An Approach to Achieve High Solids Coating

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ABSTRACT

High solids coating has been an important issue amongst the coating technologist as this route gives potential advantages not only in production cost as well as enhancement in the product quality. In the present study, the effort has been made to increase the solids level of coating color without affecting or with improved coating color rheology. It is well known that the Ground Calcium Carbonate (GCC) and clay are the main pigment of any coating color recipe. Mostly GCC is supplied in slurry form about 75% solids level while coating clay is prepared on site. Separate dispersion of clay at approx 74% solids level causes limitation to achieve high solids level of color. So to avoid further dilution of color, coating clay was added in dry form in coating color. The rheology of color was maintained with the help of Poly Vinyl Alcohol (PVA) in coating recipe. The particle size distribution of coating color was studied through particle size analyzer for the proper dispersion of color components. Significant improvement was observed in various coated paper properties like brightness, whiteness, gloss, smoothness and water retention properties of coating color with respect to control coating.

***Keywords**: Brookfield viscosity, water retention value, gloss, brightness*

Introduction

Paper makers have keen interest to search new ways to reduce overall production cost without loss of quality parameters. The high solids of coating color always draw attention of coating technologist as it opens the door to put efforts in the reduction of production cost.

It is well known to everyone the importance of maximizing the solids level of coating color. High solids coating provides uniform binder distribution throughout the coating layer because of reduced binder migration. The faster immobilization at higher solids level provides maximum overall material retention throughout the coating layer. Better packing of pigments at high solids improves the gloss and smoothness of paper as well as reduces the binder and thickener demand. Significant reduction in drying cost is the great economic benefit (1-4).

However there are some limitations to run the coater at higher solids level. Serious runnability issues may occur which needs to be encountered before running the coater at higher solids level. The excessive blade load for the control of coat weight may result in higher no. of web breaks. Rheological issues may cause poor blade runnability which leads to scratching, bleeding, whiskering problems. Thus the optimization of coating color to maximize solids level is a right approach for the producers to get benefit of high solids level (2, 5, and 6).

Each ingredient in coating color has some limitations due to its solids content, thus restricting the coating color to achieve high solids. The pigment and the binder are the major ingredients of any coating color recipe. Generally GCC slurry contains approx 75% solids level, clay slurry is prepared on site at about 74% solids and synthetic polymer emulsion contains 50% solids level, this means that upon addition of these ingredients in coating color, a considerable amount of water is added to the color, which lowers the dry solids (7, 2).

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The water retention and the viscosity of color are very critical parameters while metering of coating color. The retention of color is desired on the surface of coating layer with minimum penetration into the base. As the solids level is increased, the retention is improved. The major drawback of increased solids level is the increased viscosity of color. The optimum flow is required to control the coat weight. Thus high solids coating has some restriction because of poor rheology. So it becomes necessary to achieve low viscosity level with higher material retention at high solids level of color (5). In the present study the effort were made to achieve high water retention of color with controlled rheology at high solids level for topcoat coating formulation. The effect of high solids coating on coated paper properties was also studied.

Experimental

Materials

Precoated sheets of 15 g/m^2 coat weight were used for topcoat coating application. The base paper with a basis weight of 80 g/m^2 was made of a combination of hardwood (80%) and softwood (20%) pulp. All the pigments and chemicals were commercial grade. Finer particle size GCC (95% < 2 micron) and clay (97% < 2 micron) were used as a pigment in coating formulation. The binder used for this study was a emulsion of styrene butadiene latex (Tg: 17°C). Polyacrylate based dispersing agent and calcium stearate based lubricating agent were used as additives to provide specific functions. Ammonium zirconium carbonate based compound was introduced as an insolubilizer in color recipe. Commercial grade PVA (98-99% hydrolyzed) and Carboxy methyl cellulose (CMC) were used as a rheology modifier in coating formulation. Hexa sulpho stilbene based compound was added as an optical brightening agent (OBA).

Coating color preparation

All the ingredients in coating color were added on the basis of 100 parts of pigment. The topcoat coating formulation was prepared in

the following steps. Required weight of calcium carbonate slurry was taken in beaker and kept under agitation. Coating clay, dispersant and calculated amount of water were added to it to get targeted solid concentration. Cooked CMC paste was then added at the vortex of pigment slurry. The slurry was agitated at high speed for complete dispersion of CMC. The speed of the agitator was lowered to avoid any foam formation during addition of synthetic binder. PVA was then added as a rheology modifier to the color. Lubricant (1.0 part) and insolubilizer (0.3 parts) were added at the vortex after fixed interval of time. Finally OBA (0.3 parts) was added to the color. The pH of the color was adjusted to 8.59.0.

Paper coating application

Top coating color was applied on 21.0×29.7 cm^2 precoated base sheets using an automatic bar coater (RK-Print Coat Instruments Ltd., U.K., model K 101) equipped with wire wound rod. Coat weight for topcoat application was maintained at10 g/m^2. Coated sheets were immediately dried in an oven maintained at 105°C for 60 seconds. After the coating, the coated sheets were conditioned at 23°C and 50% relative humidity for 24 hour. Coated paper was supercalendered in plant scale supercalander by applying a linear nip pressure of 76 bars, at 50°C. All sheets were passed through two nips.

Methods

Particle size distribution of coating colors was measured on Horiba make laser scattering particle size analyzer; model no. LA910. Viscosity of coating slips was determined on brookfield viscometer; model no. DVII pro viscometer. Static water retention was measured on AAGWR water retention meter; model no. 250 (0.5 bar, 90 sec). Portable Dynamic Water Retention (DWR) meter; make ACA Systems Oy, Finland, was used for the determination of dynamic water retention value of coating colors (1.8 bar, 10 sec). Brightness and whiteness of coated sheets were evaluated with data color brightness tester; model Spectraflash 300. Gloss value of the coated sheets was measured on L&W gloss meter; model no. SE224. Roughness was measured on L&W Parker Print Surf (PPS) roughness tester. Surface strength was determined in terms of IGT pick velocity on IGT printability tester; model no. AIC25.

Results and Discussion

The present study was performed for the topcoat coating formulation containing maximum 20 parts of clay in coating recipe. Before topcoat application, the base sheets were first precoated by using 100% coarser grade GCC based formulation.

Addition of clay in dry form

Effect on rheological properties of color

This study was carried out by introducing clay in coating formulation in dry form. The solids level of control coating batch was maintained at about 68%. The trial batches were prepared comparatively at higher solids level i.e. around 70% (Table 1). Trials were also taken at reduced proportion of coating clay in coating formulation. The

Table - 1 Topcoat coating formulation

Ingredient	Control	Trail 1	Trail 2	Trail 3
GCC	80	80	85	90
Clay	20	20*	15*	10*
CMC	0.5	0.3	0.3	0.4
Synthetic binder	11	11	11	11
Solids, %	68.3	70.0	70.1	69.6
Viscosity, cp	2480	2570	2576	2660

*Clay was added in dry form

coating color viscosity of trial batches was maintained similar to control coating batch with the help of natural thickener. The other coating ingredients were kept constant for all the trials. Results of the study revealed that the amount of thickener was reduced about 20-40% to bring the viscosity level of trial coating colors similar to the control batch (Table 1). The water holding capacity of coating colors was measured with the help of static water retention meter. It has been observed that the static water retention value (the higher the value the poorer will be the water retention) of coating colors increased slightly at higher solids and similar viscosity level to the control batch (Fig. 1). Probably the reduced CMC level and increased parts of GCC are responsible for the reduction in the water holding capacity of color. The similar particle size distribution of coating colors with and without addition of clay in dry form ensures proper dispersion of coating components (Table 2).

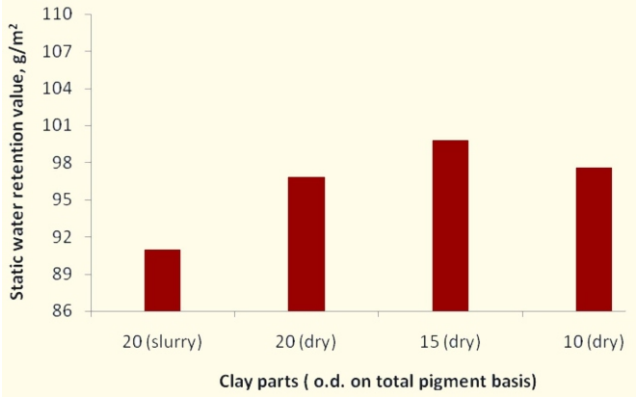

Fig. 1: Effect of addition of clay in dry form on static water retention of coating color

Table - 2 Particle size distribution of coating color

Particle size less than	Control (%)	Trail 1 (%)
10 micron	97.8	97.2
5 micron	92.2	92.0
2 micron	78.2	78.9
0.5 micron	62.9	63.6

Effect on coated paper properties

Paper gloss is an essential property of coated paper that makes the object look shiny or lustrous and depends on specular reflection from the surfaces. The high solids coating provides compactness to the coating layer with dense packing. Hence improvement in gloss was observed on increasing solids level of coating color from 68 to 70%. The gloss was increased by 4 points with addition of clay in dry form at higher solids level (Fig. 2). Thus gives us an opportunity to reduce the parts of clay in coating formulation. It was noticed that 50% substitution of clay with GCC shows similar gloss value as compared to the sheets coated with control coating formulation. As the inherent brightness and whiteness level of GCC pigment were higher than finer grade clay pigment, therefore improvement was observed in brightness and whiteness of coated sheets with reduction of clay parts from coating color formulation. Around 0.7 points increment in brightness and 3 points in whiteness were noticed at 50% substitution of clay with GCC pigment from topcoat coating formulation (Fig. 2).

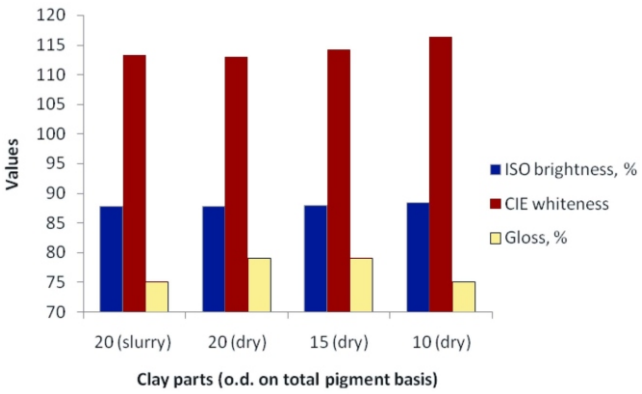

Fig. 2: Effect of addition of clay in dry form on optics of coated paper

Addition of PVA in color formulation

Effect on rheological properties of color

The PVA was introduced in coating formulation as a rheology modifier at the dose of 0.5 parts. On the basis of previous findings the coating trials were conducted with reduced parts of clay in coating formulation i.e. 15 and 10 parts as compared to control batch i.e. 20 parts. The solids level of trial coating colors were maintained in the range of 71-72% (Table 3). Binder amount were also reduced from 11 to 10.5 parts in trial coating formulations. The results obtained from this study clearly indicate that the addition of PVA in coating color not only controls the viscosity but also improves the material retention while metering of color. Results revealed that the addition of PVA further helps to reduce the parts of CMC in coating formulation. Almost 60-80% reduction was noticed in CMC parts as compared to control coating batch (Table 3). Significant improvement was observed in static as well as dynamic water retention of coating color (Fig. 3-5). Around 23-26 % reduction was noticed in static water retention value (Fig. 4) and approx. 22% reduction in dynamic water retention value (Fig. 5) of coating color. The slower dewatering in case of using PVA was studied by Jader et. all , which confirms that the formation of denser

Table - 3 Topcoat coating formulation

Ingredient	Control	Trail 4	Trail 5
GCC 95	80	85	90
Clay	20	15*	10*
CMC	0.5	0.1	0.2
PVA	Nil	0.5	0.5
Synthetic binder	11	10.5	10.5
Solids, %	67.7	71.7	71.0

*Clay was added in dry form

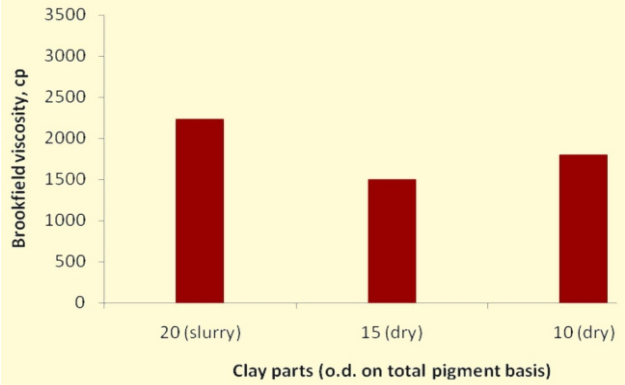

Fig. 3: Effect of addition of clay in dry form in presence of PVA on viscosity of coating color

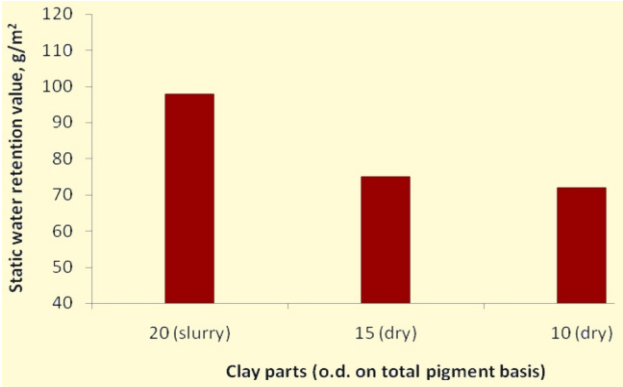

Fig. 4: Effect of addition of clay in dry form in presence of PVA on static water retention of coating color

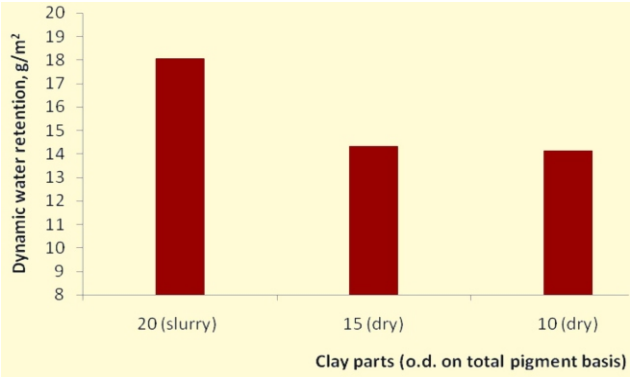

Fig. 5: Effect of addition of clay in dry form in presence of PVA on DWR of coating color

filter cake at the interface between wet coating color and base paper retards the migration rate of the color into the base paper (8).

Effect on coated paper properties

Significant improvement was noticed in optical properties of coated paper with introduction of PVA in coating formulation at high solids of coating color. Around 1.0 points gain in brightness, 7 points in whiteness and approx 2 points in gloss of coated paper were observed at 25% substitution of clay with GCC pigment (Fig 6). The brightness and whiteness were increased by 1.4 points and 8 points respectively with 50% substitution of clay with GCC pigment in coating formulation. Whereas the gloss was noticed in the similar range as compared to control batch (Fig. 6). The PVA enhances the brightness and whiteness of coated paper as it forms some sort of a complex with the primary state of OBA, thus fixing its conformation. So upon light absorption, there is less conformational change, which in turn enhances the fluorescence rate as a whole (1).

Roughness describes the topography of the surface. It should be low to attain good printing properties. Paper roughness (the lower the value the better the smoothness) as demonstrated in fig. 7 was improved by almost 10-11% with addition of clay in dry form and PVA as a rheology modifier at high solids level. Surface strength was measured in terms of IGT pick velocity. The results were obtained similar to the control coating batch even after reducing the binder parts from 11 to 10.5 in coating formulation (Fig 8).

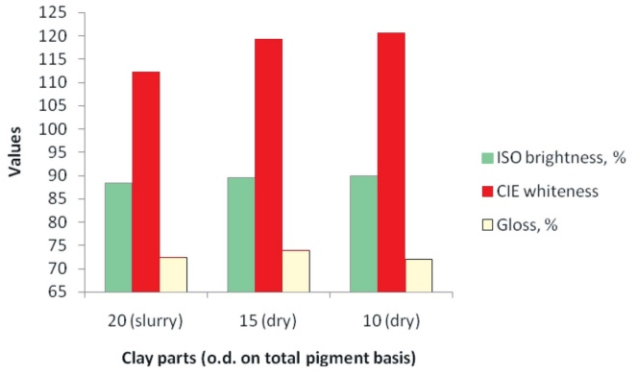

Fig. 6: Effect of addition of clay in dry form in presence of PVA on coated paper optics

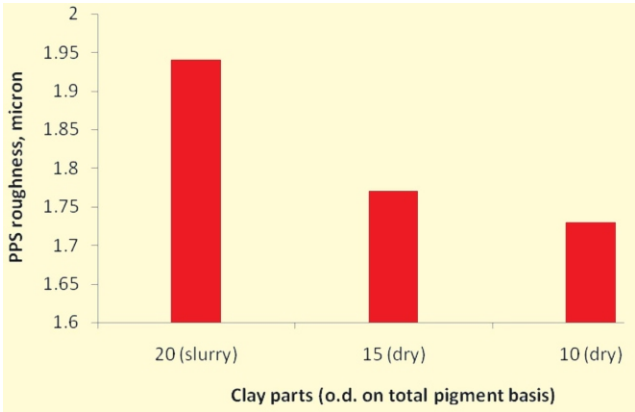

Fig. 7: Effect of addition of clay in dry form in presence of PVA on PPS roughness of coated paper

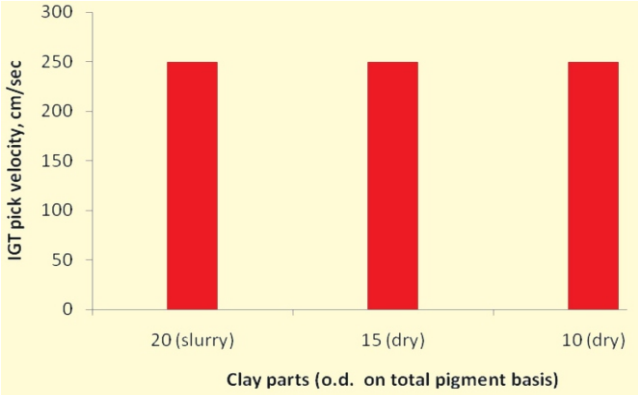

Fig. 8: Effect of addition of clay in dry form in presence of PVA on IGT pick velocity of coated paper

Conclusions

The present study confirms that the coating color containing a few parts of clay in formulation can be further modified to improve the quality of coating color as well as coated paper at reduced cost. High solids level of coating color can be achieved with addition of clay in dry form in coating formulation. Thickener amount can be reduced significantly at higher solids level. As the viscosity of coating color has been a great issue at high solids of color which can be resolved with introduction of PVA in coating formulation. PVA not only improves the water holding capacity of color but also helps to control the viscosity level.

High solids coating also offer to reduce the binder parts in coating formulation. The smoothness and gloss of coated paper were improved at high solids coating. The increased gloss of coated paper gives us an opportunity to reduce the parts of clay in coating formulation. Both the reduction in clay parts and addition of PVA in coating color improve the brightness and whiteness level of coated paper.

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