TAPPI

PROCEEDINGS

1986 Coating Conference

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TAPPI's Antitrust Policy Statement

TAPPI is a professional and scientific association organized to further the application of science, engineering, and technology in the pulp and paper, packaging and converting, and allied industries. Its aim is to promote research and education, and to arrange for the collection, dissemination and interchange of technical concepts and information in fields of interest to its members. TAPPI is not intended to, and may not, play any role in the competitive decisions of its members or their employers, or in any way restrict competition among companies.

Through its seminars, short courses, technical conferences, and other activities, TAPPI brings together representatives of competitors in the pulp and paper industry. Although the subject matter of TAPPI activities is normally technical in nature, and although the purpose of these activities is principally educational and there is no intent to restrain competition in any manner, nevertheless the Board of Directors recognizes the possibility that the Association and its activities could be seen by some as an opportunity for anticompetitive conduct. For this reason, the Board has taken the opportunity, through this statement of policy, to make clear its unequivocal support for the policy of competition served by the antitrust laws and its uncompromising intent to comply strictly in all respects with those laws.

In addition to the Association's firm commitment to the principle of competition served by the antitrust laws, the penalties which may be imposed upon both the Association and its individual and corporate members involved in any violation of the antitrust laws are so severe that good business judgment demands that every effort be made to avoid any such violation. Certain violations of the Sherman Act, such as price-fixing, are felony crimes for which individuals may be imprisoned for up to three (3) years or fined up to $100,000, or both, and corporations can be fined up to $1 million for each offense. In addition, treble damage claims by private parties (including class actions) for antitrust violations are extremely expensive to litigate and can result in judgments of a magnitude which could destroy the Association and seriously affect the financial interests of its members.

It shall be the responsibility of every member of TAPPI to be guided by TAPPI's policy of strict compliance with the antitrust laws in all TAPPI activities. It shall be the special responsibility of committee chairmen, Association officers, and officers of Local Sections to ensure that this policy is known and adhered to in the course of activities pursued under their leadership.

To assist the TAPPI staff and all its officers, directors, committee chairmen, and Local Section officers in recognizing situations which may raise the appearance of an antitrust problem, the Board will as a matter of policy furnish to each of such persons the Association's General Rules of Antitrust Compliance. The Association will also make available general legal advice when questions arise as to the manner in which the antitrust laws may apply to the activities of TAPPI or any committee or Section thereof.

Antitrust compliance is the responsibility of every TAPPI member. Any violation of the TAPPI General Rules of antitrust compliance or this general policy will result in immediate suspension from membership in the Association and immediate removal from any Association office held by a member violating this policy.

General Rules of Antitrust Compliance

The following rules are applicable to all TAPPI activities and must be observed in all situations and under all circumstances without exception or qualification other than those noted below:

1. Neither TAPPI nor any committee, Section or activity of TAPPI shall be used for the purpose of bringing about or attempting to bring about any understanding or agreement, written or oral, formal or informal, express or implied, among competitors with regard to prices, terms or conditions of sale, distribution, volume of production, territories or customers.

2. No TAPPI activity or communication shall include discussion for any purpose or in any fashion of prices or pricing methods, production quotas or other limitations on either the timing or volume of production or sale, or allocation of territories or customers.

3. No TAPPI committee or Section shall undertake any activity which involves exchange or collection and dissemination among competitors of any information regarding prices or pricing methods.

4. No TAPPI committee or group should undertake the collection of individual firm cost data, or the dissemination of any compilation of such data, without prior approval of legal counsel provided by the Association.

5. No TAPPI activity should involve any discussion of costs, or any exchange of cost information, for the purpose or with the probable effect of:

a. increasing, maintaining or stabilizing prices; or,

b. reducing competition in the marketplace with respect to the range or quality of products or services offered.

6. No discussion of costs should be undertaken in connection with any TAPPI activity for the purpose or with the probable effect of promoting agreement among competing firms with respect to their selection of products for purchase, their choice of suppliers, or the prices they will pay for supplies.

7. Scientific papers published by TAPPI or presented in connection with TAPPI programs may refer to costs, provided such references are not accompanied by any suggestion, express or implied, to the effect that prices should be adjusted or maintained in order to reflect such costs. All papers containing cost information must be reviewed by the TAPPI legal counsel for possible antitrust implications prior to publication or presentation.

8. Authors of conference papers shall be informed of TAPPI's antitrust policy and the need to comply therewith in the preparation and presentation of their papers.

9. No TAPPI activity or communication shall include any discussion which might be construed as an attempt to prevent any person or business entity from gaining access to any market or customer for goods or services, or to prevent any business entity from obtaining a supply of goods or otherwise purchasing goods or services freely in the market.

10. No person shall be unreasonably excluded from participation in any TAPPI activity, committee or Section where such exclusion may impair such person's ability to compete effectively in the pulp and paper industry.

11. Neither TAPPI nor any committee or Section thereof shall make any effort to bring about the standardization of any product for the purpose or with the effect of preventing the manufacture or sale of any product not conforming to a specified standard.

12. No TAPPI activity or communication shall include any discussion which might be construed as an agreement or understanding to refrain from purchasing any raw material, equipment, services or other supplies from any supplier.

13. Committee chairmen shall prepare meeting agendas in advance and forward the agendas to TAPPI headquarters for review prior to their meetings. Minutes of such meetings shall not be distributed until they are reviewed for antitrust implications by TAPPI headquarters staff.

14. All members are expected to comply with these guidelines and TAPPI's antitrust policy in informal discussions at the site of a TAPPI meeting, but beyond the control of its chairman, as well as in formal TAPPI activities.

15. Any company which believes that it may be or has been unfairly placed at a competitive disadvantage as a result of a TAPPI activity should so notify the TAPPI member responsible for the activity, who in turn should immediately notify TAPPI headquarters. If its complaint is not resolved by the responsible TAPPI member, the company should so notify TAPPI headquarters directly. TAPPI headquarters and appropriate Section, division, or committee officers or chairpersons will then review and attempt to resolve the complaint. In time-critical situations, the company may contact TAPPI headquarters directly.

Statement of TAPPI Antitrust policy regarding submission of copies of correspondence to TAPPI headquarters

TAPPI headquarters needs to remain aware of what particular committees and sections of TAPPI are doing or planning to do in order to better assist those groups in achieving their objectives and to continue to supervise actively the antitrust compliance of TAPPI. The Board of Directors of TAPPI therefore has adopted this formal statement of TAPPI's policy which requires that persons corresponding or receiving correspondence on behalf of TAPPI provide copies of the type of correspondence outlined below to the appropriate liaison person at TAPPI headquarters.

For this policy TAPPI does not require copies of routine, written communications regarding arrangements for speakers, meetings, travel, dinner reservations and the like.

TAPPI headquarters does require that copies of correspondence of an important nature and of non-routine matters be supplied in a timely fashion to TAPPI headquarters personnel connected with the committee or section involved as shown below:

1. Plans regarding the activities of TAPPI committees or sections.
2. Communications with other TAPPI committees or sections.
3. Communications with persons or organizations outside TAPPI.
4. All written or recurring verbal complaints or criticisms of TAPPI activities.

All correspondence falling under the above-stated policy must be forwarded promptly to the appropriate TAPPI headquarters liaison person, preferably at the time of transmittal or receipt.

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WATER TRANSPORT IN THE BLADE COATING PROCESS

ABSTRACT

In order to obtain a better understanding of water transport in blade coating, studies have been made in a new type of apparatus which allows absorption times down to 1 ms as well as increased hydraulic pressures and temperatures. The results show that absorption in a non-pressurized situation is dependent on the rate of transfer of vapour molecules to the fiber surface, whereas the pressure is the dominating force already when a low external pressure is present. Pressurized as well as non-pressurized situations can exist in coaters. The results show that the pressure is substantially more important for the water transport than the dwell time.

INTRODUCTION

In the blade coating process a rising interest in the structure of the coating layer can be found. The structure is clearly dependent on the coating process used, on the coating color, and on the paper. In most articles on the coating structure at least one of the major factors is the water transport into the sheet. The work, however, has been more concentrated on the structure itself than on the water transport; it has been concluded that water is transported into the sheet. A pressure migration is usually thought to take place in the application step and a capillary migration in the distance between the application and the blade, as well as in the distance between the blade and the dryers. No actual work which evaluates even the magnitude of the water transport in papers during the prevailing pressures and temperatures has been done, and the water penetration studies which have been made, have taken place at room temperature and with no external pressure.

The purpose of this work was therefore to study the water transport into paper at the short times prevailing in fast blade coaters, and not only at atmospheric the pressure and room temperatures, but also at elevated pressures and temperatures. The results of such a work could be used to further eludicate the blade coating process, especially the differences between the conventional flooded nip coaters and the short dwell applicators.

WATER SORPTION

The transport of water, binders and pigments into the paper during the application process in the blade coater is by no means simple. The first step is probably the founding of a filter cake of pigment through which the further dewatering takes place. Such systems are difficult, perhaps impossible to investigate, but by model experiments with water the magnitude of the interaction can be evaluated.

When making measurements, the absorption times must also be taken into account. These times can be very short, and the time under the blade in a coater running at 20 m/s is ca. 0.025 ms, the dwell in the applicator zone ca. 1.5 ms. On a low speed coater, for example 180 m/min (3m/s), coater, where the distance between the blade and the applicator is 50 cm, the time for capillary sorption is 1/6 s = 170 ms. The time before drying can be several seconds.

For measuring, therefore, an apparatus is needed which can reliably measure water absorption from virtually zero time up to several seconds. Because many of the processes involve absorption under pressure, this must also be taken into account. The use of elevated temperatures would be a further need.

One of the testers most often used for water sorption is the so called Bristow wheel (1,2,3). In this apparatus, a small headbox with a known amount of liquid is put into contact with a paper. The water, or liquid, is stained and the length of the stain at a pre-set speed is measured. The length of the stain is a measurement of the volume absorbed per surface unit of the paper. The contact-time is related to the opening of the slice in the headbox. Contact times down to about 10 ms can be reached.

The apparatus used in the present investigation works according to the same principle as the Bristow wheel. Fig. 1 shows the main characteristics.

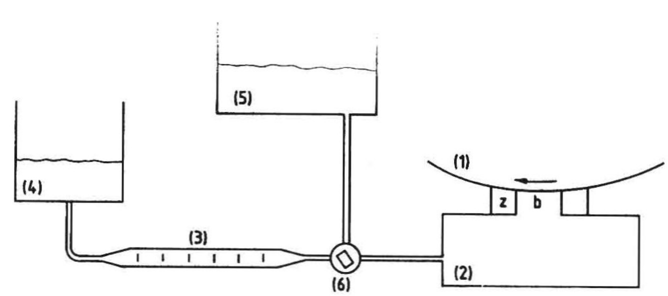

Fig. 1. System for measuring water absorption. 1. Backing roll, 2. Applicator (z = wall thickness, b = opening), 3. Burette, 4. Reservoir, 5. Reservoir for filling, 6. Three-way velve.

The speed of the backing roll can be adjusted in order to obtain contact times between the liquid and the paper in the range 0.001-20 seconds. The applicator is pressed against the backing roll with a predetermined, adjustable force. The applicator can be heated with an electric heater mounted inside. In this situation also a magnetic stirrer is put into the applicator in order to ensure an even temperature. The amount of water taken up by the paper is determined by injecting a small air bubble into the burette. The hydrostatic pressure is determined by the level in the reservoir.

This apparatus does not only allow measurements at considerably shorter times, but it can also be used to determine the absorption under pressures relevant to the coating process, as well as to determine the effect of elevated temperatures. Because of the direct volume measurement, there is no difficulty in determining the end point. (A "sharp-cut" stain is seldom obtained with the Bristow wheel.)

The contact time in the apparatus is obtained by dividing the opening of the slit and the wall thickness of the fountain by the speed of the paper (Fig. 2). In the work presented elsewhere (4), it has been shown that for most papers this distance, rather than the distance of the slit only, corresponds to the real wetting distance. It is well worth knowing that the same facts are due for the Bristow wheel as well, i.e. results obtained with the Bristow wheel must also be calculated according to the same method.

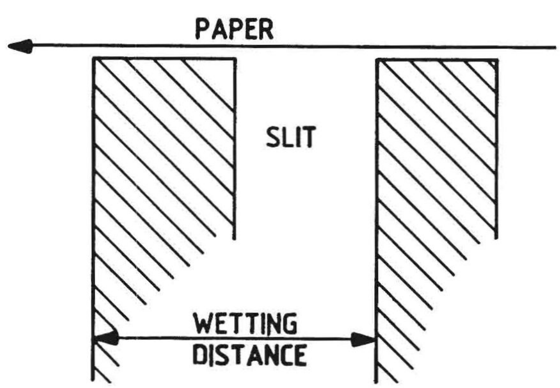

Fig. 2. Wetting distance in the applicator.

INFLUENCE OF TEMPERATURE ON WATER SORPTION

The influence of the water temperature on the water sorption,is seen in Fig. 3. As seen, the influence is very pronounced.

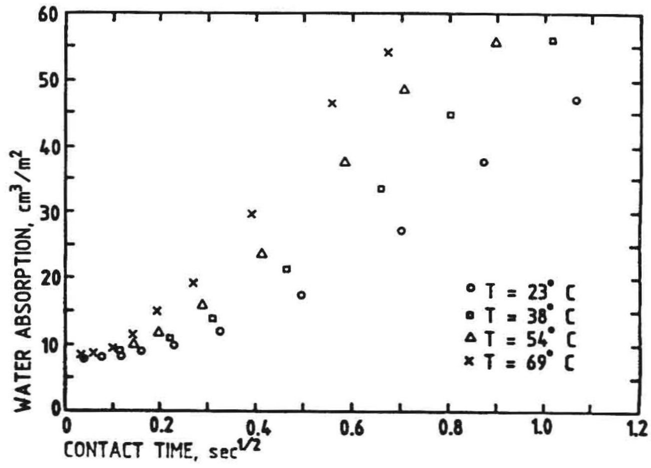

Fig. 3. Influence of water temperature on water absorption on 52 g/m^2 wood containing base paper for coating.

An increase in the temperature will decrease the viscosity as well as the surface tension water. It can be seen from the Washburn-Lucas equation (5,6)

$$l^2 = \frac{2\, r\, \gamma \cos\theta\, p_H r^2}{4\, \eta}\, t$$

where l = penetration length
r = pore radius
γ = surface tension
p_H = pressure
t = time
η = viscosity

which is frequently used to explain water penetration into paper, that the sorption is increased by the decreasing viscosity but decreased by the decreased surface tension, and that the Washburn equation cannot be used to explain the pronounced influence. However, a theory (7), founded on the idea that water vapour proceeds before the water boundary and decreases the contact angle (8,9) between paper and water, well explains the strong influence of the temperature on the water absorption. This fact indicates that the initial absorption when there is no external pressure is dependent on the transfer of vapour molecules to the surfaces on the fibres, i.e. on the vapour phase before the water boundary. At short times the water absorption is a linear function of the contact time between water and paper.

INFLUENCE OF PRESSURE ON WATER SORPTION

In Fig. 4 the influence of pressure on the sorption of water can be seen. The picture is changed from the linear relationship with time at zero pressure (the scale of the axis is the root of time), to a relationship which is parabolic, i.e. proportional to the square root of time. This indicates that the dominating process for water sorption also changes. The process, which for zero pressure was governed by the vapour pressure of the liquid, will now probably be dependent on the speed at which the air in the web is transported away. For this situation an equation can be derived (7):

$$l = \frac{(k_R^2 r^8 + 16\eta\,(p_H r^2 + 2\,r\gamma\,\cos\theta))^{1/2} - k_R r^4}{8\,\eta}$$

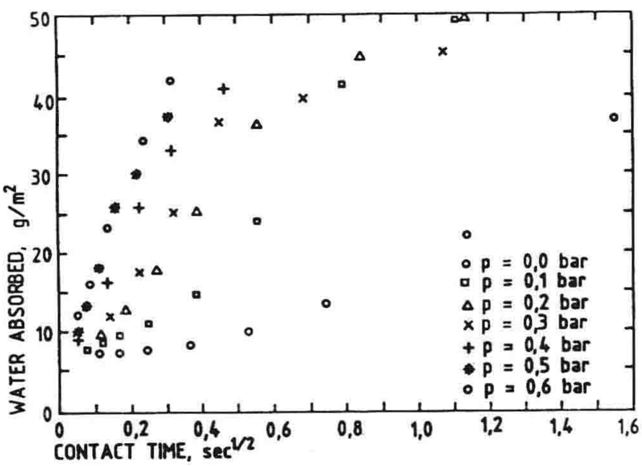

Fig. 4. Pressure penetration of water on 52 g/m^2 base paper for coating.

It can be noticed that this equation is somewhat similar to the Washburn equation previously presented and that the water absorption to this equation is dependent on the same factors in the same power as in the Washburn equation. It can be concluded here that the external pressure will be of decisive importance for the amount absorbed, and that the water amount will be dependent on the square root of time, regardless of the fact whether the Washburn equation or the air transport model is used.

WATER TRANSPORT IN BLADE COATING PROCESS

The blade coaters can be divided into several categories. The application of the coating color can be different as well as the blade configuration. The dwell time between the application and the blade can be different. From the point of view of the process as well as the water transport, the following division can be useful:

A. Applicators

1. Roll applicators
2. Contact applicators
   - jet applicators
   - fountain applicators
   - short dwell applicators
   - puddle applicators

B. Dwell time

1. Long dwell time
2. Medium dwell time
3. Short dwell time

C. Blade configuration

1. Bevelled blades
2. Low angle blades

Let us first examine the applicators. From the point of view of water transport, the main difference is the pressure exerted in the application zone. A work by Kahila (10) has shown that the pressure developed in the nip of an applicator roll is ca. 0.5-2.5 atm, and very dependent on the distance between the applicator roll and the backing roll, Fig. 5.

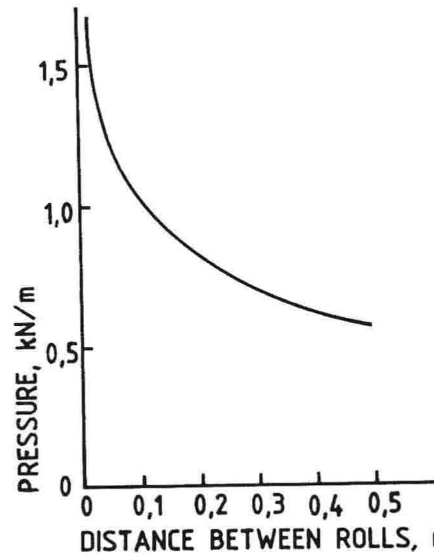

Fig. 5. Pressures in the flooded nip applicator.

Because the rolls are deformable, the distance over which the pressure is exerted is ca. 2-3 cm. It can be seen in Fig. 6 that a pressure of 0.6 atm during 0.002 s causes a water transport of about 5 g/m^2 for the LWC base paper used. It can also be concluded that if the pressure in the applicator zone is decreased, for example by increasing the distance between the rolls, then the water transport is diminished. This can be experienced as a better water retention of the coating color. This is well in accordance with practical findings reported by Ahonen (11).

For a low pressure system where the application time is of the same magnitude, i.e. the fountain, short dwell and jet applicators, it can be seen in Fig. 6 that the water transport is very much lower, in this case virtually zero, despite the fact that the paper is unsized and can be regarded as very absorbant. This means that the water retention requirements for coaters of this type are lower than for the applicator roll units.

The dwell time has during the last few years been a subject of much discussion because of the so-called short-dwell time coaters. It

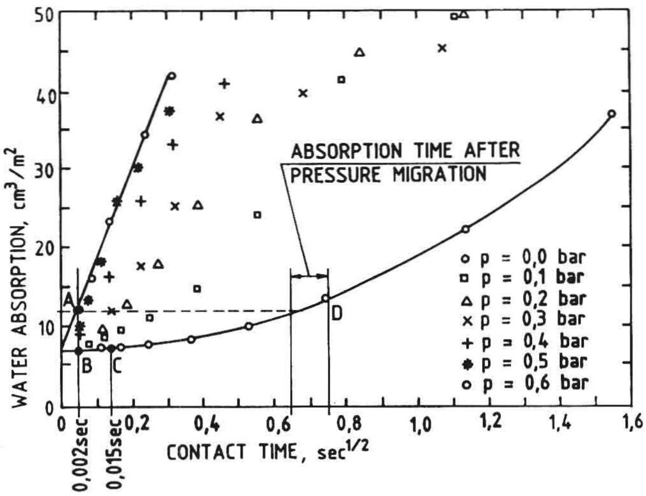

Fig. 6. Water absorption in different coating processes. A. flooded nip (12-7 = 5 g/m^2), B. Short dwell (7-7 = 0 g/m^2), C. Puddle (8-7 = 1 g/m^2), D. Long dwell (14-12 = 2 g/m^2).

can be seen in Fig. 6 what actually happens when the dwell time is increased. For the short-dwell applicator the contact time is ca. 0.002 s, which means that very little water is transferred to the paper. If the time is 0.015 s, as in a puddle coater at 800 m/min, the amount of water transferred is about 1.0 g/m^2, and for the capillary sorption after pressure migration in an applicator roll unit at 1200 m/min the amount absorbed is ca. 2-3 g/m^2.

On the basis of this discussion it is, however, quite obvious that the influence of the dwell time, also in a very absorbent paper is used, is considerably lower than the influence of pressure. Therefore should rightly the short-dwell coaters be renamed "low pressure applicators".

The fast dewatering taking place at an increasing temperature is especially interesting for board, where the temperatures are high and the times long. It can easily be understood that in a flooded nip unit the pressure pulse and the long time for capillary penetration easily can cause an excessive penetration of water, giving a very high solids content of the coating color in the boundary layer between paper and color. This easily leads to scratches and an inferior rheology.

Dewatering can also take place under the blade. The time under the blade for a machine running at 20 m/s is ca. 25 ns, i.e. 1000 times shorter than the times measured in the investigation. The pressures are appreciable, ca. 400 kPa (4 atm) (12). It can also be noted that when the color is under the nip of the blade there is no bulk of coating color from which water can be transferred; the only transfer is from the layer to the paper. If the (dangerous) extrapolation of the pressure curve in Fig. 4 is decreased to the actual times, it can be noted that a water transport of 0.5 g/m^2 can take place, Fig. 7. If a solids content of 60% is assumed, and the coat weight is 10 g/m^2, this dewatering corresponds to a solids increase of about 2%. This value is probably too low, because the pressure is higher than for the curve plotted in Fig. 7. It correlates, however, well with values actually measured for the dewatering (13).

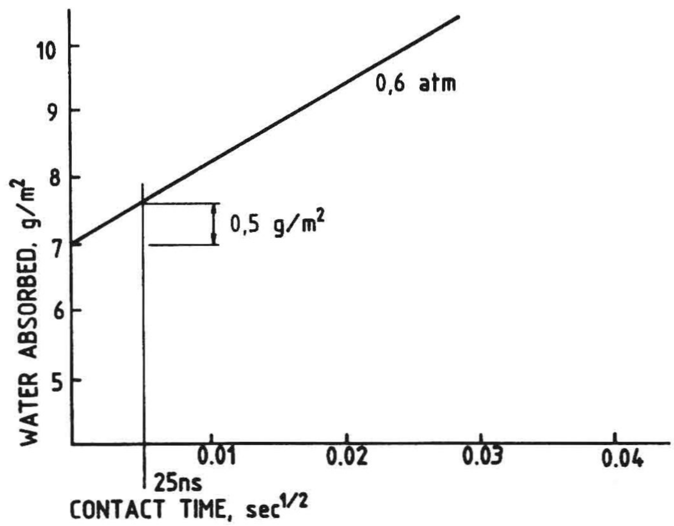

Fig. 7. Water absorption under blade tip.

For a low angle coater, the pressure zone is considerably longer, probably ca. 0.5 cm or more. For a coater running at 5 m/s (300 m/min) this means a dwell time of 1 ms under the blade. The solids increase in this case would be extensive.

CONCLUSIONS

The absorption of water during short times was found to be mostly dependent on the prevailing pressure. The pressure differences explain well the differences between different types of blade coaters in their demand for water retention and other properties of the coating color. The capillary migration which takes place between the applicator and the blade, as well as after the blade was found to be mostly dependent on the temperature, suggesting that the initial steps in the water transport in a non-pressurized system is a gas-phase transport of water vapour.

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This work was supported by a grant from the Finnish Akademi. The author thanks P. Salminen for the water sorption measurements.

COATINGS FUNDAMENTAL RESEARCH COMMITTEE

PANEL DISCUSSION ON SUSPENSION RHEOLOGY FOR COATINGS

Moderator

Professor Brian G. Higgins
Department of Chemical Engineering
University of California
Davis, California 95616

The aim of the committee on Coatings Fundamental Research is to provide a forum for researchers from academic institutions, paper and coating research laboratories, and interested practitioners of paper coatings to meet and discuss fundamental aspects of coating technology. The panel will address the fundamentals of suspension rheology and its relation to coating and optical properties and structure of paper coatings. New advances in optical methods that can deduce particle orientation in sheared suspensions, state-of-the-art rheological measurements for characterizing concentrated suspension, and the stability and interparticle interactions for colloidal systems will be discussed. Overviews on the need for coating fundamentals, and on the rheology and structure of paper coatings will provide the backdrop for the discussion.

The speakers for the session are:

1. Professor L.E. Scriven Department of Chemical Engineering and Material Science University of Minnesota
   Minneapolis MN 55455

   "Need for Coating Fundamental Research"

2. Dr. P. Lepoutre
   Pulp and Paper Research Institute of Canada
   Pointe Claire, Quebec H9R 3J9

   "Rheology and Structure of Paper Coatings"

3. Professor G.G. Fuller
   Department of Chemical Engineering
   Stanford University, Stanford, CA 94305

   "Optical Methods in Suspension Rheology"

4. Professor R. Rajagopolan
   Department of Chemical Engineering and Environmental Engineering
   Rensselaer Polytechnic Institute
   Troy, NY 12181

   "Colloidal Properties of Concentrated Suspensions"

5. Professor R.L. Powell
   Department of Chemical Engineering,
   University of California, Davis, CA 95616

   "Rheology of Concentrated Suspensions"

BUREAU OF ENGRAVING AND PRINTING EXPERIENCE WITH WATER BASED GRAVURE PRINTING

JOHN W. MERCER,
RESEARCH CHEMIST
BUREAU OF ENGRAVING AND PRINTING
WASHINGTON, D. C.
USA

ABSTRACT

This paper details the successful change-over of the Bureau of Engraving and Printing gravure postage stamp printing operation from an all solvent base ink system to an all water base system. Driving factors for this were increased safety, changing air pollution laws, organic solvent availability, and estimated cost reductions of 25 percent.

Ink problems resolved during this change include foaming, ink drying speed web breaks, press clean-up of dried ink, and corrosion. Paper problems encountered include curl, web breaks, inclusion of gum particles in the unprinted web, and mis-registration. An additional problem unique to the Bureau was the removal of particles from the paper print surface by subsequent intaglio printing on our combination gravure-intaglio press.

Present conditions successful stamp printing for paper, press speed and ink type are described, and a rapid method for distinquishing between prints made with water base gravure and solvent gravure inks is suggested.

The Bureau of Engraving and Printing (BEP) has been in gravure printing since 1967, when we contracted for printing of the first gravure United States postage stamp, the Thomas Eakins commemorative. BEP bought its first gravure press in 1970. This press, is a seven station press which can be used roll to roll, or roll to sheet.

It has in-line capabilities to apply phosphor taggants and to perforate the stamps. The first stamp from this press was the Missouri 150th Anniversary commemorative stamp issued in 1971.

The pressroom for this press has all the safeguards necessary for printing with nitrocellulose inks and highly volatile solvent systems--double covered electrical and light fixtures, airlock type double doors, grounded containers and sparkproof telephones.

During press start up and subsequent printing, we encountered the usual production problems typical of gravure printing--solvent shortages, misregistration, print mottle, snowflaking, viscosity fluctuations, and other routine problems.

Our first gravure paper was a 100 percent softwood coated sheet. We encountered problems in perforating this sheet due to the long softwood fibers causing hanging perforations, or trap doors. This perforation problem was considerably reduced by going to a paper with a 50/50 hardwood/softwood finish.

In 1972, the District of Columbia passed an air quality regulation which severely limited solvent emissions. In 1973, BEP contracted for a second gravure press, this one designed to print with water based gravure inks. Acceptance trials were held in 1975. This press, has five individual gravure units, followed by a single three color, solvent wipe intaglio unit, a flexo-type phosphor application unit with UV drier, a perforator, and a sheeter. It was anticipated that this press would become a workhorse, because of the variety of printing combinations possible. That this did not happen is not surprising in light of our inexperience with water base inks, combined with the registration problems inherent when trying to print with gravure and intaglio, two printing processes that make quite different demands on the paper.

To avoid confusion, the difference between gravure and intaglio should be defined and illustrated. The dictionary defines "intaglio" as printing in which the print image is sunk below the surface of the plate.[1] We define "intaglio" to mean printing in which the print image is composed of lines of various lengths, widths, and depths, which are engraved into the intaglio plate. Intaglio engravings are deep, intaglio inks are high viscosity, Intaglio paper is not generally coated, and the print image almost always has a distinctive three-dimensional feel to it which is not found in other types of conventional printing. These print characteristics are shown in Figure 1.

We define "gravure" to mean printing in which the print image is composed of dot patterns of various line screen sizes, which are etched or embossed into the surface of a continuous cylinder. Gravure cells are shallow, and gravure inks are low viscosity, gravure paper is usually coated for smoothness, and the printed image lies flat on the surface of the paper. These print characteristics are shown in Figure 2.

A combination of these printing processes would give the tonal gradation and color development of gravure with the snap and line clarity of intaglio. Canada and the United Kingdom had both printed and issued a combination gravure/intaglio stamp. The Canadian stamp was solvent gravure printed, used a chemically etched intaglio sleeve using paper wipe, and printed at speeds considerable slower than our 67 to 76 meters/minute. The English stamp had separate gravure and intaglio images which allows considerable float in print registration.

During acceptance trials, we encountered registration problems due to paper stretch after the web had passed through several stations of water base gravure printing, misregistration from the gravure units to the intaglio. We also encountered misregistration within the plate, because the individual stamp images were spaced one from the other based on our experience with paper printed with solvent base inks. The result of this last problem was that the stamps on the guide side would be well registered, but on the far side of the web, 47 cm wide, the images were out of register by 3-6mm.

In 1975 while acceptance trials were continuing on the combination press, the first water base gravure commemorative stamp was printed on our first gravure press. This stamp, International Women's Year was a three color design with heavy coverage, printed in self colors.[2] The paper used for this stamp was the second generation gravure paper, and the inks were developed using a maleic vehicle, which was found to give performance superior to the four other vehicle systems or the proprietary inks tried up to that time.

Other factors continued to drive further work on water base inks. Solvent cost remained high, and solvent availability was always somewhat of a problem. There was the continuing concern for employee health and prevention of fire and explosion in a solvent vapor filled room. Air quality regulations severely limited solvent emissions. The BEP determined that it was more attractive to use water based inks than to retrofit the press with emission control devices.

In the search for water based inks, the BEP received and continues to receive considerable support from the various private ink manufacturing companies.

After certification of the combination gravure/intaglio press in the fall of 1976, it was decided to print the 1976 Christmas "Winter Pastime" as the first stamp from the new press. Thirty to forty percent of the production run had already been printed with solvent inks. The remainder of the job was printed with water base inks.[3] Four color process inks with an additional line black were used to print the Currier stamp. Although the stamps should have been nearly identical, the finished stamps were unalike enough that they were given different Scott Stamp catalog numbers, based on phosphor tagging, line ink color and differences in the tendency toward snowflaking.[4] At that time the press had no electro-assist, and so it created more snowflakes than the original press which had the assist.

Even though the BEP had issued a stamp printed with water based, process color inks many problems still remained. Water based inks were prone to dry on the gravure cylinders with fairly short press stoppages; the adhesive backed paper stuck to the impression roller on emergency stops, and there were corrosion problems with the basic inks. Gravure cells were "short etched by 25 percent" to provide a shallow cell more amenable to water based inks, but the tinctorial formulations had to be altered to compensate for the reduced ink volume.[5] Although test work was conducted, because of the continued registration problems, as well as the inability to produce a combination gravure/intaglio stamp, the combination press was not used again until 1978. Two issues originally scheduled for the press had to be rescheduled onto other presses and not issued as gravure/intaglio combination stamps because of inability to print high quality, low spoilage work. Fortunately, the intaglio part of the press was able to contribute to the regular issue stamp program.

Gradually, water based ink formulas for individual colors were developed which gave satisfactory press performance. This led to the production of gravure commemorative postage stamps in the period 1977 to 1981 which were printed on the solvent gravure press, but which used one or more water base inks.

In the course of examining these various gravure images, it was discovered that solvent and water based gravure printing can be distinguished by examining the individual gravure dots. If a medium-to-heavy coverage gravure dot is uniform, it is solvent gravure. If the same coverage dot has micro craters in it, where small bubbles have burst and the ink has not leveled, the dot was printed with water base gravure inks. This is shown in Figure 3. This correlation, first discovered by our microscopist, Mr. John W. J. Collins, has held for all gravure stamps we have examined for the past four years, and we are now suggesting that it may be a general rule.