Paper Coatings and Their Influence on Offset Paper and Ink Interaction

Nick Triantafillopoulos, David Lee *

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Abstract: In multicolor offset printing, ink film splitting and tack development are, to a certain extent, dependent on surface properties of the paper. These processes and coated paper properties are effectively altered by the choice of coating raw materials and the coating application method. In the present work, we quantified ink tack buildup rates and the pick strength of coated papers, using a laboratory technique which correlates well with the performance of papers in multicolor sheetfed and web offset commercial presses. The study focuses on polymeric properties of styrene butadiene latex and coating drying conditions. Results indicate that the rate of tack buildup decreases with: (a) increasing total binder level and the presence of a soluble cobinder, such as starch, in the coating formulation; (b) a higher degree of latex polymer crosslinking and a smaller latex particle size, and (c) coating drying with infrared and forced hot air when compared to drying with infrared only. The tack rate increases correspondingly with: (a) a raised level of butadiene in the latex (within the range 35-45% which is of practical interest for paper coating latices), and (b) incorporation of polystyrene into the coating, latex particles with a relatively high Tg. Coating drying plays an important role on tack rate of the final paper, irrespective of the binder system. This is attributable to the intensity of drying; higher paper surface temperatures and air impingement in drying with hot air lead binder to migrate to the coating surface and tack rate reduces. Binder film positioning and its solubility play a significant role on ink tack rates, primarily through the affinity of the ink solvent to the binder. Building on this work, coating formulation strategies can be developed that result in better paper and offset ink interactions, ultimately resulting in papers with excellent multicolor offset printability.

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* **GenCorp Inc., Specialty Polymers Division, 2990 Gilchrist Rd, Akron, OH 44305. 330-794-6249.**

INTRODUCTION

Offset lithography, the most common form of printing, is putting increasing demands on coated paper quality. More than six color/varnish stations are common and press speeds continually increase. In multicolor offset, interaction between the ink and the coated paper is a complex but important aspect of achieving the desired printability and print quality. Significant events in this interaction are the ink film- splitting mechanism subsequent to the first film splitting and ink transfer onto a virgin paper surface. Walker and Fetsko (1955) developed the well-known equation for the initial transfers of ink from the blanket to paper. One of the most critical aspects of the equation is that ink transfer to the paper is proportional to the ink immobilization capacity of the paper surface. In multicolor printing there are multiple ink transfers. Different conditions affect each transfer as, in later stations, ink is being transferred to paper surface areas which have already received a color or have been dampened by fountain solution. Some of these conditions can be described by subsequent applications of the Walker-Fetsko equation where ink is transferred to a prewetted or preinked paper surface. The ink-paper interaction dictates film splitting and ink transfer in multiple nips. Robie et. al. (1992,1995) showed that coated papers with different ink interactivity influence the magnitude and direction of the secondary ink transfers. Consequently, coated paper surface properties, such as smoothness, porosity, absorptivity, etc., are important factors in the offset printing process and, more specifically, the ink film splitting mechanism. The ink film splitting characteristics are driven by the nature of the ink immobilization. In addition to cavitation at the printing nip and ink rheology, ink immobilization (tack buildup over time) is driven by the coated paper properties. Therefore, the makeup of a coated paper and its coating surface structure strongly influence the ink tack development. This paper focuses on how coating process and chemistry variables, with particular emphasis on styrene butadiene latex variables, influence paper and ink interaction.

Paper and ink interaction in offset printing depends upon both the coating chemistry and physical characteristics of the coating surface. Aspler and LePoutre (1991) have reviewed the transfer and setting of offset ink on coated paper. Previous studies have reported on how the fast rate of ink tack buildup is associated with printing problems such as ink piling, coating picking, and print mottle (Concannon 1992, Prufeest, 1991, Van Gilder, 1994, Sandreuter, 1994, Swan, 1973). The rate of ink tack increase is greater with more absorbent coated papers, as previously reported by Sørensen (1982) and Swan (1973). Work by LePoutre et al. (1979) with model clay and calcium carbonate coatings in a laboratory environment demonstrated that the immobilization factor in the Walker-Fetsko equation was greater for the rougher calcium carbonate coatings.

They proposed that immobilization is solely dependent upon surface voids of the coating. Gane et al. (1994) have reported that the choice of clay influences the ink tack buildup rate. Standard Particle Size (SPS) English clays have slower rates compared to U.S. delaminated kaolin clays and ground calcium carbonate in coatings containing latex and soluble binders. Differences between pigments were attributed to ink solvent affinities due to both differences in the surface chemistry, and dispersant types and level variations. Additionally, the choice of styrene butadiene latex in the paper coating composition has been shown to influence the ink tack buildup rate and press performance of coated papers. Purfeerst and Van Gilder (1991) reported that latices with lower styrene to butadiene ratios gave slower ink tack buildup rates and better on-press performance; i.e., no picking compared to coatings with higher styrene-to- butadiene ratio latices. Additional work (Van Gilder, 1994) reported that the solubility characteristics of the latex influences the rate of tack buildup. This was based on determining the solubility parameter of latices and ink solvent characteristics. The solubility parameter depends both on the physical state (i.e., state of crosslinking) and the chemical nature of the polymer (i.e., surface energy and polarity). Slower ink tack buildup rates were reported when the solubility parameter of the polymer was greatly different from that of the ink solvent. While the above studies shed light on some of the coating design variables which influence ink tack buildup rate, no systematic approach has yet been offered for coating formulation strategy. Trends that will be useful in formulating coatings are presented below based on understanding of styrene butadiene latex, coating color composition and drying variables affecting the paper and ink interaction.

The end-use properties of any coated paper are affected by two very broad classes of factors, the coating structure and the coating chemistry. The coating chemistry is influenced by the choice of the latex, pigments and other additives in the coating formulation. The final coating structure on the paper is strongly affected by both the coating color makeup and the coating application conditions (i.e., drying conditions, applicator type, solids levels, etc.).

It is extremely useful to have laboratory scale methods that allow quantification of paper and ink interaction in order to predict and control printability. Zang and coworkers (1991) reported a method of measuring ink tack as the tensile stress in ink film splitting between two rolls using a pressure sensor mounted on the printing cylinder of a laboratory press. Concannon and Wilson (1991) introduced the S. D. Warren LODCEL test as a practical method to evaluate ink tack buildup rates and coating pick failure forces. This method allows direct measurement of ink film splitting forces as applied to a substrate (i.e., coated paper) during repeated passes of the paper over an inked block. This test uses a

modified flatbed Vandercook laboratory printing press; hence ink is being transferred from a block to the motorized printing cylinder covered by a nonabsorbent blanket. A 26.7 x 5.08 cm paper sample is being attached onto a holder mounted with a force transducer which measures the split force at every pass of the inked blanket over the paper surface (Plowman, 1989a, 1989b). The signal is digitized and processed through a computer. The S. D. Warren LODCEL test method, referred to as the Paper and Ink (P&I) test, was used for the present study. More details of the test method are given in the experimental section.

The P&I test quantifies ink tack buildup by measuring the force required to split the ink film during multiple passes. The first pass is ignored because it represents ink transfer from the inked blanket onto the paper (Concannon, 1992). Thereafter, the measured forces correspond to splitting the inked blanket and inked paper until visible coating pick out (or failure) occurs. At that point the test is terminated. The final force is reported as the Force-to-Failure (FTF), expressed in grams per centimeter width of the paper sample. The total Passes to Failure (PTF) are also reported. By applying linear regression on the force data between the second and the final passes, a slope is calculated which represents the rate of ink tack buildup. Typically, stronger papers give comparatively low slopes (i.e., below 10), high PTF (e.g., over 4), and FTF of about 600-900 g/cm, for sheet offset, and 400-600 g/cm, for web offset papers (Concannon, 1992, Sandreuter, 1994).

Our experience, as well as that of others, has shown that the P&I test results correlate well with printing press performance (Concannon, 1992, Purfeest, 1991, Sandreuter, 1994). The test has been demonstrated to be an important tool in predicting the performance of coated papers in a multicolor offset press and it is an effective tool to study variables in the laboratory and correlate them to performance in the field. This allows a connection to be made during coating raw materials' development (i.e., new latices) and coating formulation and processing strategies. Following is a presentation of how the choice of selected materials, choice of styrene butadiene latex, laboratory application method and drying influence the P&I results.

EXPERIMENTAL

Coating Materials and Conditions

Paper coatings were prepared in the laboratory using dry pigments and included all- synthetic and starch cobound offset formulations. Unless

otherwise specified, most of the coatings were made of a pigment blend with 50% fine no.1 clay (Hydrafine 90™), 44% ground calcium carbonate (Hydrocarb 90™) and 6% rutile titanium dioxide (RPS™). Dispersing agent (Dispex N40™) was added at 0.45% during mixing the pigments in to a slurry. All-synthetic formulations included 0.35 parts, based on dry pigment, of a low molecular weight carboxymethylcellulose (CMC 7LEL™) and 1 part of calcium stearate lubricant. Cobound binder coatings contained from 3 to 9 parts hydroxyethylated corn starch (Penford Gum 280™). The rest of the binder was various types of styrene butadiene latices. Typically, there were 16 parts latex in an all-synthetic coating. The pH of the final coating was adjusted with sodium hydroxide to 8.0-8.5. The total solids of coatings varied between 62 and 68%, depending on the coating application method. Coatings applied with the laboratory coater CLC™ were at 65-68% total solids, while coatings applied with drawdown rods were at 61-62% solids. Laboratory CLC™ coating applications were all at 961 m/min speed, except for one case where the speed was reduced to 180 m/min. Drying was achieved with infrared and/or hot air. Our laboratory coater has an attachment with a nozzle which can discharge hot air across the whole width of the rotating CLC™ drum. The procedure for coating application with rod drawdowns is standardized, with drying always including both infrared and hot air from a hot-air gun. The raw basestock was a woodfree 74 g/m^2 sheet and the coat weight was about 14-15 g/m^2 on a single side. Coated paper samples were conditioned for 24 hrs and then supercalendered in the laboratory with variable (2-4) nips and 130-150âC. Paper gloss was in the ranges 60-65% and 70-75%, depending upon the specific coating formulation. Within the same set of data, paper samples were supercalendered under constant conditions. Paper testing was done according to TAPPI Standards and Useful Methods.

THE P&I TEST AND FACTORS INFLUENCING THE RESULTS

Our P&I setup is based on a Universal I Vandercook press, retrofitted with the equipment similar to that of the S. D. Warren LODCEL. The test is controlled by measuring the PTF, FTF, and slope of a "standard" paper at least three times during a testing session. These measurements are compared with audits from other laboratories which have the same equipment. Typically, P&I results depend on the following parameters: ink choice, printing speed, timing between passes, printing nip pressure, ink film thickness, blanket absorptivity and compressibility, temperature and relative humidity of test room, and the operator. Some of these and other issues influencing the P&I test results have been discussed by Plowman- Sandreuter (1994). Our own evaluations of the most critical factors influencing the P&I test determined that a variability of 25-30% can arise from different "kiss" impressions (i.e., the inked bed adjustment). Drifting of temperature and humidity in an uncontrolled

laboratory environment can cause variations of 20 to 25 percent. A 10-15% variability can arise from differences in the technique used by various operators (i.e., difference in applied ink film thickness onto the inked bed and the subjective determination of coating failure). Understanding these sources of variability led us to pay special attention in minimizing the contribution of these factors to the data in this work. The kiss impression was set so that we always obtained PTF, FTF and slope on a standard paper within a range predetermined in a multi-laboratory round-robin. The relative humidity and temperature of the test area were maintained around 24% and 74âC, respectively. Operator variations were minimized through all tests being run by internally certified operators. Based on our laboratory comparisons, a difference of more than 2 g/cm in slope and PTF, and 100 g/cm in FTF are considered to be real differences.

The ink we are using is a fast-setting cyan for sheet offset printing which contains 28% solvent initially, i.e., before application onto the blanket. The ink solvent is over 90% aliphatic compounds, the rest being aromatic substances. The blanket has a proprietary surface treatment provided by the equipment manufacturer to minimize absorption of the ink vehicle. The film thickness of the ink applied onto the paper sample during the first pass is approximately 0.05 mil, which is similar to that in single-ink commercial jobs (Sandreuter, 1994). Repeated passes over the paper sample occur every 7 seconds. Increasing the time interval between passes reduces slopes. P&I data reported in the paper represent averages of 12 to 30 replicates using multiple sheets from the same application.

The measurable quantities are the split force and passes to fail (PTF). The force is expressed in grams per centimeter width of the paper sample. We can measure up to 20 passes. Slope is calculated as the difference of the force between the second and last passes divided by the product of the number of passes minus two multiplied by 7 seconds. The units of slope are grams per centimeter per second (g/cm/s).

RESULTS AND DISCUSSION

The Influence of Coating Formulation Variables

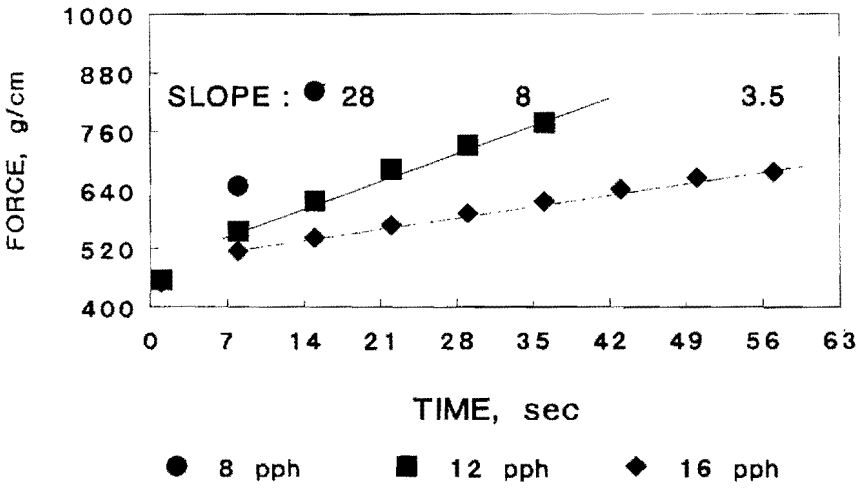
The influence of latex binder level, addition of soluble binder, non-binding polystyrene pigments, and the grade of clay was investigated. Each of the four variables has been considered independently in order to gain an understanding of the major effects associated with these key coating formulation factors. For this series of evaluations, the latex type was held constant with a 1400 ± 100Å diameter carboxylated styrene butadiene heteropolymer with a T_g of -2°C.

The binder level is a critical factor in the force to failure (FTF), slope and passes to failure (PTF). In Figure 1 the change of slope, PTF and FTF are shown for binder levels of 16, 12 and 8 pph (parts per hundred of dry pigment solids). The change in all three measurable values is substantial with the different binder levels. The slope (rate of ink tack build) drops from 28 at a binder level of 8 pph to only 3.5 at a binder level of 16 pph. Figure 1 also demonstrates a critical point in understanding the printability of any given paper. At the 8 pph binder level, the FTF for coating picking was about 840 g/cm, while the FTF were about 780 and 680 g/cm respectively for the 12 and 16 pph binder levels. In spite of the lower FTF values, there were substantially more PTF in both of the higher binder level cases. If in the first approximation these values are used as a surrogate for the ability of a paper to take multiple printing passes (i.e., multiple colors) then it becomes clear that a single-point measurement of the coating pick strength may not be a good predictor of pick resistance on the multicolor printing press.

The decrease in the slope of the papers with higher binder levels is consistent with the findings reported by Zang and Aspler (1995). These authors used model coatings dried under ambient conditions on Mylar™ substrates. According to their results, higher binder content in the coating leads to a slower tack buildup for the thin ink layer near the paper surface—not only because of reduced coating porosity, which inhibits draining the ink vehicle into the paper through capillary action, but

Figure 1

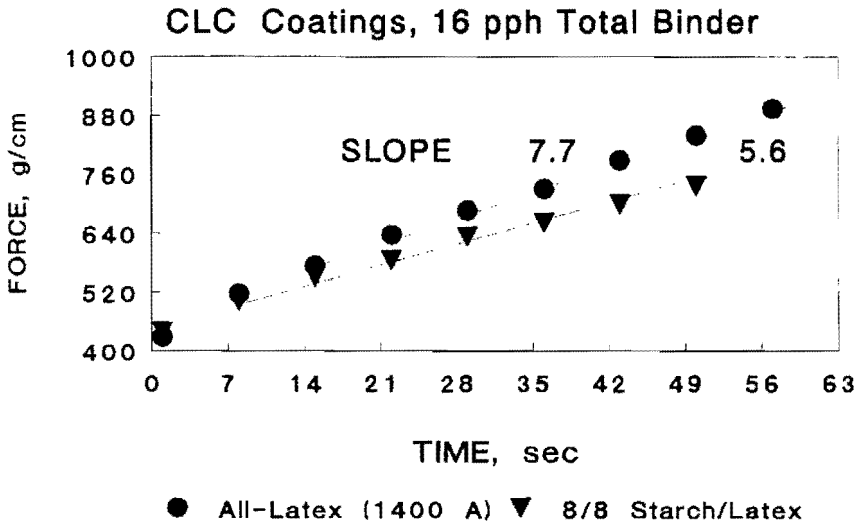
CLC All-Synthetic Coatings (1400 A)



also because of asymmetric ink film splitting. Generally, the location of ink film splitting will move away from the coating surface and move closer to the non- absorptive blanket when the binder level decreases and the ink tack is relatively high. Consequently, high binder-level coatings will give a film split closer to the symmetrical split than low binder-level coatings. Implication of the asymmetric film split in low-binder coatings is twofold. First, the ink film transferred to the paper is thinner than one-half the total film thickness. Additionally, the "openness" of the low binder coating surface structure results in faster ink setting due to increased drainage of the solvent through the coating.

Figure 2 shows that, at a constant binder level with half the latex binder being replaced with starch, there is significant change in all three measurable P&I values. The all-latex binder system was found to have a higher slope than the starch/latex cobinder system by approximately 2 units. However, the FTF was 895 g/cm for the former coating, compared to 740 g/cm for the coating with starch. Both coatings had similar gloss (57-59%) and delta gloss (18%). Although the all-synthetic coating had a higher rate of ink tack buildup, it was stronger (i.e., higher FTF and wet pick) than the starch-containing coating.

Figure 2



Typically, a higher slope is being associated with more porous coated papers. The all-latex coating presented here had a porosity value of 130s Gurley High Pressure Density (HPD) seconds for 2.5 cc of air to pass through the sheet, which is slightly less porous than the 8/8 pph starch/latex binder system at a value of 93s (± 40). (Higher HPD numbers represent lower paper porosity.) Although the coating porosities

were similar, slopes were significantly different. The difference can be attributed to lack of solvent swellability (uptake) of the starch cobinder compared to styrene butadiene. The greater swellability of the all-latex system will allow faster removal of the ink solvent than the non-swelling starch cobinder and the slope value increases.

Replacing part of the binder portion with a polystyrene pigment has a significant influence on PTF and slope, but was not observed to significantly affect the FTF. Figure 3 shows the effect of replacing 20% by weight of the binder with a non- binding, high T_g (54°C) polystyrene latex. While maintaining a constant latex level of 16 pph, the slope rose from 7.7 to 13.1. This is attributed to the change in coating porosity from 130s HPD, for the all-binding latex, to 41s HPD, for the coating containing 20% non-binding latex. The more porous coating gives higher slope due to fast ink vehicle removal. Although there is 20% less of the swellable latex available for the absorption of the ink solvent, coating porosity seems to play a stronger role than the latex solubility to solvent in ink tack buildup.

Figure 3

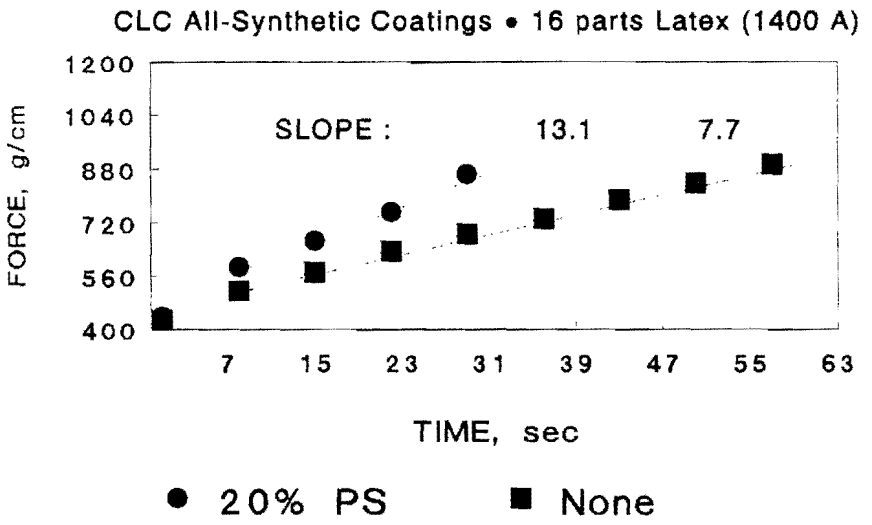
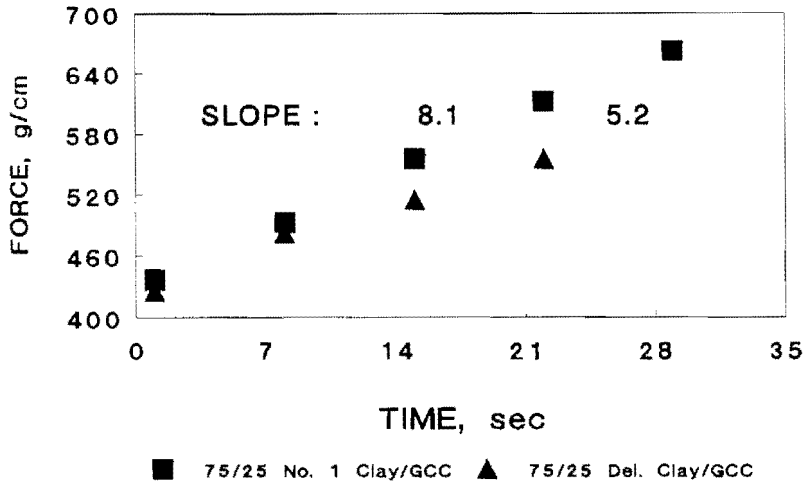


Figure 4 demonstrates the effect of replacing a no. 1 grade clay with a delaminated kaolin clay in coatings with 25% calcium carbonate. The coating containing the fine particle size no. 1 clay had a higher slope and FTF. The lower slope of the coating containing delaminated clay arises from more effectively covering the coating surface, and reducing porosity, due to the high aspect ratio of the delaminated particles. Generally, one expects the lower slope coating to have the greater PTF, but this is not true here. The lower PTF and the lower ultimate FTF values correlate with the relative weak z-direction strength of the delaminated clay

compared to the strength of the no. 1 clay (Inoue and LePoutre, 1992). This case illustrates the need to consider both the PTF and the slope in order to fully assess P&I interaction.

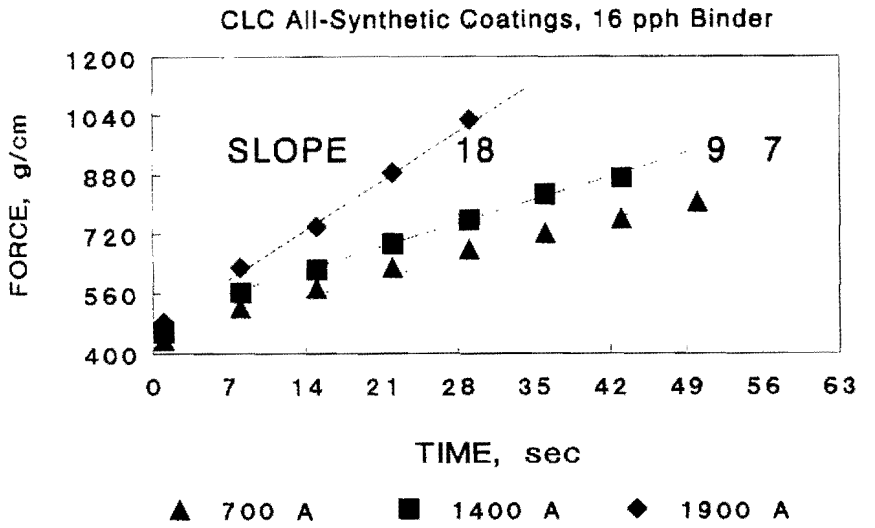
Figure 4
CLC, 16 pph Total Binder/ 4 pph Starch



The Influence of Styrene Butadiene Polymer Variables

The importance of latex particle size is well known in coating rheology and well established in regard to pick strength. The smaller the latex particle typically the better the coating runnability. Similarly, the smaller the latex particle size, the higher the pick strength. Figure 5 compares the effect of particle size for three latices with diameters of 700Å, 1400Å, and 1900Å. The backbone chemistry and colloidal systems in all three latices were the same. The T_g of all three latices was, therefore, constant at about -2°C. The smaller the particle size of the latex, the more PTF and the lower the slope. The FTF was about 800-870 g/cm for the two coatings with 700Å and 1400Å latices, but increased to 1030 g/cm with the largest particle size latex. Both coatings with 700Å and 1400Å latices had similar porosities at 130 s and 110 s HPD, respectively. The 1900Å latex gave a much more open (more porous) coating with only a 50s HPD. To a large extent, the slope and PTF are determined by the coating porosity.

Figure 5

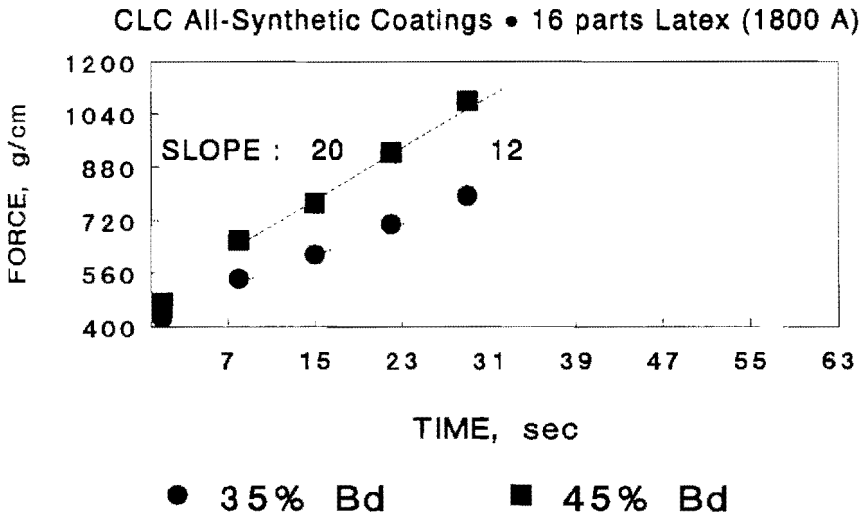


Of course, advantages in coating strength are counter balanced by disadvantages in optical end-use properties. Under the same supercalendered conditions, the coatings with the two large-particle size latices had paper gloss of approximately 60%, while the coating with the smallest size latex had gloss of about 52 percent. The proper choice therefore of latex variables can give optimum coating strength without compromising other important properties. In the particular series of latices evaluated here, the latex with a particle size of approximately 1400Å gives good strength and gloss.

The butadiene level of a styrene butadiene copolymer affects the performance of coatings through several mechanisms. First, it is through alteration of the T_g and the film-forming characteristics of the latex. Second, it is the influence on the crosslink density, or gel level, of the polymer. Figure 6 shows a comparison of two coatings where the latex butadiene level has been changed from 35-45% by weight with the use of different amounts of a chain transfer agent during emulsion polymerization. Although PTF remain constant, both the FTF and slope decrease as the butadiene level drops. Both the polymers were 1800Å film forming latices, with a gel content of about 50 percent. The porosity of the 35% butadiene latex coating was 43s HPD, compared to 55s for the 45% butadiene latex coating. The lower FTF with lower butadiene was expected due to loss of latex film strength. A higher butadiene level also has a greater tendency to swell from the ink solvent and therefore takes up the ink solvent faster. Additionally, this leads to ink film splitting closer to the paper which would result in a thinner ink layer and

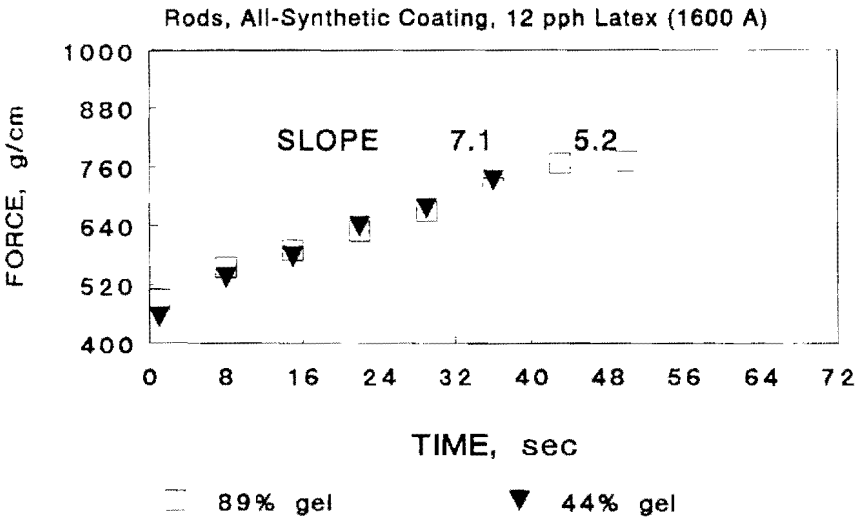
a lower volume of solvent. Therefore, the coating with the higher butadiene content latex immobilizes the ink faster, resulting in a faster ink tack build rate and higher slope.

Figure 6



The gel content of a latex is an important factor in the paper coating performance. Figure 7 shows that the effect on slope is small but measurable. The latex with 44% gel had a higher slope than the latex with 89% gel. In this case it is not possible to separate the related effects of decreased gel content with increased porosity. The 44% gel latex coating had 30s HPD, compared to the 89% gel latex system having a 60s HPD. Whether the increased rate of tack buildup is caused by the increased porosity, increased swellability of the latex, or both cannot be determined because of the interdependence of porosity and gel. Low-gel latices produce porous coatings.

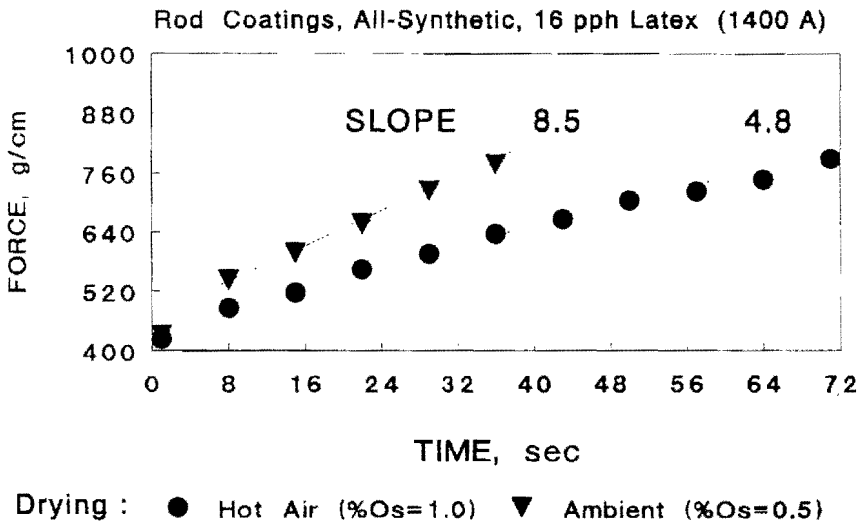
Figure 7



The Influence of Application and Drying Conditions

Coating application solids and drying conditions are widely recognized for having a significant effect on end-use performance of a coated paper. Figure 8 compares the performance of two radically different drying conditions in application with rod drawdowns using a 1400Å film forming binder with T_g below room temperature (- 2°C). In one case, the coating was dried using hot forced air only; while in a second case, the coating was allowed to dry at ambient room conditions (24°C). The coating with hot air drying gave slower ink tack buildup (i.e., lower slope) and much more PTF at constant FTF than the coating dried under ambient temperature.

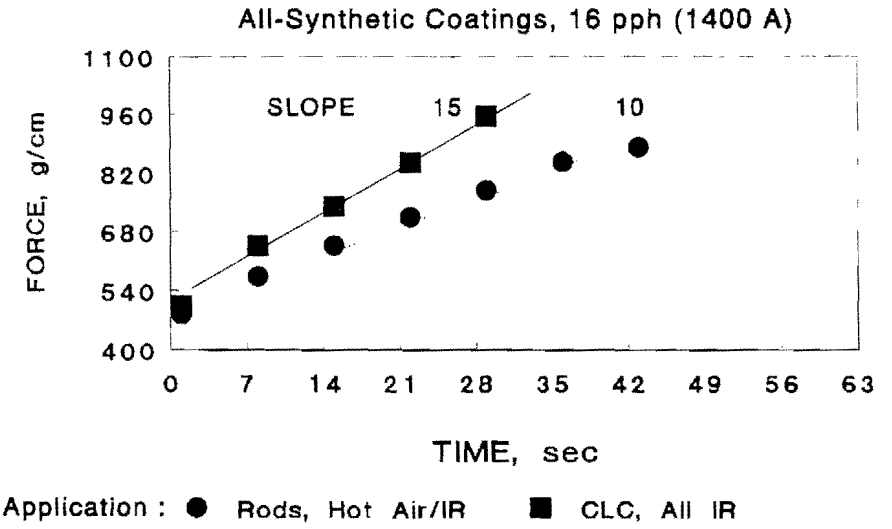
Figure 8



Part of these differences can be explained by the relative positioning of the latex between samples dried under variable conditions. To establish that connection, paper samples were taken and stained with osmium tetroxide to label the butadiene portion of the latex. Since the only unsaturated bonds for the osmium tetroxide to react with are the unsaturated butadiene bonds in the latex, the osmium tetroxide is a label for the latex position. The result of ESCA (Electron Spectroscopic Chemical Analysis) experiments showed 1.0 atomic percent of the osmium tetroxide in the hot air dried samples compared to only 0.5% for the ambient dried system. The data represent an average of six multiple readings at different sheet locations. The difference clearly demonstrates that in the hot-air dried sample there is a greater concentration of the latex in the top 50Å of coating depth compared to the sample dried under the much less rigorous conditions of room temperature. Forced air drives the binder to the coating surface, decreasing the slope. The hot air system has almost double, i.e., 11 compared to 6 PTF, compared to the ambient- dried system. The FTF remains unchanged, which suggests that the main failure mechanism was basesheet failure. Regardless of the failure mechanism, i.e., basesheet failure or coating pick, drying conditions during coating influence coating structure formation and the final product properties. Changes in drying conditions which influence printability may be detectable by P&I testing.

Figure 9 compares two drying and two separate application techniques. The same latex system was used as in the previous comparison, but this time coatings were applied with rods and the laboratory coater. The rod coatings were at 62% solids, while the coatings applied with the coater were at 65% solids. Slow hot air and infrared drying conditions were used in the first case, while only infrared conditions at high speed (910 m/min) were used in the second case. The coating applied with rods gave slower ink tack buildup and two more PTF than the coating applied with the laboratory coater. Since coating porosity was the same for both coatings, 120 s HPD, drying intensity must have made the difference. The more vigorous drying conditions of combined hot air and infrared resulted in a lower slope and more PTF than the coatings dried with infrared only; probably due to positioning of the latex film closer to the top of the coating surface in the former case. Clearly, coating porosity alone does not completely explain the P&I performance of coated papers.

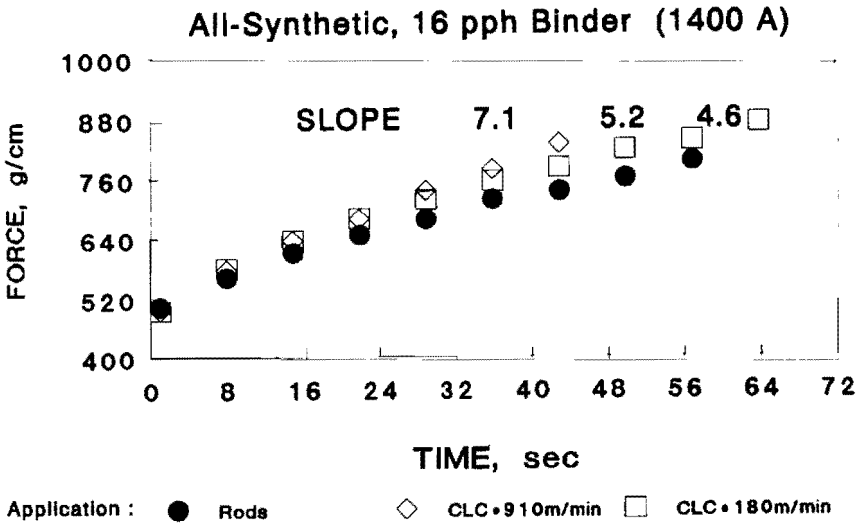
Figure 9



In order to further evaluate the effect of drying intensity, a set of experiments were conducted using hand rod drawdowns along with laboratory coater applications at two different speeds. The idea was to improve drying intensity and length of drying time with the laboratory coater. Figure 10 compares three coating application cases. Rods application, with 62% solids and hot air and infrared drying, had the most intense drying conditions, while the CLC™ at 180 m/min were less intense and the conditions at 910 m/min were the least intense. At 910 m/min, the coating has less residence time under the infrared and forced air heating sections of the coater than does the coating at 180 m/min. The

PTF increases and the slope decreases with the slower coater speed. There is no significant difference between the rod drawdown and the 180 m/min laboratory coater coatings. The least intense drying conditions (910 m/min) had a higher rate of tack build and significantly fewer PTF than either of the other two conditions. Even though it would take more replicates than were conducted in this series of experiments to be certain, the P&I performance of coatings applied at low speed with the laboratory coater is similar to the P&I values of rod drawdowns, which represent conditions closer to practical interest.

Figure 10



CONCLUSIONS

Table 1 summarizes the coating formulation effects on the P&I interaction test. As the binder level increases, the PTF increase and the slope decreases. The effect is greater with synthetic binders (styrene butadiene latices) than with natural binders, such as an ethylated corn starch. When part of the latex binder is replaced with a non-binding polystyrene pigment, the PTF decrease, while the slope increases. The level of film forming binder in the coating formulation is very significant in affecting both the slope and pass-to-failure. The use of fine kaolin clay in contrast to a delaminated clay will increase both the PTF and slope. All of these effects are combinations of physical (i.e., coating porosity) and chemical (i.e., binder swellability to ink vehicle) effects. More porous coatings allow for fast draining of the ink solvent through pressure and capillary penetration; therefore, ink tack buildup is fast. Coatings with more affinity (e.g., more solubility) to the ink solvent also increase the rate of ink tack buildup.

Table 1

P&I Stability Test COATING FORMULATION EFFECTS		
VARIABLE	PTF	SLOPE
Increased Binder Level	Increase	Decrease
Addition of Soluble Binder	Small Increase	Decrease
Polystyrene Pigment	Decrease	Decrease
Finer vs. Delaminated Clay	Increase	Increase

The effects of latex variables are summarized in Table 2. Particle size has a very significant effect on both the slope and the PTF. As the particle size increases, the PTF decrease while the slope increases. The primary factor for these changes within a given latex chemistry system is the change in the coating structure (porosity); the smaller the particles the greater the number of particles per unit weight. The effect of changing the butadiene level at a constant crosslink density is small but significant. Increasing the butadiene level will result in a slight decrease in the PTF along with an increase in the slope. As the crosslink density of a latex increases, at a constant butadiene level, the PTF increase while the slope decreases.

Table 2

P&I Stability Test LATEX EFFECTS		
INCREASING	**PTF**	**SLOPE**
Particle Size	Decrease	Increase
Butadiene Content	Small Decrease	Increase
Polymer Crosslinking	Increase	Decrease
Finer vs. Delaminated Clay	Increase	Increase
Latex Level	Increase	Decrease

It has been long recognized that latex variables, coating variables and drying variables all are very significant factors in the interaction between ink and paper in offset printing. The P&I interaction test has been used as a laboratory tool to identify factors in all three areas that are important. This work demonstrates that aspects of the latex binder (gel, particle size, monomer ratios and types) are very important and controllable factors in modifying the nature of paper and ink interaction.

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