PROCEEDINGS
OF THE
TECHNICAL ASSOCIATION
OF THE
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TAPPI
PRESS

1980 COATING CONFERENCE

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TECHNICAL ASSOCIATION
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1980 COATING CONFERECE

TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY

13 March 1980

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1981 COATING CONFERENCE
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If you, or one of your associates, are willing to accept this challenge, then start NOW! Contact Don Whitehead, the 1981 Technical Program Chairman, to indicate your interest in submitting a paper. Then please submit an abstract of the paper by September 19, 1980.

We ernestly solicit papers from three major areas: Paper Mills and Paper Company Technical Groups, Allied Research Organizations and Suppliers to the Paper Coating Industry.

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Technical Program Chairman
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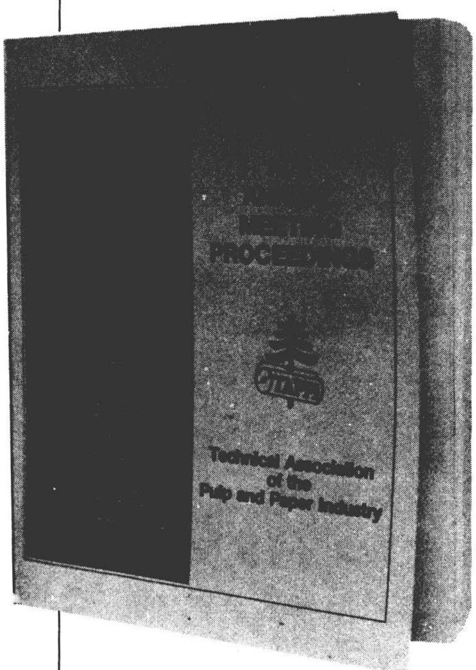
Attachments



Conference *Proceedings*: a coming of age

Last month at the Annual Meeting in New York City, each delegate received a copy of the *Annual Meeting Proceedings* containing a complete record of the papers presented at the technical sessions. This is not unusual. As a matter of fact, delegates to Annual Meetings and all other TAPPI conferences have been receiving *Proceedings* for a number of years. What was different this time was that each and every paper presented at the meeting was included, as well as position papers by the chairman of each panel discussion.

You might say that you have already seen TAPPI *Proceedings* that contained all papers presented at a conference. And you would be right. The Engineering Division has been publishing 100% of its papers since 1968. Several other TAPPI Divisions have also been successful in achieving this goal, notably, the Environmental Division and — on some occasions — the Corrugated Containers Division, the Coating and Graphic Arts Division, and the Paper Synthetics Division. The difference at this year's Annual Meeting was that 100% publication of the papers was mandatory.

The Technical Operations Council, made up of representatives of all TAPPI Divisions, realizes the importance of the *Proceedings* as a service to members and, effective Jan. 1, 1979, has made it mandatory for all conference presentations to be published in the *Proceedings*. Unless a paper is submitted in time for printing in the *Proceedings*, it simply cannot be presented at the meeting. (Early submission of the manuscript also permits review of the paper for full compliance with antitrust requirements before presentation.) This 100%-publication policy means then that whether you attend a conference or whether, as a nonregistrant, you merely purchase — at a cost equivalent to about a 1-day room charge — a copy of the *Proceedings*, you will have access to all the information formally presented at the conference.

For the past few years, TAPPI *Proceedings* have been indexed and/or abstracted by many international information services, such as The Institute of Paper Chemistry, Engineering Index, and Chemical Abstracts. Therefore, when a paper is published in the *Proceedings*, it becomes part of the world's retrievable technical literature.

Standing orders for the *Proceedings* have been accepted at TAPPI headquarters for some time, and there is no doubt that with the publication of all conference papers in the *Proceedings*, the benefit to be derived from these books is even greater. Authors will benefit because their work becomes part of the retrievable literature and is protected by copyright at the time of presentation.

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The Association is committed to the prompt dissemination of all technical and scientific information formally presented at TAPPI meetings. With publication of all conference papers in the *Proceedings* and with the continued monthly publication of *Tappi* magazine, the mechanism to do this job is now 100% operational.

William L. Cullison
Director of Operations
and Treasurer
TAPPI

CONTENTS

PAPER IN POST-INDUSTRIAL AMERICA -- THE CHALLENGES AND OPPORTUNITIES OF A TRANSFORMATIONAL MARKETPLACE

David Snyder
Internal Revenue Service
and *Futurist* Magazine
Washington, D.C.

The 1980's will be a watershed for several key aspects of the American enterprise. By the end of the decade, we will have undergone significant changes in our energy costs and sources, our lifestyles, our basic educational delivery systems, our relationship to the workplace as the primary basis of economic productivity. The most probable nature of these changes and their implications for the paper industry and paper products will be discussed.

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THE INFLUENCE OF THE COATING PIGMENT ON MISSING DOTS IN LIGHTWEIGHT COATED GRAVURE PAPER

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ABSTRACT

English Coating Clay, English Coating Carbonate, Domestic No.2 Clay, Brazilian Coating Clay and a number of experimental English clays have been evaluated in single pigment coatings on European LWC base paper.

The laboratory gravure print quality, measured by the incidence of missing dots, ranks inversely with the fluid packing characteristics (viscosity) of the pigments suspensions.

The experimental clays, designed to have poor packing, gave better print quality at equivalent coat weights or equivalent print quality at lower coat weights compared with the standard clays.

Compressibility ratios of the coatings ranked in order of print quality and were slightly higher than the compressibility ratios of the base paper.

Print quality was not directly related to pigment fineness.

INTRODUCTION

The work described in this paper was prompted by the conditions and requirements of the European Market for lightweight coated paper (LWC) in the Gravure Sector of the market. This differs from the U.S. practice mainly in the predominant use of synthetic latex coating pigment binders and in the very high print quality requirements in the printed paper. The quality emphasis concentrates on the fidelity of light half tone reproduction as indicated by the degree of speckle resulting from missing dots.

The print quality of lightweight coated paper can be influenced by many factors. Pritchard and Firsdale(1) demonstrated the role of smoothness and absorbency of the printed surface. Smoothness was the more important.
Conrad(2) considered the mechanism of ink transfer from the print cylinder and stressed the role of capillary suction in pulling the ink out of the gravure cell. It may be that suction helps when surfaces that are not absolutely smooth are printed.
Miller and Plante(3) related missing dots to paper surface defects using optical techniques.
Swan(4) described the benefits of electro-assist in improving print quality.
Kunz(5) illustrated the improvements in smoothness of German LWC paper over the period 1968 to 1976. He also pointed to the difference in stiffness of U.S. papers using starch as a coating adhesive and European paper using synthetic latex binders.
Weigl, Waltner and Weyh(6) reviewed the role of the pigment, its packing characteristics and the gelling behaviour of the coating colour when it is applied to the paper. Capillary absorption was important for good gravure print quality.

A limited replacement of fine particle size pigments with coarse materials was possible without loss of quality.
Stephan, Voss and Hottentrager(7) related the surface profile of coated board to missing dots. A numerical value for mean roughness was obtained from profile measurements, which related to print quality.

To achieve good print quality many aspects of the base sheet preparation and coating are controlled by the paper maker. One of these is the use of coating pigment mixtures. A very wide range of clays from many sources are used. These include U.S. No.1, No.2 and delaminated clays, English coating and filler clays and filler clays originating in Germany. Although in many instances economic motives must contribute to the decision to use mixtures, it is also believed that such mixing of coating clays contributes to the printability of the coated paper.

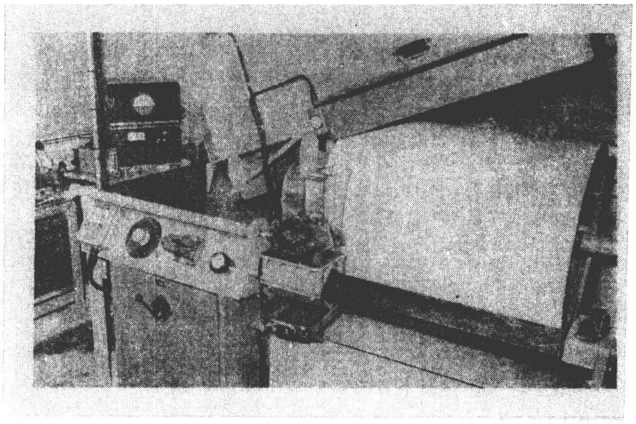
In Europe, as in the U.S., there is a desire to reduce the total weight of LWC partially in response to the cost of postage and partially in response to the increasing size of mail order catalogues. Acceptable print quality of paper coated with coat weights below 9 to 10 gsm per side appears to be difficult to achieve.

The work in our laboratories concentrates on the behaviour of single coating pigments in a standard formulation. This is to highlight differences in the pigment property contribution to print quality.

EXPERIMENTAL TECHNIQUES

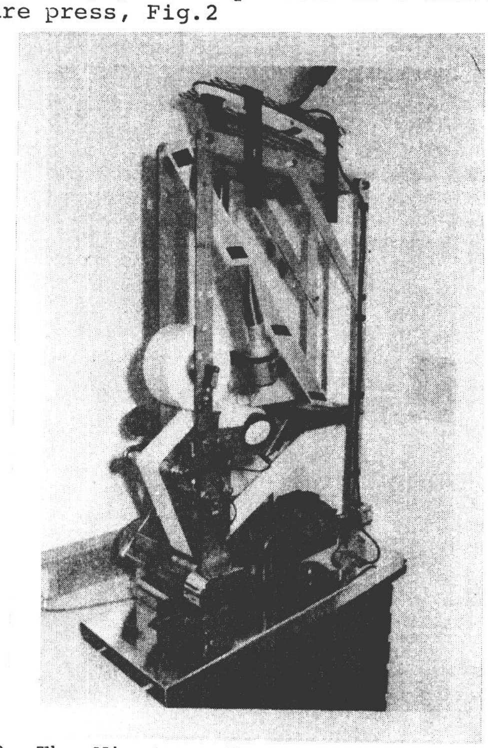
PRINT QUALITY

To assess print quality, suitable base paper was coated on a Heli-coater(8) laboratory blade coater, Fig.1.



1. The Heli-coater

The coated paper was calendered and the calendered paper was printed on a Winstone gravure press, Fig.2



2. The Winstone Gravure Press

The sequence of processes needed to obtain the final print and the natural variability of the base sheets resulted in fairly high levels of experimental error in early work. A large number of runs over a wide range of coat weights was used to derive significant results. More recently error has been reduced by careful attention to detail in the experimental technique.

The Latex adhesive based colour formulation is given in Table 1a; an alternative formulation using starch as the adhesive is given in Table 1b.

Table 1a

Pigment	100 parts
Latex, Acronal 425D	4.5 parts
Sodium Hydroxide to pH	9.0
Water to give a Brookfield Viscosity at 100 rpm between 15 and 20 Poise	

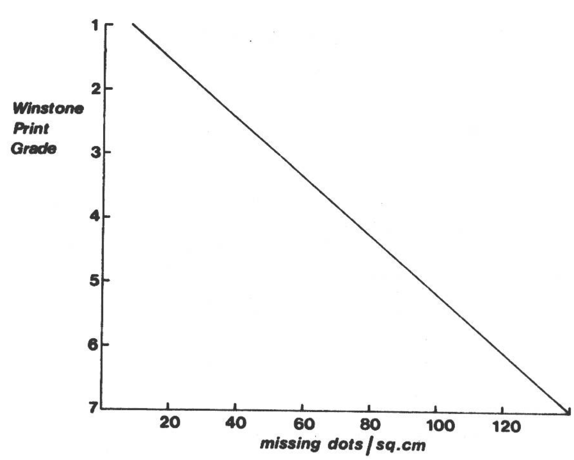
Table 1b

Pigment	100 parts
Starch, Viscosol 410	8 parts
Calcium Stearate, Napcote	0.8 parts
Sodium Hydroxide to pH	8 to 8.5
Water to give a Brookfield Viscosity at 100 rpm between 15 and 20 Poise	

Coating speed was 400 m/minute
Calendering, after conditioning for 16 hours at 50% RH and 23°C, was 10 passes through a laboratory calender at 36 m/minute, 65°C, with a roll pressure of 66 kN/m (except where otherwise specified).

The base paper was a German uncoated rotogravure base with a substance of 39 gsm.

The test cylinder in the Winstone press had 'hard dot' cells 80 microns in diameter, 18 microns deep, with 59 dots per centimetre. Printing conditions, such as roll pressure and ink viscosity, were standardised to give a measurable number of missing dots on a reference paper of acceptable commercial quality. Print quality was determined by subjective ranking of test prints against a set of standard prints, graded from 1 to 7 in half grade steps. The relationship between print grade and numbers of missing dots per square centimetre is given in Fig.3. As an alternative to subjective ranking, missing dots can be counted by eye or by instrumental techniques such as Quantimet(9).



3. Print Grade v. Missing Dots per cm^2

THE PIGMENTS USED

The pigments used in the experiments reported here are described in Table I.

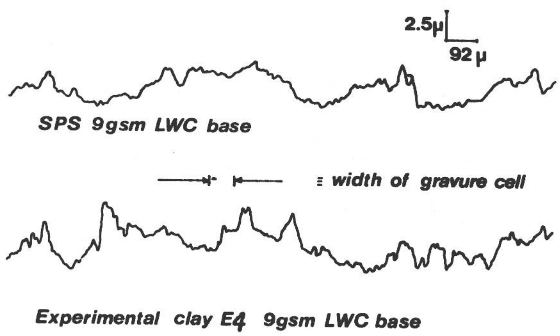
TABLE I

Pigment	% finer than 2µm	% coarser than 10µm	Viscosity Concentration*
English coating clay, SPS	80	0.1	69
" " " Dinkie A	75	0.5	71
" " " Dinkie B	64	6	65
U.S.No.2 " "	83	0.5	74
Brazilian " "	98	0.3	74
English coating calcium carbonate	85	0.5	78
Experimental clay E1	1µm-½µm)	fractions of SPS	
" " E2	5µm-2µm)		
" " E3	38	5	65
" " E4	34	5	66
" " E5	53-69	4-12	

* Viscosity concentration is a standard method of test of E.C.C. International[11] which measures the concentration of a chemically deflocculated and physically dispersed aqueous slurry of the pigment, which has a viscosity of 5 Poise on a Brookfield viscometer at a spindle speed 100 r.p.m.

SURFACE PROFILE

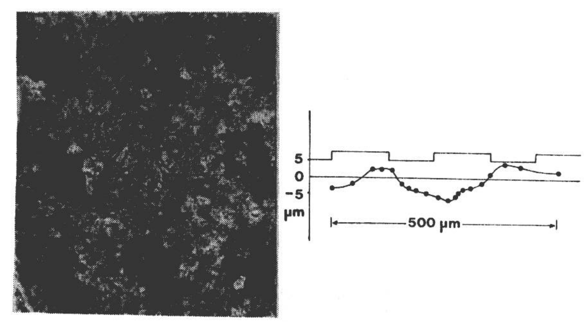
Two methods for surface profile measurement were used. The Talystep[10] instrument records the movement of a lightly loaded diamond stylus as a paper sample is drawn beneath it. Vertical and horizontal movements are shown on a trace which gives a picture of the surface along the line of traverse. An example of such a trace is given in Fig.4.



4. Example of Talystep Traces

The Stereoscan electron microscope can also be used by producing stereo pairs of photographs from the variation of specimen tilt in the microscope. The relative position of points on the two images permit the calculation of the horizontal position of the points relative to a reference plane. From this information a contour map of the surface can be drawn, Fig.5.

Both surface profile measurements can be related to missing dots on the printed paper.

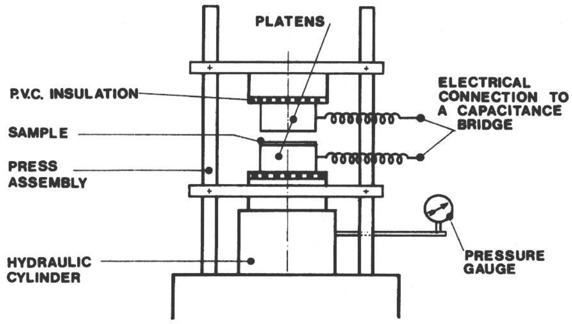


5. Stereoscan Contour Map and derived Section

COMPRESSIBILITY

The extent to which the paper and its coating deforms under the pressure of the printing cylinder can affect the possibility of contact between ink and paper. Although direct measurement of deformation against compressible force is the preferred technique, the absence of a suitable instrument led to the use of the method described here.

Two polished metal surfaces, flat to better than 1µm, were mounted in a hydraulic press. The metal surfaces when separated by paper, or a coating layer, formed a condenser when a small alternating (1 kHz) electrical potential difference was applied across them, Fig.6. The capacitance of a condenser is inversely proportional to the separation of the plates, assuming that the dielectric constant of the separating medium does not change; hence the ratio of capacitance at the test pressure (C_p) to that of a low initial pressure (C_{100}) will give a measure of the compression ratio over the two pressures.

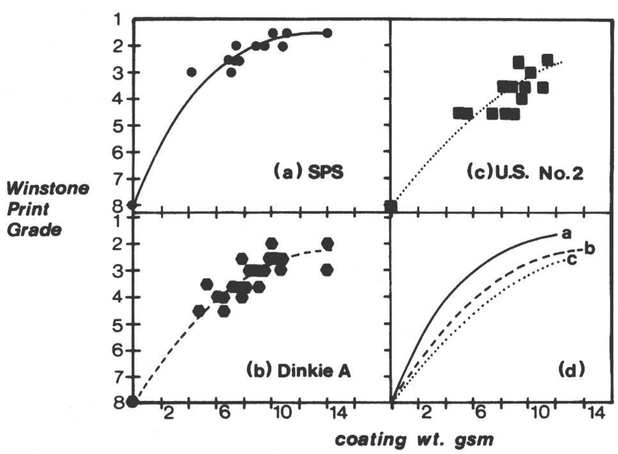


6. The Compression Apparatus

Samples tested by this method were, coated paper, uncoated base paper and coatings applied to a non compressible substrate, such as aluminium foil, which also ensured good electrical contact with one face of the coating. Only coatings prepared with polyacrylate latex adhesive were used in the compression work.

RESULTS AND DISCUSSION OF THE COATING AND PRINTING EXPERIMENTS

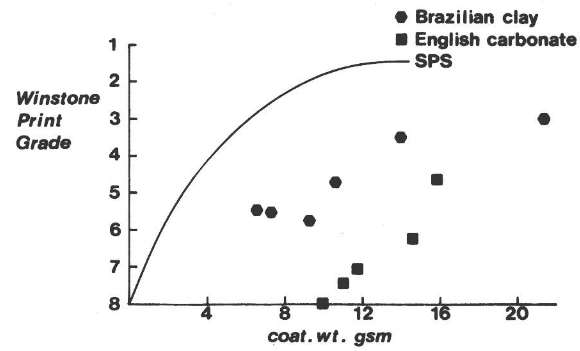
Early single pigment coatings, using the European colour formulation, are shown in Figures 7a, 7b and 7c. Despite the scatter, statistical analysis suggests that there are real differences between the sets of results. Best fit curves are brought together in Figure 7d and rank the print quality as an inverse of the pigment packing as shown by the aqueous suspension viscosity. This is in line with the suggested influence of Relative Sediment Volume proposed by Weigl[6].



7. Single Pigment Clay Coating with Latex Binder

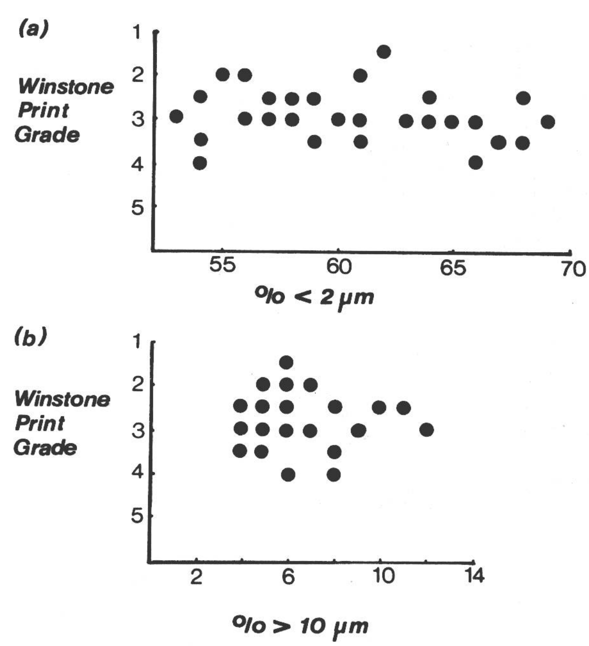
Two pigments with better packing characteristics than those used above are fine ground natural calcium carbonate and Brazilian kaolin. These produce very poor print quality when used as sole pigments, Fig.8.

The results obtained with the Brazilian clay indicate that pigment fineness does not necessarily ensure good print quality.

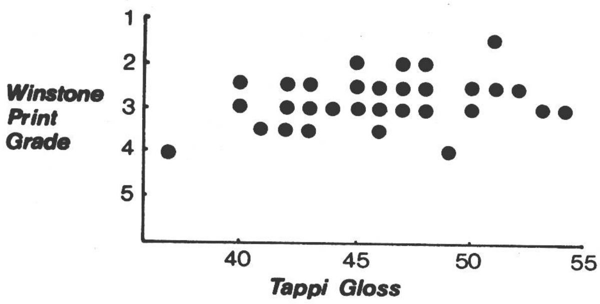


8. Single Pigment Calcium Carbonate and Brazilian Clay with Latex Binder

A series of experimental English clays, E5, produced from a common source by delamination techniques, provided a range of particle size distributions. The results of coating and printing with these clays, interpolated for 10 gsm, again indicate that the print quality need not be related to coating pigment particle size, Figures 9a and 9b. The same series of results indicate little effect of gloss variation on print quality <u>under constant calendering conditions</u>, Fig. 10.

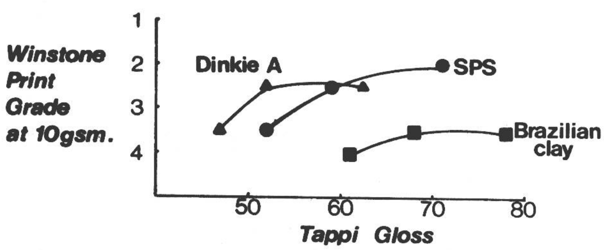


9. Relation between Particle Size and Print Grade for Delaminated English Clay



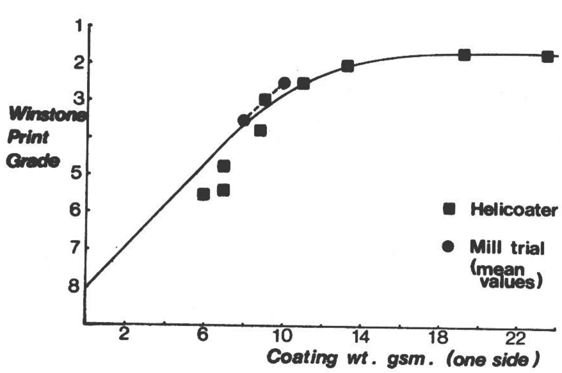
10. Gloss - Print Grade

Higher gloss derived from higher calendering pressure will result in an improved print quality although the improvement is limited to about 1 unit of print grade, Fig.11



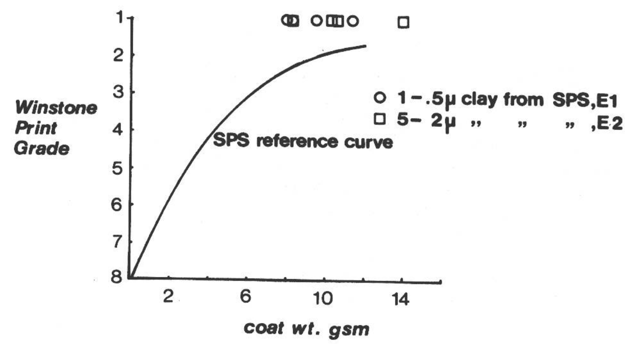
11. Effect of Calendering at 44, 88 & 158 kN/m

Correlation between laboratory coating, using the Heli-coater, and mill practice is given in Fig.12. The range of results for the mill trial, using the same pigment and base paper as that used in the laboratory coatings, are mean values over the range of coat weights resulting from the trial. Both laboratory and mill trial papers were printed on the Winstone press.



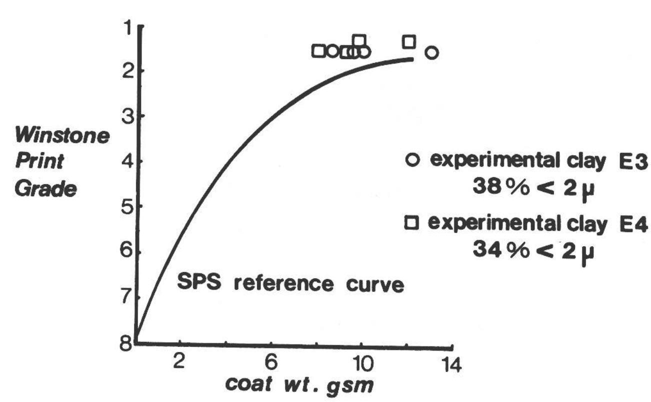
12. Laboratory Coating and Mill Trial Results for Dinkie B

The packing characteristics of kaolin can be changed by narrowing the size distribution. The four experimental clays, E1 to E4 all had reduced particle size ranges compared with standard production clays. These clays had a particular property of carrying the good printing properties of the coated paper into a region of coat weight below 10 gsm. Figure 13 shows the fractions from SPS. Both gave better print results than the standard SPS although one represented a fraction from the fine end of the SPS size spectrum while the other was a fraction from the coarse end, so that the mean particle size of the former was finer and the mean particle size of the latter was coarser than the source clay.



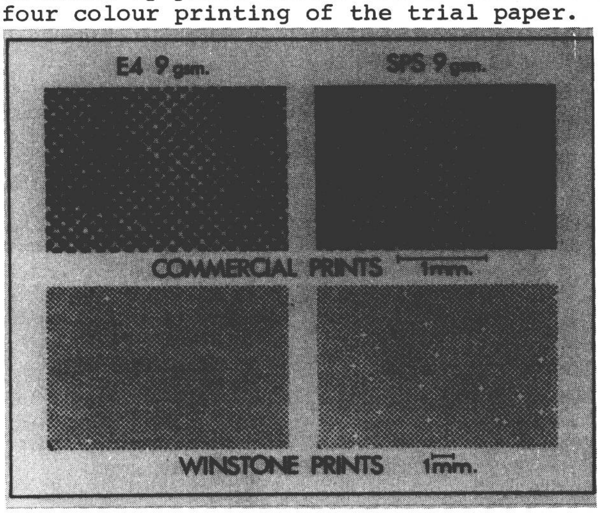
13. Coating with Experimental Clay Fraction from SPS

Clays E3 and E4 were coarser than clays conventionally accepted as coating clays. Nevertheless they demonstrated a similar behaviour to the fine fractions, in lowering the coat weight at which high print quality can be achieved, Fig.14. Because such coarse fractions need not be more expensive to produce than standard coating clays, unlike the fine fractions taken from the coating clays, they could form the basis of a new pigment for very light weight coated paper.



14. Coating with Experimental Coarse Clays

Samples of Heli-coated papers coated with the coarse clay and SPS were printed on a commercial, sheet gravure press to confirm the results obtained on the laboratory Winstone press. An example of the results is given in Fig.15. Further confirmation was obtained by pilot coater trials followed by four colour printing of the trial paper.



15. Examples of Print Results from one of the Experimental Coarse Clays v. a Standard Coating with SPS

Although this work is concerned primarily with the problem of the pigment/print quality interaction it is worth noting that the use of very coarse clays would adversely affect a number of coated sheet properties such as brightness, opacity and gloss. As an example, the gloss results are given in Table II. The fine clay fractions do not suffer from these disadvantages but would be very expensive to produce.

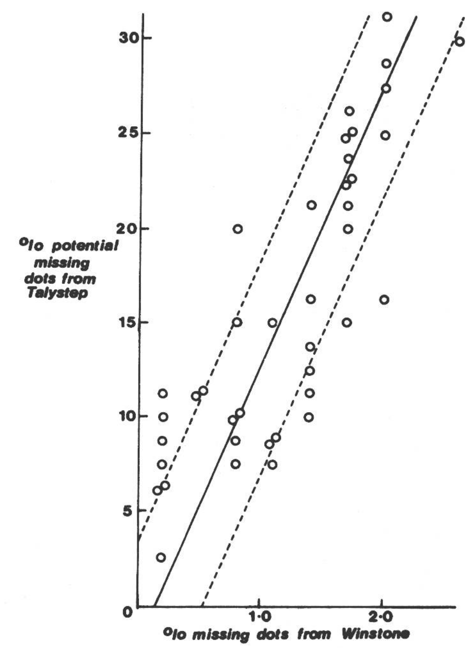
TABLE II

Pigment		TAPPI Gloss @ 10 g.s.m. Lab Calendered
SPS Clay		56
Experimental Clay	E1	75
" "	E2	48
" "	E3	40
" "	E4	39

The starch based formulations gave such poor results when printed under the standard experimental conditions that detailed analysis was not carried out. However, even here the experimental, narrow size distribution, coarse clay was significantly better than the other pigments. A results summary is given in Table III.

THE SURFACE PROFILE OF THE COATED SHEET

Stephan et al[7] have demonstrated the influence of roughness in the gravure print quality of heavy weight coatings. For their roughness determination they separated the surface profile trace into a long wavelength and short wavelength component. The roughness was determined by the short wavelength component. Our work using LWC paper has concentrated in the effect of the long wavelength component of surface profile, where depression greater than the diameter of a gravure cell are identified. By assuming a small compression of the peaks of the paper surface, the probable number of missing dots along a profile can be estimated. Such an estimate correlates to some extent with the print grade of the paper measured by missing dot counting, Fig.16.



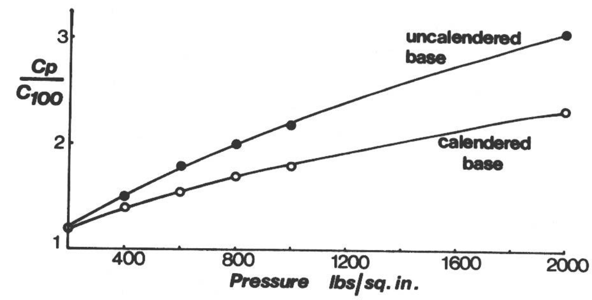
16. Possible percentage Missing Dots v. Experimental percentage Missing Dots

TABLE III

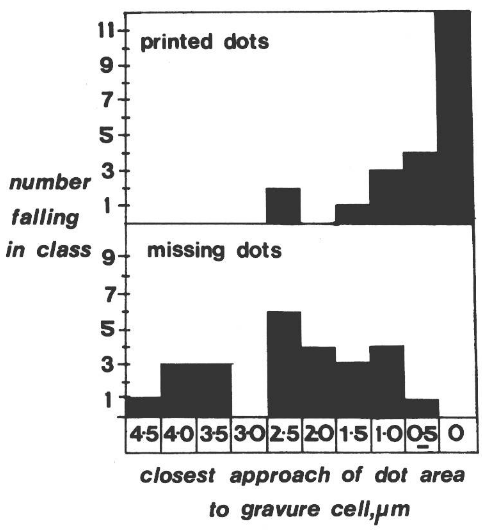
Results for 10 g.s.m. Starch Based Coatings

Calender pressure (kN/m)	TAPPI Gloss 66	TAPPI Gloss 130	Print Grade 66	Print Grade 130
Pigment				
SPS	50	59	>7	>7
U.S. No.2	51	60	>7	7
English Coating Carbonate	30	35	>7	>7
Experimental Clay E4	34	42	5.5	5

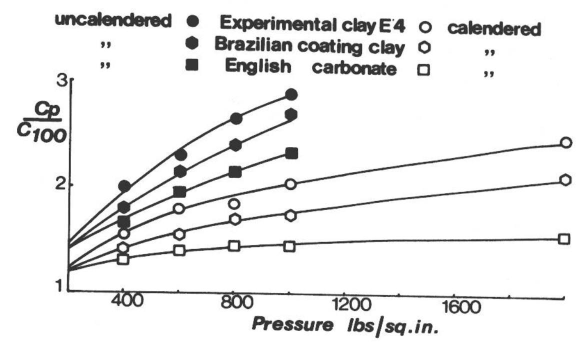
If the printed samples are examined by the stereoscan technique it is possible to measure the closest approach distance of the paper surface to the gravure cylinder, in the area where a dot has, or has not printed, i.e. in the area of the gravure cell. The results of such an examination are presented as a histogram in Fig.17. There is considerable overlap in the depth of depression where a dot will or will not print so that deformation of the paper surface in the printing process may be significant.



18. Compression Ratios of Base Paper



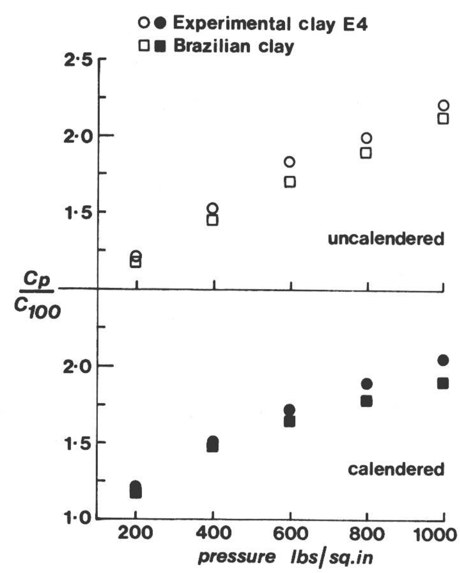
17. Distribution of Printed and Unprinted Depressions in the Paper Surface



19. Compression Ratios of Single Pigment Coatings on Aluminium Foil

THE COMPRESSIBILITY OF PAPER, COATINGS AND COATED PAPER

Fig.18 illustrates the compressibility ratio of a German LWC coating base paper measured over a pressure range of 0 to 2000 p.s.i. (0 to 13.8 M.Pa). The compressibility ratio is the ratio of the capacitance at the test pressure to the capacitance at 100 p.s.i. The use of such a ratio meant that results could be expressed independently of sample thickness and that at 100 p.s.i. sample contact with the condenser plates would be good. It is recognised that the pressures used in this work are considerably higher than the pressures encountered by the paper in the nip of a rotogravure press. Nevertheless the technique does measure a bulk property of the paper which may be relevant to the printing result. Figure 19 illustrates the compressibility ratios of a series of coatings on aluminium foil. Figure 20 illustrates the compressibility ratios of 10 g.s.m. single sided coating of the base showing the combined paper and coating result for the two clays tested. The compression ratios at 1000 p.s.i. are collected in Table IV.



20. Compression Ratios of Single Pigment Single Sided Coating, at 10 gsm, on 39 gsm Base

TABLE IV

$\frac{C_p}{C_{100}}$ at 1000 p.s.i. (6.9 M.Pa)

	Uncalendered	Calendered 66kN/m
Base sheet	2.6	1.6
E4 coating	3.8	2.1
Brazilian Clay coating	3.4	1.5
Carbonate coating	2.7	1.1
Base sheet plus single sided coating		
E4	3.2	2.1
Brazilian clay	2.8	1.9

It was a surprise to the authors that the compression ratio of the clay coatings could be higher than that of the base sheet. The compression ratios of the coatings showed significant differences for the different pigments. In particular the rankings of the compression ratios follow the rankings of the print quality established in the first part of this work.

The actual specific compressibility i.e. the compression per unit thickness per unit pressure does vary with the applied pressure and is indicated by the slopes of the curves in Figures 18, 19 and 20. The slope of the curves suggests that the compressibility is higher at the lower pressures, so that the influence of the compressibility of the coatings could be significant during the printing process.

CONCLUSIONS

1. Single pigment light weight laboratory coatings on light weight base paper show that the pigment does influence gravure printability.

2. Good printability correlations can be obtained for LWC gravure systems between the Heli-coater and mill results.

3. The coatings prepared with the latex adhesive can have compressibilities greater than that of the base paper.

4. Heavy calendering will not necessarily compensate for pigment deficiencies.

5. Coating clays with narrow size distribution can give very good printability even when the clay is very coarse by conventional standards.

REFERENCES

1. PIRA Printing Laboratory Report, No.54, December 1963.

2. Printing Technology, December 1964, P.62

3. TAPPI 1968 51, No.4, P.180.

4. PIRA International Conference on Gravure Printing, 27th February, 1974.

5. Wochenblatt für Papierfabrikation 1977, 20, P.821.

6. Wochenblatt für Papierfabrikation 1978, 6 P.225.

7. B.A.S.F. Symposium, June 1979.

8. Wochenblatt für Papierfabrikation 1978, 7 P.281.

9. The Microscope Vol.22, 1st Quarter 1974.

10. Whitehouse D.J. and J.F. Archard, Proc. Roy. Soc. Lond. A 316 P.97-121 (1970).

11. E.C.C. International Test methods P.106.

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QUALITY OPTIMIZATION BY CONTROL OF COATING STRUCTURE

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ABSTRACT

A study was made of factors affecting coating structure of LWC-paper. Analysis of dewatering characteristics is an indication for the magnitude of the immobilization solids level. Immobilization or agglomeration solids level shows an excellent correlation with fibre coverage and rotogravure printability in terms of missing dots. Agglomeration solids level can be controlled by establishing a pigment binder interaction either by a reduction of surface charge density of the binder, or by increasing the adsorption affinity on the pigment surface. Particle size distribution of the Pigment is the other major factor affecting printability. Coarser clays are more easily dewatered by hydrostatic pressure pulses and agglomeration solids is attained sooner.

INTRODUCTION

Coating of paper is performed to change its surface physical and physico-chemical properties and to improve printability and optical characteristics. Optimum printability requires a compromise between smoothness and capillarity. Both factors are controlled by pigment-distribution, pigment-orientation and-packing and binder distribution. Combination of above mentioned parameters dictates formation of a certain type of coating structure. Quality requirements for LWC-rotogravure papers in Europe have reached such a level that maximum fibre coverage by careful control of coating structure to achieve optimum printability is required.

All conventional paper coating formulations consist of a disperse pigmentphase and a disperse or dissolved binder phase with water acting as vehicle. Speed and type of dewatering is the most decisive factor controlling formation of a certain type of coating structure. The following principal, partially cumulative dewatering steps occur during application of a coating colour.

1. application: dewatering by pressure filtration
2. metering action of blade: dewatering by pressure filtration
3. distance from blade to drying section: dewatering by capillary forces
4. drying: dewatering by evaporation

1. Application of a coating colour by means of an applicator roll or similar elements generates a rather high hydrostatic pressure in the nip between applicator roll and paper web resulting in a pressure filtration effect. To prevent deep penetration of coating colour into the porous base stock, flow resistance of coating colour squeezed into pores of the base paper should increase as fast as possible to attain an equilibrium counter pressure. This desirable effect can be achieved either by an extremely fast loss of water due to hydrostatic pressure gradients or by an excessive increase in viscosity due to loss of small volume increments of water.

Between applicator roll and blade further dewatering at the interface base stock / coating colour may occur, but on a fast running coater this effect is, mainly because of the small time increments involved, negligible.

2. The metering action of the blade generates a further, short time pressure pulse. Obviously a coating colour which has not penetrated into the base stock during application can be more easily egalized and metered, requiring lower blade pressure. More coating remains on the base stock surface resulting in better fibre coverage.

The pressure pulse generated by the action of the blade contributes to further dewatering. The surface of the wet coating film after the blade shows a nearly ideal, plane surface. If the solids level of the coating film immediately after the blade is relatively low, further dewatering by capillary forces occurs.

3. Dewatering by capillary forces causes, by formation of agglomerates, micrograin structures resulting in a roughening effect of the wet coating film surface (Figure 1). Depending on the immobilization solids level, different contour following behaviour of the coating film is observed. At a coatweight of 10 g/m² thickness of the wet coating film is in the range of abour 10,4 μ at a solids level of 60 %. Further volume contraction due to dewatering results in a thickness reduction to about 8,4 μ at an immobilization solids level of 67 %. If immobilization takes place at a solids level as high as 75 % thickness of the remaining gelled coating film is only 6,4 μ. The lower the immobilization solids level, the better contour following properties are obtained (Figure 2) and the higher the bulk of the immobilized coating layer. To prevent formation of cracks in the coating layer during drying, immobilization should take place by formation of a mechanically rather rigid pigment matrix.

Uniform water absorption capacity of the substrate is of crucial importance for formation of the macro coating structure. Differences in water absorption capacity of the base stock are a result of differences in mass distribution of fibres, i. e. formation.

Low water absorption capacity of certain basestock areas stock means that immobilization solids level of the wet coating film in these areas is finally reached in the drying section of the coater.

Rapid dewatering caused by intense surface evaporation results in fractionation effects. Highly mobile pigment fines and binder particles are transported by convection currents to the surface of the coating layer. These migration effects are responsible for quality defects of the coated sheet like uneven ink receptivity commonly known as mottling.

4. Dewatering by evaporation unavoidably causes convection currents within the pigmentmatrix, resulting in an accumulation of mobile pigment fines and binder particles on the surface. This transport phenomena reduces capillarity of the coating surface, thereby lowering ink receptivity. Coalescence of synthetic binder particles on the surface creates local stress points within the pigmentmatrix leading to imperfections in the coating structure like cracks.

Accumulated deposits of synthetic binder on the coating surface may cause sticking on the calendar rolls. Theoretically it can be concluded that during application, metering and drying of a coating colour the location of the geometric point, where immobilization of the wet coating film occurs, is of prime importance for formation of a desirable coating structure. As immobilization is a dynamic process, speed and geometry of the coater are, apart from coating colour and raw stock composition, controlling parameters for the magnitude of the immobilization solids level. For formation of an optimum coating structure, immobilization of a coating film should take place immediately after the web has passed the blade.

This theoretical conclusion is confirmed by practical observations, that with coating systems which do not show a "mirror" after the blade, excellent fibre coverage is obtained.

General requirements for a coating colour, sufficing the above mentioned parameters, are good flow properties at low shear rate and rapid increase in viscosity during dewatering.

Principally two general approachs can be used to adjust immobilization solids level. Either like in figure 3 at the same dewatering speed, viscosity of the coating colour increases excessively parallel with a rather small increase in solids level, or water retention capability of the coating colour is reduced in such a way that after the blade a solids level is obtained which is high enough that corresponding viscosity behaviour of the concentrated coating colour results. The latter approach is, because of obvious reasons, like dilatancy streaks etc. not feasible. A combination of controlled waterrelease properties of the coating colour in conjunction with the above mentioned viscosity-solids level dependence seems the most viable way to control immobilization characteristics.

In an attempt to use an analysis of water release properties of a coating formulation as an indicator for coating structure formation, a simple dewatering test using ceramic plates was developed. Dewatering characteristics of coating formulations and pigment slurries were correlated with their actual performance, especially with respect to printability.

DETERMINATION OF IMMOBILIZATION SOLIDS LEVEL

1. Dialysis of a coating colour against saturated NaCl-solution demonstrates that dewatering speed decreases as solids level increases until finally equilibrium conditions are attained. Parallel with a decrease in dewatering speed, a rapid