

Saturating kraft requirements for decorative and industrial laminates

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ABSTRACT: *Saturating kraft or core stock has grown into a specialty product with unique requirements. The important characteristics of this product include absorbitivity, dimensional stability, and surface properties. The absorbitivity is dependent on paper properties, resin properties, and treater process and design. The critical paper properties related to dimensional stability include the ratio of the number of fibers lying in the machine direction and cross direction of the paper sheet. Fiber structure and sheet formation are also important parameters.*

KEYWORDS: *Core stock, dimensional stability, laminates, saturation.*

There are five important attributes in the manufacture of core stock:

- Controlled resin pickup and penetration
- Dimensional stability
- Control of surface strength
- Low basis weight variability and good formation
- Freedom from pulp dirt and marks
- Freedom from sand.

One of the most critical considerations for the papermaker is designing saturating kraft grades to control resin pickup at the level specified by each converter. In addition, there must be adequate penetration of the resin into the pores of the sheet.

The finished laminate must be dimensionally stable in order to avoid cracking or seam separation problems in the final product.

Surface strength is important because the paper is rewet in a resin bath which can cause fiber picking in the dryer section of the treater. Excessive curl in the treated core stock will lead to severe manufacturing problems in laying up the decorative laminate. Core stock must therefore be free of curl after the resin impregnation.

The issues of basis weight variability and good formation go hand-in-hand. The converter views formation in terms of the uniformity of light transmission through the sheet. This relates to very small variations in basis weight. As shown later, the degree to which the dimensional stability of

the paper can be controlled is related to formation. Poor formation and basis weight control can lead to poor laminate surface quality and poor uniformity of bonding during the pressing operation.

Pulp dirt or marks in the sheet caused by the papermaking process can telescope through into the final laminate with concomitant loss of products. Finally, low sand count in the sheet provides improved tool wear in the finishing of decorative laminate.

Resin pickup and penetration

The rate and amount of resin pickup and penetration is a primary concern to the converter. Resin pickup is the weight increase of the paper after absorbing the resin expressed as percentage as shown in Eq. 1:

$$\% \text{ Resin Pickup} = 100 (T - U)/T \quad (1)$$

where

T = treated weight

U = untreated weight.

Resin penetration describes the flow of the resin into the sheet center. If the fibers in the center of the sheet are dry, the penetration is generally considered inadequate.

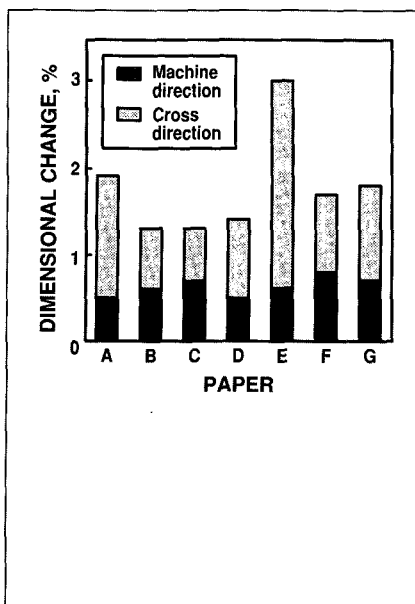
Laminates require different levels of resin pickup and penetration depending on the various end uses.

Resin costs can be 1.5 times as much as that of other raw materials used in the production of laminates. From an economic standpoint, therefore, any decrease in resin content while maintaining final product quality is advantageous. When the treater process is

I. Factors influencing resin pickup and penetration

Resin variables
Molecular weight
Solids content
Viscosity
Surface tension
Paper variables
Void volume
Density
Porosity
Sizing
Additives
Treater process variables
Resin temperature
Oven temperature
Design
Dip and scrape
Dip and squeeze
Coating
Sky rolls

1. Dimensional stability of several papers



II. Approximate response of paper and resin to humidity changes compared to 50% RH

	Machine direction	Cross direction
Paper	±0.5%	±1.2%
Resin	±0.1%	±0.1%
Laminate	±0.3%	±0.7%

+ is response to 98% RH and - is response to 2% RH.

the limiting factor for production, improvements in pickup can increase total productivity.

There are a wide variety of resin and paper properties which can contribute to resin pickup and penetration. **Table I** delineates several of the primary factors.

For saturating kraft suppliers, resin variables and treater process variables are completely dependent on the laminator. It is necessary to concentrate on developing the proper paper variables for each laminator. Since every laminator has unique requirements, cooperation between saturating kraft suppliers and laminators is necessary.

Dimensional stability

The dimensional stability of saturating kraft is an important contribution to the final laminate product. A sheet with poor dimensional stability can cause separation of the decorative laminate from the veneer base or an undesirable separation of the seams in the final product. Cellulose fiber is a very hydrophilic material. As humidity varies, the cellulose fiber imbibes water and swells.

Figure 1 shows the response of different types of paper to changes in

relative humidity. In the machine direction, paper will swell only about 0.5% as the humidity changes. Swelling in the cross direction is greater and can range from about 1–3%. **Table II** shows the response of paper, resin, and laminate to changes in humidity. Unlike the paper base sheet, the resin is completely uniform in all directions. Typical commercial resin will swell about ± 0.1% over the humidity range of 2–98%.

In the laminate, the machine direction will swell about 0.3%, while the cross machine direction experiences about 0.7% swelling.

The resin is actually preventing the fiber from swelling. These results suggest that the laminate dimensional stability would improve if there were reduced swelling of the cellulose fiber.

Relation of fiber structure to swelling tendencies

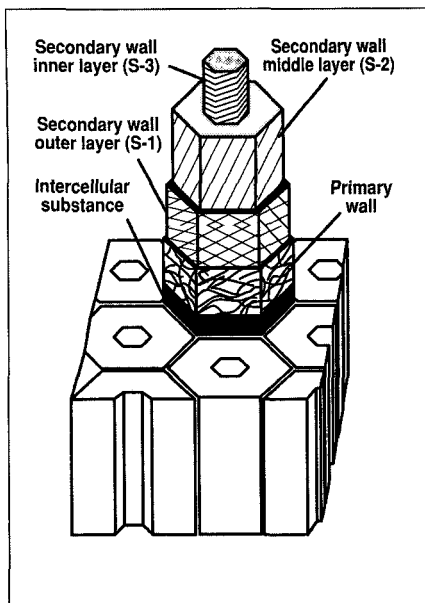
The first step in understanding the role of the fiber in sheet swelling is an examination of the structure of the cellulose fiber. **Figure 2** is a schematic representation of a cellulose fiber. The fiber is composed of the primary layer, the S-1 layer, and the S-2 layer. In each of these layers, the cellulose mol-

ecules are long straight chains with specific orientations. In the primary layer, the chains are relatively short. The orientation is mostly random. The principal bulk of the fiber is contained in the S-2 layer where the cellulose molecules have formed a cross-hatched, spiral pattern. This cross-hatched pattern of cellulose molecules restrains the fibers from swelling along the axial direction but allows them to swell in the radial direction.

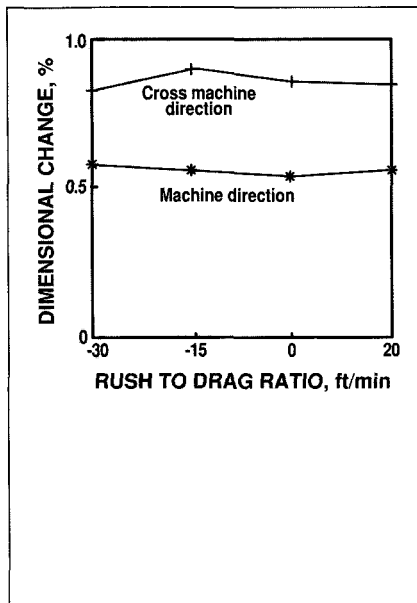
Using this structural property, it is possible to postulate that the swelling in a paper sheet relates to the number of fibers which lie in the machine direction and the cross direction, respectively. If more fibers lie in the machine direction than the cross direction, then the machine direction will swell less when the paper sheet imbibes moisture, because of the restraining effect of the cellulose.

Figure 3 shows the result of a study in which the number of fibers in the machine and cross directions have been systematically varied. It shows that ratio of rush to drag influences the overall swelling of the sheet. The operating parameter of rush to drag controls fiber ratio which is the number of fibers in the machine and cross machine directions. As the sheet becomes

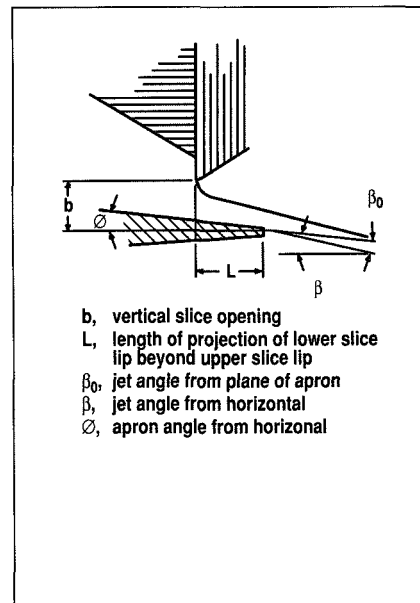
2. Cellulose fiber



3. Paper dimensional stability



4. Schematic of headbox



more square, i.e., contains an equal number of fibers lying in the machine and cross direction, the sheet dimensional stabilities become more uniform.

Two questions arise. How can the papermaker influence the machine to cross direction ratio of fibers? What effect does this ratio have on other sheet properties?

Headbox control

On a paper machine, the ratio of the wire speed to the velocity of the headbox jet controls the fiber orientation. **Figure 4** schematically shows the arrangement of a headbox. The vertical slice opening is the principal headbox parameter controlling the fiber orientation, since it determines the velocity of the jet delivery onto the wire. Another important headbox parameter is pressure. These two headbox parameters determine the velocity of the jet as it exits the headbox.

The speed of the wire itself, which is controlled by the machine drive, is also influential. Theoretically, when the spouting velocity of the headbox is equal to the wire speed, there will be no preferential orientation of fiber other than that induced by shear forces in the headbox itself.

When the wire speed is lower than the jet speed, there is a preferential orientation in the cross machine direction, since the waterjet is in essence pushing itself into the wire. This is called "rushing" the sheet.

If the jet speed is slower than the wire speed, then fibers are preferentially oriented in the machine direction. This situation is called "dragging" the sheet.

Figure 5 shows the relationship between the laminate stability and the rush to drag ratio. The jet speed is exactly matched to the wire speed, i.e., the most random sheet possible. The change from this equilibrium point in either direction causes the dimensional stability to decrease. These results are consistent with the laboratory results shown earlier and suggest that control of rush to drag ratio can assist in control of dimensional stability in the core stock.

Formation

The operation of a headbox also greatly affects sheet formation, which is another primary area of concern to the laminator. **Figure 6** shows the effect of rush to drag ratio on sheet formation. It indicates that formation fol-

lows the same trend as dimensional stability and fiber orientation. Formation improves as the sheet becomes more square. This is one of the rare occasions in papermaking when two critical parameters are improved by the same papermaking tool.

Conclusion

The requirements of the converter for saturating kraft are continuously changing. Linerboard or near-linerboard sheets were satisfactory at one time. Presently, a sophisticated approach is necessary to develop a sheet with well controlled properties. Resin pickup and penetration vary between laminators and product lines. It is necessary to develop and control carefully the paper requirements to meet these demands. One approach to maintaining dimensional stability is the control of jet to wire speed of the paper machine. It is necessary, however, to consider other factors such as formation in implementing this control. The trend of the laminating industry in the past 20 years has led to the development of heavyweight sheets which puts increasing demand on paper machine control. **□**

Suggested references

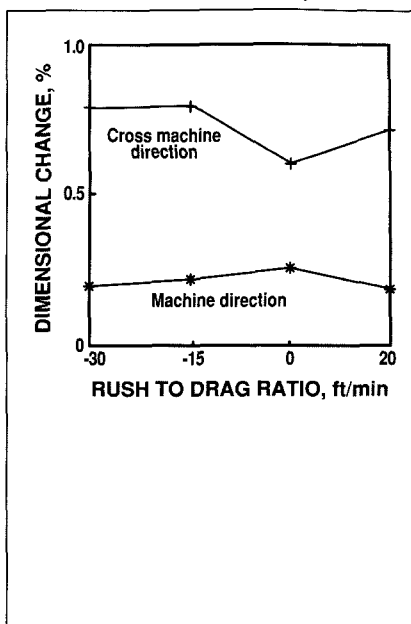
1. Adams, D. O., TAPPI 1983 Plastic Laminates Seminar, TAPPI PRESS, Atlanta, p. 7.
2. Morton, R. and Crosby, C. M., Tappi J. 52(4): 681(1969).
3. Manson, D. W., TAPPI 1985 Wet End Operation Seminar, TAPPI PRESS, Atlanta, p. 97.
4. Kershaw, T. N. and Bambrick, T. J., TAPPI 1985 Wet End Operation Seminar, TAPPI PRESS, Atlanta, p. 5.
5. Nelson, H. C., Tappi J. 43(4): 330(1960).
6. Manson, D. W., in Pulp and Paper Manufacture (M. J. Kocourek, Ed.), TAPPI PRESS, Atlanta, 1991, Vol. 7, Chap. VIII.
7. Brazier, K. A. and Ellis, R. L., TAPPI 1987 Nonwovens Conference, TAPPI PRESS, Atlanta, p. 221.

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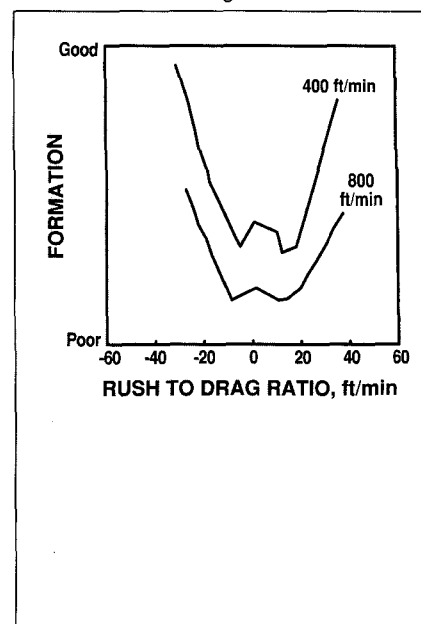
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5. Laminate dimensional stability



6. Effect of rush to drag ratio on formation



CORRECTION

Incorrect figure printed

An error occurred in a paper by Rajinder S. Seth, A. Gordon Robertson, Yiu-Wing Mai, and John D. Hoffman entitled "Plane stress fracture toughness of paper," published in the February issue of *Tappi Journal*. In Fig. 2 on page 111, the load-displacement curve was incorrectly represented. The correct figure appears here.

2. Load-displacement curves for DENT specimens with ligaments 12 and 24 mm. The test material is No. 8 in Table I.

