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The Evaluation of Coated Papers Containing Varying Amounts of Thermoplastic Adhesives

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THE EVALUATION OF COATED PAPERS CONTAINING VARYING AMOUNTS OF THERMOPLASTIC ADHESIVES

Submitted to Dr. Alfred H. Nadelman as partial fulfillment of the requirements for a Senior project in the Curriculum of Pulp and Paper Technology at Western Michigan College of Education, Kalamazoo, Michigan.

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Abstract:

Information is given on the effects of various concentration of styrene-butadiene latex and oxidized corn starch as binders in coated papers. Also data is given on the effects of increased amounts of styrene-butadiene latex in starch clay systems with respect to viscosity.

Indroduction

The early attempts to use thermoplastic adhesives in the coating field were in the early twenties (1). At that time natural rubber latex was used as an adhesive for mineral pigment coated papers. Difficulties were encountered with the use of natural latex as an adhesive with coated papers as the coating did not have good aging qualities (1).

In the early 1930's two patents were issued related to the use of natural rubber latex modified by both casein and shellac (2). Here again the process did not become of commercial important because of poor aging qualities of the coated paper.

Prior to World War II there were few "synthetic latices" on the market to use as adhesives in coated papers (1). The cost of these "synthetic latices" were too high for commercial users.

As of the present time there are only a few latex adhesives that have been suitably developed and sold in considerable quantity as paper coating adhesives. One of them is Dow Latex 512K, a styrene-butadiene copolymer (1). With the use of 512 K the aging qualities were as good or better than the normal aging qualities of regular adhesives used in coated papers (2).

Physical Constants of Dow Latex 512 K (3)

Per cent solids by weight	45.0
Specific Gravity (25° C.)	1.005
Weight per gallon (pounds)	8.4
Weight of solids per gallon (pounds)	3.8
pH of Latex	10
Viscosity (cps. at 25° C.)	10-12
Particle size (microns)	0.2
Surface tension (dynes /cm at 25° C.)	28-32
Specific gravity od solids	1.01
Index of refraction of solids	1.567

Evaluation of Pick

One of the major problems in the evaluation of coated papers that contain thermoplastic adhesives is the measuring of the pick of the coating. The Dennison wax test in many cases does not give comparable results on papers that contain thermoplastic adhesives. The best method of measuring the pick on thermoplastic coatings is the use of mechanical pick testers or proof presses.

Davidson-Pomper Pick Tester (4)

The Davidson-Pomper pick tester operates on the principle of a small variable speed printing press. Samples of the coated paper to be tested are placed on a rubber covered grippe cylinder. The feed bed of the pick tester is heated by a unit which is controlled by a thermostat at 90° F.

Ink plates of stainless steel are heated to uniform temperature on the bed of the press and are driven through

between the samples on the rotating gripper cylindes and the bed of the press at a selected rate of speed and under uniform pressure. The ink used is a tacky testing ink, such as IPI's Tack Grade Black number 6 to number 8 for operation at 90° F. The drive roll for the stainless steel ink plates is rubber covered and its speed may be selectivily varied within the range of 0 - 740 FPM.

In testing the samples the speed is set near the value at which picking is expected to occur and the plate is fed into the tester, thereby printing on the sample in the same manner as a rotary printing press. The samples are then inspected for picking. Tests are then made with new samples on the same stock at lower or higher speeds until the speed at which picking begins to occur is found. The speed at which picking begins to occur isactually a measure of the "pick" of the sample.

Bonding Strength Meter of the IGT (5)

The Institute for the Graphic and Allied Industries of Amsterdam, Netherlands has designed and constructed an apparatus to obtain a correct evaluation of the printability of paper. Essentially, the apparatus is a small printing press, which has been equipped with all the possibililies of control and adjustment of a production press.

Mention may be made in this connection of the possibility of changing the cylinder covering and controlling pressure and speed of printing.

The results obtained with this apparatus also gives a good impression of the suitability of the printing ink applied, so that the paper and printing ink can be made to harmonize, an additional advantage being that this can take place within a very short time, with a minimum consumption of paper and printing ink. The operation of the apparatus is based on the following principle.

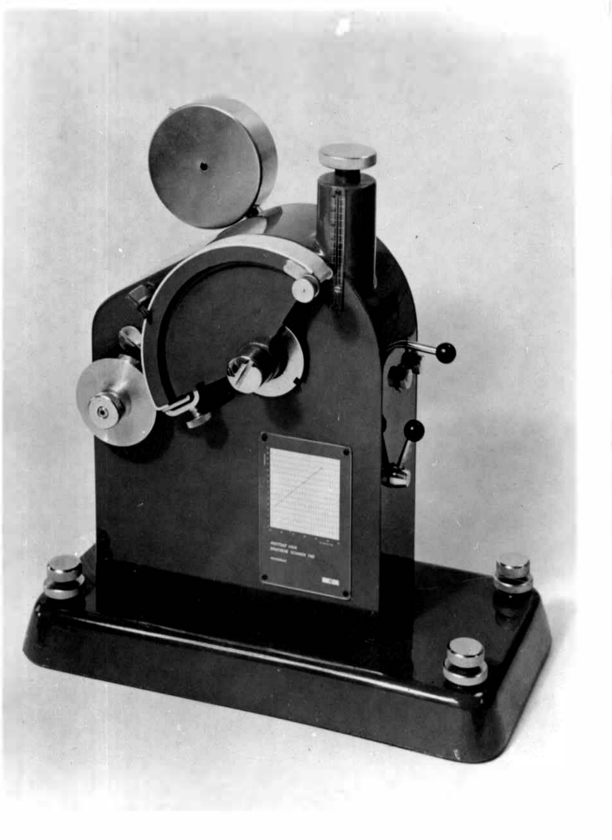

Fig. 1 IGT Bonding Strength Meter

A strip of paper, placed on a cylinder covering about 1 mm in thickness, is attached to the circumference of a bronze sector fixed to a shaft. An inked disc, rotating a round a spindle, is pressed with a certain pressure against the circumference of the sector.

When the sector is set in motion, its circumference, with the paper strip attached, moves along the rotating ink disc. When the ink disc has run the length of the sector, the paper strip will show a print having the length of the circumference of the sector and the width of the ink disc.

As the sector moves along the inked disc with increasing speed, the printing speed will, dependent on the quality of paper and printing ink used, at a certain monent, become too great, and the paper will begin to pick. The moment at which this takes place is very clearly visible on the paper strip, while also the speed at which this happened can be read off.

A primary requirement to be met in designing the proof-printing apparatus was that the way in which the sector was set in motion, and the range of speed in successive experiments, should be perfectly the same.

This can be siply ensured by fixing a weighted lever to the sector shaft, as it is shown in the picture.

When for instance the weighted lever is placed at an angle of 45^{o} to the perpendicular and then released, the primary requirement for satisfactoy operation of the apparatus has been met and we may be sure of reproducibility. The inked disc can therefore be considered to be the printing plate and the sector the counter pressure cylinder. The paper strip is attached at one end to the circumference of the sector, which prevents the paper from wrinkling or being stripped up during printing. A brush keeps the strip tight as shown in figure 1.

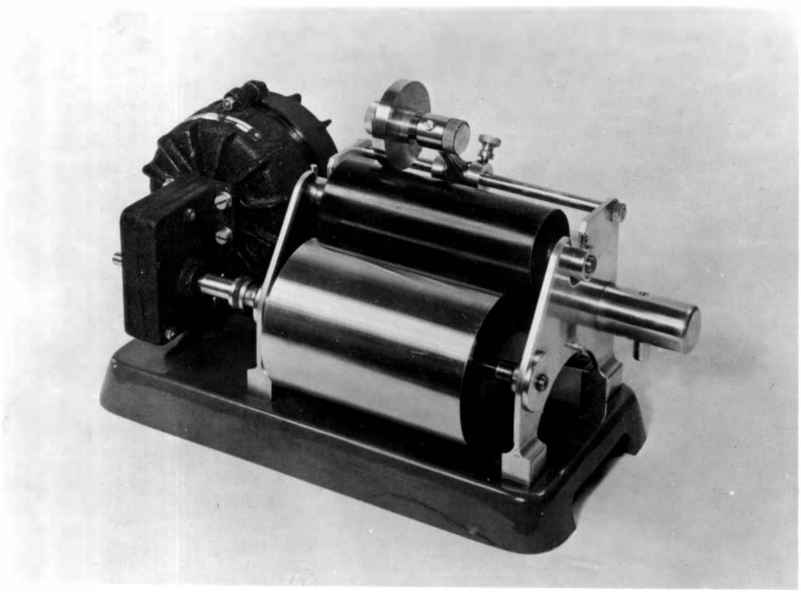

Fig. 2 Inking Mechanism

The inked disc is detachable and can be provided with an uniform and reproducible layer of ink on the inking mechanism belonging to the proof-printing apparatus. This inking mechanism consists of two steel rollers one of which contacts the ink disc (see fig. 2).

The Hercules Print Tester (6)

Like the other two pick testers, the Hercules print tester is an instrument to measure the pick resistance of mineral-coated printing papers.

The fundamental parts of the Hercules Print Tester consist of three units. They are the following: (1) a small rubber inking foller about 5/8 of a inch in width and about 2½ inches in diameter; (2) a variable-speed motordriven combination printing foller and driving wheel; and (3) an impression cylinder which carries the sample and a combination drive wheel.

Operation of the instrument proceeds as follows. A strip of paper 7/8 by 8 inches is mounted on the impression cylinder. It is held in position by a clip in the leading ind and by the slotted flanges at the edges of the arc over which the sample is drawn. The temperature of the plate cylinder is read from the thermometer attached to the instrument. If the temperature is not in the desired range, the printing plate is adjusted to the desired temperature.

After the temperature has been adjusted, a predetermined volume of ink is applied to the surface of the rubber inking roller. After the ink has been applied to the inking roller, the plate cylinder is put into motion by starting the electric motor. The motor is connected to the cylinder through cone-type variable-speed transmission. In order to distribute the ink evenly over the surface of the two rollers, the inking roller is swung into contact with the plate cylinder and slowly oscillated by hand. With the inking roller still in contact with the plate cylinder, the impression cylinder is released and allowed to make one revolution in which the sample is printed. The setting of the variable-speed transmission determines the speed of the printing cycle.

"The major variables in this process are; (1) speed of printing, (2) ink viscosity or tack, (3) ink temperature, (4) volume or weight of ink used, and (5) impression pressure."

The Warren M. P. Tester (7)

The Warren pick tester compares directly the coating strength of any coated paper with that of a standard coated paper of known strength.

A strip of paper to be tested cut about $1\frac{1}{2}$ by 8 inches and standard test paper cut the same size are clamped side by side on the surface of a rotatable cylinder.

A metal plate having a solid area 2 by 2 3/4 inches which is coated with printing -ink is then driven at a known controlled speed into simultaneous printing contact with the two paper strips. The test is repeated until the speed is obtained where the ink picks coating from one of the strips. The speed is then increased until the coating is picked from the second strip. By this method the relative strength of the two coatings is readily obtained.

<u>Rotary Pick Tester</u> (8)

Unlike the other four pick testers described, the pick tester developed by the Kimberly-Clark Corporation does not use ink for a picking medium. For a picking medium, a Newtonian fluid, such as blown castor oil is used.

The pick tester consists of a stationary, rubber covered impression roll and a movable black Carrarra glass plate carrying a uniform film of castor oil. The arrangement of the pick tester is similar to that of a flat bed cylinder printing press. The plate is driven by a specially designed cam which produces a variable speed proportional to the distance traversed.

In operation the paper is attached to the impression roll. A draw bar is used for spreading the fluid film into contact with the plate. A bead of castor oil is placed on the plate ahead of the bar, and the inking cam is engaged.

The velocity at which picking starts is read directly off a scale on the front side of the machine. The picking is measured in kilopoise/cm/per second. This is obtained by multiplying the scale reading by the viscosity of the oil at the testing temperature of the oil used.

Proof Press For The Evaluation Of Pick

Both the Vandercook Number 4 proof press or the Miehle Vertical Model V 50 printing press may be used for the evaluation. Zucker using the Vandercook proof press, claimed that differences between coatings could be found, which didn't show up by ordinary means when 500-poise ink was used. (9)

Dennison Wax Test on Thermoplastic Binders

No significant correlation was found between Dennison wax test values and press-resistance ratings when papers contained some thermoplastic material in the coating adhesive. (6) A significant correlation was found between Dennison wax test values and press pick-resistance ratings for coatings that contained nonthermoplastic adhesives. (6)

It is claimed by Dow, when 512 K is used as the sole adhesive, that the adhesion of the coating for printing bears no relation to the wax number. (10) However, the relationship has more meaning when Dow Latex 512 K is used as a modifier for a standard adhesive. It may give a wax number one or two waxes below the standard for a

similar grade without 512 K. (10)

Properties Imparted To Coatings Where Part of The Starch Was Replaced By 512 K.

This modification is said to improve the flexibility, folding qualities, smoothness, gloss, and wet rub resistance. (10) A 50% replacement of the binder with 512 K is said to permit the use of 10% more solids for brush and air coatings.

Summary

This survey of the literature available shows that there is need for work on the evaluation of coated papers containing varying amounts of thermoplastic adhesives. Although Stibert and other have done considerable work on the evaluation of Dow Latex 512 K at several concentrations, there is need of more work to be carried out in the evaluation of the picking of the coating at varying concentrations of the latex adhesive.

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THE EVALUATION OF COATED PAPERS CONTAINING VARYING AMOUNTS OF THERMOPLASTIC ADHESIVES

EXPERIMENTAL WORK

June 2, 1952
Roderick A. Perkins
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Experimental Work:

The experimental work consisted of making up a number of coatings containing various concentrations of oxidized corn starch and styrene-butadiene latex as binders. The total adhesive requirement was 16.9 percent based on the clay. The coatings were applied to sheets and the properties of the coated sheets were evaluated after calendering.

Adhesive Ratio Used:

Coating colors of the following adhesive ratio were made up:

1. 100 percent latex and 0.0 percent starch.
2. 75 percent latex and 25 percent starch.
3. 50 percent latex and 50 percent starch.
4. 25 percent latex and 75 percent starch.
5. 10 percent latex and 90 percent starch.
6. 0.0 percent latex and 100 percent starch.

Coating Formula Used:

1780 grams of clay O. D. (Edgar Brother Co. H.T.)
600 grams of water
5 cc. of 50 percent caustic
30 grams of Flint flakes (sodium stearate technical grade)
100 grams of water
5.4 grams of tetrasodium pyrophosphate (T.S.P.P.)
302 grams of adhesive O. D.

Order of Mixing:

The clay and the 600 grams of water were kneaded in the Day mixer until a smooth paste was formed. Then the caustic and the sodium stearate (that had been heated in 100 grams of hot water) were added. After the above mixture had been well kneaded, the T.S.P.P. and the adhesive were combined with the color. Enough water was used to adjust the solids to 40.0 percent and the pH too 9.0.

Preparation of the Latex For the Above Formula:

The latex was stabilized by adding 3 percent casein based on the oven dry latex solids, which had been cut with 10 percent caustic solution. The latex solution, with the casein added, was adjusted to 42 percent total solids.

Preparation of the Starch For Above Formula:

The starch was cooked at 20 percent solids for 15 minutes at 190^{o} F. The starch solution was then cooled to room temperature and water was added to adjust the solids back to 20 percent solids.

Properties of The Coating Colors:

Brookfield viscoities were made on the various coating colors (See Table 1). Figure 1 represents a graphical record of the viscosity properties of the various coating colors.

VISCOSITY PROPERTIES OF THE VARIOUS ADHESIVE RATIO OF THE COATING COLORS:

Brookfield viscosities in centiposes. Temp. 26° C.
Total adhesive 16.9 percent based on the clay.
Total solids 40 percent; pH 9.0.
Starch: Oxidized corn (Stein-Hall Supercote #10).
Latex: Styrene-butadiene (Dow 512 K Latex).

Starch:	0.0%	25%	50%	75%	90%	100%
Latex:	100%	75%	50%	25%	10%	0.0%
R.P.M.						
10	20.0	36.0	40.0	56.0	72.0	124.0
20	18.0	26.0	30.0	38.0	52.0	80.0
50	23.2	30.4	34.4	40.8	47.2	57.6
100	32.0	36.8	40.0	46.4	54.0	64.8

Table 1

Preparation of Coated Samples:

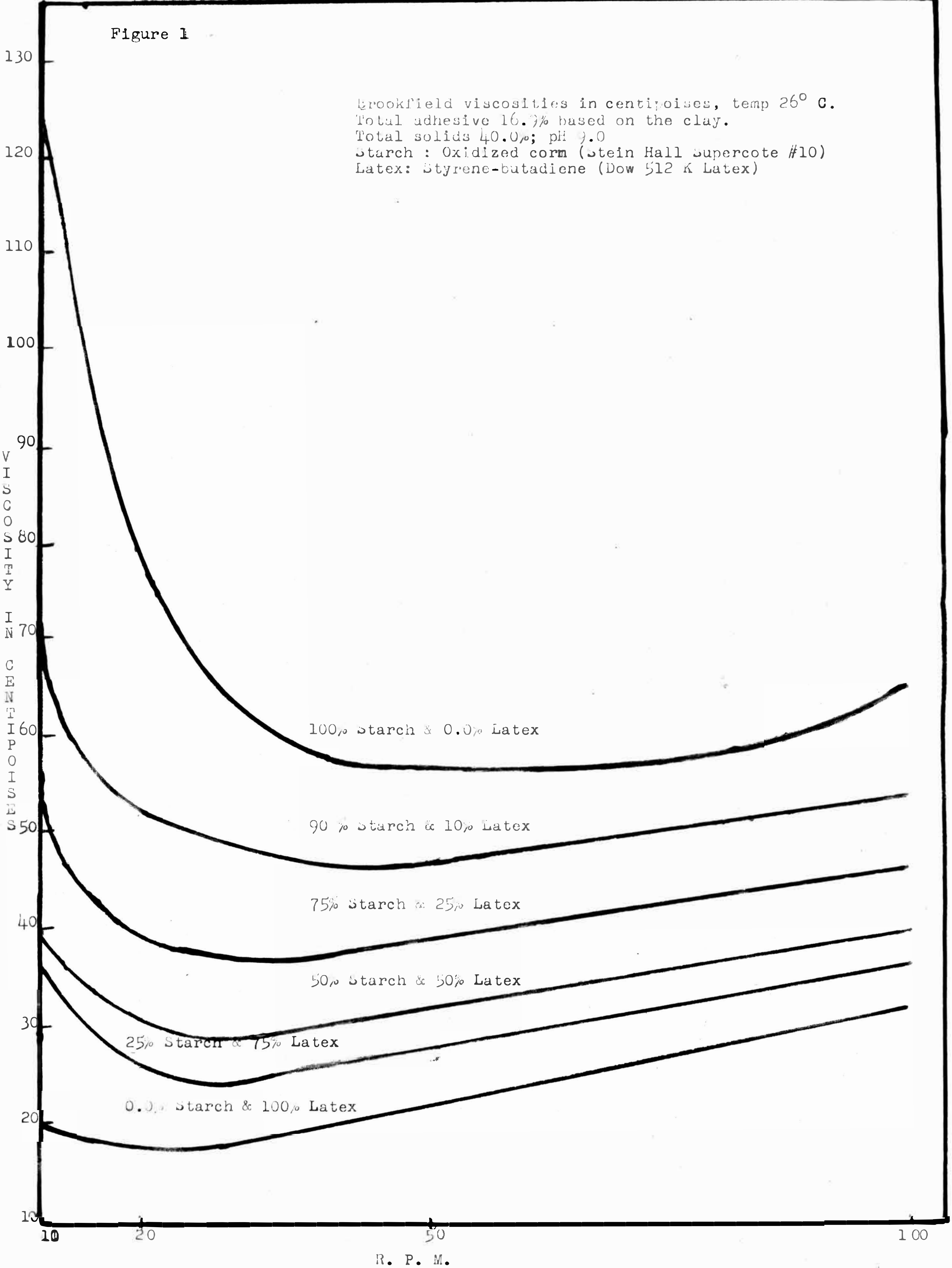
All the coated samples were made from a uniform supply of coating base stock. The basis weight of the paper before coating was 42 pounds per ream (25 x 38-500).

The six coating formulations were applied with a number 18 R. D. (wire wound) rod with the exception of the 100 percent latex coating, which was applied with a number 14 R. D. (wire wound) rod. The coating weight applied was 14 ± 1 pound per ream.

The coated samples were allowed to air dry at room temperature and were calendered under identical conditions after drying.

VISCOSITY PROPERTIES OF THE VARIOUS ADHESIVE RATIO OF THE COATING COLORS

Figure 1



Evaluation of The Coated Samples:

The following tests were made on the coated sheets after calendering. All tests were carried out under standard conditions of 50 percent relative humidity at 73° F. Calendered samples of the various coating colors are enclosed for inspection (Figure 2).

1. Photovolt Brightness.
2. Bausch and Lomb Opacity.
3. Photovolt Gloss.
4. Bekk Smoothness.
5. Pick Resistance.
6. Printability.
7. Fastness to Light.

In table 2, under brightness are the results of the brightness of the calendered samples in percent reflectance. All brightness tests were taken on a Photovolt meter and compared with a calibrated reference standard.

Table 2 also shows the percent gloss determined on the calendered samples. All gloss readings were made on a Photovolt meter with a gloss attachment.

In table 2, under opacity, the tests are recorded for the calendered samples. All tests were made with Bausch and Lomb opacimeter.

Table 2 also shows the results of the fading tests. The tests are reported in the amount of brightness loss after

Figure 2

50% Latex and 50% Starch

75% Latex and 25% Starch

100% Latex and 0.0% Starch

25% Latex and 75% Starch

10% Latex and 90% Starch

0.0% Latex and 100% Starch

PROPERTIES OF THE CALENDERED SAMPLES

Gloss: Photovolt in percent.
Brightness: Photovolt in percent.
Opacity: Bausch and Lomb in percent.
Fastness to Light: (Original Brightness - Brightness after 20 hrs.)
Printability: Vandercook number 4 Proof Press.
Picking: Davidson-Pomper Pick Tester.
Smoothness: Bekk in seconds.

Starch:	0.0%	25%	50%	75%	90%	100%
Latex:	100%	75%	50%	25%	10%	0.0%
Tests						
Gloss	41.2	41.4	43.3	43.3	43.0	40.0
Brightness	72.6	73.5	75.5	74.5	74.9	74.7
Opacity	90.5	91.1	91.6	90.9	90.5	90.4
Smoothness	332	286	280	302	279	215
Fastness*	3.5	2.0	1.5	1.5	1.5	2.0
Printability	4.0	2.5	3.0	2.7	3.5	3.0
Picking	10	8	6	5	4	4

* Data obtained by Mr. Phillip Avery

Table 2

20 hours of fading in the Fade-Ometer.

In table 2, under smoothness, the smoothness tests are reported in seconds. All smoothness readings were made on a Bekk smoothness tester.

Table 2 also shows the results of the printability of the calendered samples. The printability was evaluated by the use of Vandercook number 4 proof press using a printing plate containing both half tone areas and solid areas. A sample of the printing is enclosed for inspection (Figure 3). All the printability tests were made with I. P. I. Diene Vapor Black ink number 1. Printability of the four areas of

PROOF MADE ON VANDERCOOK NUMBER 4 PROOF PRESS FOR RATING PRINTABILITY

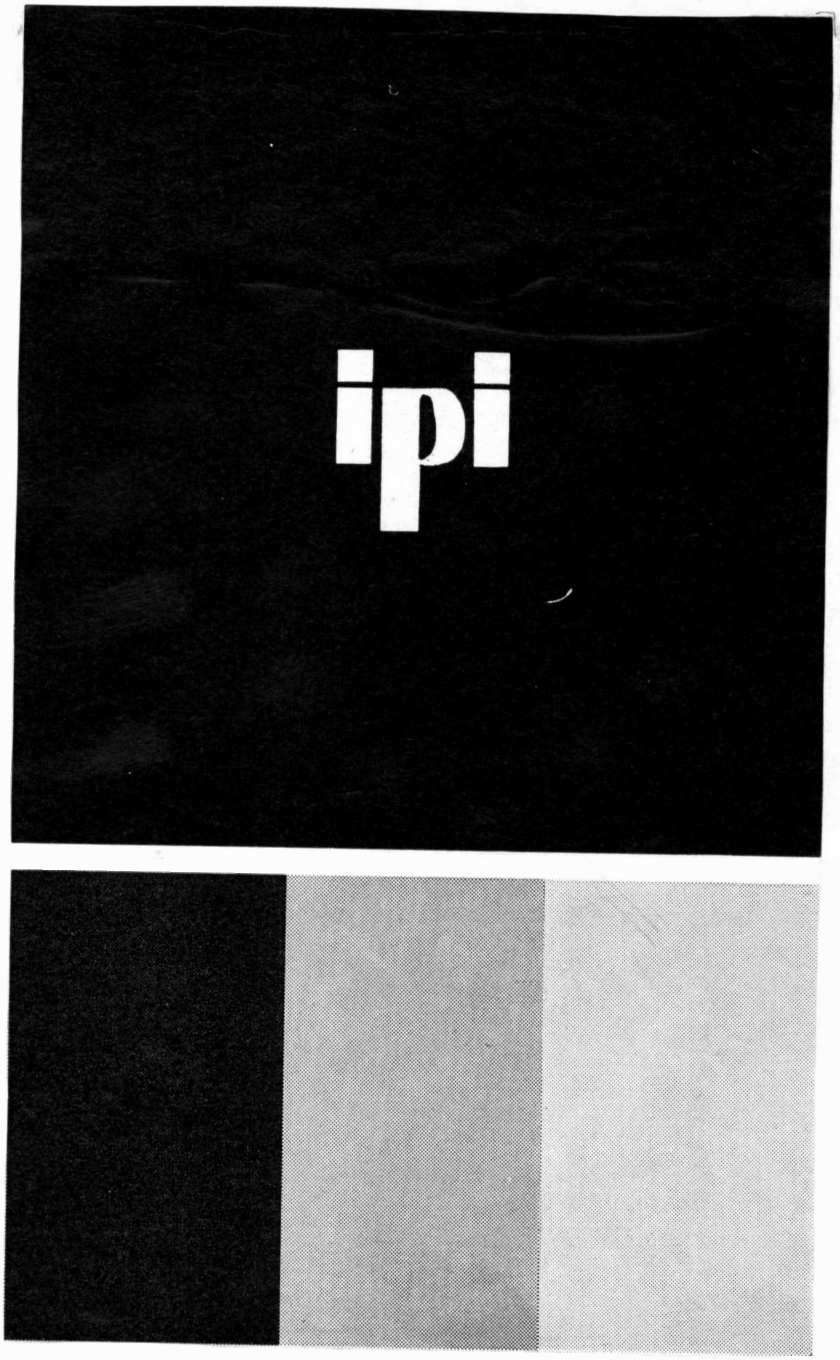


Figure 3

plate was examined under 20 power magnification and rated by the following numerical rating:

Excellent printability........0
Good printability.............1
Average printability..........2
Fair printability.............3
Poor printability.............4

The ratings given in table 2 under printability are the average sum of the individual printing areas of the proofs for two printed proofs. The tests listed are accurate, but the tests are not precise as only two tests were made do to the limited number of coated samples available.

Picking resistance was measured by the use of the Davidson-Pomper Pick Tester. A rating of 10 was given to the sample which had the best resistance to picking. A rating of 1 would be given to a sheet which had very little resistance to picking.

Summary:

Laboratory tests on the coating colors show that increased amounts of styrene-butadiene latex in the starch system lowered the viscosity of the coating colors. Also when a considerable portion of the total adheive was latex, the thixotropic properties of the coating were gradually reduced and finally eliminated.

Tests on the calendered samples coated with various ratio of starch and latex show no significant difference

in the brightness, opacity, and gloss.

It may be stated in general that increased amounts of latex in the coatings increase the Bekk smoothness of the calendered samples. The binding power of latex adhesive is superior to starch alone or to starch-latex combination.

Conclusions:

Viscosity tests on the coating colors show that the use of increasing amounts of latex lowers the viscosity. Also the thixotropic properties of the coating colors were gradually reduced and finally eliminated. When considerable portions of the adhesive is latex the picking resistance is markly improve over a coating containing 100 percent starch as binder.

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