Properties of liners

Presented by
Ram Kumar Sunkara
FCBM work shop

Raw Material consumption in %

<table>
<thead>
<tr>
<th>Material</th>
<th>Consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper consumption</td>
<td>95.13%</td>
</tr>
<tr>
<td>Starch consumption</td>
<td>3.49%</td>
</tr>
<tr>
<td>Stitching Wire Cons.</td>
<td>0.63%</td>
</tr>
<tr>
<td>Bundling strap cons.</td>
<td>0.38%</td>
</tr>
<tr>
<td>Printing ink</td>
<td>0.38%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100.00%</strong></td>
</tr>
</tbody>
</table>

S. S. Consultants, Pune. www.ramkumarsunkara.com
Elements of Liner board

- Strength required to add to the column strength
- Good print characteristics
- A degree of water resistance
- Ability to bond quickly to the medium.

Elements of twin layer Liner

- Top outside layer, around 30% of total thickness. Processed for
  - Smoothness
  - Appearance
  - Water resistance
- Base layer, around 70% of total thickness. Processed for
  - Strength
  - Slightly rougher and more absorptive.
### Key characteristics of Liner

<table>
<thead>
<tr>
<th>Moisture</th>
<th>Basis weight or GSM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bursting strength</td>
<td>Porosity</td>
</tr>
<tr>
<td>Caliper</td>
<td>Internal bond</td>
</tr>
<tr>
<td>Tear Factor</td>
<td>CD Stretch</td>
</tr>
<tr>
<td>Sizing</td>
<td>Smoothness</td>
</tr>
<tr>
<td>Compression resistance – RCT / SCT</td>
<td>Double fold</td>
</tr>
</tbody>
</table>

### Moisture content

- Moisture content is the amount of water present in liner expressed as a percent moisture content.
- Various hand held instruments are available to measure conductivity capacitance, which is related to the moisture content of paper.
- TAPPI – T 412 is the reference test method
Moisture content

• Liner moisture content should be uniform throughout the roll.
• Both in MD (machine direction) and CD (cross direction)
• It should be neither too low nor too high and should vary relatively little from roll to roll.

Moisture – Potential problems

• Moisture variation leads to warping of the combined board.
• It can affect bond formation between flute tips and the facings.
• It can effect the folding properties of the combined board.
• Very low moisture content can retard the receptivity of liner to adhesive causing problems on single facer.
Moisture – Potential problems

• Very low moisture in liner can lead to score line cracking.
• Very high moisture can lead to excessive CD shrinkage.
• Roll to roll moisture variation can cause board warp.
• CD moisture streaks can cause ‘S’ warp and blisters.
• Low moisture can lead to web breaks.

Basis weight

• Basis weight is a measure of the weight per unit area.
• Generally expressed as grams per square meter at a specified moisture level.
• TAPPT – T 410 is the reference test method.
• Non-uniformity of basis weight causes problems through the effects of variation in other properties.
Basis weight – Potential problems

• Non-uniform basis weight leads winding quality of the paper roll.
• Weight variation of container.
• Affects the liner meter-age in production.

Sizing

• Sizing is a characteristic pertaining to liner’s ability to resist water penetration and adsorption.
• TAPPI – T 441 test method is used to quantify the degree of sizing in liner.
• Most adhesives used in corrugated box manufacturing are water based, thus the rate at which liner absorbs water can affect the quality of bonding.
Sizing – Potential problems

• If liners are slack sized (high Cobb), it may dewater corrugating adhesives before the gel temp is reached, resulting in a weak “chalky” bond.
• If liners are hard sized (low Cobb), it may inhibit penetration of the adhesive into the fiber structure resulting in a poor bond with little fiber pull or tear.

Sizing – Potential problems

• Considerably more amount of ink will be required on high Cobb liner to achieve the same color density.
• If liner Cobb is very low, we may require to reduce the speed of printing machine to avoid smearing of ink.
• Moisture in higher in high Cobb paper as compared to regular Cobb paper at the same humidity.
Bursting strength

• Bursting strength is a measure of the force required to break through a given area of the board as pressure is applied to one side.
• Bursting strength is also referred to as “Mullen”
• The bursting strength of liner has no direct effect on combing the board or in converting operations.

B.S – Potential problems

• The bursting strength of corrugated board is a direct function of the liner bursting strength, thus B.S below specified value for liner may result in corrugated board that fails to meet grade requirements.
• Most impact is on “COST”
Compression resistance

• Compression resistance correlates with the vertical stacking strength potential of the corrugated boxes.
• There are two commonly used methods for measuring compression resistance in liner
  • RCT (Ring crush test)
  • SCT or STFI (Short span compression test)

Compression resistance

• TAPPI – T 818 test method measures the RCT of liner
• TAPPI – T 826 test method measures the SCT of liner.
• RCT or SCT value has no direct effect on combined board or converting operations.
Compression – Potential problem

- Failure to meet specified minimum RCT or SCT values on liner will result in boxes that will not meet stacking strength expectations.

Porosity

- Porosity is the measure of how easily air can pass through liner.
- Porosity is measured using a Gurley tester (TAPPT – T 460) or Sheffield tester (TAPPI – T 524)
- Gurley test measures the time required to pass a given volume of air through the sample.
- Sheffield test measures the rate at which air passes through the sample.
Porosity

• Porosity of liner affects the rate at which air, water vapor and to some extent liquids will pass through or will be absorbed by the liner.

• Porosity can have an effect on corrugator operations by affecting the rate at which moisture, in form of water vapor, can be removed from liners or how receptive the liners are to adhesive.

Porosity

• It can affect converting operations with respect to ink absorption rates.

• It can affect vacuum type box set up equipment and case sealing operations.

• Low porosity create more difficulty in removing excess moisture on the corrugator pre-heaters because the low porosity inhibits the movement of water vapor through the liner.
Porosity

• Low porosity also inhibit liquid penetration into the surface, leading to bonding problems particularly at the single facer.
• Or to ink penetration into liner leading to slowing down the machine to avoid smearing.
• On folder gluer, due to adhesive hold out more time is need to press down.

Porosity

• High porosity liners can create
  • Corrugator bonding problems
  • Variation from the color expected of a liquid ink.
  • Glueability problem on folder gluer through excessive absorption of glue before closure takes effect.
• Excessive air flow through the high porosity liner inhibits the creation of sufficient suction causing problems in vacuum setup equipments.
Smoothness

• Smoothness is a measure of the uniformity and evenness of the liner top side.
• It is measured using a Sheffield tester. The relevant test method is TAPPI – T 538
• The smoothness of liner surface influences the ability of the corrugated converter to print on the surface.

Smoothness

• Rough linerboard surface leads to printing definition issue as well as ink coverage issue.
• Due to the uneven surface of the liner we have increase printing pressure leading to loss of corrugated board caliper and excessive distortion of the printing plates.
Liner Cracking Issue

- The occurrence of Liner cracking becomes more prevalent
  - at low humidity
  - the ductility of surface fibers becomes diminished as may occur through application of starch coating or
  - in the case of low freeness pulp being used in the top ply of multi-ply sheets.

Liner Cracking Issue

- The basic mechanism for cracking is the higher stresses that occur on the surface fibers when a sheet is folded.
- These stresses become greater for higher basis weights where the bending strains in the outer layers are directly proportional to the thickness “t” of the corrugated board for a given bending radius of curvature “R”.
Liner Cracking Issue

- When corrugated board is folded along the score line, high tensile stresses and strains are induced in top ply (double face liner).
- As the tensile stresses and strains induced in the double face liner approach and equal the limiting strength of the double face liner, cracking will occur.
Score line cracking issue

• There two types of score line cracking in MD direction. That is along the flute direction.
  • **Score cracking or rupture:** In this case the liner split completely exposing flute in segments or continuously.
  • **Checking:** Incomplete split not all the way through the outer liner. That is flute is not exposed. Only the outer ply of the twin layer test liner splits.

Score line cracking
Score line cracking

Score line cracking
Liner Cracking Issue

• The main reason for score line cracking is increased tensile stiffness and shear stiffness.
• Any paper manufacturing technique which increases the tensile and shear stiffness such as –
  • Increasing inter fiber bonding
  • Surface starch treatment
  • Addition of stiffening agents
    Will increase the tendency of the liner to crack.

Double fold

• This is a conventional TAPPI method T 511.
• Sample strip under tension is placed in a clamping folding head which oscillates, folding the strip through 135º until the strip beaks at the fold.
• A larger number of folding cycles should indicate a greater resistance to cracking.
• A typical double fold values for Liner Kraft ranges from 40 to 60 in CD direction and 175 to 250 in MD direction.
Double fold

- CD double fold number responsible for height score line cracking (on line scorer)
- MD double fold number responsible for length–width score line cracking.

Tear Factor

- This is a conventional TAPPI method T 414.
- The Internal tearing resistance of paper is measured as the amount of work done in tearing a piece of paper through a fixed distance, after the tear has started.
- A typical tear factor values for Liner Kraft ranges from 100 to 160
Tensile elongation or Stretch

• Cracking occurs when the tensile strains due to the bending and direct tension in the outer plies of double facer liner exceed the allowable stretch in those plies.
• What this means is that tensile load – elongation characteristic of the double face liner are of importance as a consequence.

Tensile elongation or Stretch

• CD stretch is nearly twice the MD stretch.
• It very important to control MD stretch.
• In paper making the MD stretch tends to very low so care should be taken to maintain it to at least 2%
• CD stretch of at least 3.5% will reduce the risk of score line cracking perpendicular to flute (Height scoring)
Caliper

- Caliper is a measure of the thickness of liner.
- TAPPI – T 411 is the test method used for measuring the caliper.
- Variation in CD caliper leads corrugator operations.
- Uneven caliper of liner leads to poorly wound paper roll and varying roll hardness leading to varying web tension as rolls unwind causing board warp.

Internal bond strength

- Internal bond strength is a measure of tensile strength of liner in the ‘z’ direction, i.e. perpendicular to plane.
- There are several test methods to measure internal bond strength –
  - ‘ZDT’ method using TAPPI – T 541
  - Scott bond tester using TAPPI – T 403
  - Mullen ply bond tester using TAPPI – T 522
Internal bond strength

• The impact of low internal bond strength is felt more at the time of using corrugated boxes rather than during production time.
• Low internal bond will lead to weakness of glued manufacturers joint.
• Low internal bond leads to peeling problems on the liner surface due to frictional forces.