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The Effect of Surface Pretreatment on Binder Penetration in Coated Board

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THE EFFECT OF SURFACE PRETREATMENTS ON BINDER
PENETRATION IN COATED BOARD

by

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

Western Michigan University

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Abstract

A study was performed to determine the effects of surface size pretreatments on binder penetration into coated board. Sixteen point board was sized with water, oxidized starch, polyvinyl alcohol and a 20:1 mixture of the two utilizing the blade coater. This treated board was then coated with a latex-clay coating on the air knife coater.

Testing of the board samples showed that the coated board pretreated with the oxidized starch had the best surface strength and ink hold-out characteristics. This was followed by the mixture and finally by the polyvinyl alcohol. The coated board with no surface size had the worst strength and printing characteristics, while the water pretreated stock was slightly better but worse than the three surface sizes.

It is theorized that the results of the study are related to the depth of penetration of the surface size employed. Due to lower solids, less viscosity and different chemical structure, it is felt that the polyvinyl alcohol may have penetrated deeper into the basestock than the oxidized starch. Therefore with this deeper penetration, the surface size would be less effective in keeping the coating binder near the surface. This could result in lower surface strength and less ink hold-out.

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Introduction

The purpose of this study is to examine the effects of various surface sizes on paperboard. Surface sizing application is used for basically three reasons. First it is to resist excessive water penetration so that the sheet will retain sufficient strength for the coating operation. Second, it imparts smoothness to the basestock. Thirdly, the surface size is used to resist penetration of the basestock by the coating binder. This paper will deal primarily with this last effect. The experiment is designed to study three types of surface sizes and their effects on binder penetration.

Theoretical Review

There are basically five areas where we can exercise some control over the coating process. These include color formulation, application, properties of the substrate, drying, and calendering. The latter two are normally machine-limited while the first two have been thoroughly studied (1,2,3,4,5,6). Therefore it is the intent of this paper to hold the other four areas constant and study how the properties of the substrate affect binder penetration.

There are also many variables within the basestock itself which can influence penetration. Some of these include type of furnish, freeness, degree and type of sizing, moisture, porosity, and basis weight, among others. Most of these variables are grade-limited so it was decided to vary the amount and type of sizing to notice its effects on binder penetration while holding the other variables constant.

Sizing

Many people have concurred that the sizing of the basestock definitely influences the penetration of the coating (7,8,9,10,11). But just what is sizing? Dreshfield does a thorough job of defining this by saying that size is "any chemical, other than bleach, fillers, pigments and dyes which are added to the papermaking furnish or subsequently applied after the web is formed, which alter those characteristics of the sheet that relate to the transudation or absorption of liquids which come into contact with the web." Therefore sizing itself would be the application of these chemicals. (12)

The two principal sizing processes are internal sizing and surface sizing. Internal sizing consists of mixing the sizing agent with the fibrous furnish and forming the entire mass into the sheets containing a relatively uniform distribution of fibers and size. On the other hand, surface sizing involves the application of sizing agent to the surface of the already formed paper. This is usually done in a size press or on the calanders.

Sizing agents increase the angle of contact formed between liquid and the paper. The rate of penetration of liquids into paper depends upon the ratio between the surface tension of the liquid and this contact angle. Surface tension, or capillary suction, is the force that tends to pull the liquid into the capillaries of the sheet. The contact angle determines the component of the capillary suction that is effective along the axis of the capillary. These are related by the Cobb formula for the rate of penetration of liquids:

$$l^2 = \frac{r\sigma\cos\theta t}{2\mu}$$

Where l is the depth of penetration in cm.

r is the pore radius in cm.

σ is the surface tension of penetrating liquid in dynes/cm.

θ is the contact angle

t is the penetration time in seconds

μ is the liquid viscosity in poises (13).

Because sizing agents increase the contact angle, they reduce the component of the capillary force drawing inward (14).

With internal sizing, the sizing agent doesn't reduce the porosity of the sheet, r , but rather brings about changes in the wetting properties of the fibers. In this case the size precipitates onto the fibers where it makes the fibers hydrophobic. Complete fiber coverage is not attained, but the precipitate is close enough together to reduce the wetting of the fibers.

Surface sizing reduces penetration of liquids by closing the pores of the sheet, by raising the contact angle, or both. This method of sizing is primarily concerned with surface films and consequently it is usually desirable to keep the size on the surface of the sheet as much as possible where it will do the most good. However, surface-sized sheets should not be visualized as having a continuous film covering the entire surface as this condition is rarely attained. In a study by Lee, he noted that starch covers the surface very irregularly, being thin in some spots and thick in others (15). The better, more expensive sizes such as polyvinyl alcohol and carboxymethylcellulose (CMC), produce a more continuous film, but even these are broken by the presence of fibers extending from the surface of the web.

As stated before, the sheet is usually surface-sized with a size press or with wet boxes at the calander stack. This latter method is normally used only with heavy papers such as paperboard. It is possible to do this without any extra drying being required because of the considerable amount of latent heat which is present in the sheet. The small amount of liquid which remains can be absorbed throughout the board without any appreciable increase in moisture content.

Some people believe that the use of starch for surface sizing has been around for as long as paper, beginning with the Chinese in 310 A.D. (16). Starch is the most popular surface sizing agent due to its uniform quality, abundant supply, wide range of viscosities and particularly its low price. Corn and potato are the predominant types of starch used.

Oxidized starches are produced from common starch by treating the aqueous starch suspension with a hypochlorite solution containing

a slight excess of sodium hydroxide. When the desired degree of oxidation is obtained, the excess chlorine is removed by adding an anti-chlor, the slurry adjusted to the desired pH, filtered, washed and dried. By varying the amount of hypochlorite, time, temperature and pH, a series of oxidized starches can be produced (17).

Oxidized starches have many advantages over common starch. They gelatinize at lower temperatures, have a shorter cooking time, and give slurries with greater clarity, increased adhesiveness, less viscosity and a marked reduction in their ability to retrograde. In addition, this type of starch has been shown to cause fibers to lay down and has increased pick and ink holdout values (18). The higher viscosity oxidized starches have shown to be more efficient with calender sizing and are usually applied in the 5 - 7 % solids range (19).

Polyvinyl alcohol has been shown to improve on the surface sizing properties of starch (20,21). This substance has excellent barrier properties and enhances the printability of a sheet along with increasing ink and wax holdout, smoothness, gloss, fold and mullen strength and resistance to water, grease and picking. The following figures taken from a previous study show some of the improvements of polyvinyl alcohol over oxidized starch (21). (See following page)

Polyvinyl alcohol, PVOH, is produced by first reacting acetylene and acetic acid to form vinyl acetate and then polymerizing this vinyl acetate to form polyvinyl acetate. This is then subjected to a hydrolysis process to form polyvinyl alcohol. (The details of its production are not relevant here and the reader is referred elsewhere if more information is desired (21,22)).

PVOH is a light, off-white powdery resin when pure. It is water

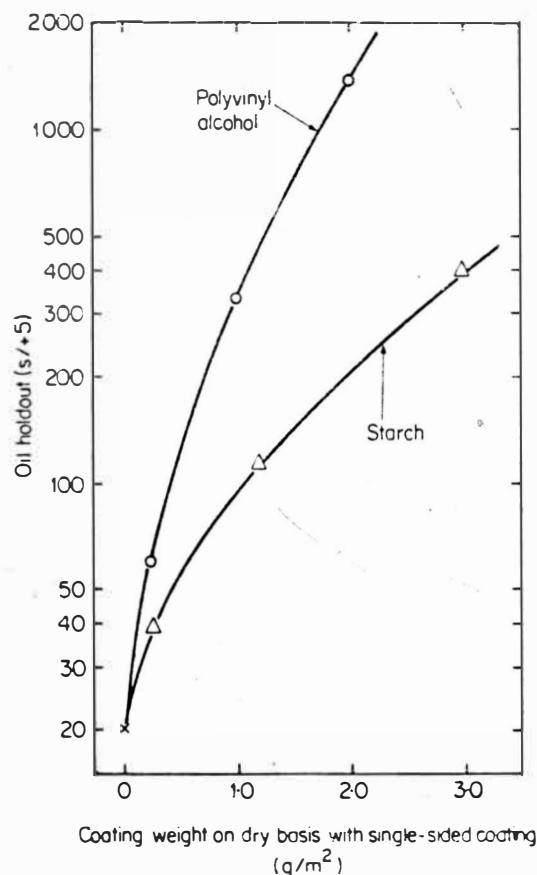


Figure 12.21 Oil holdout of printed paper sized with fully hydrolysed, d.p. = 1700 polyvinyl alcohol and medium-viscosity oxidized starch

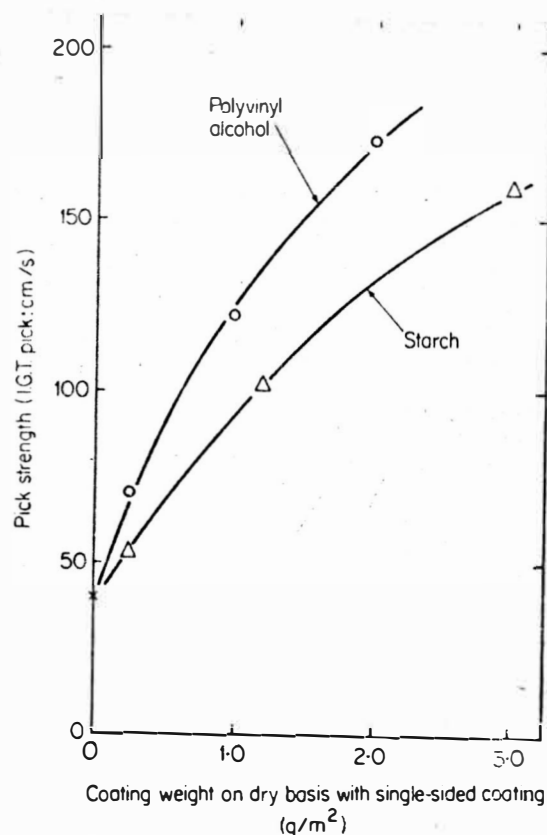


Figure 12.18 Pick strength of printed paper sized with fully hydrolysed, d.p. = 1700 polyvinyl alcohol and medium-viscosity oxidized starch

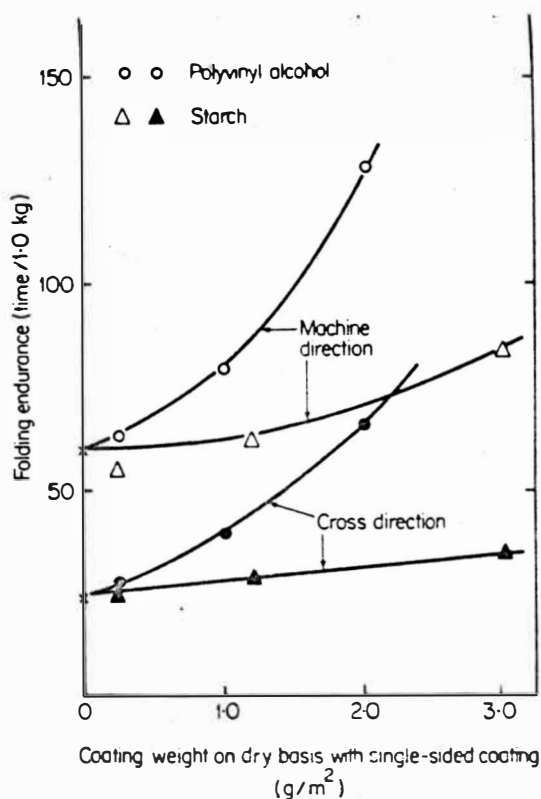


Figure 12.20 Folding endurance of printed paper sized with fully hydrolysed, d.p. = 1700 polyvinyl alcohol and medium-viscosity oxidized starch

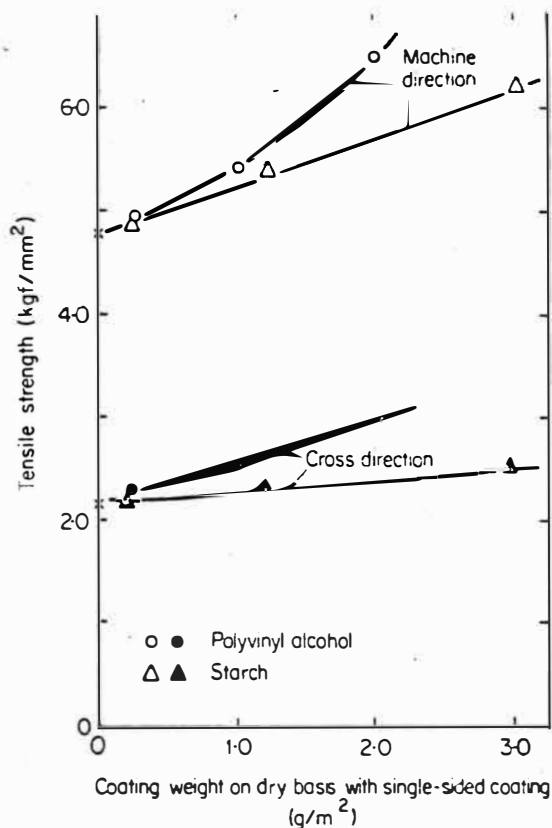


Figure 12.19 Tensile strength of printed paper sized with fully hydrolysed, d.p. = 1700 polyvinyl alcohol and medium-viscosity oxidized starch

soluble and is available in a number of grades, each differing in degree of polymerization and percent hydrolysis. These differences affect the physical and chemical behavior of a particular grade and give the user an extremely flexible series of resins with which to work. For wet box sizing, a fully hydrolyzed, high viscosity PVOH applied at 1 - 3 % solids is effective (19).

Combining oxidized starch and PVOH and using this mixture as a surface sizing agent is gaining acceptance in the paper industry today. The main reason for this is the economic benefits which can be obtained by using less PVOH (23,24). Although the addition of starch to the PVOH lowers its quality as a surface sizing agent, it has been found that even one part PVOH to twenty parts starch gives a marked increase in film strength over just starch (25). Other strength and printing properties improvements are also seen (23,24). The following table compares some values obtained from earlier experimentation (21). Notice that in almost all cases the polyvinyl alcohol gives the best values followed by the combination of PVOH/starch and then the oxidized starch alone.

Characteristics of Size Press Treated Paper

	<u>Starch</u>	<u>Starch/PVOH (1:1)</u>	<u>PVOH</u>
Burst Factor	1.17	1.36	1.36
Stiffness Factor	77	77	81
Permeability	49	95	325
Oil Holdout	76	86	100
Dennison Wax	8	9	9
Printing Gloss	Fair	Good	Excellent
Breaking Length	3.93	4.03	3.69

Binder Penetration

A coating formulation is basically made up of three components; pigment, adhesive (binder), and water, along with other minor components which add various properties to the coating. The pigment imparts the optical properties to the sheet, while the water is the carrying vehicle. The adhesive's job is two-fold; 1) to anchor the coating to the raw stock and 2) to bind the pigment particles together. Failure of either of these two aspects can be very detrimental to a successful printing application. These problems arise when there is excessive binder penetration into the sheet or abundant binder migration to the surface.

Binder migration is a term used to describe the movement of the binder back to the surface of the sheet as the coating is dried. This normally happens with cylinder drying cans and has been shown to be lessened when using infrared radiation (11,26,27,28,29). If during conventional drying the temperature is too hot or the drying happens too quickly, the water evaporating from the sheet carries with it the pigment and the binder. Since the adhesive has a lower specific gravity than does the pigment, it moves to the surface more easily and dries there (30). This leads to such problems as railroad tracking, mottle and variable ink absorption.

Binder penetration into the sheet may be controlled by the interaction of the substrate, pigment and binder (9). Fluctuating either one or all of these will result in a difference in penetration. This penetration of liquid into the basestock is essentially a three stage process; 1) wetting of the fibers, 2) a rapid rise of penetration caused by defect zones in the sheet and 3) a slow "bulk" migration (31).

These three stages of penetration are functions of two forces, capillary penetration and pressure penetration. With pressure penetration, it has been seen that the binder and water migrate together into the sheet (9). This is mostly controlled by viscosity, nip clearances, speed, particle packing and rheological properties. This pressure penetration is related to the Poiseuille equation:

$$V = \frac{P r^4 t}{8 \mu L}$$

Where V is the volume absorbed
 P is the pressure
 r is the pore radius
 t is the time
 μ is the viscosity of the liquid
 L is the length of the capillary

Most people agree that with capillary penetration the water migrates ahead of the adhesive (9,30). This type of penetration is a function of the interfacial tension of the fluids and fibers along with the contact angle between them (7). This was shown earlier with the Cobb equation. Both types of penetration are present in a coating and/or surface sizing operation.

This experiment will be set up to study the effects of surface sizing on the penetration of the binder into paperboard. In order to study this, the pigment and binder of the coating must remain constant. Also the drying will be kept at a level where binder migration back to the surface is kept to a minimum. Other machine variables such as speed, nip clearances and air knife pressure will also be kept constant.

Oxidized starch, polyvinyl alcohol and a mixture of the two will be used as the surface pretreatments. This is done due to the high use of these substances when sizing board.

Experimental Procedure

Two rolls of paperboard originally obtained from Hercules Incorporated were stored in the pilot plant and available for use in this study. These samples were tested using the water drop test to qualitatively test the level of internal sizing. Both tested nearly the same and did not exhibit any characteristics which would be adverse to the trial. The caliper of the board used was .0016 of an inch.

The surface sizing agents were cooked up one day in advance of the trial. Stayco A, manufactured by the Staley Company, was chosen for the oxidized starch. This was done because of the desire to use a high viscosity starch in the study, correlating to what is commonly used in the board industry. The starch was cooked in small batches at 20% solids. The starch was added to cool water, heated to approximately 200°F and then cooked at this temperature for an additional fifteen minutes. All of the cooking was done under constant agitation using the three-blade laboratory mixer. After cooking, the starch was diluted to 7% solids.

Dupont Elvanol 71-30 was the polyvinyl alcohol employed in this study. Again this type was chosen due to the desire to use a fully hydrolyzed, high viscosity PVOH. This size was cooked by adding the Elvanol to cool water and heating it up to 195°F under constant agitation by the laboratory mixer. This cooking was done at 2% solids and water was added after the cook to maintain the PVOH at this concentration.

The mixture of the oxidized starch and polyvinyl alcohol was made at a 20:1 ratio. The cooking was done separately, the sizes thoroughly mixed and diluted to 5% solids.

Note: The values of 7% solids for the starch, 2% solids for the PVOH, 5% solids and 20:1 ratio for the mixture, were all suggested to the author by people in the board industry and previous studies which had been successful in employing these levels when surface sizing board. It was decided to use these concentrations to see what effect they had on the sizing of board prior to a coating application.

In order to apply the pre-treatments to the board a system was designed to pump the size from a bucket through a multiple hole attachment. This sprayerhead was taped to a bar just before the applicator roll nip of the blade section of the coater. In this way the size could be applied to the applicator roll and metered off by the blade. The excess size drained down through the trough into the bucket where it was recycled through the system. (See Figure 1). By doing this it cut down on the amount of size to be cooked up.

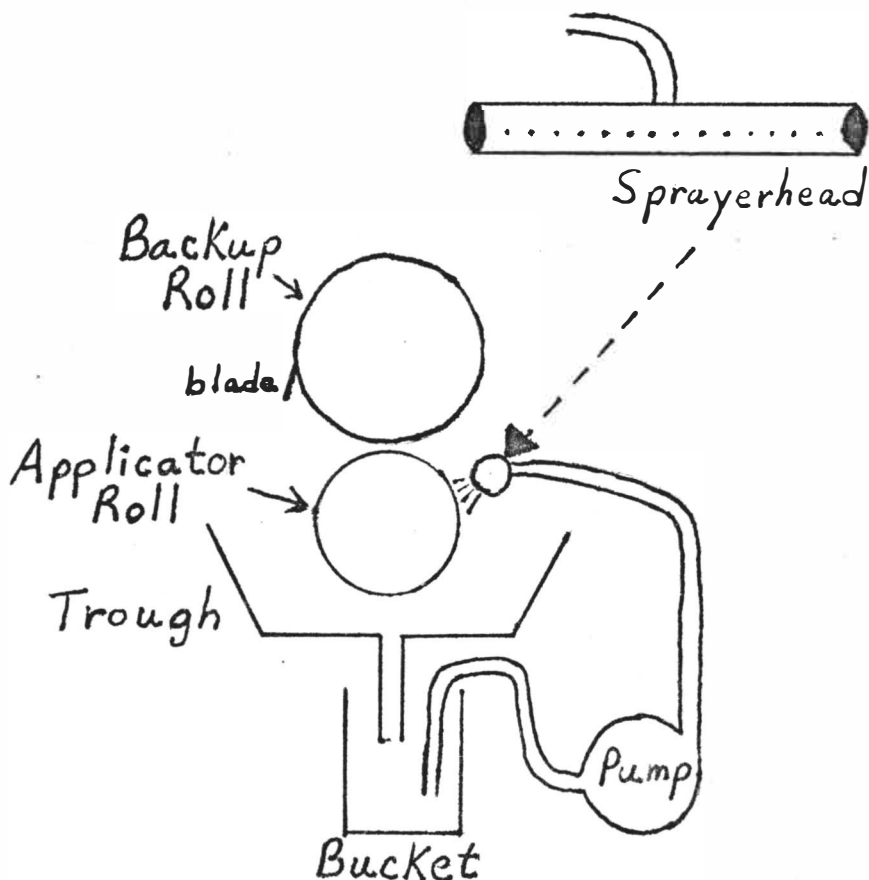


Figure 1

The trial was run in two separate stages. In the first stage, the pretreatments were applied using the blade coater and then dried. The board was then run through the coater again and coated with the air knife. The speed of the machine was 250 feet per minute in both runs and all three dryer sections were set at 250°F. This was done to help minimize binder migration back to the surface.

During the pretreatment stage, the gap at the applicator roll nip was set at .1105 on the gauge. This corresponded to approximately a 2x thickness of the board and was done to reduce the pressure in the nip but still allow it to become flooded. During the run the blade pressure was reduced from 25 psi to 10 psi to generate two different levels of treatment. This was done with all the sizes but in doing so ruined any chance of getting an accurate value for amount of pick-up at each level. The mixture was run second followed by the PVOH. Water was run between each size to clean out the system. The buckets of size were weighed before and after the run to try and determine the pick-up.

When the board was coated the air knife pressure was set at 3/4 psi on the gauge. This corresponded to a value of approximately 11-12 lbs./3000 ft.² coat weight. This value was satisfactory due to the desire to get a moderate, uniform coat weight. One square foot pieces of paper, or flags, were taped to the web as it was running. This prevented that area of the board from being coated. By weighing the board at both the coated and uncoated areas, coat weight was determined.

The coating formulation consisted of Hydrafine clay, Dispex and Dow Latex 620 (styrene butadiene). This was mixed at 55% solids with

.1 part Dispex and 15 parts SBR to 100 parts clay.

The run went smoothly and no problems were encountered. Each pretreatment was applied for approximately three minutes to obtain a consistent sample. Immediately after coating the roll was slabbed down and the coat weight determined. Representative samples of the board with just coating, water pretreatment, and the three surface sizes at both levels were then stored in the constant humidity, constant temperature testing lab in the pilot plant.

The tests run on this board were Dennison wax pick, K & N ink absorption, IGT pick test, Vandercook Press print test and the Kaltec Liquid Permeability test. The board was tested both calandered and uncalandered. The calandering was done on the small calander stack in the print testing laboratory. The board was calandered at 30 psi for a total of 4 nips.

Discussion of Results

The results of this study show a general trend when one compares the strength and printing characteristics of the coated board samples. In almost all cases the surface sizing of the board with the oxidized starch before coating showed to be the best pretreatment to improve pick strength and ink hold-out. This was followed by the 20:1 mixture of oxidized starch and polyvinyl alcohol, and finally the PVOH alone. The pretreatment of the board with only water also showed some improvement over no pretreatment but was still less advantageous than the three surface sizes. In all cases the board coated with no pretreatment had the poorest strength and ink hold-out results.

As stated earlier, previous studies have all shown that surface sizing with polyvinyl alcohol improves on the strength and oil hold-out properties of starch (20,21,23,24). This was seen at both lower concentrations and levels of addition. Therefore why do the coated samples pretreated with polyvinyl alcohol have poorer ink hold-out and strength results? A probable answer to this question lies in the depth of penetration of the pretreatments. This variable depth can be attributed to a variety of reasons.

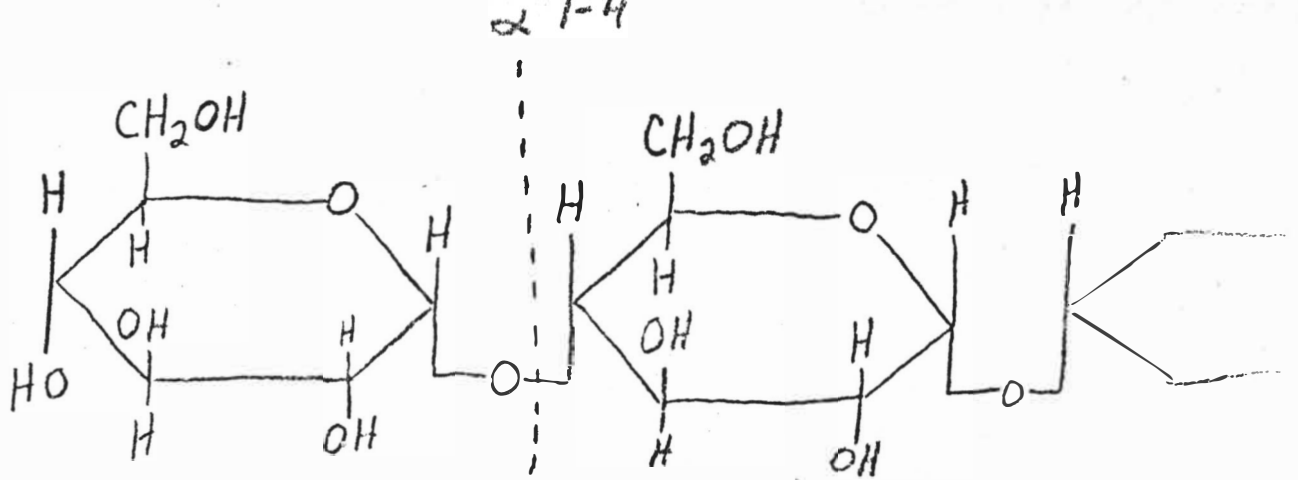
First the viscosity of the pretreatments was different. Looking at the aforementioned Cobb equation for the capillary penetration of liquids, $l^2 = \frac{r \cos \theta}{2\mu} t$, and the Poiseuille law for pressure penetration, $V = \frac{\pi r^4}{8\mu L} t$, one can see that as the viscosity of the surface size

decreases, both the depth and volume of the size into the sheet increases. Both pressure and capillary penetration were present in this

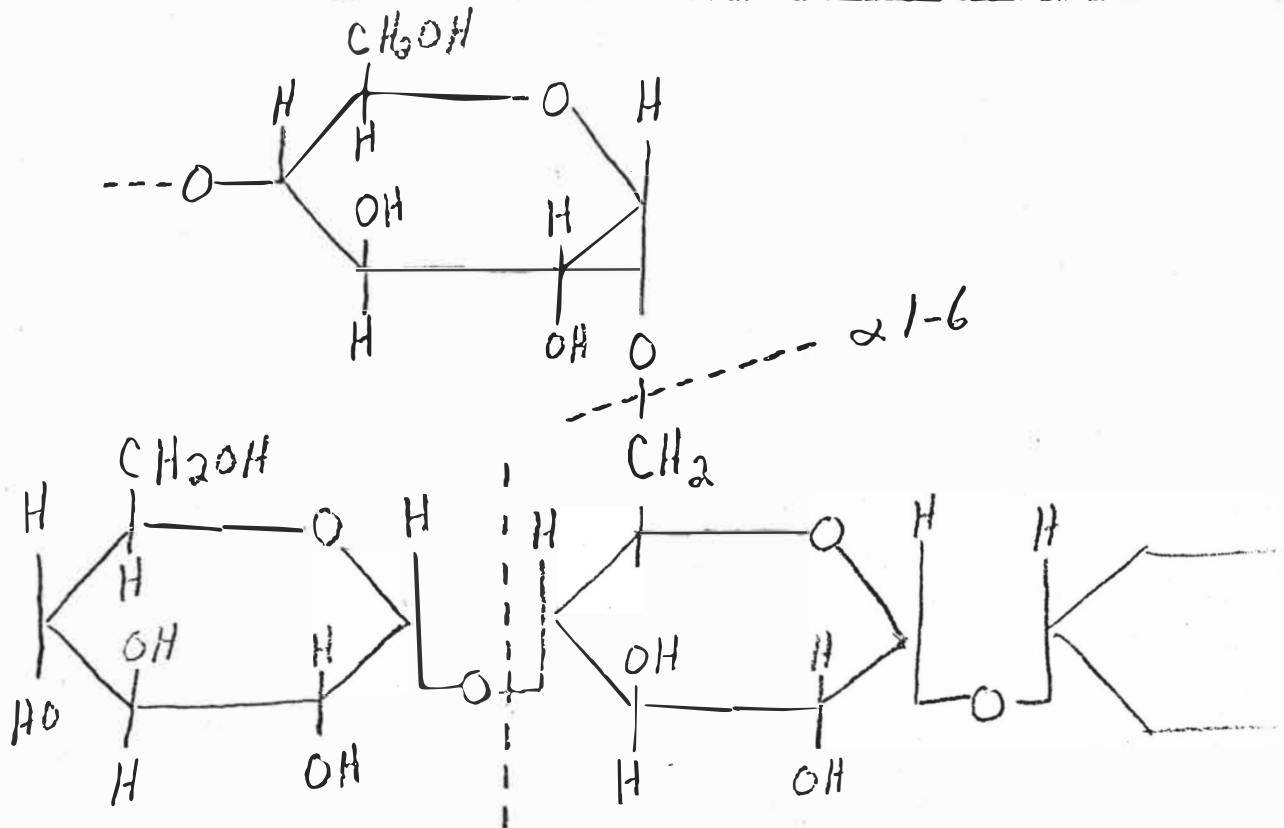
study. The viscosities of the pretreatments studied were 30 cps. for polyvinyl alcohol, 35 cps. for the mixture and 40 cps. for the oxidized starch. Although the exact depth of penetration cannot be determined, these viscosity differences should have caused the lowest viscosity material (PVOH) to penetrate the farthest.

Related to the viscosity is the concentration, or percent solids, of the sizes employed. Starch was run at 7% solids, while the mixture was at 5% and the PVOH at 2%. Increasing the solids will increase the viscosity of the solution but more importantly could increase the amount kept on the surface of the web. Although the pick-up levels were approximately the same, 2.5 lbs./1000 ft.², the increased solids level may have an effect on the amount of actual sizing material applied to the sheet. More size would be expected to plug more pores resulting in less penetration.

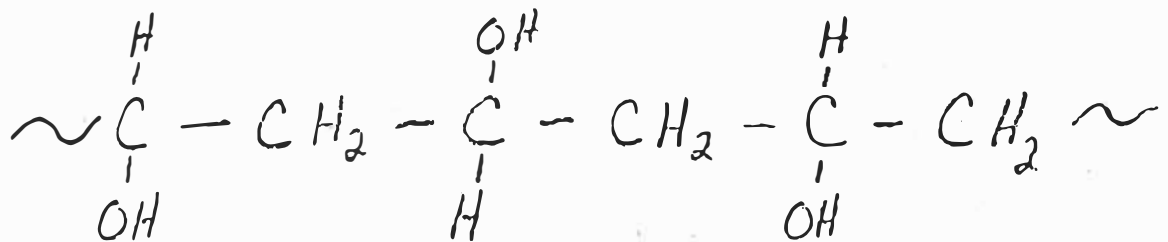
Finally the chemical structures of starch and polyvinyl alcohol are different. Starch is a mixture of 1-4 alpha-glucose amylose which is linear, and 1-4 alpha-glucose amylopectin which has extensive 1-6 branching. Polyvinyl alcohol on the other hand consists of straight chain molecules. (See following page). Under pressure the differences in the chemical structure and physical size will have less effect on penetration due to the high forces involved. But with capillary penetration, it is possible that the more highly branched starch molecules would be less likely to penetrate than the straight chain polyvinyl alcohol. With the set-up which was used on the blade coater in this experiment, more time was available for capillary penetration. Therefore it is expected that the amount and effects of the capillary penetration were greater than the pressure penetration. Coupling this



1-4 alpha-glucose amylose



1-4 alpha-glucose amylopectin



Polyvinyl Alcohol

with the lower solids and lower viscosity, the polyvinyl alcohol would have a tendency to penetrate further into the sheet than the starch.

Working with this theory, it would seem that the deeper penetration of the pretreatment would be less effective in keeping the coating binder near the surface. This would leave the pigment particles less tightly held together resulting in lower surface strength and less ink hold-out. This theory follows what possibly happened in the study. The PVOH penetrated deeper than the starch allowing more binder to penetrate which resulted in the lower values.

The reason for improvement of the strength and printing characteristics using water as a pretreatment vs. no pretreatment is unknown. It is possible that the application of the water and the subsequent drying altered the pore structure of the sheet in such a way that less binder could penetrate the sheet.

As is seen in the tables, the surface sizes were run at two different levels of treatment. As stated earlier, accurate values as to the differing amounts picked up at these levels could not be found. After looking over the results of the tests, no conclusive statements can be made concerning the level change of the surface sizes. Therefore the separate pretreatments will just be considered to have one average value in the reading, although shown at two levels in the tables.

Dennison Wax Pick

This test was performed using the variable tack-graded waxes in the print testing laboratory. The waxes were melted, applied to the board and allowed to set for five or more minutes before being pulled off. The results of this test showed ply-bond failure of the

board samples before any picking of the coating occurred. This was true in all samples, both calandered and uncalandered. This is attributed to the molten wax forming a strong bond with the styrene butadiene binder of the coating. Therefore when the wax is pulled from the surface, this bond is stronger than the plybond of the sheet.

IGT Pick Test

This test was done in accordance with TAPPI Standard T 499 and is used to measure the surface strength of paper through simulation of the printing process. The test was run at increasing velocity with the setting at a maximum of 2 m/ses. A medium viscosity oil obtained from the IGT Company was used as the testing substance. The results of this test show the oxidized starch pretreated board to be the strongest followed by the mix and finally the polyvinyl alcohol. This would seem to follow the theory that the starch kept the binder closer to the surface where it better anchored the pigment particles together and to the surface. (See Table 1).

K & N Ink Absorption

This test is designed to measure the ink hold-out of a sheet of paper. Brightness of the board samples was taken and then standard K & N ink was applied using a roller. The ink was allowed to stay on the board for two minutes and then wiped off. The brightness of the inked board was then taken. The percent reduction in brightness which supposedly correlates to ink absorption is what is shown in Table 2. This reduction is calculated using the formula:

$$\frac{\text{brightness original} - \text{brightness inked}}{\text{brightness original}}$$

IGT Pick

	Uncalandered	Calandered
Starch 1	164 cm	170 cm
Starch 2	159 cm	168 cm
Mixture 1	147 cm	141 cm
Mixture 2	148 cm	152 cm
PVOH 1	145 cm	155 cm
PVOH 2	142 cm	159 cm
Water	132 cm	123 cm
No Pretreatment	112 cm	120 cm

Table 1

K & N Ink Absorption

(Uncalandered)

	<u>Original Brightness</u>	<u>Inked Brightness</u>	<u>Percent Reduction</u>
Starch 1	72.9	61.7	15.4
Starch 2	72.6	61.3	15.6
Mixture 1	72.3	60.5	16.3
Mixture 2	73.0	60.9	16.6
PVOH 1	72.9	60.6	16.9
PVOH 2	72.1	58.9	18.3
Water	72.9	57.2	21.5
No Pretreatment	72.2	55.8	22.7

(Calandered)

	<u>Original Brightness</u>	<u>Inked Brightness</u>	<u>Percent Reduction</u>
Starch 1	68.2	62.5	8.4
Starch 2	68.2	62.0	9.1
Mixture 1	69.1	61.8	10.6
Mixture 2	69.1	62.1	10.1
PVOH 1	69.4	61.5	11.4
PVOH 2	68.2	61.2	10.3
Water	69.0	59.7	13.5
No Pretreatment	67.9	57.9	14.7

Table 2

This test shows that the board with the oxidized starch pretreatment has the best ink hold-out characteristics. This is followed by the polyvinyl alcohol-starch mixture and lastly by the PVOH alone. Although the calandered samples have lower reduction values due to the closing of pores in this operation, the trend is still the same. Notice that the water pretreatment improves somewhat over the coating applied alone but still does not help as much as the other surface sizes.

Kaltec Liquid Permeability Tester

This test is based on how long it takes for a given amount of liquid to pass through a nip at constant pressure and speed. This liquid passes through the nip due to two factors, the absorbency of the sheet and the surface roughness. By measuring the times for this liquid to pass through the nip and putting them into a computer program, this tester gives us values of surface roughness and permeability. Although this test is not a TAPPI Standard and actually is still in the developmental stages, the theory behind it has been around since 1957, being developed at the Institute of Paper Chemistry (32).

The results of this test are erratic and any possible trends are hard to see. Due to problems still to be solved within the system, the roughness values were questionable and discarded. Utilizing an oil which corresponds to one which would be used in offset printing, the following results are shown for speeds of .1 and .3 cm/sec. (See Table 3). The units of permeability, P_e , are cubic centimeters of oil absorbed per square meter of board, with the higher numbers being more permeable. As the values will change with varying speeds, pressures

KALTEC Liquid Permeability

(.1 cm sec)

	Uncalandered	Calandered
	<u>Pe</u>	<u>Pe</u>
Starch 1	6.65	4.65
Starch 2	5.68	4.95
Mixture 1	7.10	5.10
Mixture 2	6.66	4.96
PVOH 1	6.51	5.03
PVOH 2	7.18	5.10
Water	7.20	5.51
No Pretreatment	7.32	5.45

(.3 cm/sec)

	Uncalandered	Calandered
	<u>Pe</u>	<u>Pe</u>
Starch 1	10.64	8.05
Starch 2	10.46	8.01
Mixture 1	10.94	7.92
Mixture 2	10.88	8.47
PVOH 1	11.25	8.12
PVOH 2	9.97	7.90
Water	10.41	8.42
No Pretreatment	11.53	8.50

Where Pe = cubic centimeters absorbed/square meter of board

Table 3

and operators, the important things to look for here are the relative values to one another. The coating seems to once again be the most absorbent followed closely by the water pretreatment. Oxidized starch shows to be the best size to use to keep the oil out while no difference can be noted between the polyvinyl alcohol and the mixture. Whether or not the small differences between the results of the test are significant or not is unknown at this time.

Vandercook Press Print Test

This is another test which is not a TAPPI Standard but does correlate well with what actually happens when the board is printed. It is a qualitative test which relies on the spreading of ink over the board samples in an actual press. By watching the ink dry a person can visually determine which size has the better ink hold-out characteristics. Due to operator and press variability, the results of this test are again relative only. One can only compare the samples which are being run together through the press. By varying the types of board samples in the press at one time, it was seen that the board pretreated with polyvinyl alcohol was more absorbent than either the PVOH-starch mixture or the oxidized starch, which was the least absorbent. No difference was seen between the different levels of the surface size. Once again the board coated with no pretreatment was slightly more absorbent than the water pretreated samples.

Conclusions

It can be stated that a study of this type can be carried out on the pilot plant coater. No previous work of this type utilizing a blade coater to apply a surface size was found in the literature search. Therefore, there was some question as to the feasibility of doing this. The positive results obtained from this study show that it is possible.

Secondly, pretreating the paperboard before coating does have a positive effect on increasing the final surface strength and ink hold-out properties of the coated board. The coated board pretreated with water showed slight improvements over the board coated with no pretreatment applied, but was still less effective than the three surface sizes. Oxidized starch showed to be the best pretreatment for improving on the ink hold-out and surface strength characteristics of the coated board. This was followed by a 20:1 mixture of this starch and polyvinyl alcohol, and lastly by the polyvinyl alcohol alone.

Finally, it is theorized that the depth of penetration of the surface pretreatment into the board may be the overriding factor in the test results. Due to lower solids, less viscosity and a linear chemical structure, it would seem that the polyvinyl alcohol would penetrate deeper into the board than the mixture and/or oxidized starch. This would lower its effectiveness in keeping the coating binder near the surface, resulting in lower surface strength and less ink hold-out.

Recommendations for Further Study

After completing this study and noting its results and conclusions, it is felt that it would be beneficial to repeat this work keeping the percent solids constant for all pretreatments. In this way one could find out if the variability of the percent solids has an effect on the results.

Also this study should be repeated and samples of the pretreated board tested before and after coating. Although previous studies have all shown polyvinyl alcohol to be a superior surface size as compared to oxidized starch, it would be interesting to note the effects of these sizes when applied by the blade coater.

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