Coated Linerboard
An Evolving New Grade of Coated Paperboard

Charles P. Klass
Director of Paper Technology
The Kohler Coating Machinery Corporation

"Visual appeal linerboard" is one of the fastest growing value-added segments of the containerboard and corrugated market. There is continued pressure to upgrade quality. For a growing number of users of corrugated containers, "plain brown boxes" are neither plain nor brown anymore. Many customers who made the switch from brown to mottled white over the past several years are now seeking a surface with better optical uniformity. There is continued pressure toward multicolor printing and direct process color printing.

Current US consumption of linerboard is about 20.5 million tons. About 10 million tons of this is printed for use either as outside liner on corrugated containers or for displays. Ten years ago, only about 5% of linerboard was either white top or mottled white. At present, about 28% of printed liner is on a surface other than brown, including mottled white, white fiber top, and coated. Packagers and corrugators forecast that by the turn of the century, at least 50% of all printed liner will be on a surface other than brown. Assuming an average 3% GDP growth rate, this would translate to a US market for about 5.5 million tons of visual appeal linerboard by the year 2000. It is unlikely that all of the incremental 3.3 million tons of demand for white surface, high print quality liner will be obtained from white fiber topped products. There is also a likelihood that the growth rate of linerboard coating will be even faster overseas, especially in developing countries, than in the USA. Thus this market represents true new growth of consumption in coating materials rather than displacement of existing materials by other products.

The primary motivation for growth in visual appeal liner is external to the corrugated industry and may be generally expressed as having two sources:

- Residual demand for better print quality at an economical cost in corrugated containers;
- Changes in retailing--specifically, continued growth of mass merchandising leading to less personal selling and more dependence on product information provided on the package--four sided, multicolor graphics which create product differentiation at the point of sale.

Mass merchandisers have replaced salespersons with clerks or central check out. The package itself is the salesperson. It has to have visual impact, color, brightness, and excellent graphics. This level of quality is difficult to obtain with the long practiced method of flexo printing on the board or box after it has been laminated on the corrugator. In an attempt to meet the quality requirements, some packaging producers started laminating preprinted coated paper (box labeling or overwrap) onto the board after it was corrugated. This was a difficult process with high waste rates and problems with register and dimensional mismatch. In the late 1970's the technology and equipment were developed to solve the misregister problem. The corrugator could be run so as to make the printing appear in the right position on the finished container, i.e. the liner could be "preprinted" using better quality printing processes than could possibly be carried out on a wavy surfaced corrugated board.

Preprint grew through the 1980's. Most preprint operations use flexo printing. There is some use of offset printing, and a few installations use rotogravure.

Figure 1 illustrates the quality/cost/performance relationships of the six major grades of paper currently used for preprint. The positions on the graph attempt to rank them by overall contribution including:

- aesthetics,
- press performance,
- combinability,
- sheet balance,
- strength properties, particularly edge crush,
- score cracking resistance,
- cost.

It can be seen that the most effective approach to make a suitable sheet at economical cost would be to find a way to improve kraft linerboard to give it the print surface quality associated with coated SUS and SBS but at a lower cost.

Producers of coated SUS lose productivity when running the lower basis weights needed for preprint. For this same reason, it would not be practical to install an on machine air knife coater on a high speed, high production rate linerboard machine. It is practical, however, to off machine coat linerboard to make the needed grade. Before discussing the required coating processes to make a coated preprint linerboard, it is desirable to review the changes in direct print corrugated.

The flexo printing process has been subject to numerous improvements over the past decade. To improve fidelity, plate makers have reduced thickness from 0.067 to 0.045 inch (1.7 to 1.14 mm). Doctor blades on anilox rolls are becoming commonplace. In some cases, foam material is being added as a layer on the impression cylinder, a "shock absorbing" layer, or under the plate. Photopolymers have improved dot accuracy. Optimized ink transfer, targets for color accuracy and tone, and improved register are now parts of the direct print process in many plants. Printing on corrugated boxes, not preprint, has improved to include 150-line screen and process color.

Today, many box makers are looking to achieve "preprint" graphic quality through direct print on corrugated. Achieving this may require a different combination of sheet properties and surface characteristics. Some of the grades which perform well on preprint presses, such as coated SBS and coated SUS, are problematic in direct print. The major problem area is the lack of drying in direct print operations. On a case making machine, the sheet is gripped by belts immediately after printing. If the surface cannot absorb the ink vehicle (water) rapidly, there will be belt marks on the printed surface.

Paper machine improvements have made lighter weight high performance liners a reality. The use of bleached fiber as top liner has an unfavorable effect on sheet structural properties, especially at lower weights. Additionally, bleached fiber usage can complicate papermaking. Since the amount of white fiber required per unit area to get a given brightness and optical uniformity is constant regardless of overall basis weight, the bleached fiber ratio increases as sheet weight decreases. Problems with delamination are common when trying to make white top liner at low basis weights.

A number of box plants have begun coating on the corrugator over the past several years. They apply premixed coatings which are expensive. Theses coatings are latex based and have large proportions of titanium dioxide pigments. Most of the coaters used are rod coaters. With this combination, it is necessary to apply heavy coat weights to obtain optical uniformity. This coating process produces a sheet surface which is not optimized for flexo printing. In addition, some plants have found it necessary to reduce corrugator speed when coating. Most corrugated plant managers would prefer not to coat on the corrugator and resort to it out of economic necessity.

There is a growing need for a range of coated linerboard grades to meet the requirements of a changing marketplace.

It appears that the market is trending toward a range of four grades which may be classified according to the following characteristics:

C Brightness (standard deviation of brightness to indicate degree of optical uniformity),
C Surface properties including smoothness and scuff resistance,
C Type of printing to be done on the surface.

I. Premium White for Preprint and Displays

<80 TAPPI Brightness (SD <1)
<150 Sheffield smoothness
Process color flexo or offset printing

II. No. 1 Standard White

78-80 TAPPI Brightness (SD 1-2)
Scuff resistant
Multicolor direct flexo printing without drying
Limited process color printing

III. No. 2 White

70-75 TAPPI Brightness (SD 3-5)
Scuff resistant
Flexo line art and type printing

V. No. 3 Economy White

- 60-65 TAPPI Brightness (SD 3-8)
- Optical uniformity not critical
- Scuff resistant
- Flexo line art and type

Grade IV is the equivalent of the current common mottled white. Grade III is the premium white top similar in optical uniformity to the sheet being made by multi-ply forming. Grades I-II require coating to obtain optical uniformity.

With the proper combination of coating formulation and coating process, it is practical to make Grades II-IV without the use of titanium dioxide. Grade I can be made with much lower percentages of titanium dioxide than currently used by the two major US. producers of clay coated SUS. The surface produced is scuff resistant, glueable with standard adhesives, and direct flexo printable without supplementary drying. The coating does not adversely affect the strength properties of the linerboard base stock.

The economics of coating using these formulations and technology make it practical to make an improved quality sheet at a cost less than or equivalent to the cost of white fiber. In fact, a sheet with Grade IV quality can be made for less than the cost differential between standard and mottled white liner. Grades I-II can be made for costs lower than bleached board or the cost of materials for on-corrugator coating.

It is practical to coat any basis weight of linerboard. Both natural kraft and recycled fiber linerboard can be coated. Smoothness and sizing of the linerboard can impact the amount of coat weight and the formulation required.

To obtain optimum performance from the coating materials, it is usually necessary to apply more than one coating. Different types of coater application equipment may be used at each coating station.

Three coating stations may be required to make Grade I. If smoothness is not a critical requirement, the required brightness and optical uniformity may be obtained with two coating applications.

It is practical to make Grades III and IV with a single application of coating, but significantly lower coating material cost and better overall economics can be achieved with two coating applications. Economical production of Grade II requires two coating stations.

Coaters may be categorized into three types:

- Leveling coaters which fill the valleys and trim off the peaks such as smooth rod and blade coaters.
- Contour following coaters which apply a uniform thickness of coating such as air knife and transfer roll coaters.
- Volumetric metering coaters which fall in between the above two, such as threaded or wire wound rod coaters.

Compared to white coating base stock, linerboard is a relatively rough and dark surface. The coating must not only hide the brown base sheet but also improve the uniformity of the surface as a printing medium.

If a blade or smooth rod coater is used as the sole coater, there will be a variation in coating thickness which will result in optical mottle which is often more severe than that obtained with white fiber applied by a secondary headbox.

If an air knife or other contour following coater is used as the sole coater, the dark base sheet can be successfully hidden. Optical uniformity is obtained but the resulting sheet is not smooth. This is further complicated by the fact that contour following coaters must be run at relatively low solids and viscosity. When an air knife coating is applied directly to a relatively porous unbleached or recycled kraft sheet, there is likely to be significant soak in. Water transported into the base sheet causes fiber swelling and can also cause dusting.

The optimum process for white (or color) coating of brown kraft linerboard usually involves precoating with a leveling coater at high solids, followed by contour following coating. The precoating formulation is designed to provide a balance of optical improvement and uniform coating holdout for the next coating applied. When a contour following coating is applied over a properly precoated linerboard base sheet, optically uniform hiding of the dark base sheet is achieved with minimal use of expensive pigments.

If finished sheet smoothness is critical, the optimum process is usually leveling precoating at high solids, contour following coating to achieve optical uniformity, and rod/blade top coating. This is essentially the process used by the major producers of coated SUS.

Drying of the coatings is a critical unit operation to achieve a quality coated surface. In most cases, a combination of infrared and high velocity air drying is used.

Modern linerboard machines are large, high production units. Until the market for coated linerboard develops sufficiently to justify dedicated machines, it will be desirable to coat off machine. Running an on machine coater section only a small fraction of the time would be likely to cause efficiency and quality problems.

An off machine linerboard coater is usually designed for a speed of about 1000 feet/minute (300 M/min), which is compatible with contour following coaters. With 60 inch (1.5 meter) diameter rolls of linerboard, a 1000 fpm coating line speed provides a minimum of 20 minutes run time between roll changes, which is desirable from an operating efficiency point of view.