coating material from both sides of web **10".** Since it is not necessary that the web be otherwise supported adjacent my improved wiper, these wipers may be spaced apart from each other in a manner so that one does not interfere with or affect operation of the other.

In practicing my improved method of coating in such as web system B, web **10** is drawn over support rollers **11** and **12** at a predetermined rate, a web coating being applied to the moving web **10** by such as a coating applicator **13.** Coating applicator **13** is disposed sufficiently close to wiper A so that the applied coating will not dry to any appreciable degree before engagement thereof with wiping roll **17.**

Wiping roll **17** has a surface speed of rotation which is at least equal to the surface speed of movement of web **10,** usually greater than the surface speed of movement of web **10,** the rate of rotation thereof being sufficient to create a negative hydrodynamic pressure at the nip of engagement of the wiping roll with the coating applied to the traveling web.

As shown in FIG. **2,** if web **10** becomes slack, such as by relaxation of the tension thereof, or even break of the web at some point after the coating has been applied, the negative hydrodynamic pressure at the nip of engagement of the wiping roll with the coating applied to the web will draw web **10** onto wiping roll **17,** providing continued doctoring by wiper A. Thus, a web break does not necessarily require a machine wash-up.

Although my improved method of coating does not require the provision of a backing roll or other support at the point of doctoring, it is of course obvious that a backing roll or other support could be provided at the area of doctoring.

As is well known in the art, a trailing blade coater may produce scratches in the coating when foreign matter lodges under the tip of the blade. Due to the reverse motion of wiping roll **17** in my method of coating, any foreign matter collected thereon will be removed by wiper means **18,** wiper A thus being self-cleaning.

Another source of scratches which may be caused by a trailing blade coater is associated with dewatering of the coating under the blade. Dewatering is a complicated function of coating and web properties and is accentuated by the extreme pressure which develops at the tip of a trailing blade. In the practice of my invention, the development of a negative hydrodynamic pressure at the nip of engagement of wiping roll **17** with the coating applied to the web will reduce dewatering and thereby further lessen the possibility of scratches in the coating.

In the coating of a traveling web according to my invention, the speed of rotation of the wiping roll is such as to split or shear the layer of coating composition applied to the web, the excess coating composition being carried away from the nip of engagement of the wiping roll with the coating at a speed greater than that at which the coating reaches such nip of engagement. This prevents accumulation of a pool of coating composition in front of the nip of engagement such as might tend to exert pressure against the web and force the same away from the wiping roll, which would cause uneven coating. No visible pattern is associated with the splitting or shearing of the film of coating according to my invention. This absence of pattern is believed to occur because the coating meniscus which is being split is so fine that the pattern, if any, is invisible.

My improved method of coating may be used on any flexible web bearing a readily shearable layer of a coating composition. The invention was, however, primarily developed in connection with high solids aqueous mineral coatings on webs of paper. Such high solids coatings usually have a solids content of between 50–70%, and include one or more minerals, one or more adhesives, and aqueous additives to control flow properties, etc. Mineral pigments such as kaolin, calcium carbonate, titanium dioxide, and the like are used; together with adhesive matter such as modified starch, soy protein, synthetic latex, and the like; in an aqueous vehicle which is preferably slightly alkaline.

FIG. **4** illustrates the results of a series of high solids coating tests. Curve D illustrates high solids coating with a solids content of 64.5% and curve E illustrates high solids coating with a solids content of 61.7%. In these tests, the wiping roll was pre-set about 0.003 inches from the web and the coating used was 100 parts kaolin, 7.5 starch and 7.5 latex (dry weight).

Reference points **25** and **26** of curve D and **27, 28** and **29** of curve E illustrate the excess coating weights which result from high solids coating in accordance with previously practiced methods of coating at conventional reverse roll coater speeds. These previous methods caused a development of hydrodynamic pressure at the nip of engagement of the roll coater with the coating applied to the traveling web which forced the web away from the roll coater. When conventional roll coating methods were used it was observed that, although the wiping roll was pre-set at 0.003 inches from the web, the high solids coatings were about 0.010 inches (0.23 mm) thick when wet. It thus appeared that the hydraulic wedge of coating at the nip of engagement of the roll coater with the web deformed the rubber covering of the backing roll by about 0.007 inches. Pressure at the nip also caused the coating to spread laterally, resulting in ridges of coating at the edges of the wiped area.

Reference points **31, 32** and **33** of curve D and **34** and **35** of curve E illustrate the coating weights which result from wiping roll coating in accordance with my method of high solids coating of flexible sheet material.

As previously discussed, my method of high solids coating develops a negative hydrodynamic pressure at the nip of engagement of the wiping roll with the coating, providing a smooth, even, pattern free coating in which there is no lateral spreading of the coating. Although tests in accordance with my method of coating were also conducted with a pre-set gap of 0.003 inches between the wiping roll and the web, coating weight was less than 0.001 inches (0.025 mm) mm) thick when wet. This illustrates the principle of attraction of the web to the wiping roll by the negative hydrodynamic pressure at the nip of engagement of the wiping roll with the coating, which left a gap of approximately 0.002 inches between the web and the backing roll. This shows that, although a backing roll was used in these tests for uniformity, the same is not necessary in my improved method of coating flexible sheet material.

A large number of further tests were conducted to prove the effective ratio of wiping roll speed to web speed according to my high solids coating method. In one series of these tests, I used a coating composition of 100 parts kaolin, 7.5 parts starch and 7.5 parts SB latex (dry weight), varying coatings solids weight thereof, applying the same on a surface sized book paper web, at various web speeds and various wiping roll speeds, as follows:

Example 1—At a web speed of 1,100 ft./min. and a wiping roll speed of 1,100 ft./min., the coating weight of a 61.7% high solids content coating was 10.2 gsm.

Example 2—With a web speed of 1,100 ft./min. and a wiping roll speed of 1,650 ft./min., the coating weight of a 61.7% solids content coating was 8.6 gsm.

Example 3—With a web speed of 1,100 ft./min. and a wiping roll speed of 1,100 ft./min., the coating weight of a 64.5% solids content coating was 24.0 gsm.

Example 4—With a web speed of 1,100 ft./min. and a wiping roll speed of 1,650 ft./min., the coating weight of a 64.5% solids content coating was 20.0 gsm.

Example 5—With a web speed of 1,100 ft./min. and a wiping roll speed of 2,200 ft./min. the coating weight of a 64.5% solids content coating was 16.7 gsm.

Further series of tests were conducted using the coating and web compositions of Examples 1–5, and maintaining web speed to wiping roll speed of 1:1.5 at various speed levels, as follows:

Example 6—With a web speed of 1,100 ft./min. and wiping roll speed of 1,650 ft./min., the coating weight of a 62.7% solids content coating was 13.5 gsm.

Example 7—With a web speed of 1,600 ft./min. and wiping roll speed of 2,400 ft./min., the coating weight of a 62.7% solids content coating was 11.9 gsm.

Example 8—With a web speed of 2,200 ft./min. and wiping roll speed of 3,300 ft./min., the coating weight of a 62.7% solids content coating was 8.9 gsm.

Another series of tests were run using the coating and web compositions of Examples 1–5, and maintaining a constant ratio of web speed to wiping roll speed of 1:2, applying a 64.9% solids content coating at various speed levels, as follows:

Example 9—With a web speed of 1,180 ft./min. and a wiping roll speed of 2,360 ft./min. the coating weight was 15.3 gsm.

Example 10—With a web speed of 1,750 ft./min. and a wiping roll speed of 3,500 ft./min., the coating weight was 17.3 gsm.

This latter example shows that coating weight increased slightly with machine speed. This difference in behavior was probably due to differences in the coatings. That is, in Example 9 the coating was shear thinning and, in Example 10, the coating was slightly shear thickening, as determined by the Hercules viscometer.

The results of tests using coatings of different solids content at a constant web speed of 1,300 ft./min. and wiping roll speed of 2,600 ft./min., are shown in FIG. 5. In these tests, the web was a surface sized book paper, and the coating formulation was 100 parts kaolin, 5 parts starch, and 10 parts SB latex (dry weight).

Example 11—With a solids content of 56.5%, the coating weight was 4.6 gsm.

Example 12—With a solids content of 61.7%, the coating weight was 6.4 gsm.

Example 13—With a solids content of 66.5%, the coating weight was 12.5 gsm.

A test was also conducted to show that the coating weight is dependent upon the composition of the web. In this test, under the same conditions as set forth in Example 12, but using a non-surface sized book web, the coating weight was 10.6 gsm. However, since characteristics of the same kind of paper will differ from mill to mill and even order to order, no definite parameters of paper composition can be established. Each run will therefore necessitate some finite adjustment, as is well understood in the art.

Another test was conducted to show the effect of viscosity on coating weight. In this test, I used a coating composition of 100 parts kaolin and 12 parts starch, having a solids content of 61.5%, and applied the same on a surface sized book paper web, at a web speed of 1,500 ft./min. and a wiping roll speed of 2,600 ft./min., the coating weight was 8.3 gsm. In comparison of this coating weight with that of Example 12 above, it was determined that the higher viscosity of this test sample accounted for the higher coating weight thereof. This shows that the solids per unit of volume of coating increases as the viscosity increases. The effect of the former can be eliminated by calculating the volume of wet coating applied. In FIG. 6, the applied volume of wet coating is plotted against Brookfield viscosity (100 rpm). The results show that increasing the viscosity by 1,000 cps increased the coating volume by 1.5 cc.

It is obvious that the coating formulation could be diluted to a solids content below 50%. However, since the coating weight of higher solids, referring to Example 11, was already below 5.0 gsm, the lower limit used in practice with a trailing blade coater, there was no practical reason for handling lower solids.

It is also within the scope of my invention to apply coatings having a solids content above 66.5%, the highest level noted in the foregoing examples, by slightly changing the coating formulation. I might, for example, use 85% low viscosity kaolin, 15% low viscosity calcium carbonate, and 12 parts of a low viscosity adhesive. In this way, the viscosity may be kept within the 5,000 cps limit at 69% solids, providing a coating weight of 12.5–13.0 gsm. Note that this is not much higher than was obtained at 66.5% solids content. This was due to the fact that, by holding viscosity down, the effect of viscosity on coating weight was not felt.

Various changes may be made to the form of the invention herein shown and described without departing from the spirit of the invention and the scope of the following claims.

I claim:

1. A method of applying a high solids coating to a traveling web of flexible sheet material which includes the steps of applying a high solids coating to the web in a quantity in excess of the amount desired to be coated thereon, positioning a wiping roll to engage and wipe and smooth the coating thus applied to the traveling web, rotating the wiping roll in a direction and at a surface speed of rotation sufficient to create a negative hydrodynamic pressure at the nip of engagement of the wiping roll with the coating applied to the traveling web, cleaning the surface of the wiping roll so that it continually presents a clean surface at the nip of engagement of the wiping roll with the coating applied to the traveling web, and drying the coated web.

2. A method of applying a high solids coating to a traveling web of flexible sheet material as specified in claim 1 which includes the steps of applying a high solids coating to both sides of the traveling web in a quantity in excess of the amount desired to be coated thereon, positioning a wiping roll to each side of the traveling web, to engage and wipe and smooth the coating on both sides of the traveling web, rotating each wiping roll in a direction and at a surface speed of rotation sufficient to create a negative hydrodynamic pressure at the nip of engagement thereof with the coating which it is positioned to engage, and claaning the surface of each wiping roll so that it continually presents a clean surface to engage and wipe and smooth the applied coating.

3. A method of applying a high solids coating to a traveling web of flexible sheet material which includes the steps of applying a high solids coating to the web in a quantity in excess of the amount desired to be coated thereon, positioning a wiping roll to engage and wipe and smooth the coating thus applied to the traveling web, rotating the wiping roll in a direction opposed to the direction of movement of the traveling web and at a surface speed of rotation at least equal to the surface speed of movement of the traveling web and in a range to leave on the web the desired weight of high solids coating, cleaning the surface of the wiping roll so that it continually presents a clean surface to engage and wipe and smooth the coating applied to the traveling web, and drying the coated web.

4. A method of applying a high solids coating to both sides of a traveling web of flexible sheet material which includes the step of applying a high solids coating to both sides of the web in a quantity in excess of the amount desired to be coated thereon, positioning a wiping roll to engage and wipe and smooth the coating on both sides of the traveling web, rotating each wiping roll in a direction opposed to the direction of movement of the traveling web with respect thereto, at a surface speed of rotation at least equal to the surface speed of movement of the traveling web, and in a range to leave on the web the desired weight of high solids coating, and cleaning the surface of each wiping roll so that each wiping roll continually presents a clean surface to engage and wipe and smooth the coating applied to the traveling web.

5. A method of applying a high solids coating to a traveling web of flexible sheet material as specified in claim 3 in which the high solids coating has a solids content of at least 50%.

6. A method of applying a high solids coating to a traveling web of flexible sheet material as specified in claim 5 in which the solids content of the high solids coating is less than 70%.

7. A method of applying a high solids coating to a traveling web of flexible sheet material as specified in claim 3 in which the high solids coating comprises a high solids aqueous mineral coating composition including mineral pigment, adhesive matter, and an aqueous vehicle.

8. A method of applying a high solids coating to a traveling web of flexible sheet material as specified in claim 7 in which the mineral pigment is selected from a group consisting of kaolin, low-viscosity kaolin, calcium carbonate, low-viscosity calcium carbonate, titanium dioxide, and mixtures of the same, and the adhesive material is selected from a group consisting of starch, soy protein, and synthetic latex, and mixtures of the same, and wherein the aqueous vehicle is slightly alkaline.

9. A method of applying a high solids coating to a traveling web as specified in claim 3 in which the traveling web is paper selected from the group consisting of non-sized, internally sized and surface sized paper, and in which the high solids coating applied thereto comprises a high solids aqueous mineral coating composition.

10. A method of applying a high solids coating to a traveling web of flexible sheet material as specified in claim 5 in which the traveling web is paper selected from the group consisting of non-sized, internally sized and surface sized paper, and in which the high solids coating applied thereto comprises a high solids aqueous mineral coating composition.

11. A method of applying a high solids coating to a traveling web of flexible material as specified in claim 10 in which the high solids squeous mineral coating composition includes mineral pigment, adhesive matter, and an aqueous vehicle.

12. A method of applying a high solids coating to a traveling web of flexible sheet material as specified in claim 11 in which the mineral pigment is selected from a group consisting of kaolin, low-viscosity kaolin, calcium carbonate, low-viscosity calcium carbonate, titanium dioxide, and mixtures of the same, and the adhesive material is selected from a group consisting of starch, soy protein, and synthetic latex, and mixtures of the same, and wherein the squeous vehicle is slightly alkaline.

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