12-1984

An Analysis of Binder Migration During Drying at Different Rates

Tokunbo S. Onadipe
Western Michigan University

Recommended Citation

Onadipe, Tokunbo S., "An Analysis of Binder Migration During Drying at Different Rates" (1984). *Paper Engineering Senior Theses*. 458.
https://scholarworks.wmich.edu/engineer-senior-theses/458

AN ANALYSIS OF BINDER MIGRATION DURING DRYING AT DIFFERENT RATES

BY

Tokunbo S. Onadipe

A Thesis submitted
in partial fulfillment of
the course requirements for
The Bachelor of Science Degree

Western Michigan University
Kalamazoo, Michigan
December, 1984

ABSTRACT

The objective of this laboratory study is to quantitatively analyze the distribution of adhesive during drying at different rates. The effect of binder migration on physical paper coating properties was also studied. This report reviews past laboratory studies on binder migration, and the factors that affect binder migration. The coating application was done on a laboratory keegan coater. Dried coating was physically removed using a surface grinder, and the grind offs were analyzed for latex concentration, to determine the degree of binder migration. A gravimetric method of analysis was used to separate the latex and clay. Results showed that the degree of binder migration was proportional to drying rates. The physical coating properties of gloss, ink absorption, and opacity were found to be inversely proportional to the surface concentration of binder. In conclusion, gravimetric analysis could be satisfactorily used for binder migration studies, provided that an accurate method of abraiding the coating is available. The main purpose of this study is to gain an understanding of the mechanism of binder migration during drying at different rates.

Key Words

Binder Migration

Penetration

Coated Papers

Absorption

Drying

TABLE OF CONTENTS

INTRODUCTION

Adhesive redistribution or binder migration, as it is more commonly called, is the selective movement of adhesive through a pigmented coating (1). During the application and drying of a paper coating, small adhesive particles tend to migrate both to the surface of the coating and into the paper substrate; therefore causing various problems such as railroad tracking and variations in coating surface properties(1).

The objective of this laboratory study is to show by quantitative analysis the relationship between drying rate and the degree of binder migration. Also, to show the effects of drying dwell time on the physical properties of a coated paper. The long term goal is to gain a better understanding of the mechanism of binder migration and hopefully find a means of preventing it or keeping its effects at a minimum.

THEORETICAL DISCUSSION

Binder Migration in Paper Coating

The term Binder Migration is usually associated with synthetic binders, high-speed coating and high velocity hot air dryers (4). A commonly accepted theory is that binder migration follows the same pattern as water flow within the pigmented coating before the coating loses enough water to solidify (1). Perry (3) considered this as an internal process of liquid flow, classified as a mass transport phenomenon.

It is generally agreed (1, 2, 4) that binder migration towards the coating surface receives more attention than binder migration toward the substrate; this is because of the highly visible defects caused by binder migration to the surface during the drying process.

Problems Caused by Binder Migration

A number of investigators (1, 2, 5-8) have shown that Binder Migration causes significant changes in coating properties. Solids level is said to go up as a result of binder migration into the paper substrate resulting in dilatancy and streaks. This usually inhibits the performance of the jet when using air knife coater.

Eames (9) theorized that weakening of the base stock is due to binder migration to the surface. Lower pick resistance, blister resistance, ink absorption, calendered gloss and glueability were all attributed to binder migration to the surface of the coating. Higher rates of drying along with binder migration can contribute to severe patterning and railroad tracking (1).

Factors affecting Binder Migration

According to Heiser et al (8), bidirectional distribution of binder (towards substrate and towards coating surface) is mostly affected by a combination of base stock structure and drying rate. Base stock absorbency aided by capillary forces in one direction is opposed by the evaporation in the opposite direction with percent solids acting like a resistance between the two porous systems (10). Studies (8-10) have shown that hydrocolloids, viscosity of the coating color, externally applied pressure, coat weight and the type and amount of binder used affect binder migration.

Clark et al (10) theorized that Migration of pigments must also occur, but to a limited extent; since the pigment particle sizes are of the same order of magnitudes as the pores into which they must migrate.

Therefore the accompanying binder migration is affected by Migration of pigments. The relationship of base stock structure to coating gloss, ink gloss, and halftone dot reproduction studied by Heiser et al (8), showed that surface topography of the base stock affects binder migration. They concluded that increasing the drying rate without changing the coating weight caused changes in the internal and surface morphologies of the coating, which is attributed to binder migration.

Molecular weight is said to affect binder migration (10); lower molecular weight fraction of a binder system may migrate with water while the higher molecular weight fraction remains in the color.

Eklund and Palsanen (11) also investigated the influence of base stock and drying conditions on binder migration. They showed that migration during drying was most marked for wood-free, low-absorbency papers; whereas groundwood-containing, highly absorbent papers are not sensitive to variations in drying.

Galusha and King (6) state that coat weight, viscosity, steaming and supercalender pressure has considerable effects on Binder Migration.

Suggestions for Controling Binder Migration Problems

Heiser et al (4) offered the following suggestions as a possibility of achieving some degree of control of Binder Migration:

"1) High drying rates should be avoided until the coating has set and the possibility of migration eliminated.

2) Web lead length between coater and oven should be sufficiently long to allow some migration into the base stock to develop good keying and fiber bond; since moisture absorbed by base stock helps set the coating faster and can aid in reducing migration to the coating surface.

3) High % solids should be used; since higher solids mean less evaporation of water is necessary before the coating sets. Therefore minimizing binder migration.

4) Minimum coat weight required to do the job should be applied; since thinner coating will set faster because the volume of water to be absorbed or evaporated is reduced in proportion to the reduction of coating weight.

5) Run as high a color viscosity as possible. Everything else being equal, higher viscosity tends to retard migration. However, this should be balanced off against the possibility of increased water retention by certain viscosity-producing additives.

6) Reducing the temperature of the dryer drums under the air caps of heated drum dryers will prevent or minimize railroad tracking.

7) Use the minimum total binder level needed to reduce drying capacity."

Previous Studies

There are relatively few studies dealing with the direct analysis of binder migration in the literature; however, most of the studies on coating penetration are indirectly related to binder migration.

The distribution of starch in clay coatings was studied quantitatively by Dappen (2). By measuring the weight of binder present in the layers of coating grind offs, he observed that rapid air drying produced a non-uniform distribution of binder due to binder migration towards the coating surface.

Fifi and Arendt (12) studied the effect of coating penetration on the print and optical quality of coated supercalendered light weight paper. They measured the rate and degree of coating penetration using a specially designed "Ink Penetrometer", which consists of the Universal IGT tester equipped with a bench blade operator. By measuring the change in paper backside reflectance after application of dyed coating and using the Kubelka Monk theory, they were able to calculate the rate and degree of coating penetration. Their results showed that reduced coating penetration improves ink holdout, print smoothness, and print eveness of the coated supercalendered paper.

Van der Vloodt (13) used the liquid spreading techniques to study the effect of coating penetration on print properties. This technique is based on the idea that the lower the absorbency and surface roughness of paper, the larger the area of the stain one will observe for a fixed amount of nip-applied fluid. Therefore, correlating area of stain with penetration rate.

Levlin and Nordman (14) used a radioactive tracer for calculating ink penetration; and measured the change in the velocity of sound as water penetrates through paper to determine penetration rate.

Clark et al (10) did a study titled "Liquid Migration in Blade Coating." They measured optically the rate of liquid transfer from coating color to paper under the influence of capillary forces and the high pressure experienced at a blade coater nip. By extrapolation, they found the actual penetration which might be expected previous to and at the nip of a pond-type coater. They concluded that in capillary migration, which is controlled by surface tension forces, water tends to migrate ahead of the binder, but in pressure migration--controlled largely by the viscosity of the migrating phase and the packing of the pigment particles under pressure-binder and water migrate together.

Jayme and Traser (15) applied the Multiple Internal reflectance method to study Liquid Migration in paper coatings. With the aid of infrared spectroscopy, they studied the penetration of organic compounds into a base stock. Using Maxwell's equation, they determined the penetration depth of coatings.

Heiser and Cullen (1) developed a gravimetric method of analysis to study the effect of binder migration on physical paper coating properties. With the aid of electron micrographs of latex-clay coated surfaces, a visual analysis of the distribution of adhesives throughout a pigmented paper coating under various machine coating conditions was done. Their result showed that different latex particle size gave the same degree of binder migration. The quantity of binder migration was found to be inversely proportional to total coating solids. Gloss, ink receptivity, and glueability were found to be inversely proportional to the surface binder level.

Gravimetric Method of Analysis (1)

The gravimetric method of analysis for determining binder level at various points of a coating, involves the use of a mechanical abrading device, followed by a chemical quantitative analysis of the grind offs. Quantitative analysis consists of washing the sample through an acid insoluble filter with sulfuric acid which will remove the cellulose, then washing the sample with hot concentrated nitric acid which will remove the latex. The latex content of each sample analyzed can then be calculated as percent latex using the equation:

$$\%\ \text{latex} = \frac{T_s - T_n}{T_s}$$

where

T_s = total dry weight of sample after sulfuric acid wash;

T_n = total dry weight of sample after nitric acid wash.

STATEMENT OF THE PROBLEM

The main purpose of this laboratory study is to quantitatively analyze the degree of Binder Migration during drying at different rates, and to investigate the effects of drying rates on the physical properties of the coated paper. Drying rate can be varied by varying the dwell time of the paper under the dryers of a keegan coater, thereby keeping coat weight and speed constant. The goal at this time is to gain a better understanding of the phenomenon of binder migration and its relationship to drying rates.

EXPERIMENTAL APPROACH

The experimental part of this study was designed to quantitatively show the distribution of adhesive throughout a pigmented paper coating under variable drying rate. The experimental procedure was divided into seven parts:

1. Base Paper Testing
2. Preparation of Coating Formulation
3. Coating Method
4. Trial Runs
5. Coated Paper Testing
6. Surface Grinding
7. Gravimetric Analysis.

Base Paper

The base paper used for this study was made on the Western Michigan University pilot paper machine. The pulp used was bleached Rayonier Kraft softwood blended with Weyerhaeuser Kraft hardwood. It was refined to 350 csf using the pilot plant beater and claflin refiner. 250 ml concentrated H_2SO_4 and 720g $cacl_2$ were added to the pulp during beating in order to adjust pH and calcium levels. The retention aid used was alum at 12% solids at an addition level of 2%. The finished base paper was slit into rolls--2000 ft. in length and 7-3/8" in width, a size which fits the keegan coater.

Following is a description of the Base paper.

TABLE I: Base Paper Properties

Basis wt.	43.6 lbs./ream (25x38-500)
Furnish	50% Softwood Kraft 50% Hardwood Kraft
Internal Size	0%
Moisture	4.6%
Caliper	4.1
Opacity	72.7%
Brightness	81.9 G.E. Brightness
Surface Size	0%

Coating Formulation

Coating was prepared using the calculated values in Table II and the following procedure, for a 60% solids coating.

Procedure

1. Measure out 86 ml of distilled water into a metal beaker.
2. Add 2 g of T.S.P.P.
3. Using the laboratory cowels mixer, start mixing the water and T.S.S.P.
4. Measure out 500 g Hydraprint Delaminated clay and periodically disperse it in the beaker while mixing for a period of 5 minutes. (NOTE: This should have been a minimum of 20 minutes after all clay was added.)
5. Measure out 200 g SBR Latex (Dow 620) and add it to the contents of the beaker.
6. Mix for an additional 5 minutes.
7. Use the Brookfield Viscosity meter to find the viscosity at 70 RPM and 100 RPM.

TABLE II: Coating Formulation

BASIS : 500 g clay (Hydraprint Delaminated H.B.)

LATEX : S.B.R. (Dow 620)

DISPERSANT: T.S.P.P.

DISPERSATOR: Cowels Mixer

Dry Wt. (grms.)		% Solids	Wet wt. (grms.)
Clay:	500	70%	$\frac{500}{.7} = 714$
20 pph Latex:	100	50%	$\frac{100}{.5} = 200$
TOTAL =	600		TOTAL = 914
0.5% T.S.P.P. = 2 grms			

FINAL % Solids = 60%

$$\text{Volume of Water Needed} = \frac{600}{0.60} - 914$$

$$= 86 \text{ ml.}$$

TABLE III: Brookfield Viscosity of Coating

R.P.M.	SPINDLE #	FACTOR	READINGS	VISCOSITY (cps)
20	5	200	58	11,600
100	5	40	65	2,600

VISCOSITY IN cps = (FACTOR) (READING)

Coating Method

The coated paper studied for this experiment was prepared on the Western Michigan University keegan coater. This unit employed a puddle type trailing blade head. The drying section consists of five infrared dryers that are removable. A special blow dryer (Varitemp Heat Gun Model VT. 750A) was attached to the drying section. The coater itself is about 5 ft. long, 15 inches wide and about 3 ft. high.

Trial Runs

Four different machine runs were produced based on the positions of the removable dryers. The first run employed all the dryers plus an attached blow dryer. Paper was dried from the coated surface during all the trial runs. The second run employed the blow dryer and dryers 1, 2, 3, and 4. The third run employed the blow dryer and dryers 1 and 2. The fourth run employed the blow dryer only. The rationale behind this arrangement is that by shorting the dwell time of drying we can decrease the mass of water evaporated per unit time; thereby decreasing drying rate. For detailed machine conditions during the run, see Appendix I.

Physical Properties of Coated Paper

The coated roll was cut into samples of 12" x 7-3/8" and conditioned in a constant humidity room for 48 hrs. The samples were tested for caliper, K & N Ink Absorption, Brightness, Opacity, IG.T pick strength, Parker Print. surface and Gloss' after six nip passes through the super calender at nip pressure of 20 psig. Results are included in Appendix II.

Surface Grinding

The objective of surface grinding is to collect samples of the dryed coating so that it can be quantitatively analyzed for percent binder remaining in the coating after migration of some portion of the binder. The procedure employed a mechanical abrading device called a Handee Grinder. This portable sanding device was available at the Physics Department of Western Michigan University. It has a rotating cylinder tip of about 1/2" diameter and 1/2" long and it is electrically driven. In order to get a reproducible pattern of sanding, the Handee Grinder was attached in place of the disk of a Sanford Surface grinder. Attached to the main shaft was a micrometer gauge with a pointer that touches the surface of the paper as it's being abraded. The gauge has an indicator that tells how much is being abraded.

The coated paper sample was laid flat on a steel plate that has pin size holes distributed on it, vacuum was applied to keep the paper in position. The whole assembly was then laid on the platform.

The platform was moved from left to right using a hand wheel, and back to left in a prescribed manner while the Handee Grinder remains fixed but with its head rotating and abrading the paper. The sanding job was not very successful, the paper was unevenly abraded, sometimes we have torn paper. The intention was to abrade 0.0007" (the difference between base stock caliper and coated paper caliper). But we abraded too much sometimes, and too little some other times. This problem can be attributed to the unevenness of the vacuum plate combined with surface topography of the paper. After grinding one sample from each trial run, the grind offs were collected in small labelled beakers ready for quantitative analysis.

Gravimetric Analysis

The Gravimetric Analysis was carried out using the following procedure in sequence.

Procedure

1. Dilute concentrated sulfuric acid in a ratio of 2 parts acid to one part distilled water.
2. Dissolve 1 ml of 30% Dupanol in 16 oz. of distilled water.
3. Weigh the grind offs to 4 decimal places using an Analytical Balance.
4. Add 5 ml of Dupanol solution to the grind offs and swirled until the sample is completely wetted out.
5. Prepare the filtering unit by attaching a syntered glass crucible to a water aspirator.
6. Add 30 ml of H_2SO_4 solution to the grind offs and swirl to mix. Allow to stand for 10 minutes with occasional swirling to dissolve cellulose.
7. Wash the sample from the beaker onto the filtering unit under mild suction. Wash with distilled water to remove all traces of acid and wetting agent.
8. Dry the crucible together with the sample to constant weight at 110°C, cool and weigh to 4 decimal accuracy.
9. Again apply mild suction to the filtering unit, and wash the material on it with two 30 ml portions of boiling concentrated nitric acid. Hot acid will remove dissolved latex. Then wash thoroughly with distilled water.

10. Again, dry the crucible to constant weight and weigh.

11. Find the difference in the two weights, which represents the amount of latex present in the original sample. Report this as percent latex present in the original sample; using the equation:

$$\% \text{ latex} = \frac{T_s - T_n}{T_s}$$

where T_s = total dry weight of sample after sulfuric acid wash

T_n = total dry weight of sample after nitric acid wash.

12. Repeat steps 1 to 11 for Runs #2, #3, and #4.

Results of Measurements and calculations is included in Appendix III.

PRESENTATION OF RESULTS

The four samples coated according to dryer arrangements, showed latex concentration ranging from 1.99% to 7.40%; based on clay and binder. A plot of % latex against dwell time (as shown in Fig. 1) indicated that latex concentration increases as dwell time increases. The analysis showed that more binder migrates to the surface of the paper as drying rate increases.

A plot of percent Latex against Gloss (as shown in Fig. 2) indicated that gloss decreases as latex concentration at the coating surface increases. Also, a plot of K & N ink absorption against latex concentration indicated that ink absorption decreases as latex concentration increases (see Fig. 3).

The results obtained for IGT picking resistance cannot be correlated with percent latex; since we have immediate picking in the first 3 samples tested. A comprehensive tabulation of all the test results is shown in Table IV.

Brightness of the four trials run showed a slight decrease as percent latex increased. But the span of the readings is only 1.1 points, indicating that there may be no correlation between brightness and percent latex. Opacity also decreases as percent latex increases with a span of 3.1 points. Parker Printability Surface and compresibility showed no correlation with percent latex or drying rates.

FIG 1: A plot of % Latex in the Coating (based on clay and latex) against Dwell Time

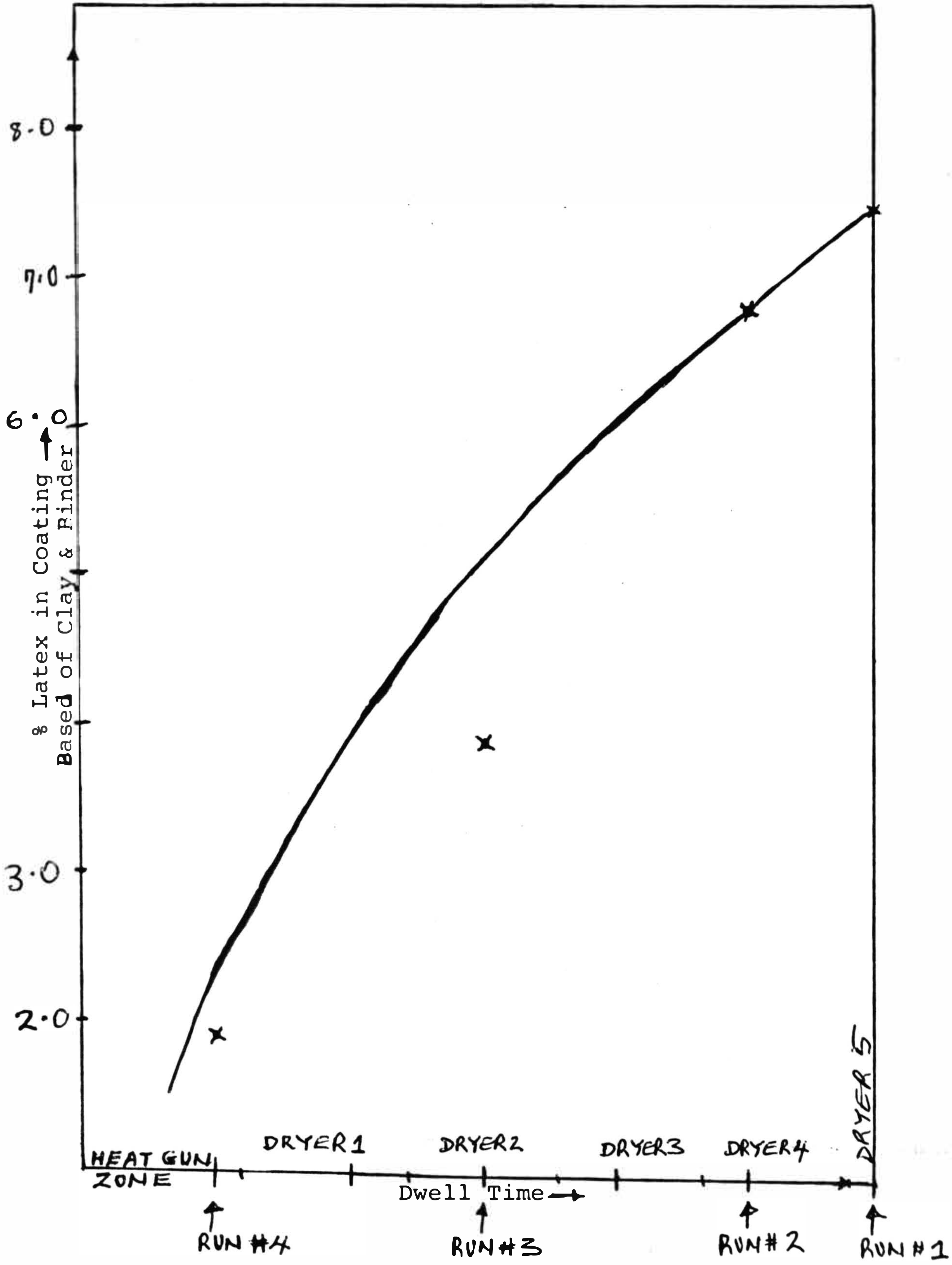

FIG 2: A plot of % Latex in the Coating (based on clay and latex) against Gloss

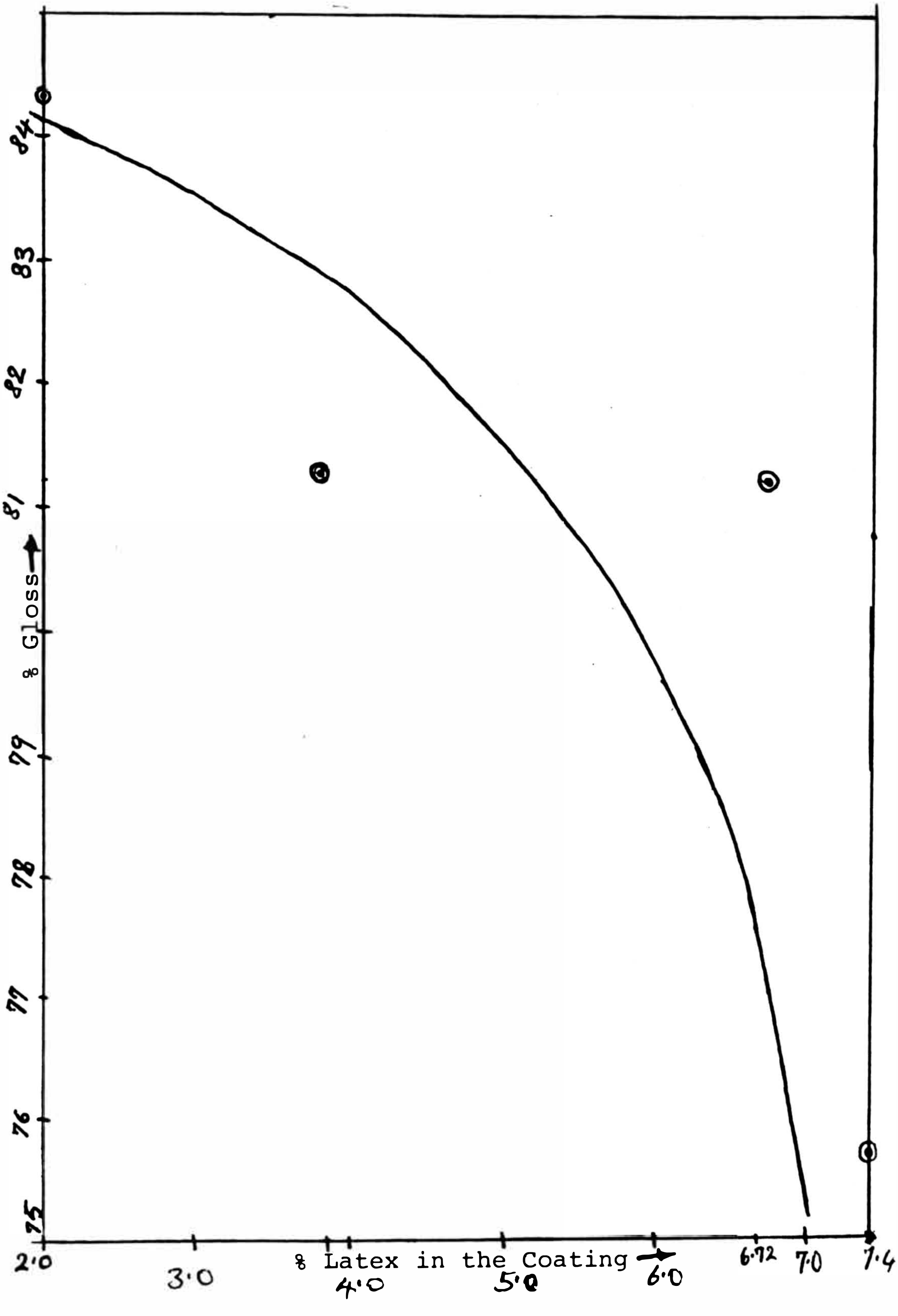

FIG 3: A plot of % Latex in the Coating (based on clay and latex) against K & N Ink Absorption

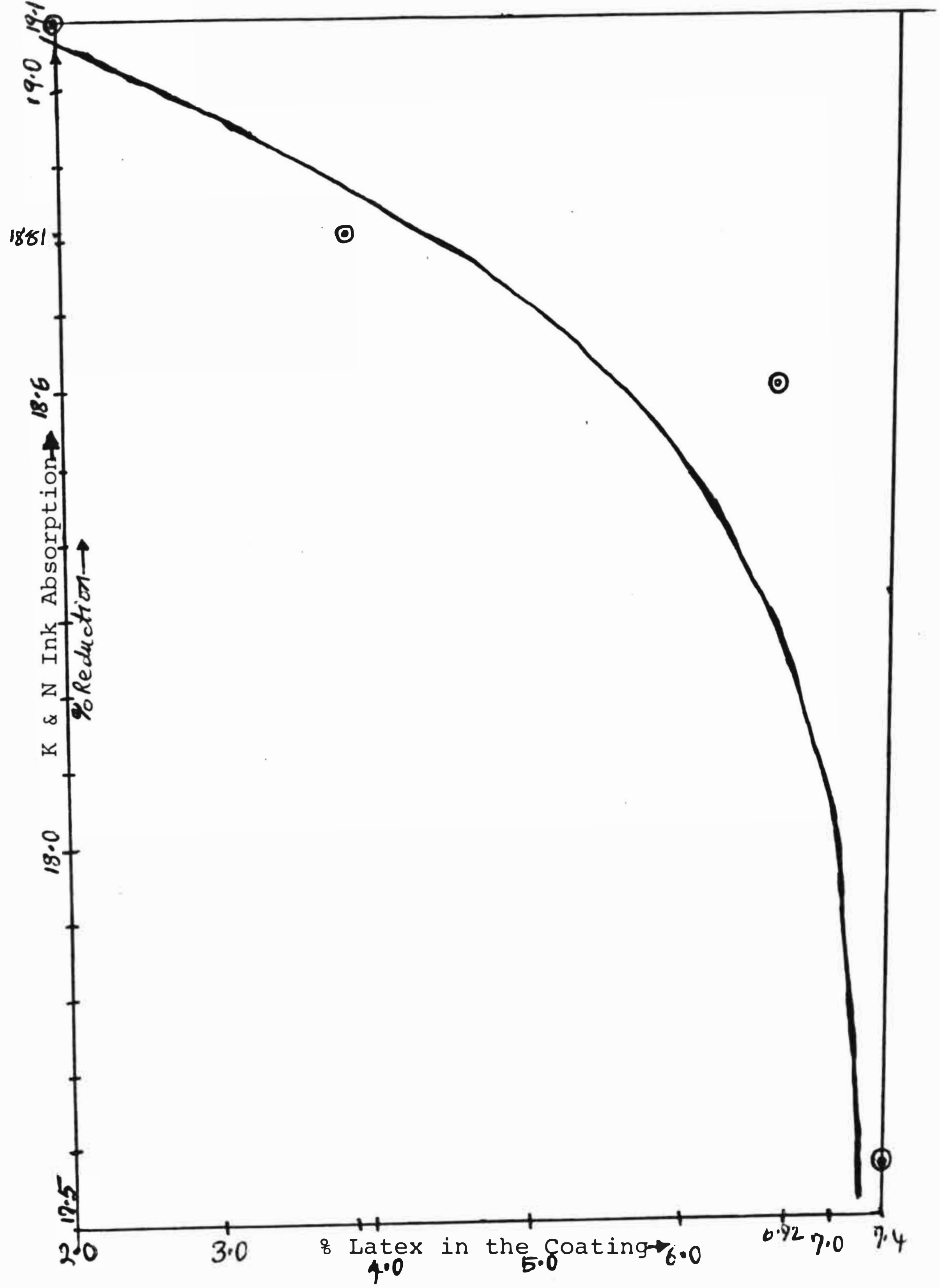

TABLE IV: PRESENTATION OF RESULTS

RUN #	DRYER SET UP	DWELL TIME	% LATEX In Sample Based on Clay + Binder	GLOSS (%)	IGT PICK (m/s) using ink	K & N INK ABSORPTION (% Reduction)	BRIGHTNESS (%)	OPACITY (%)	PARKER PRINT SURFACE (NM)		
									at 10 psi	at 20 psi	comp
#1	HEAT GUN + DRYERS #1,#2,#3 #4,#5	LONGEST	7.41%	75.7	0	17.56	80.5	88.2	3.92	3.44	1.1
#2	HEAT GUN + DRYERS #1,#2,#3 #4	LONGER	6.72%	81.2	0	18.59	80.9	89.1	3.82	3.35	1.1
#3	HEAT GUN + DRYERS #1,#2	LONG	3.87%	81.3	0	18.81	81.2	89.8	3.82	3.3	1.2
#4	HEAT GUN ONLY	SHORT	2.00%	84.3	10 0.5@m/s	19.1	81.6	91.3	3.9	3.3	1.2

CONCLUSIONS

The conclusions drawn, based on the apparatus used for this project are as follows:

1. Gravimetric Analysis in combination with surface grinding is not an accurate method of analyzing Binder Migration. A better means of abrading the coating should be sought. The presence of fibers in grind offs makes calculations inaccurate.
2. The direction of migration is controlled by drying rate. At higher drying rates, binder seems to migrate towards coating surface, while at lower drying rates, the direction seems to be towards the substrate. Assuming that water leads binder during drying, then the more energy put into driving the water out, the more binder migrates to the surface. The degree of binder migration is proportional to drying rates.
3. Calendered gloss, K & N ink absorption, Opacity, and Brightness are inversely proportional to surface binder concentration. Binder Migration did not appear to affect I.G.T. picking strength.

RECOMMENDATION

In the conditions studied in this work, the degree of water absorption by the base stock and its effect on binder migration was never understood. Therefore, it is suggested here that the effect of Base stock absorbency be studied.

LITERATURE CITED

1. Heiser, E. J. and Cullen, D. W., Tappi 48 (8) : 80A (1965).

2. Dappen, J. W., "The Distribution of Starch in Clay Coatings", Ph.D. Thesis, The Institute of Paper Chemistry, Appleton, Wis., 1950, Tappi 34 (7) : 324 (1951).

3. Perry, J. H., "Chemical Engineers Handbook", N.Y., New York, McGraw-Hill (1963).

4. Heiser, E. J. and Kaulakis, F., "Tappi Monograph Series" No. 37, New York, TAPPI, ch. 3 pg 55.

5. Streaker, W. A., Tappi 51 (10) : 105A (1968)

6. Galusha, C., and King, G. D., Tappi 45 (10) : 178A (1962).

7. Bergomi, J. G. Jr., Tappi 51 (11) : 496 (1968).

8. Heiser, E. J., Baker, H. M. and Herr, J. W., Tappi 53 (9) : 1739 (1970).

9. Eames, A. C. Tappi, 43 (1) : 2 (1960).

10. Clark, N. O., Windle, W. and Beazley, K. M., Tappi 52 (11) : 2191 (1969).

11. Eklund, D. E. and Palsanen, J.A., Tappi, 53 (10) : 1925 (1970).

12. Fifi, P. A. and Arendt, F. P., Tappi, 53 (10) : 1954 (1970).

13. Van der Vloodt, P. A., Publication 25, Research Institute for the Printing and Allied Industries T.N.O., March 1967.

14. Levlin, J. E. and Nordman, L., The Paper Maker 154 (4) : 64 (1967).

15. Jayme, G. and Traser, G., Das Papier, 25 (7) : 356 (1971).

APPENDIX

APPENDIX I

VI KEEGAN COATER RUNS

Process: Puddle type trailing blade coating process.

DRYER TYPES: INFRARED HEAT COILS

ATTACHMENT: VARITEMP HEAT GUN (MODEL VT 750A)

TRIAL RUNS	DRYER ARRANGEMENT	TEMPERATURE (°F)	MACHINE SPEED (ft/min)
			Estimates
#1	HEAT GUN	250	= 22
	DRYER #1	300	
	DRYER #2	300	
	DRYER #3	300	
	DRYER #4	300	
	DRYER #5	300	
#2	HEAT GUN	250	= 22
	DRYER #1	300	
	DRYER #2	300	
	DRYER #3	300	
	DRYER #4	300	
#3	HEAT GUN	250	= 22
	DRYER #1	300	
	DRYER #2	300	
#4	HEAT GUN ONLY	250	= 22

APPENDIX II: PAPER TESTING

1. COAT WT. DETERMINATION

COATED PAPER (g)	BASE PAPER (g)	Coat Wt.	
		g/m^2	lb/ream (25 x 38-500)
1.5982	1.1528	24.4212	16.4842
1.5480	1.1618	21.1753	14.2932
1.5971	1.1785	22.9518	15.4924
1.6137	1.1546	25.1724	16.9913
		MEAN: 23.43	MEAN: 15.85

2. CALIPER

BASE STOCK (mils)	COATED PAPER (mils)
4.2	4.9
4.1	5.0
4.0	5.1
4.1	4.8
4.2	4.7
4.3	4.9
4.2	4.8
3.9	4.7
4.0	4.9
4.0	5.0
MEAN = 4.1	MEAN = 4.88

APPENDIX II (Cont.)

3. BRIGHTNESS, OPACITY, K & N INK ABSORPTION, & GLOSS

RUN #	OPACITY (%)	BRIGHTNESS BEFORE (%)	BRIGHTNESS AFTER (%)	K & N INK Absorption (% Reduction)	CALENDERED GLOSS (%)
1	88.2 88.1 88.4 88.0 88.3 $\bar{x}$ = 88.2	80.0 80.5 80.9 80.8 80.4 $\bar{x}$ = 80.5	63.7 63.3 63.1 62.4 62.2 $\bar{x}$ = 62.94	= 17.56	74.7 75.3 75.5 77.6 75.4 $\bar{x}$ = 75.7
2	89.1 89.3 89.3 89.1 89.0 $\bar{x}$ = 89.16	81.0 81.4 81.1 81.2 80.0 $\bar{x}$ = 80.94	63.0 62.8 62.2 62.9 60.85 $\bar{x}$ = 62.35	= 18.59	78.2 77.5 83.9 83.9 82.4 $\bar{x}$ = 81.2
3	89.2 92.8 90.6 87.4 89.1 $\bar{x}$ = 89.8	81.2 80.9 82.0 81.2 80.9 $\bar{x}$ = 81.2	62.0 61.7 63.2 63.9 60.95 $\bar{x}$ = 62.35	= 18.81	80.2 81.4 80.2 83.9 80.7 $\bar{x}$ = 81.3
4	90.0 93.4 90.4 91.2 91.3 $\bar{x}$ = 91.3	81.7 81.8 81.4 81.6 81.5 $\bar{x}$ = 81.6	61.2 60.9 61.8 65.0 63.4 $\bar{x}$ = 62.5	= 19.1	82.3 89.6 84.9 81.4 83.2 $\bar{x}$ = 84.3

APPENDIX II (Cont.)

I.G.T. PICKING RESISTANCE AND PARKER PRINTABILITY SURFACE

RUN	IGT (m/s)	PARKER PRINTABILITY SURF.		
		AT 10 (psi)	AT 20 psi	COMPRESIBILITY FACTOR
	0.0	3.8	3.6	3.92/3.44
	0.0	4.0	3.4	
1	0.0	3.9	3.5	= 1.1
	0.0	3.9	3.3	
	0.0	4.0	3.4	
		$\bar{x}$ = 3.92	$\bar{x}$ = 3.44	
	0.0	3.7	3.4	3.82/3.35
	0.0	3.9	3.3	
2	0.0	3.9	3.3	= 1.1
	0.0	3.8	3.4	
	0.0	$\bar{x}$ = 3.82	$\bar{x}$ = 3.35	
	0.0	3.8	3.3	3.82/3.3
	0.0	3.9	3.2	
3	0.0	3.8	3.3	= 1.2
	0.0	3.8	3.2	
	0.0	3.8	3.3	
		$\bar{x}$ = 3.82	$\bar{x}$ = 3.3	
	10.0	3.9	3.2	3.9/3.3
	10.0	3.85	3.25	
4	10.0	3.95	3.3	= 1.2
	10.0	4.0	3.4	
	10.0	3.9	3.3	
		$\bar{x}$ = 3.9	$\bar{x}$ = 3.3	

APPENDIX III

GRAVIMETRIC ANALYSIS

% LATEX BASED ON CLAY + BINDER + FIBER $= \frac{T_s - T_n}{T_t}(100)$

Where:

T_t = TOTAL Dry Wt. of Sample.

T_s = TOTAL Dry Wt. of Sample after H_2SO_4 Wash.

T_n = TOTAL Dry Wt. of Sample after HNO_3 Wash.

CRUC. Wt. = Wt. of crucible.

RUN #	CRUC. Wt. (g)	T_t (g)	T_s (g)	T_n (g)	% LATEX	Correction 12/8/84
1.	77.1035 ∴T_t	79.3553 = 2.2518	79.3110	79.1475	7.2608%	% Latex = $\frac{T_s - T_n}{T_s}$ = 7.40%
2.	79.5143 ∴T_t	81.6753 = 2.1610	81.6628	81.5185	6.6775%	6.71%
3.	78.3184 ∴T_t	81.0935 = 2.7751	81.0886	80.9815	3.8593%	3.86%
4.	78.0612 ∴T_t	80.6588 = 2.5976	80.6451	80.5935	1.9864%	1.99%