Nov. 24, 1964

R. T. CARPENTER

METHOD OF BLADE-COATING UTILIZING HIGH ANGLES OF FLEXIBLE BLADES

3,158,498

Filed Nov. 13, 1961

3 Sheets-Sheet 1

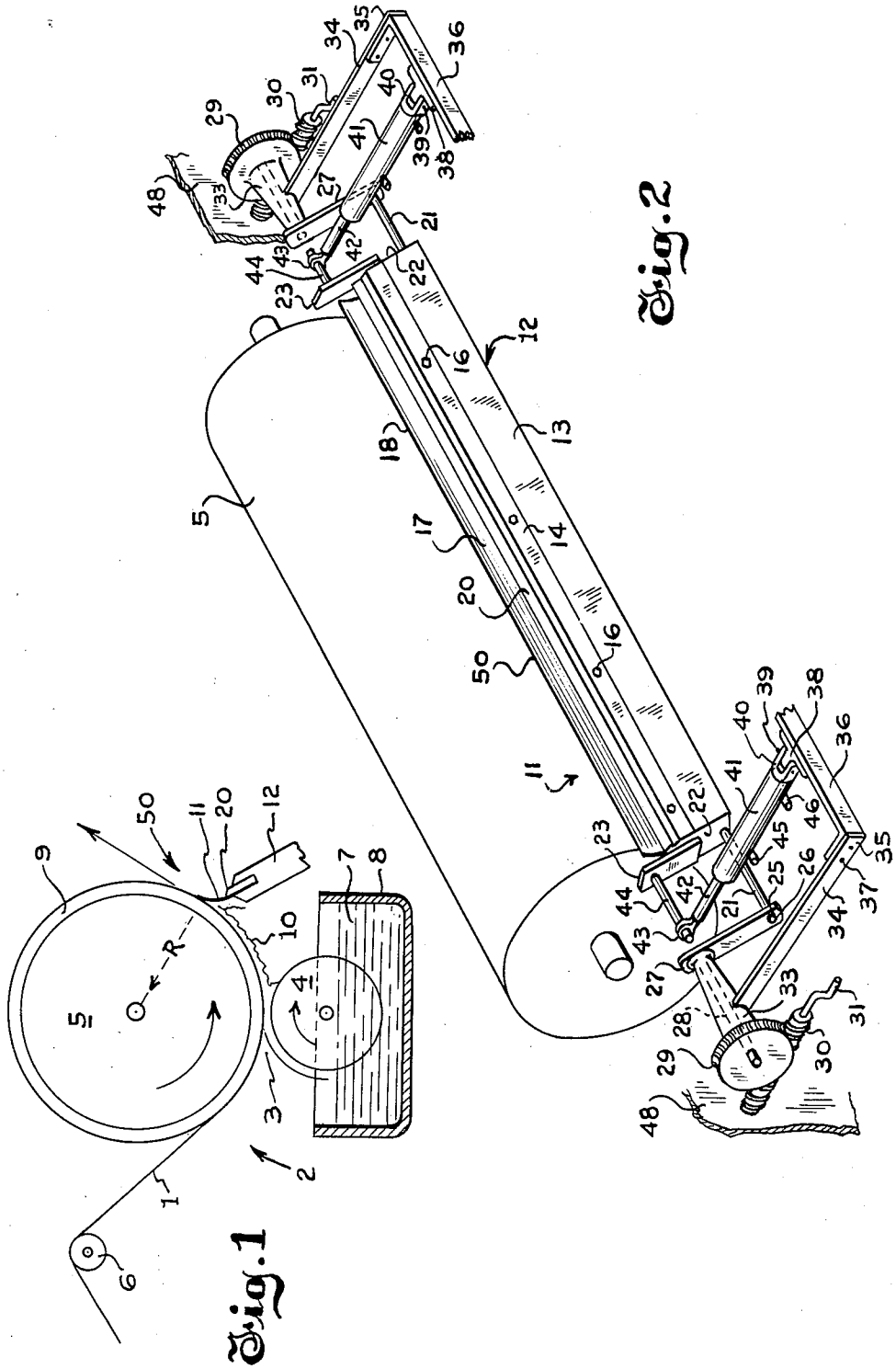


Fig. 2



Fig. 1

Nov. 24, 1964 R. T. CARPENTER 3,158,498
METHOD OF BLADE-COATING UTILIZING HIGH ANGLES OF FLEXIBLE BLADES
Filed Nov. 13, 1961 3 Sheets-Sheet 2

Fig. 3

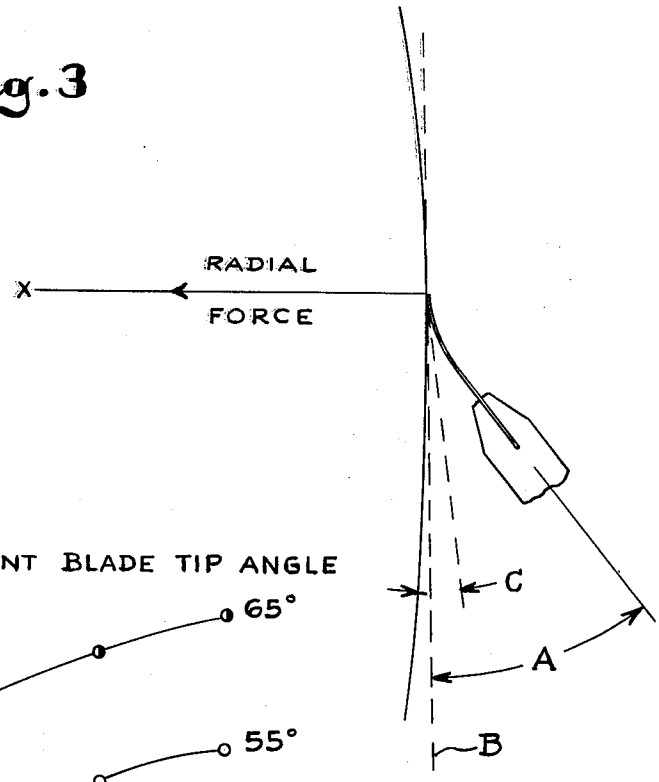
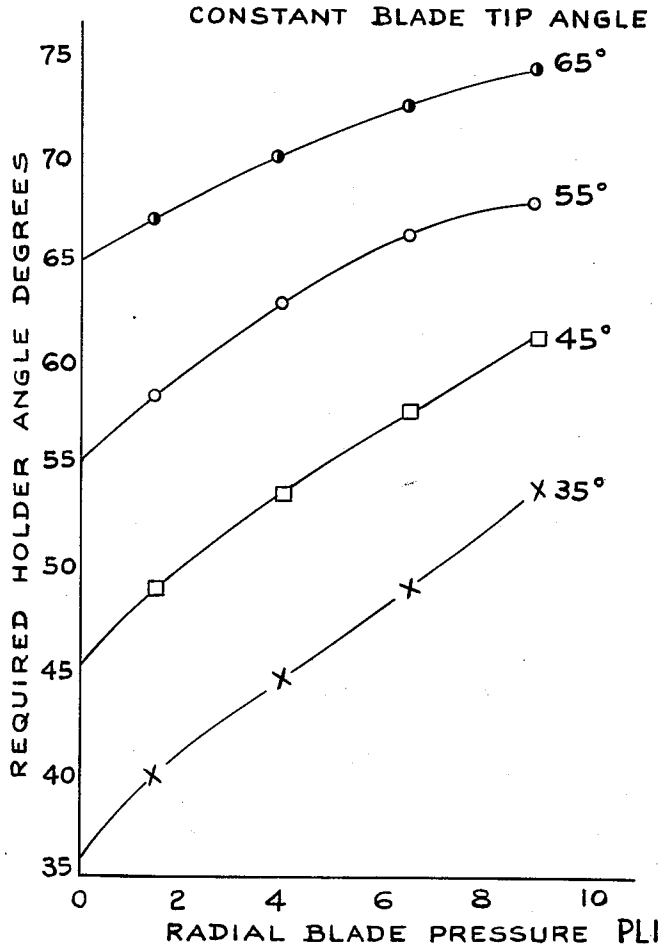



Fig. 4



Nov. 24, 1964

R. T. CARPENTER

METHOD OF BLADE-COATING UTILIZING HIGH ANGLES OF FLEXIBLE BLADES

3,158,498

Filed Nov. 13, 1961

3 Sheets-Sheet 3

Fig. 5

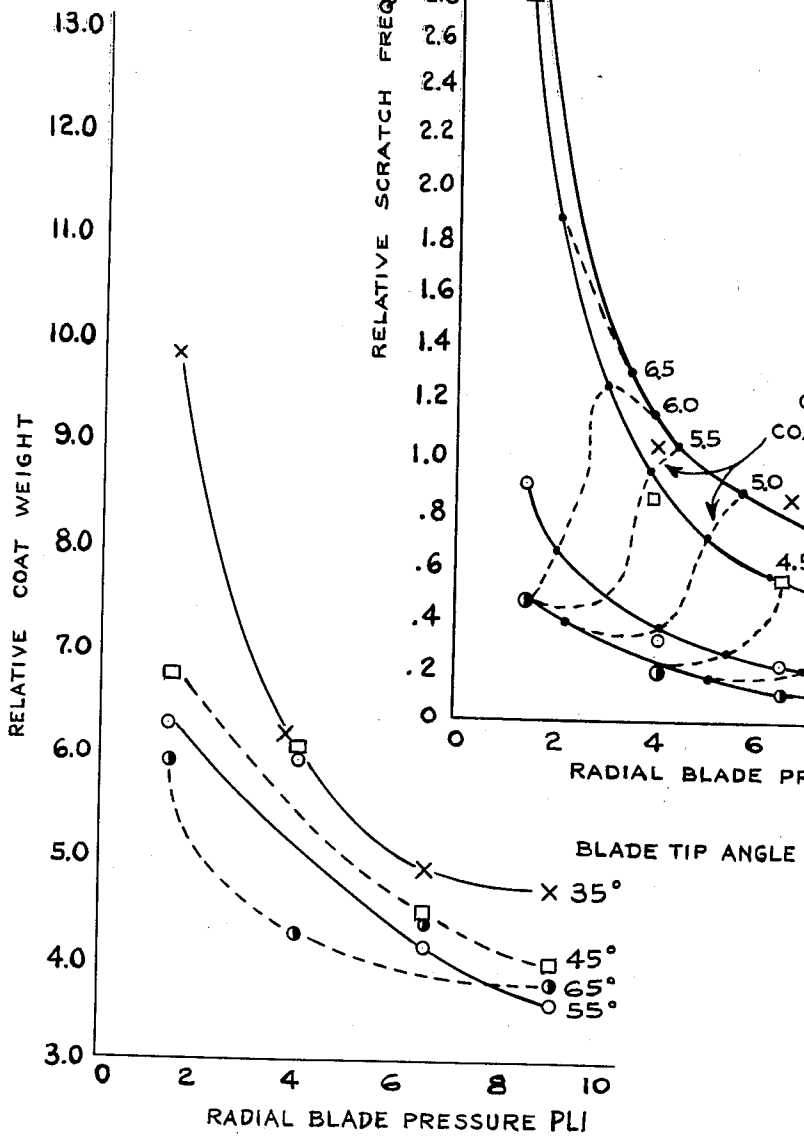
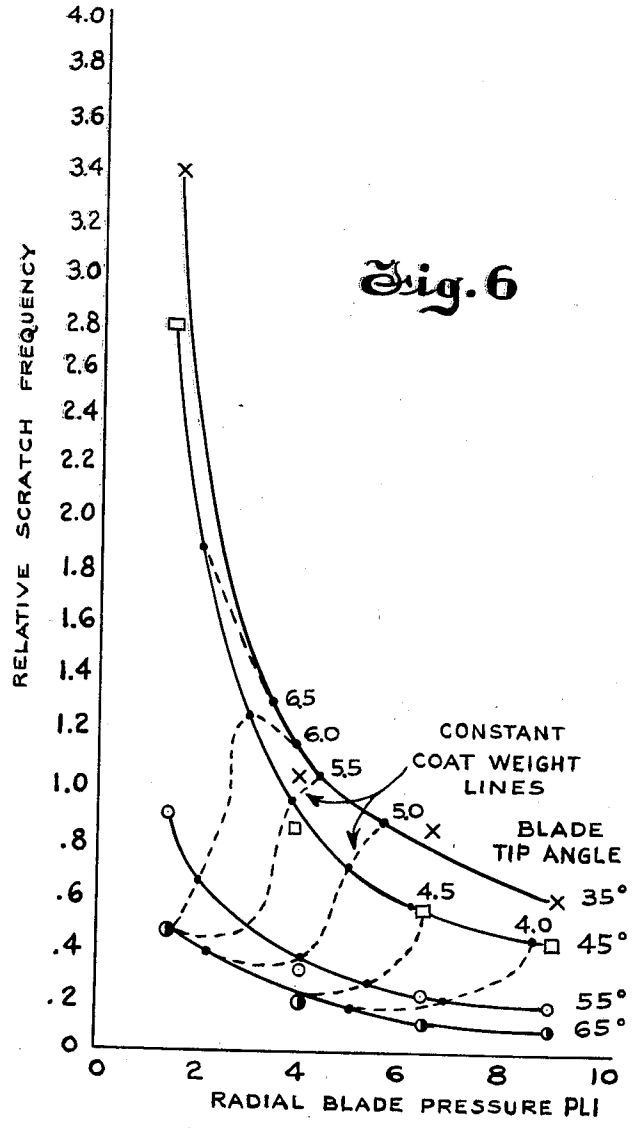



Fig. 6



United States Patent Office 3,158,498 Patented Nov. 24, 1964



3,158,498

# METHOD OF BLADE-COATING UTILIZING HIGH ANGLES OF FLEXIBLE BLADES

Russell T. Carpenter, Neenah, Wis., assignor to Kimberly-Clark Corporation, Neenah, Wis., a corporation of Delaware

Filed Nov. 13, 1961, Ser. No. 151,957
2 Claims. (Cl. 117—102)

This invention relates to the application of coating materials to traveling webs and is particularly concerned with the coating of paper webs in a flexible knife blade coating operation.

In the coating of paper webs compositions which are essentially aqueous fluid suspensions of adhesive and pigment are commonly employed. Such coatings are termed mineral coatings; in one usual mode of coating application an excess of the coating material is furnished the web and a flexible knife blade is employed to trowel or smooth the coating onto the paper, the excess of coating being removed by the blade.

Occasionally hard particles of such a composition or even particles of foreign material are carried with the coating composition or the web itself to the area of contact of the blade and paper web. Lodging of such particles between the blade and the paper then may result in marking or scratching of the coating on the web. In extreme cases the web may even be torn as it passes beneath the blade.

In customary practice the traveling web with the excess of coating thereon is carried on a moving resilient surface beneath the flexible blade. The blade is itself carried in a suitable holder, and the holder and blade are pressured against the web and resilient surface. The pressure is applied to the holder and the blade, a portion of which projects from the holder and is forced to the web to effect the troweling action.

Such flexible blades yield under the applied pressure. It has now been found that the surface characteristics of such paper webs may be materially improved if the effect of the yielding of the blade is properly taken into account when carrying out the coating operation. More specifically, it has been discovered that, as the pressure on the blade holder is increased, the tip angle of the blade decreases and this tip angle materially affects the tendency of the coating to scratch or streak. Tip angle as herein defined is the angle formed between the blade at its line of contact with the resiliently supported web and a tangent to the supported web at the line of contact. It has been found that the greater this tip angle, the less is the tendency for scratching of the coating to occur; that is, the more perpendicularly the blade extends toward the web, the less is the extent of scratching which occurs.

While scratches are minimized as to number, the higher tip angles also tend to reduce the weight of coating imparted to the web; in many instances coat weight is of importance and must be maintained in a substantially constant range for a given grade of paper in order that good printing and other desired qualities will be assured. It has additionally been found that at the high tip angles suitable for the attainment of scratch reduction and minimization, blade pressure itself may be lowered to compensate for the tendency of the high tip angles to reduce the applied coat weight. Thus, by correlating blade tip angle and blade pressure, coat weights adequate for standard paper grades are readily achieved. While coat weight itself may be desirably increased by increasing the coating composition solids, such is not a necessary step; however, it is to be noted that high coating composition solids may be employed to facilitate the attainment of high cost weights and that high tip angles favor the



usage of relatively high composition solids even at relatively low blade pressure.

Blade pressure as referred to hereinafter and in the appended claims is set forth as the radial load in pounds per lineal inch imposed by the blade on the roll. More specifically, it is the force per lineal inch along the radius of the backing roll at the point of blade-roll or, more specifically, web contact.

It is accordingly a primary object of this inveniton to provide a novel process for the application of coating materials to traveling webs.

It is a particular object of this invention to provide a novel process for the application of mineral coatings to traveling paper webs in such manner that the surface characteristics of the resultant paper are much improved, particularly with respect to scratch frequency on the coated surface.

The invention may be practiced by the employment of many different mechanical constructions, and therefore, the arrangement set forth in the accompanying drawings is to be regarded as illustrative only and for the purpose of more clearly setting forth the features of the invention.

Other objects and advantages attained by the process of invention will become apparent from the drawings wherein:

FIG. 1 is a view illustrating the cooperative relationship between a blade and holder, a paper web and backing roll, and the coating composition supply in a preferred embodiment of the invention;

FIG. 2 is a perspective view illustrating the blade, blade holder and a means for application of pressure to the blade;

FIG. 3 is a diagrammatic view emphasizing the angular relationship of the blade holder and the blade tip;

FIG. 4 is a graph illustrating the relationship of holder angle and tip angle relative to blade pressure in pounds per lineal inch for one blade arrangement;

FIG. 5 is a graph illustrating the relationship of coat weight and blade pressure for various blade tip angles in the blade arrangement corresponding to that of FIG. 4;

FIG. 6 is a graph illustrating the relationship of scratch frequency and blade pressure for various blade tip angles and includes iso-coat weight lines. In the drawings corresponding numerals, where convenient, designate similar parts.

Referring to the drawings more in detail and initially particularly to FIGS. 1 and 2, the numeral 1 designates a traveling paper web which is passed to the coating device generally indicated at 2. The coating device 2 is suitably a unit of a papermaking machine on which machine the traveling web is formed, smoothed and dried to a moisture content of approximately 4–6% prior to entry to the coater. Alternatively, the coater device may be separate from the papermaking machine as is known to the art. In either event the paper is coated and then dried; for most purposes, as in the manufacture of bookpaper, coating is applied to both sides of the sheet either successively or simultaneously and, in each mode of coating, a flexible blade may be employed to remove excess coat material and to trowel the coating composition to the paper web. Where coatings are applied successively, it is customary to dry the web between applications.

In the device of FIG. 1, one side of the paper is coated; it will be understood that the coating apparatus is then followed by suitable dryers.

The paper web passes into the nip 3, which nip is formed by applicator roll 4 and backing roll 5. The web itself has a thickness of about 0.003 inch and the roll gap at the nip is suitably about 0.0045 inch. This gap may vary with the viscosity and solids content of the coating composition as well as with web thickness but is readily set to provide an excess of coating on the traveling web.

The applicator roll 4 is driven in rotation in the direction indicated by the arrow and carries coating composition 7 contained in the trough 8 to the nip 3. Such roll is suitably of rubber and may have a Pusey and Jones plastometer (⅛" ball) of between about 85 and 150. In general, the softer rolls are preferred. The backing roll 5 is also driven in rotation in the direction indicated by the arrow; this backing roll has a resilient rubber covering 9 suitably of a density of between about 47 to 90 as measured on a Pusey and Jones plastometer with a ⅛ inch ball; a backing roll having a density of 74 is quite suitable and has been employed in the practice of the present invention.

The applicator roll, backing roll and trough are coextensive longitudinally. The backing roll is rotated at about 800 f.p.m., that is, at web speed, while the applicator roll speed is roughly ¼ to ⅙ of machine speed.

As generally indicated in FIG. 1, the web 1 travels with the excess 10 of coating material thereon from the nip 3 on the backing roll 5 to the flexible blade 11 retained in the blade holder 12 and shown more specifically in FIG. 2.

The distance between the nip 3 and blade 11, as well as the speed of web travel, governs the dwell time or period during which the excess of coating is carried on the web. A longer dwell time contributes to higher coat weights, other factors being equal. Thus, the position of blade 11 with respect to nip 3 provides a control factor for coat weight.

Blade holder 12 comprises a body part 13 and a removable cover 14 secured to the body 13 by a plurality of bolts 16. The blade 11 is confined by the cover and body portion and has an extension 17, the tip 18 of which bears against the roll-supported web in the course of a coating operation.

Blade 11, in the practice of the invention, is a flexible blade and its bends under the application of pressure. One suitable structure comprises a blade of tempered steel of a thickness of about 0.012 and the blade is honed at its tip to aid conformity initially to the surface to which it is applied. Honing is not necessary as the blade will wear in very quickly in operation, however, honing does assist this wearing-in action. Blade 11, to strengthen it and to improve blade service life, may itself be provided with a backing blade 20 which lies flat with the blade 11, and is retained by the holder 12 but which projects from the holder to a lesser extent than does the knife blade itself.

The blade holder 12 includes pivot stud shafts 21 rigidly affixed to the holder rearwardly at opposite holder ends 22. Forwardly at each end the holder 12 has secured thereto, as by a weld or otherwise, pressure bars 23. The holder is itself in operation carried into a desired angular relationship with the web and backing roll on the shafts 21 by suitable means now to be described. Pressure is then applied to the holder through the pressure bars to rotate the blade extremity into pressured contact with the web and backing roll.

The ends 22 of the blade holder 12 are each similarly mounted and, accordingly, specific reference, for convenience, will be made only to the arrangement at one end in the following description of FIG. 2.

As shown, stud shaft 21 is received rotatably in a bearing 25 defining aperture 26 of link 27. Link 27 at its other end fixedly receives a rotatable shaft 28. Shaft 28 at one of its extremities is keyed to a gear 29 which meshes with a worm 30. Worm 30 may be rotated by hand or by a suitable motor connection. As shown in the drawings, the worm 30 is provided with a handle 31. Accordingly, rotation of worm 30 drives gear 29 and shaft 28 in rotation, thereby moving the link 27 in an arc; the shaft 21 and blade holder 12 are thus also moved in an arc, permitting an angular adjustment of the blade relative to the web and backing roll.

The shaft 28 over an intermediate portion of its length is protected by a housing 33; welded or otherwise suitably secured to the housing 33 is an arm 34 which extends rearwardly downwardly terminating in an angular projection 35. An angle element 36 is adjustably secured to the arm and its projection as by cooperating nuts and bolts indicated at 37.



Angle element 37 provides for the mounting of one end of an air cylinder-piston combination. For this purpose angle element 36 carries a rigid member 38, a pin 39 passes through ears 40 fixedly mounted on the air cylinder 41 and through an aperture in the member 38, thereby providing for pivotal movement of the air cylinder; the piston rod 42 at its forward extremity is provided with a bearing 43 defining an aperture for the receipt of stud shaft 44 which projects from the pressure bar 23; air inlet and air outlet ports to the cylinder are designated at 45 and 46 respectively.

As now will be appreciated, air pressure applied to the air cylinders 41 will cause pivotal movement of blade holder 12 and shaft 21 with respect to the link 27 and the web and backing roll. Suitably, at each end of the blade holder mountings 48 are provided for support.

As illustrated in FIGS. 1 and 2, the line of contact 50 of the blade with the backing roll is suitably well below a horizontal line passing through the backing roll. The angle between a horizontal radius and a radius to the line of contact may be in conventional practice about 30–45 degrees. If desired, however, the blade may be positioned at the extremity of a horizontal radius as indicated in FIG. 3. It is not necessary that the force exerted by the blade be applied radially as such radial force may be calculated; in FIG. 3 the force is applied radially.

As shown in FIG. 3, the blade holder 12 forms the angle A with the tangent B to the backing roll 5 at blade contact line 50. As may be clearly noted from the illustration, the blade extension 17 is bent by the pressure applied into angle C formed between the tangent B and the blade tip 18 for considerably less than the angle A.

FIG. 4 illustrates the relationship of the blade holder angle to blade pressure for a constant tip angle under particular conditions. These conditions are that the blade itself be tempered steel of a thickness of about 0.012 inch, and that the blade extension from the holder be about ¾ of an inch. Also, in this instance a backing blade having a projection 20 of about ½ inch is employed. While the blade tip angle will change somewhat under varying conditions, such as the projection from the holder, whether or not a backing blade is employed, the flexibility of the blade material, and the like, the relationship shown in FIG. 4 is indicative of conditions generally found. Routine experiments may be made to determine specific numerical data for other conditions.

As may be seen from FIG. 4, the required blade holder angle setting to maintain a constant tip angle with increasing blade pressure increases relatively rapidly at the lower tip angles but is still a materially significant factor at tip angles of even 65 degrees. Thus, as shown in FIG. 4, a tip angle of 65° at a pressure in the range of 8 to 10 pounds per lineal inch is provided by a holder angle of about 75°; also, a tip angle of about 55° is provided by a holder angle of about 65° at these higher pressures. But at more useful lower pressures where blade wear is lessened due to the lower pressure, a holder angle of about 58° may provide the tip angle of 55°.

This blade tip angle is also an important factor in blade coated weight control and scratch mark elimination, as FIGS. 5 and 6 respectively illustrate.

Coat weight decreases sharply with increasing blade pressure at the useful tip angles, the decrease being greater at the smaller angles; however, lower tip angles (FIG. 5) at any particular pressure result in the achievement of higher coat weights.

Further, scratch frequency in the coated sheet decreases sharply with increased blade pressure, the change being

greater at lower blade tip angles and in the lower ranges of applied pressure. Above about 45 degrees tip angle the scratch frequency decreases sharply, particularly at lower blade pressures. Also, at these lower blade pressures, coat weight is relatively high—entirely satisfactory for most blade coating operations.

Accordingly, in a preferred embodiment of a method of invention, the blade tip angle is adjusted to 55 degrees or higher, and the applied blade pressure is relatively low, suitably about 1½ pounds per lineal inch. To achieve this with the blade and the holder specifically described hereinbefore, the blade holder is set at approximately 58 degrees.

The coating supply in trough 8 under the noted conditions may have the following formulation:

| | Parts by weight |
|---|---|
| Clay | 70 |
| Sodium hexametaphosphate | 0.2 |
| Calcium carbonate | 30 |
| Caustic | 0.2 |
| Starch | 17 |
| Calcium stearate | 0.5 |

Water sufficient to make 58% solids.

The viscosity of the coatings in a plurality of trials ranged upwardly from about 32° Brookfield at 50° C. with a No. 6 spindle at 100 r.p.m., which is equivalent to 32 poises. The upper limit in the test data was approximately 45 poises.

The web itself to which the coating is applied in the procedure had a 55-pound basis weight uncoated, basis weight being predicated upon 500 sheets, 25 inches by 38 inches.

Under such circumstances at an operating speed of 800 f.p.m. in a papermaking apparatus, the coating weight per side is approximately 7 pounds and the total coat weight is approximately 14 pounds.

In practice, in the setting of the blade for effecting a coating operation, the holder angle is selected to provide a tip or effective angle which, at a given radial pressure on the blade, provides a desired coat weight; the coat weight is influenced to some degree, and increased, by higher solids content of the coating composition but commonly in practice the solids content is between about 55–60% in accordance with usual coating practice. The blade holder angle is selected from predetermined data to achieve the desired tip angle at an appropriate pressure (FIG. 4). The tip angle is itself less than the holder angle and less than 90°. Surprisingly, the higher tip angles contribute both to a lessened scratch frequency and the use of lower radial blade pressure.

With apparatus such as described hereinbefore, the holder angle, tip angle and pressure may be altered during the course of a run; on occasion such may be desirable to effect optimum control of the web being coated. The data which correlates the coat weight, scratch frequency, pressure and blade holder, and tip angles are of assistance in this connection also.

Preferably, lower pressures of less than about five pounds per lineal inch but greater than one pound per lineal inch are employed; such contribute to longer blade life.

In the graphs the symbols of a square, a circle, a half-moon and an X have been employed to designate actual test points of similar curves. Dotted lines have been utilized in FIG. 6 to indicate isocoat weight lines. For specific blade materials, blade projections and unbacked blades, the specific data vary but the curves shown are representative.

In order to accurately evaluate the procedure described, that is, the utility of relatively high tip angles to minimize scratching and the correlation of relatively high tip angles with blade pressure to both minimize scratching and secure an appropriate coat weight, grit has been deliberately introduced into test formulations of the coating. This grit was silicon carbide of approximately 120 mesh and it was included in the coating formulation to the extent of 0.025% by weight. Such introduction made it possible to obtain reproducible scratch values in the coated paper. As may be noted from the graphs set forth hereinbefore, the high tip angle contributes materially to scratch frequency reduction.

It is to be noted that in the structural arrangement specifically described, the blade tip and the shafts 28 and 44 are in lineal alignment. Such arrangement provides for accurate change of blade angle. In some arrangements for the practice of the invention the blade angle could be arranged to be high, at least 50° tip angle, and provision need not necessarily be made for blade angle change in the manner shown.

It will be understood that this invention is susceptible to modification in order to adapt to different usages and conditions and, accordingly, it is desired to comprehend such modifications within the invention as may fall within the scope of the appended claims.

What is claimed is:

1. The process of producing a coated paper web on a continuous basis which comprises the steps of:

(*a*) driving in counter-rotation a coating applicator roll and a resiliently covered backing roll which is disposed vertically above the coating applicator roll and forms with the coating applicator roll an open gap;

(*b*) supporting a substantially dry, uncoated paper web, which is of insufficient thickness to close said gap, on the periphery of the said backing roll and passing the web through said gap while applying an excess of an aqueous mineral coating composition with said applicator roll to said web in the gap;

(*c*) disposing a flexible blade with a tip thereof on the backing roll-supported web along a longitudinal line of blade contact which is 30 to 45° below a horizontal radius of the backing roll and at least 45° around the backing roll in the direction of backing roll rotation from the said gap;

(*d*) disposing said flexible blade along said line of blade contact such that in the unpressed condition of the flexible blade the angle formed between a tangent to the backing roll at the line of blade contact and the unpressed blade is greater than 58° and less than about 75°;

(*e*) pressing the so-disposed flexible blade to the said line of blade contact such that the blade is flexed to a substantial degree and the angle formed between the tangent to the backing roll and the tip of the blade decreases but is between about 55° and 65°;

(*f*) and removing the excess portion of the applied mineral coating composition from the said web on the said backing roll while smoothing the remainder on the web by withdrawing the web substantially continuously between the blade and backing roll while the flexible blade is so pressed to the web on the backing roll, and whereby the tendency of such flexible blade pressing on the aqueous mineral coating composition to produce scratches in the coating on the web is minimized.

2. The process of producing a coated paper web on a continuous basis which comprises the steps of:

(*a*) driving in counter-rotation a coating applicator roll and a resiliently covered backing roll which is disposed vertically above the coating applicator roll and forms with the coating applicator roll an open gap;

(*b*) supporting a substantially dry, uncoated paper web, which is of insufficient thickness to close said gap, on the periphery of the said backing roll and passing the web through said gap;

(*c*) applying with said applicator roll to said web in said gap an excess of an aqueous mineral coating composition having a viscosity of between 32 and

45 poises and a solids content of between about 55 and 60%;

(*d*) disposing a flexible blade with a tip thereof on the backing roll-supported web along a longitudinal line of blade contact which is 30 to 45° below a horizontal radius of the backing roll and at least 45° around the backing roll in the direction of backing roll rotation from the said gap;

(*e*) disposing said flexible blade along said line of blade contact such that in the unpressed condition of the flexible blade the angle formed between a tangent to the backing roll at the line of blade contact and the unpressed blade is greater than 58° and less than about 75°;

(*f*) pressing the so-disposed flexible blade to the said line of blade contact with a pressure of between about 1 to 5 pounds per lineal inch of the blade so that the blade is flexed to a substantial degree and the angle formed between the tangent to the backing roll and tip of the blade is between about 55° and 65°;

(*g*) and removing the excess portion of the applied mineral coating composition from the said web on the said backing roll while smoothing the remainder



in the web by withdrawing the web substantially continuously between the blade and backing roll while the flexible blade is so pressed to the web on the backing roll, and whereby the tendency of such flexible blade pressing on the aqueous mineral coating composition to produce scratches in the coating on the web is minimized.

References Cited in the file of this patent

UNITED STATES PATENTS

| | | |
|---|---|---|
| 2,229,621 | Bradner | Jan. 21, 1941 |
| 2,312,927 | Murray | Mar. 2, 1943 |
| 2,368,176 | Trist | Jan. 30, 1945 |
| 2,534,320 | Taylor | Dec. 19, 1950 |
| 2,746,878 | Rush | May 22, 1956 |
| 2,946,307 | Warner | July 26, 1960 |
| 3,006,275 | Allen | Oct. 31, 1961 |
| 3,080,847 | Justus | Mar. 12, 1963 |
| 3,088,842 | Kuhnel | Mar. 7, 1963 |
| 3,097,107 | Martinek | July 9, 1963 |

FOREIGN PATENTS

| | | |
|---|---|---|
| 863,426 | Great Britain | Mar. 22, 1961 |