PEER REVIEWED

ABSTRACT

The study was conducted to establish base parameters for future studies of one-sided film transfer coating. Simple, unoptimized coatings containing U.S. clay or ground calcium carbonate (GCC) were studied to evaluate the impact of coating pigment on the runnability of the paper web and the coating color at high machine speeds (1200–2000 m/min). Results demonstrate that the coating color composition and the machine speed influence the point of web release during the film transfer process. GCC's lower aspect ratio translates to a wetter coating layer exiting the transfer nip—and thus a longer web release—at a given level of coating film on the transfer roll. Increasing the solids content of GCC (from 63% to 66%) reduced the distance before web release. A comparable increase in solids content for the clay pigment had no effect on web release.

Application:

A preliminary study demonstrating that the web release in a film transfer coating process can also be influenced by changing coating color composition. A homogenous web release line is essential for the coated paper quality.

Influence of coating composition on web release in high speed film transfer coating

JOHAN GRÖN, ERJA NIKULA, AND HENRIK SUNDE

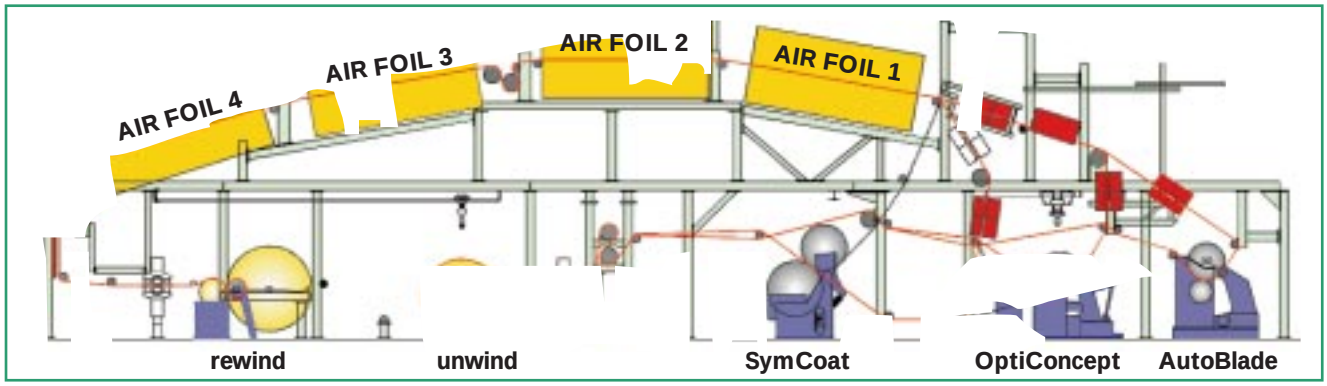
THE FILM TRANSFER COATING process is of interest to papermakers because it reduces the mechanical stress imposed on the paper web *(1)*. The reduction in stress translates to fewer web breaks and thus higher machine efficiency. However, production at high speeds (>1500 m/min) requires control to keep product quality within desired limits. The recent development of smooth premetering rods was a welcome improvement because it gave better coating profiles for high solids content coating colors *(1)*.

The film transfer process includes an initial stage, where a coating film is premetered onto a transfer roll and then applied to the paper web in a roll nip. Pressure filtration of the coating color—involving dehydration or dewatering of the coating color—is proposed to determine the outcome of the process *(2)*. From this perspective, the pressure dewatering of the coating color in the nip controls how much of the premetered coating film is transferred to the paper, along with the runnability properties of the process and the final quality of the coated surface. A proposed model for the dewatering mechanism in both blade coating *(3)* and film transfer coating *(4)* suggests the effects of the flow resistance created by particle packing and continuous phase viscosity during static pressure dewatering. This model was recently applied in a film transfer study comparing experimental and calculated results *(5)*.

In a recent study involving two different pigment systems [clay and calcium carbonate ($CaCO_3$)] and a mixture of these pigments, different coating color properties were achieved with respect to dewatering and immobilization *(6)*. The difference in properties was primarily due to the physical and chemical properties of the pigments and—within each pigment system—the addition of CMC (carboxymethyl cellulose). The study showed that pigment packing and continuous phase viscosity determine the difference between the initial coating solids and the immobilization solids of the coating color. This difference, in turn, determines the transfer of a premetered coating film to the paper. Coating colors based on clay pigments immobilize at a lower solids level than $CaCO_3$ pigments *(3, 6)*.

The amount of premetered film also determines the maximum transfer ratio—the difference between the premetered coating film and the wet coat weight (calculated from the paper coat weight)—of the coating color to the paper during pressure dewatering of the coating film in the nip. This transfer ratio is affected by pigment type and is reduced with higher machine speeds and a lower initial solids content of the coating color. These factors determine the amount of wet coating in the nip outlet, which then determines the distance to the web release point. The amount of CMC added to a pigment system has an additional effect on the web release, but its effect is less than that of the chosen pigment.

The initial aim was to establish a base for further studies of the film transfer process by determining the impact of simple coating color compositions on the point of web release. Note that the coating colors used in this study were *not* optimized with respect to the final coating layer or coated paper quality. Control of the web release point, where the coating layer splits and the web is released from the film transfer roll, is essential at high machine speeds (1200–2000 m/min) to achieve acceptable runnability for both the paper web and the applied coating film. It is possible to physi-



1. Pilot coater

cally move this release point. However, without fundamental understanding of the coating color properties and performance, efforts to adjust the release point could have a deleterious effect on the quality of the coated layer and the performance of the coating color.

EXPERIMENTAL DESIGN

Material

The coating colors consisted of 100 pph of a commercial delaminated U.S. clay pigment (Nuclay, Engelhard Corp., Gordon, GA) or a ground calcium carbonate pigment (HC 60F with 60% <2 µm, Omya Trading Oy, Förby, Finland), dispersed with 0.25 parts of a salt of polyacrylic acid (Polysalz S, BASF GmbH, Ludwigshafen, Germany). A styrene–butadiene (S/B) latex (Styronal FD-516, Raisio Chemicals Oy, Raisio, Finland) was used as binder in this study, and 12 pph were added to the coating colors. The binder is a copolymer of styrene–butadiene latex with a glass-transition temperature of 2°C and a particle size of 160 nm. CMC (FinnFix 5, Metsa Specialty Chemicals Oy, Äänekoski, Finland), with a molar mass of 43,000 (std. dev. ±12,000) and a degree of substitution at 0.8, was used as a water soluble thickener in the coating colors. CMC was added at three levels (0, 0.3, and 0.7 pph). An optical brightener of a stilbene derivative (Blankophor P, Bayer AG, Germany) was added at 0.3 pph. The pH was adjusted with NaOH to 8.0 ± 0.2 for the clay-based coating color and to 8.5 ± 0.2 for the GCC-based coating color. The formulations of the studied coating colors are presented in **Table I**.

Components	Commercial name	COATING COLORS Clay	GCC
Composition, pph			
Pigment	Nuclay	100	…
	HC 60	…	100
Binder (S/B latex)	Styronal FD-516	12	12
Water-soluble thickener	CMC FF-5*	0/0.3/0.7	0/0.3/0.7
Optical brightening agent	Blankophor P	0.3	0.3
Solids, %		59.0 (±0.3)	65.0 (±0.5)
pH		8.0 (±0.2)	8.5 (±0.2)

I. Composition of clay-based and GCC-based coating colors

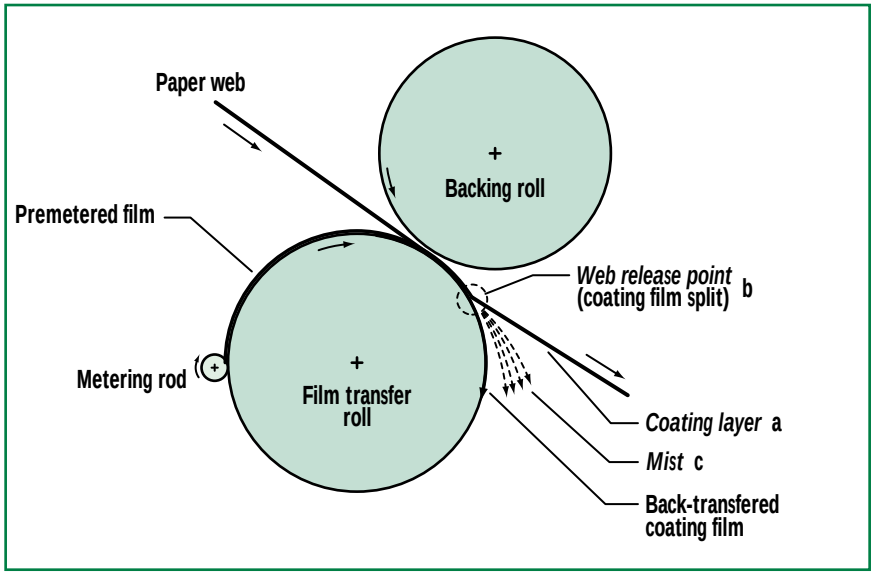
Coating color characterization

Coating color properties are reported in **Table II**. Rheology was investigated with a Bohlin VOR rheometer (Bohlin Rheologi Ab, Lund, Sweden). Dewatering was measured using the ÅA-GWR method (Åbo Akademi gravimetric water retention meter, Oy Gradek Ab, Grankulla, Finland). Continuous phase was obtained by centrifugation of the coating color at 46,000 *g* for 60 minutes. The viscosity of the continuous phase was measured in an Ubbelohde capillary viscometer (Schotts Geräte Ic, Schotts Geräte GmbH, Germany). The solids content of the continuous phase was determined gravimetrically by evaporation at 105°C until the weight of sample was stable. Continuous phase solids approximated the amount of solids in the separated phase.

The Bohlin VOR rheometer was used to study the rheological behavior of the coating colors at low shear rates. Viscosity at low shear rates (0–1460 s^{-1}) and viscoelastic properties were measured in a Couette flow geometry. Plastic viscosity and yield stress were calculated using the Bingham plastic flow model, since the coating colors showed an approximate Bingham plastic flow. Oscillation measurements were performed within the linear viscoelastic region and provided information about the storage modulus (G'), loss modulus (G''), and the phase angle (δ) registered at a constant angular frequency (ω) of 1 Hz. The storage modulus reflects the elasticity (stored elastic energy), while the loss modulus describes the viscous effects of the sample. The phase angle is the ratio of the loss modulus and the storage modulus at the angular frequency used. The phase angle reflects the deformation contribution in the elastic or viscous components. A larger phase angle (0° <δ

	DELAMINATED U.S. CLAY CMC content, pph			GROUND CALCIUM CARBONATE CMC content, pph		
	0	0.3	0.7	0	0.3	0.7
Solids content, %	59.3	59.0	58.8	65.2	64.9	65.0
pH	8.0	8.0	8.0	8.5	8.5	8.5
Viscosity, mPa·s						
at 46 s^{-1}	25.1	43.7	63.7	149.5	220.0	425.0
at 1,460 s^{-1}	16.2	14.6	17.7	34.4	53.6	61.1
at 250,000 s^{-1}	10.5	13.9	16.2	9.5	10.7	13.2
Plastic viscosity, mPa·s	…	41.2	53.9	25.9	39.8	58.6
Yield stress, Pa	3.2	8.0	11.3	3.8	16.5	25.6
Storage modulus (G´), Pa	…	24.3	103	10.8	14.2	26.3
Loss modulus (G´´), Pa	…	210.6	10.0	12.5	16.4	27.4
Phase angle, δ	…	22.6	19.8	49.8	49.2	46.3
Dewatered amount, g/m^2	160.1	123.8	103.6	310.9	223.2	214.2
Continuous-phase viscosity, mPa·s	1.05	1.39	2.12	1.01	1.54	2.16
Immobilization solids, %	75.5	76.5	75.6	86.7	86.0	85.9

II. Properties of clay-based and GCC-based coating colors



2. Positions for process monitoring in a one-sided film transfer unit

Property	Measured value
Grammage, (dry) g/m^2	33.1 ± 0.2
Moisture content, %	3.1 ± 0.1
Ash content, %	8.2 ± 0.2
PPS-s10 µm	
Top side	6.72 ± 0.15
Wire side	5.00 ± 0.12
Bendtsen smoothness, mL/min	
Top side	336 ± 20
Wire side	214 ± 10
Bendtsen porosity, mL/min	300 ± 7

III. Base paper properties

<90°) indicates a greater influence of viscous flow behavior *(7)*.

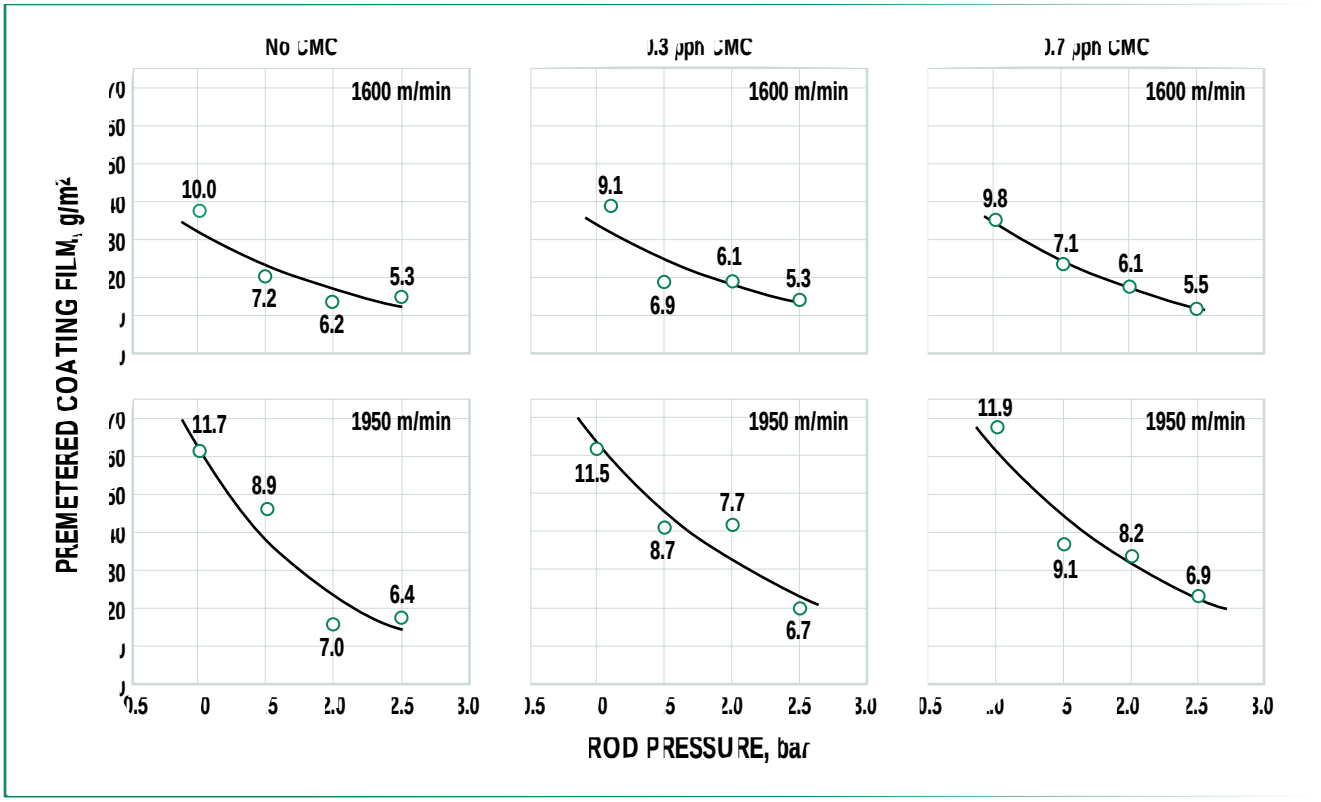
The water retention of the coating colors was determined using the ÅA-GWR method at a pressure of 50 kPa and a contact time of 120 s *(8)*. The method is based on pressure filtration of the continuous phase through a polycarbonate filter membrane with a pore diameter of 5.0 µm (Poretics Corp., Livermore, CA) into a substrate of 100% cellulose (Whatman 17 Chr, Whatman Scientific, Maidstone, UK). The dewatered amount is reported as grams per square meter.

Base paper

Base paper was tested using the appropriate SCAN standard testing methods. The results are reported in **Table III**. The following paper properties were determined in the laboratory: grammage (SCAN P5:63), ash content (SCAN P5:63), moisture (SCAN P4:63), Hunter 75° gloss, PPS-s10 porosity (air-leak method using Parker Print-Surf apparatus with a clamp pressure of 10 kg/cm^2), Bendtsen smoothness (SCAN P21:67), and PPS-s10 roughness (SCAN P21:67). All paper testing was performed in a conditioned test atmosphere of 23 ± 1°C and 50% ± 2% RH (SCAN P2:75).

Pilot coater conditions

The coating process was performed on a one-sided film transfer unit (SymCoat, Valmet Corp., Jyväskylä, Finland) at the Valmet Research Center (Järvenpää, Finland). The pilot coater is illustrated in **Fig. 1**. The machine speed used in the study were 1600 and 1950 m/min, except for the runs investigating the influence of increasing machine speed. In those tests, machine speeds ranged from 1200 m/min, with stepped increases of 200 m/min up to 1800 m/min and, finally, the maximum speed of 1950 m/min. Targeted coat weight was 8.0 g/m^2 and a moisture content of 5.5%. The application of the coating color was performed as a



3. Amount of premetered film as a function of premetering rod load at two levels of machine speed and three levels of CMC content in clay-based coating. The values at each data point represent the associated coat weight (g/m²).

rod application with a smooth rod (diam. = 25 mm) at a rod rotation speed of 50 rpm. To achieve different coat weights, bottom-hose rod pressures were varied from 80 kPa to 250 kPa, with the top hose pressure fixed at 20 kPa throughout the trial. The feed from the coating pump was kept constant at 6.0 L/s/m. The hardness of the applicator polyurethane roll cover was 35 P&J, and the steel backing roll had a chromed surface. Nip pressure between the backing roll and the film transfer roll was maintained constant at 30 kN/m. Web tension after the roll nip was kept constant at 300 N/m.

Process measurements

The film transfer process was monitored during the trial by measuring (a) the amount of coating film premetered on the film transfer roll, (b) the distance from the nip outlet to the release point of the paper web, and (c) the amount of coating color misting out of the nip. These are illustrated in **Fig. 2**.

The amount (g/m^2) of wet coating film premetered on the film transfer roll was determined by a "scraping-off" method. A device was built to remove coating color from the roll surface on a specific width (0.033 m), time scale (seconds), and machine speed (m/s). The removed coating color was gravimetrically determined, and an amount of coating per area was obtained at a given speed.

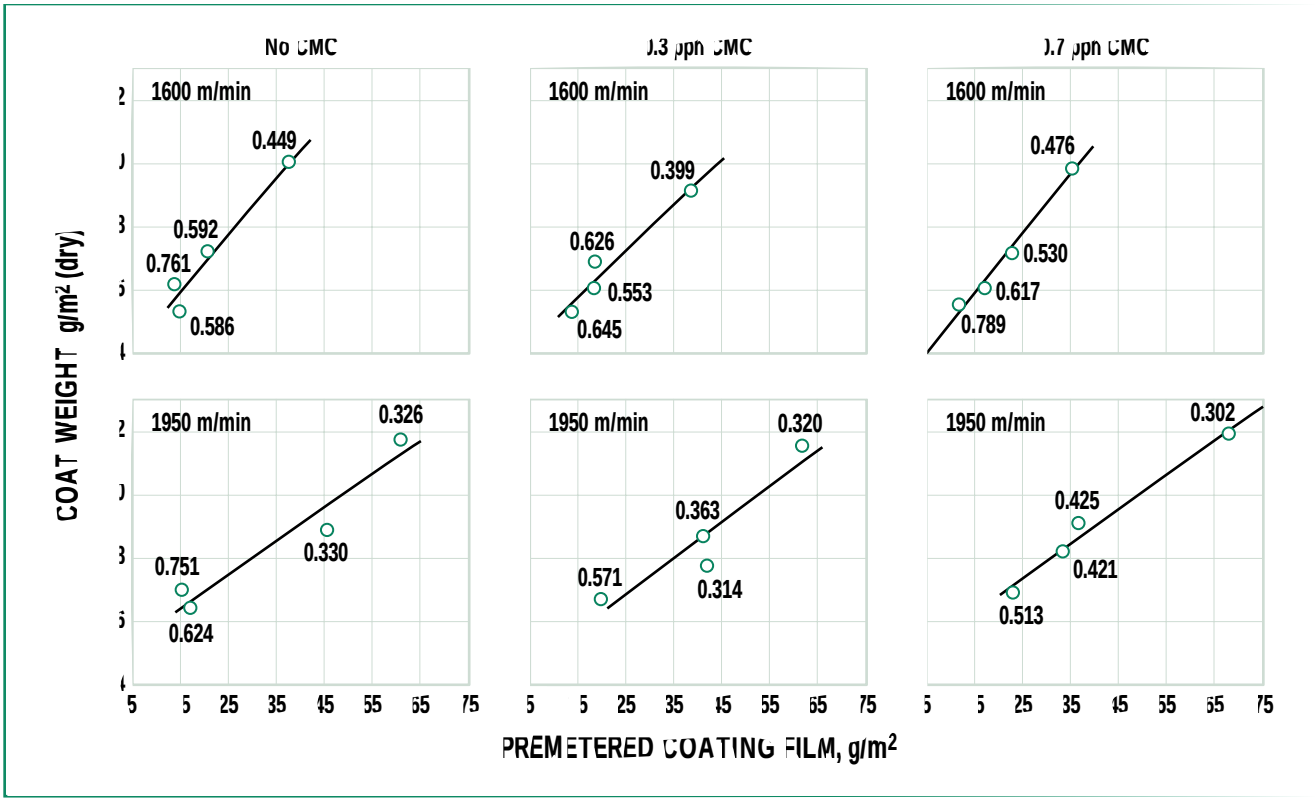
The amount (g/60 s/A4 sheet) of coating mist in the pressure nip outlet was gravimetrically determined. This was done by gathering the mist on an A4-size sheet during 60 seconds in the middle of the web width at a distance of approximately 150 mm straight out from the nip outlet (**Fig. 2**).

The distance (millimeters) between the nip outlet and the release point of the paper web was measured on the film transfer roll for each trial point at a constant web tension after the nip. A certain release angle (take-off angle, θ) is formed when the paper web releases from the film transfer roll. The release of the paper web is discussed later in greater detail.

RESULTS AND DISCUSSION

Film transfer process

To describe the coating process in greater detail, the transfer of the coating color to the paper must first be defined. The mechanism has been discussed on a more theoretical level for lower machine speeds in recent studies *(4, 5)*. The film transfer mechanisms at high machine speeds do not differ from those at lower speeds. However, the runnability aspects become more critical as speed increases. This emphasizes the need for greater knowledge of the process mechanisms in order to achieve the required quality of the final product at high machine speeds.



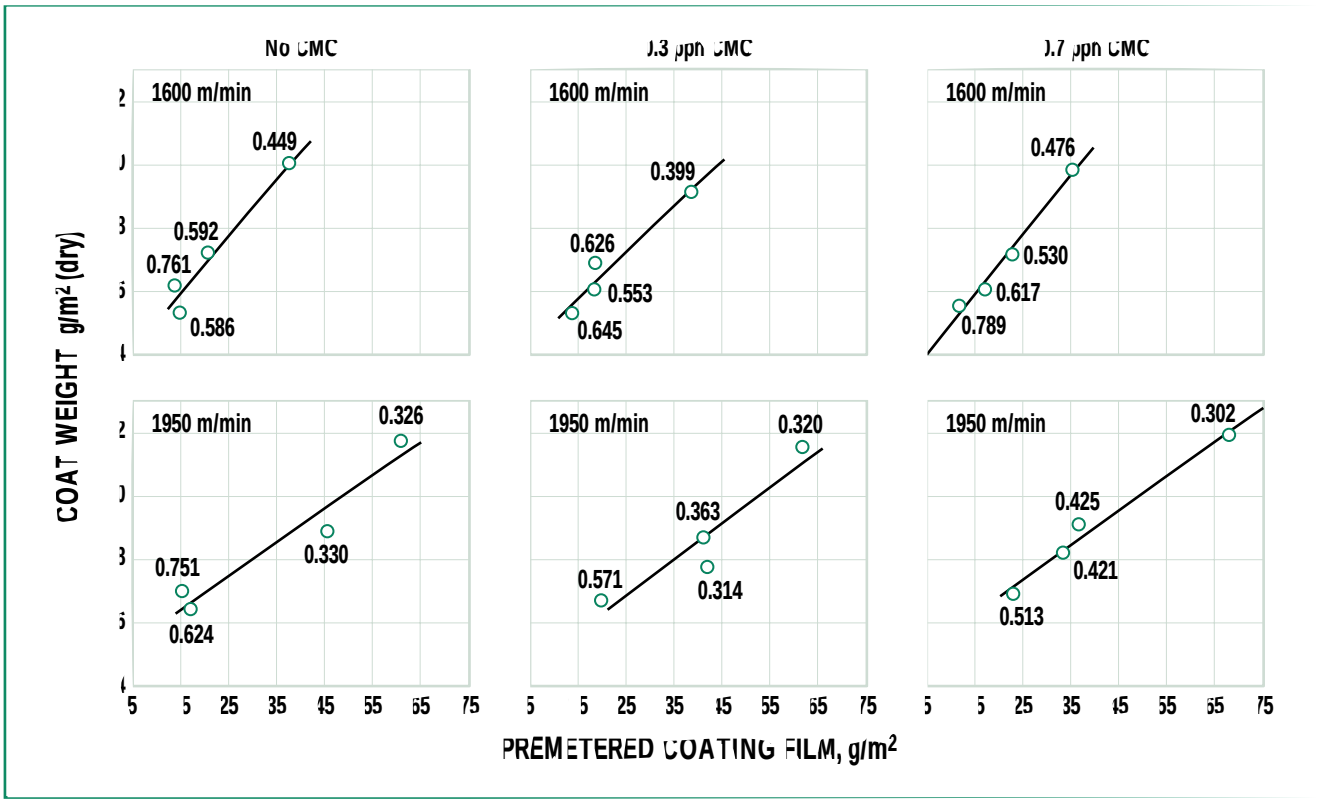
4. Coat weight as a function of the premetered coating film at two levels of machine speed and three levels of CMC content in clay-based coating. The values at each data point represent the associated film transfer ratio.

Premetering of the coating film. The film transfer process begins with the application of a premetered coating film on the transfer roll with a smooth application rod in a coating chamber sealed with a perforated blade. The loading pressure of the application rod is adjusted, where the rod is pressed against the film transfer roll, and the amount of coating passing underneath is adjusted. This premetering process is described in **Fig. 3**, with the amount of premetered film depicted as a function of the rod pressure. The figure is divided into three columns representing different amounts of CMC and two rows depicting two machine speeds. Within the separate graphs, the achieved coat weights are marked for each trial point. Note that the higher machine speed (1950 m/min) causes higher hydrodynamic force on the rod and an increase in the amount of premetered film at a given rod pressure. The curve has a logarithmic shape in the graphs in **Fig. 3**, and there seems to be a leveling of the curve at lower amounts of premetered film because of the high rod pressures. The coat weights achieved with a given amount of premetered film are described within each graph, but these results will be discussed later.

Transfer of the coating film. After a coating film is premetered on the film transfer roll, it is transported into a nip between the transfer roll and the backing roll. When it reaches this nip, the premetered coating film transfers to the paper web as a function of film amount, coating color composition, base paper properties, and nip pressure.

The amount of premetered coating film is one of the most important factors determining the maximum amount of coating that can be transferred to the paper. In **Fig. 4**, the amount of premetered coating is depicted as a function of the achieved dry coat weight. To illustrate the ratio between the premetered film and the coating transferred to the paper, the transfer ratio is included for each of the trial data points in the figures. Clearly, a higher amount of premetered coating is required to achieve the same coat weight when the speed is increased. This is probably because of the lower percent transfer of the premetered wet coating to the paper when the total amount of coating is increased. In other words, less water is transported out of the coating suspension because of the shorter dwell time. High amounts of premetered coating film might require a longer nip dwell time to reach a higher transfer ratio. The mechanism for the transfer of coating to the paper will be discussed separately. Dewatering of the coating color in the transfer nip probably needs to be increased at higher machine speeds to achieve the same level of coating transfer.

The formula for the transfer ratio is defined in Eq. 1:



5. Film transfer ratio as a function of the premetered coating film at two levels of machine speed and three levels of CMC content in clay-based coating. The values at each data point represent the associated mist values (g/60 s/A4 sheet).

$$\text{transfer ratio} = (\text{CW} \cdot 100)\,(X \cdot m)^{-1} \quad (1)$$

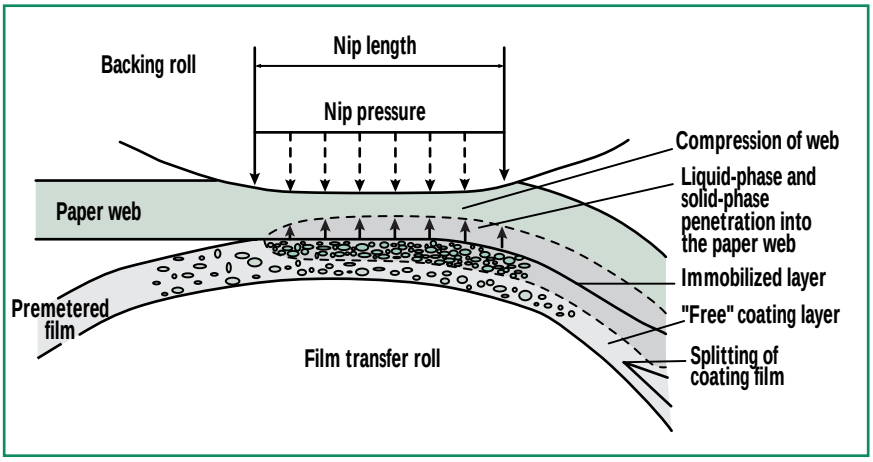
where,

CW= coat weight, g/m^2
X= solids content, %
m= amount of premetered film, g/m^2.

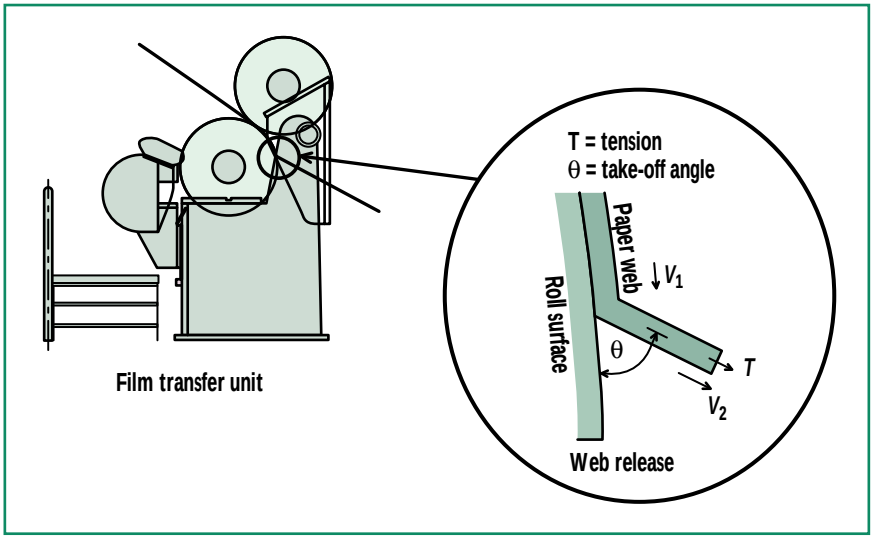
Since the misting of coating at the nip outlet is related to the amount of "free" coating, i.e., non-immobilized coating, optimized premetered films will contain lower amounts of wet or "free" coating when the film splits at the web release point. The misting tendencies at high machine speeds (2000 m/min) have been investigated more carefully in a separate study for coating colors with different characteristics such as pigment systems, thickening effects of the continuous phase, and solids content *(9)*. According to the results from the present study, misting of the coating color at the point of web release appears to increase substantially at transfer ratios below the range of 0.30 and 0.40, as seen in **Fig. 5**. At these transfer ratios, the amount of premetered coating film reaches undesirably high levels exceeding 40 g/m^2, causing an exponential increase in misting or even splashing in the nip outlet. With the coating colors used in this study, the undesirably high level of coating film provided coat weights of 11–12 g/m^2.

Film transfer process. A static pressure dewatering of the coating film is suggested to take place in the transfer nip, according to a mechanism proposed in recent studies *(2–4)*. The dewatering mechanism occurs as a pressure filtration of the coating color through a more compact pigment layer in the coating–paper interface, as seen in **Fig. 6**. The pressure dewatering of the coating color in the nip, solid/liquid phase penetration, and the dewatering–immobilization properties of the coating color influence the transfer of the premetered coating color to the paper. This proposed mechanism for the one-sided film transfer process is illustrated in **Fig. 6**. To get a more complete picture of the film transfer process, the coating color penetration into the base paper has to be included in the mechanism as done in **Fig 6**.

The coating film transported to the nip is proposed to penetrate and immobilize because of pressure dewatering, thereby creating an infinite viscosity. The transition area—the area that develops between the immobilized layer and the coating color with an initial solids content—consists most probably of an area with a solids content gradient. The nature of this transition zone, i.e., its existence and thickness, has been widely discussed previously and is not addressed further in this study. However, its influence on the film-splitting mechanism is probably significant. The coating film probably splits in the area with the lowest resistance in the *z*-direction, which



6. Penetration followed by pressure dewatering and film transfer of coating color to the paper in the pressure nip between the rolls



7. Variables for web release of an inextensible web

naturally is the area with the lowest solids content or the "free" coating layer.

Factors determining the release of the paper web

The release of the paper web from the film transfer roll in a one-sided film transfer process is determined by the film-splitting properties of the "free" coating layer. In other words, the point of web release is dependent on the tension vectors created by the web tensions, penetration of coating into the web, and the internal strength of the coating color. To evaluate the influence of the process parameters, the composition of the premetered coating color (pigment type, thickener amount, and solids content) and machine speed were studied regarding the release of the paper web.

Basics of web release. The web release from the surface of the film transfer roll is illustrated in **Fig. 7**, which shows the parameters in Eq. 2, a basic equation describing web release.

$$T = V_1 \cdot \sin \theta \qquad (2)$$

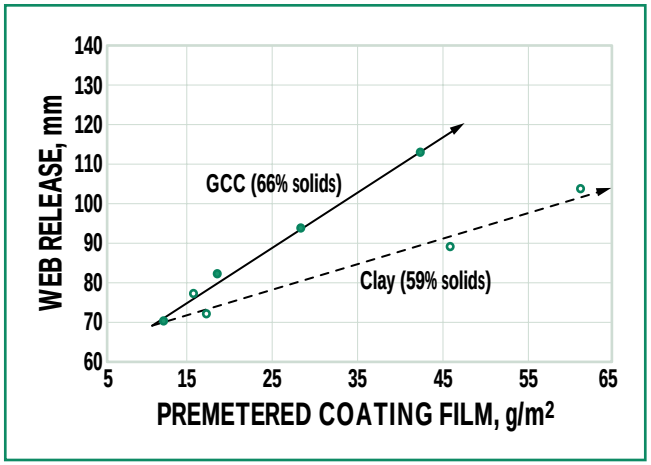
where

T= web tension
V= web speed
θ= take-off angle *(10).*

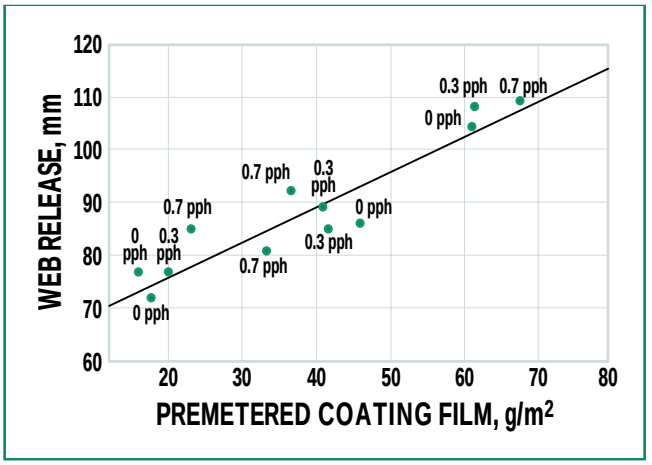
In our study, the web tension, T, after the pressure nip is constant at 300 kN/m, with machine speed, V, and take-off angle, θ, as variables. The take-off angle thus increases with increasing machine speed. The increase in take-off angle is caused by an increase in the distance of web release, since the meeting point is constant. The split resistance of the coating layer is constant in these situations and does not influence the point of web release. This resistance, i.e., viscosity or viscoelasticity, created by the coating color must be incorporated into the model to obtain a better picture of web release.

Coating color composition. The influence of pigment was studied at a machine speed of 1950 m/min by using a delaminated U.S. clay, with a high particle aspect ratio, and a ground calcium carbonate (GCC), with a low aspect ratio. To be able to study the impact of the two pigment systems, the coating colors were prepared to solids contents of 59% (clay pigment) or 64% (GCC pigment) to achieve comparable volume concentrations. No water-soluble thickener (CMC) was added to the suspensions of pigment and latex for this series of high-speed trials. CMC was omitted to avoid its impact on the internal strength caused by differences in association with the pigments.

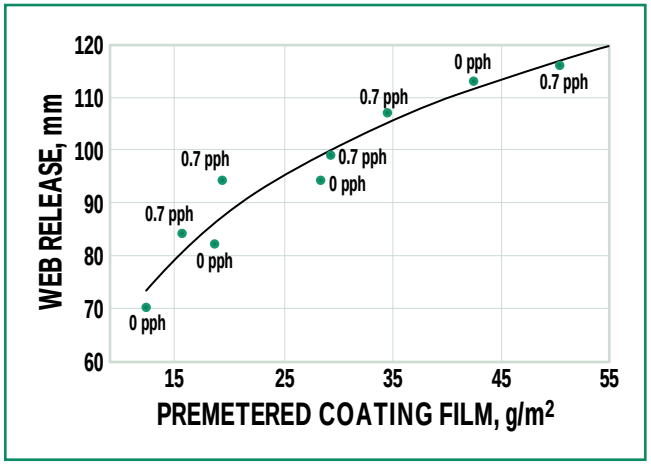
The results from the comparison regarding the pigment systems (delaminated U.S. clay and GCC) are presented in **Fig. 8**, which shows web release as a function of the premetered film amount. The GCC coating had a higher web release value than the clay coating at a given amount of premetered film. This is probably caused by a major effect on the coating color viscosity, the result of dewatering, in combination with the difference between the immobilization solids and the initial solids for the premetered coating films.



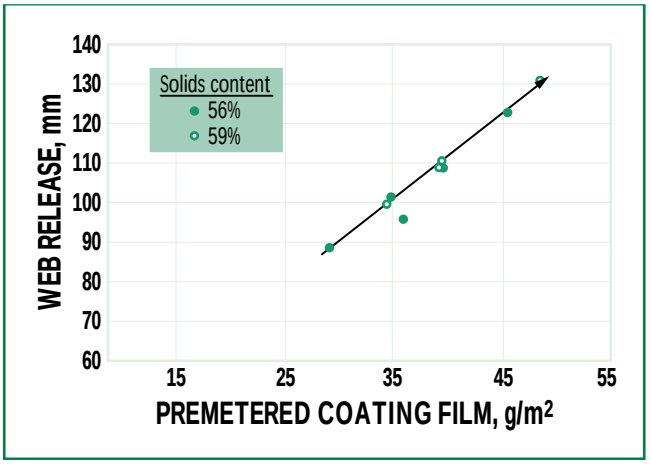
8. Web release as a function of the amount of premetered film at high speed (1950 m/min) for coating colors containing pigment [delaminated U.S. clay or GCC (60% <2 µm)] and S/B latex and no CMC



9. Web release as a function of the amount of premetered film for clay-based coating at different CMC contents (0, 0.3, and 0.7 pph) at 1950 m/min



10. Web release as a function of the amount of premetered film for GCC-based coating at different CMC contents (0, 0.3, and 0.7 pph) at 1950 m/min

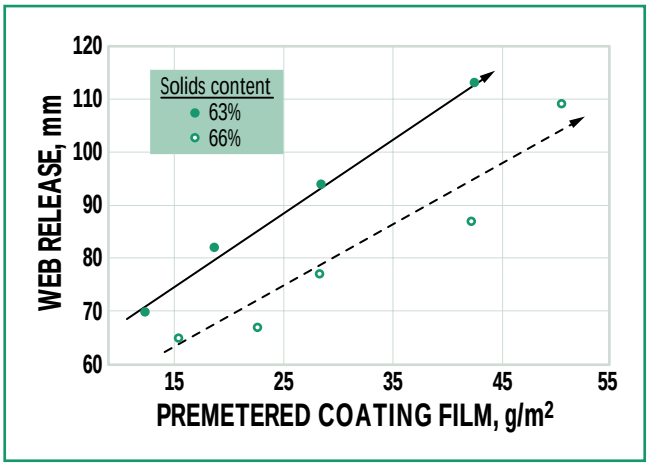


11. Web release as a function of the amount of premetered film for clay-based coating at different solids contents at 1950 m/min

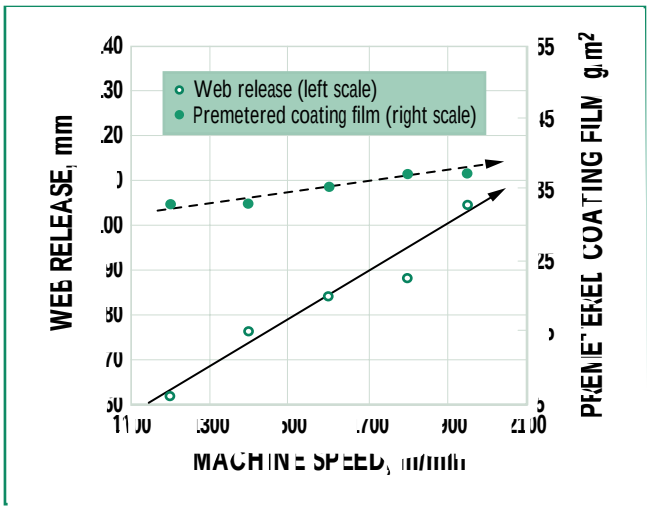
The difference between the immobilization solids and the initial solids level is higher for the GCC coating color (86% vs. 65%) than for the clay-based coating color (75% vs. 59%). (Note that the initial solids contents for both coating colors were chosen to obtain comparable levels of volume concentration, as mentioned previously.) Because of the larger difference for the GCC coating color, the coating layer is possibly wetter, with the homogeneous wet contact increasing the distance of web travel before release. When the coating film is more dewatered or drier, the homogeneous wet contact within the coating layer has a lower resistance to splitting.

The influence of the water-soluble thickener (CMC) in the two pigment systems was unclear, since there was no major difference in the web release for the different amounts of CMC. This was surprising, since the amount of CMC is supposed to exert a strong influence on the viscosity of the coating color and thus on the splitting of the coating film at the nip outlet. This is especially true in the case of GCC-based coatings because of the low association between CMC and GCC. Web release as a function of the amount of premetered film at different levels of CMC addition is presented in **Figs. 9 and 10** for the clay and GCC pigment systems, respectively.

The solids content of a premetered coating film also affects the web release for a coating color system. This was studied for both the clay and the GCC pigment systems, with each at two different solids contents 56%/59% and 63%/66%, respectively. The results for the clay and GCC pigment systems are presented in **Figs. 11 and 12**, respectively. The general conclusion from these two comparisons is that a wetter coating color or thicker layer of "free"



12. Web release as a function of the amount of premetered film for the GCC-based coating at different solids contents at 1950 m/min



13. Web release and amount of premetered film as functions of machine speed for clay-based coating

coating color in the nip outlet creates a higher web release resistance and delays splitting of the coating film. The difference between the two solids contents is clear for the GCC coating colors, whereas the clay-based coating colors do not show the same clear difference in web release.

Machine speed. The influence of machine speed (1200, 1400, 1600, 1800, and 1950 m/min) on the coater runnability was studied at a target coat weight of 8.0 g/m^2 with a coating color based on delaminated U.S. clay. The solids content of the coating color was 57%. Results are presented in **Fig. 13**, with the web release and the amount of premetered film depicted as functions of the machine speed.

The web release seems to be dependent on the time available for dewatering of the coating color at an increased machine speed, resulting in an increase in web release distance with machine speed. This seems to be a reasonable explanation, since the amount of premetered film is only slightly affected by the increased machine speed. The time available for dewatering in the nip is reduced, thus increasing the amount of "free" coating in the nip outlet. In an earlier study, this was found to increase the web release distance because of a higher internal strength, the result of a more homogeneous wet contact in the coating layer.

The misting tendency increased from 0.5 g/60 s/A4 sheet to 13.0 g/60 s/A4 sheet above 1800 m/min. Given the range of misting that can occur, this is only a slight increase. Misting tendency is really an optimization issue coating film transfer, where the goal is to transfer maximum coating to the paper at higher machine speeds, even when there is less time available for dewatering.

KEYWORDS
Calcium carbonate, calcium compounds, carbonates, clay, coated papers, coating color, coating, coloring materials, film coated papers, film splitting, high velocity, machine speed, pigment, runnability, splitting, surface finishing, tension, velocity, web tension.

CONCLUSIONS

The properties of the coating color can create large differences in the point of web release after the pressure nip during high-speed film transfer coating. This must be taken into consideration when developing strategies for film transfer coating (one- or two-sided), where the goal is to obtain an even release line on the film transfer roll surface. This study shows that physical control is not the only means of controlling the point of web release. The nature of the coating color—and especially the choice of pigment—exerts a significant influence on the point of web release. Thus any effort to physically change the point of web release requires an understanding of coating color behavior to avoid damaging the coating layer surface during web release.

Increasing the machine speed increases the distance between the nip outlet and the point of web release at a constant web tension. The increased machine speed reduces nip dwell time—the time available for dewatering—which leads to a more "free" coating at the nip outlet. Changes in the pigment composition also had a large impact on the web release. Indeed, pigment composition and coating color solids content had a greater effect than the amount of CMC in the coating. At a given level of premetered coating film on the transfer roll, the clay-based coatings provided an earlier release of the web than the GCC-based coatings. This was due to the higher delta solids for the GCC coatings. (Delta solids is the difference between initial coating solids and the solids of the immobilized coating layer.) The higher delta solids for GCC coatings vs. clay coatings suggests that GCC coatings emerging

from the nip have a more homogeneously wet "free" coating film. The wetter coating translates to a higher release resistance than for the inhomogeneously or partly immobilized clay-based coating film.

To obtain the same coat weight, higher amounts of GCC-based coating color must be applied on the film transfer roll. This increases the amount of wet "free" coating in the nip outlet, which increases the distance to the release point. In general, increasing the amount of free coating (i.e., non-immobilized coating) in the nip outlet increases the release resistance, thus increasing the distance between nip outlet and web release point. TJ

Grön is a senior product development engineer in Valmet Corp. Rautpohja Works, P.O. Box 587, FIN-40101 Jyväskylä, Finland. Nikula is a research manager, process research, Valmet Corp., Wärtsilänkatu 100, FIN-04400 Järvenpää, Finland. Sunde is a development manager at the Lappeenranta Paper Mill, UPM-Kymmene, Kaukas, FIN-53200 Lappeenranta, Finland.

Received for review March 6, 1996.
Accepted Oct. 22, 1996.
Presented at the TAPPI 1996 Coating Conference.

LITERATURE CITED

1. Rantanen, R., *Wochbl. Papierfabr.* 120(6): 193(1992).
2. Baumeister, M. and Kraft, K., *Tappi* 64(1): 85(1981).
3. Letzelter, P. and Eklund, D., *Tappi J.* 76(5): 63(1993).
4. Letzelter, P. and Eklund, D., *TAPPI 1996 Coating Conference Proceedings*, TAPPI PRESS, Atlanta, p. 269.
5. Trefz, M., *TAPPI 1995 Coating Conference Proceedings*, TAPPI PRESS, Atlanta, p. 435.
6. Grön, J. and Kuni, S., *TAPPI 1995 Coating Conference Proceedings*, TAPPI PRESS, Atlanta, p. 447.
7. Fadat, G., Engström, G., and Rigdahl, M., *Rheol. Acta* 27: 289(1988).
8. Sandås, S. E., Salminen, P. J., and Eklund, D. E., *Tappi J.* 72(12): 207(1989).
9. Grön, J., Sunde, H., and Nikula, E., *TAPPI 1996 Metered Size Press Symposium Proceedings*, TAPPI Press, Atlanta, p. 21; scheduled for publication in *TAPPI J.* 80(8): xx(1997).
10. Mardon, J., *Paper Timber J.* 11: 797(1976).