Predicting the Relative Efficiency of Lint Control Strategies on Supercalendered Papers: Effect of Testing Conditions

François Brouillette
Ciba Industrial Chair on Paper Chemicals
Integrated Pulp and Paper Center
Université du Québec à Trois-Rivières
C.P. 500
Trois-Rivières, QC Canada
G9A 5H7

ABSTRACT

In a previous paper, we have shown that a simple pull-tape method could be successfully used to evaluate the relative efficiency of lint reduction chemicals in both laboratory studies and mill trials. These results were obtained on paper grades containing marginal amounts of filler (newsprint and directory). The application of the same procedure to filler containing grades like SCB or SCA is more problematic. Practical experience has lead to believe that, contrary to newsprint and directory, the amount and the nature of the material detached from SC paper surface depends greatly on the humidity at which the test is performed and the pressure applied during the test. Consequently, the objective of this study was to determine the effect of testing conditions on the pull-tape lint test by analyzing not only the total amount of detached material but also its composition at different humidity and pressure levels. As expected, results indicated that for the same filler level, increasing the pressure applied to the sample or the humidity level caused more material to be detached from the sheet. However, the composition of this material was not significantly different with increasing pressure or humidity. Tape tack was found not to have an effect on the test result when no delamination occurs and same pressure is applied to the sample. From these observations, it was possible to conclude that reproducible results can be obtained for a SCB paper sample by performing the test at the same absolute humidity. Finally, the results obtained during a pilot papermachine trial confirmed that the pull-tape lint test could be used as a fast and reliable way of predicting the relative efficiency of different lint reduction additives. However, these results should only be used to indicate trends in the linting propensity of the paper. Extrapolation of the relative improvement in performance to pressroom operations would be hazardous.

INTRODUCTION

The availability of a rapid and simple test to determine the contamination potential of a particular paper printed with the heatset offset process is still a major concern for many papermakers. Several methods attempting to simulate the printing process have been developed, but most of them are time consuming, operator-dependant and not readily applicable in a mill environment [1]. More recently, we have seen the development of simple pull-tape and image analysis methods [2]. Even though these methods do not reproduce the printing conditions found in the heatset offset process (no wetting, no inking), the amount of material detached from the sheet have been shown to correlate well with the number of copies that could be printed before contamination problems are experienced. It has also been shown that a pull-tape method could be successfully used to evaluate the relative efficiency of lint reduction chemicals both in laboratory studies and mill trials [3,4]. These results were obtained on paper grades containing marginal amounts of filler (newsprint and directory). The application of the same procedure to filler containing grades like SCB or SCA is more problematic. Practical experience has lead to believe that, contrary to newsprint and directory, the amount and the nature of the material detached from SC paper surface depends greatly on the testing conditions: relative humidity, amount and type of application of pressure and, to a lesser extent, temperature. Consequently, the objective of this study was to determine optimal testing conditions by analyzing not only the total amount of detached material but also its composition at different humidity and pressure levels.

METHODS

Paper tested. The SCB paper used in this study was produced with a stone groundwood, kraft and high yield sulfite pulp furnish. Filler content was 18%. Paper samples were stored in the testing room immediately after they were received. All the lint measurements were made 48 hours after receiving.
Tapes tested. Tape tack is a critical parameter of the pull-tape test and is presented here as a relative tack value. This relative tack is based on the reference tape currently used at UQTR for the lint test on newsprint samples:

\[
\text{Relative tack} = \frac{\text{Tested tape tack (N/cm)}}{\text{Reference tape tack (N/cm)}}
\]

Tapes having relative tack of 0.15, 0.38, 0.92 and 1.00 (reference tape) were tested.

Experimental conditions

Several humidity levels and weights have been tested at room temperature \((24.3 \pm 1.8°C)\). In order to attenuate the effect of even small temperature variations, absolute humidity was used instead of relative humidity. Absolute humidity was calculated with a psychrometric software using temperature and relative humidity readings. Temperature and relative humidity were monitored every 15 minutes. Paper samples were conditioned for 48h in the testing room before they were tested for linting. Pressure was applied on the samples by hand with metal rolls weighting from 1.5 to 13 kg. Table 1 summarizes experimental parameters used for the linting tests.

Table 1. Experimental conditions tested

<table>
<thead>
<tr>
<th>Relative tack</th>
<th>Weight (kg)</th>
<th>Relative humidity (%)</th>
<th>Absolute humidity (calculated) (g water/kg air)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.15</td>
<td>1.501</td>
<td>25</td>
<td>4.43</td>
</tr>
<tr>
<td>0.38</td>
<td>3.080</td>
<td>35</td>
<td>6.45</td>
</tr>
<tr>
<td>0.92</td>
<td>7.965</td>
<td>45</td>
<td>9.71</td>
</tr>
<tr>
<td>1.00</td>
<td>12.933</td>
<td>55</td>
<td>11.88</td>
</tr>
<tr>
<td></td>
<td></td>
<td>65</td>
<td>12.56</td>
</tr>
</tbody>
</table>

Fiber detection

The amount of material detached from the sheet (linting level) was determined using the method described earlier [3]. To facilitate fiber detection, samples were scanned in grayscale mode. Because of the three-dimensional nature of the fibers, scattering of the scanner beam occurs and fibers will have a darker shade on the scanned image. In consequence, a very low reflectance background was used to optimize fiber detection.

Characterization of detached material

After each lint test, material attached on the tape was detached with a water/solvent mixture. Particle size distribution of the fiber suspension was measured with a FQA fiber length analyzer. Detached material was then collected on a 0.45 µm cellulose nitrate membrane and dried at 110°C to determine relative amounts of fibers/fines, synthetic polymers and filler by thermogravimetric analysis using a method developed for stickies[5].

RESULTS AND DISCUSSION

Effect of humidity and pressure

Humidity can affect both tape tack and contact surface between tape and sheet (fiber swelling). Past experience on newsprint samples have shown a non-linear increase of the amount of detached material with humidity. SC papers have a much smoother surface than newsprint, so the total tape-sheet contact surface is much larger and higher lint results should be expected for the same testing conditions. Figure 1 confirms that the SCB paper tested here exhibited much higher pull-tape lint results than newsprint, even if the pressure applied to the sample was 10 times smaller (1.5 kg vs. 13 kg for newsprint). However, the amount of material detached from the SCB paper varied linearly with absolute humidity. Correlation coefficient was very high at 0.9976.

Increasing pressure on tape will compress the sheet and increase the contact area between the surface of the sheet and the tape. Figure 2 shows that increasing the weight roll from 1.5 to 13 kg increased the amount of detached material by a factor of about 3. There seems to be a linear relationship between the pressure applied or weight used
and the test result for all tested weights. Comparison of curve slopes indicated that the rate of increase is slightly more important at higher absolute humidity values, but the curve obtained at 9.71 g water/kg air did not follow the same trend. Additional data would be necessary to confirm the slope increase.

![Figure 1. Effect of humidity on linting test results for newsprint (weight = 13 kg) and SCB (weight = 1.5 kg)](image1)

![Figure 2. Effect of pressure on linting test results at various absolute humidity levels](image2)

**Effect of tape tack on detached material**

Tape tack was found to have a complex effect on test results (Figure 3). Up to a specific tack value, located between 0.16 and 0.40 relative tack, no material is detached from the sheet. Once this threshold value was reached, material began to be removed. However, the amount of material remained constant up to 1.00 relative tack for the 1.5 and 3 kg weights. A second threshold seemed to occur between 0.92 and 1.00 relative tack for the 8 and 13 kg weights.
This second threshold and the very steep increase that followed correspond to the point where sheet delamination started to be observed. Visual observation of the scanned images confirmed this hypothesis. One important conclusion that can be drawn from Figure 3 is that tapes with different tack values will give similar results as long as they do not cause sheet delamination and same pressure is applied to the sample.

![Graph showing effect of tape tack on detached material](image)

**Figure 3. Effect of tape tack on detached material (Absolute humidity = 6.45 g water/kg air)**

**Characterization of detached material**

One of the objectives of this study was to determine if the composition of the material detached from the sheet by the tape is influenced by the humidity level at which the lint test is performed. Figure 4 presents a composite graph of all experimental conditions tested. It shows that thermogravimetric analysis of the detached material gave constant proportions of fibers, fines and filler for all experimental conditions. It contained 96±1% fibrous material and 4±1% filler. This result is quite different from the proportions found in the original sheet which contained 82% fibers and 18% filler. Increasing pressure on the tape promoted the detachment of a larger amount of material, but this material contained almost exclusively fibers and fines. Fiber length distributions were also similar for all tested conditions with over 97% of the fibers being smaller than 750 µm with a maximum frequency at 150 µm. Fines content was constant at 25%.

We can conclude that most of the incompletely bonded particles on the surface of the SCB sheet tested here were fibers having inadequate surface area or shape with small amounts of filler attached to their surface. The identification of individual or “free” filler particles will require a more complete geometric analysis of the scanned image. Improvements are presently made to our image analysis software to make this identification possible.

**Method verification (Lint reduction additive pilot papermachine trial)**

The last stage of this study was to test the method with and actual paper to determine if it could detect the effect of an anti-linting aid. During a pilot papermachine trial that was run on the Centre spécialisé en pâtes et papiers (Cégep de Trois-Rivières, Québec, Canada) pilot papermachine, several chemical additives known to reduce linting were tested in the production of a SCB paper similar to the one used above. Complete results of this pilot trial will be presented in a subsequent paper. Figure 5 shows the linting levels measured on the felt and wire side of the sheet. Results include runs with retention aids (Blank, no additives), a cationic wax emulsion at 0.4 kg/t, a liquid cationic starch runnability aid at 3 kg/t and a phosphate ester emulsion at 0.5 kg/t. All dosages are given on an active content basis. The test method was able to detect significant variations between lint reduction additives. The most effective additive was the phosphate ester emulsion with a 41% reduction of linting on both sides of the sheet. However, these
results should only be used to indicate trends in the linting propensity of the paper. It is not possible to conclude that paper treated with the phosphates ester will print 41% more copies than an untreated paper before lint related problems occur in the pressroom. The method also detected a strong twosidedness of the sheet produced with the cationic wax emulsion. A negative interaction of the cationic component of this additive with the retention aids may have caused this problem.

Figure 4. Effect of absolute humidity on the composition of detached material (all relative tacks/pressures)

Figure 5. Variation of the linting potential of paper produced with lint reduction additives (pilot papermachine trial)

Finally, it was important to determine if the method was really measuring the linting propensity of paper and not just changes in surface roughness. Figure 6 shows the linting potential of all the paper samples produced in the pilot trial against sheet surface roughness. The graph clearly demonstrates that there is not correlation between linting (% area)
and surface roughness. The lint test results could be used as a reliable way of predicting the relative efficiency of different lint reduction additives.

.Conclusions

The effect of three important parameters of the pull-tape lint test, pressure applied to the sample, tape tack and humidity level, was evaluated on a SCB paper. While newsprint samples usually exhibited non-linear increase of the test result with increasing humidity, SCB gave a linear correlation. The effect of pressure on test results was also significant, but again a linear correlation was found. Tape tack was found not to have an effect on the test result when no delamination occurred and same pressure was applied to the sample. From these observations, it was possible to conclude that reproducible results can be obtained for a SCB paper sample by performing the test at the same absolute humidity. It is not necessary to use very low humidity levels like it is the case for newsprint to avoid large variations between measurements.

Finally, the results obtained during a pilot papermachine trial confirmed that the pull-tape lint test could be used as a fast and reliable way of predicting the relative efficiency of different lint reduction additives. However, these results should only be used to indicate trends in the linting propensity of the paper. Extrapolation of the relative improvement in performance to pressroom operations would be hazardous.

Acknowledgements

The author wants to acknowledge the financial contribution of the Ciba Industrial Chair on Paper Chemicals. The technical assistance of Josée Doucet and Olivier Riffard (IUT Génie chimique, Université Paul-Sabatier, Toulouse, France) was also greatly appreciated. Finally, we would like to thank Abitibi-Consolidated, Laurentide Division, for supplying all the paper samples.

References


Predicting the Relative Efficiency of Lint Control Strategies on Supercalendered Papers: Effect of Testing Conditions

François Brouillette
Ciba Industrial Chair on Paper Chemicals
Integrated Pulp & Paper Center
Université du Québec à Trois-Rivières
Introduction
Linting

- Linting is still a major issue in many papermills
- Linting occurs
  - In the dryer section
  - On converting equipments (Offset presses)
- Fibers are detached from paper surface
- “SC lint” also contains filler
- Consequences
  - Increased washing frequency
  - Deteriorated printing quality
Lint testing

- Availability of a rapid and simple test to determine the contamination potential of a particular paper
- Several « printing » methods have been developed
  - Time consuming
  - Operator-depandant
  - Not readily applicable in a mill environment
- Pull-tape and image analysis method
  - Rapid and simple
    - Sensitive to environmental parameters
Pull-tape sampling

• Does not simulate printing conditions
  – No wetting, no inking
  – Material found on the tape may not be the same as what is found on contaminated blankets

• But…
  – Good correlation with number of copies before contamination problems are experienced
  – Successfully used to evaluate the relative efficiency of lint reduction chemicals both in laboratory studies and mill trials

• Most results were obtained on paper grades containing marginal amounts of filler (newsprint and directory)

• The application of the same procedure to filler containing grades like SCB or SCA has not been studied
Objectives of this work

• Determine optimal testing conditions for the evaluation of the linting (or contamination) potential of a SC paper

• With the standard test, we have been analyzing…
  – **Total amount of detached material (in % area)**

• This study also looked at the effect of other parameters on material composition
  – Humidity
  – Pressure applied
  – Tape tack
Experimental
**Tested material**

- **Paper**
  - SCB paper
  - SGW, kraft and high yield sulfite furnish
  - 18% filler
- **Storage and conditioning**
  - Samples stored in the testing room immediately after receiving
  - All the lint measurements were made 48-72 hours after receiving

- **Tape**
  - Tape tack presented as relative values
  - Based on reference tape currently used at UQTR

\[
\text{Relative tack} = \frac{\text{Tested tape tack (N/cm)}}{\text{Reference tape tack (N/cm)}}
\]

- Tapes having relative tacks of 0.15, 0.38, 0.92 and 1.00 (reference tape) were tested
## Experimental conditions

<table>
<thead>
<tr>
<th>Relative tack</th>
<th>Roll weight (kg)</th>
<th>Relative humidity (%)</th>
<th>Absolute humidity (g water/kg air)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.15</td>
<td>1.501</td>
<td>25</td>
<td>4.43</td>
</tr>
<tr>
<td>0.38</td>
<td>3.080</td>
<td>35</td>
<td>6.45</td>
</tr>
<tr>
<td>0.92</td>
<td>7.965</td>
<td>45</td>
<td>9.71</td>
</tr>
<tr>
<td>1.00</td>
<td>12.933</td>
<td>55</td>
<td>11.88</td>
</tr>
<tr>
<td></td>
<td></td>
<td>65</td>
<td>12.56</td>
</tr>
</tbody>
</table>

- Absolute humidity was used instead of relative humidity
- Eliminates the effect of temperature
- RH is temperature dependant
Fiber detection

- Linting level was determined using the method described earlier* with UQTR software
- Samples scanned in grayscale mode to facilitate fiber detection
- A very low reflectance background was used to reduce scattering of the scanner beam

Characterization of detached material

• Material attached on the tape was detached with a water/solvent mixture

• Particle size distribution of the resulting fiber suspension was measured with a FQA fiber length analyzer

• Detached material was then collected on a 0.45 µm cellulose nitrate membrane and dried at 110°C

• A thermogravimetric method* was used to determine relative amounts of
  – Fibers/fines
  – Synthetic polymers
  – Filler

Evaluation of method - Pilot PM trial

• Evaluation of method sensitivity
  – Pilot PM trial
  – Production of a SCB paper similar to the one used above
  – Several anti-linting aid tested

• Trial run on former CSPP (Trois-Rivières QC) pilot papermachine
  – Fourdrinier
  – 30 m/min
  – Offline supercalender

• Complete results of this pilot trial will be presented in a subsequent paper
Results
Effect of humidity on linting test results

- Humidity can change
  - Tape tack
  - Contact surface between tape and sheet (fiber swelling)

- Newsprint
  - Non-linear increase of the amount of detached material with humidity.

- SC papers
  - Linear correlation ($R^2=0.9976$)
  - Higher lint results are observed even with lower pressure

- Why?
  - Much smoother surface than newsprint
  - Tape-sheet contact surface is much larger
  - Fiber swelling is reduced
    - Chemical pulp and filler

![Graph showing the effect of humidity on linting test results for Newsprint (W=13kg) and SCB (W=1.5kg).](image)

Abs. humidity (g water/kg air)

Detached material (% area)
Effect of pressure on linting test results

- Increasing pressure on tape
  - Compresses the sheet
  - Increases the contact area between the surface of the sheet and the tape
- A 3x factor is observed when weight roll is increased from 1.5 to 13 kg
- Linear relationship
- Rate of increase is slightly more important at higher absolute humidity values
- Additional data would be necessary to confirm the slope increase (9.71 g/kg curve does not follow the same trend)
Effect of tape tack on detached material

- Tape tack had a complex effect on test results
- Up to a specific tack value, no material was detached from the sheet.
- Once this threshold value was reached, material began to be removed
- The amount of material remained constant up to 1.00 relative tack for the 1.5 and 3 kg weights
- For higher weights, a second threshold was observed
  - Between 0.92 and 1.00 relative tack
  - Point where sheet delamination started to be observed.
- Visual observation of the scanned images confirmed this hypothesis
- Tapes with different tack values will give similar results as long as they do not cause sheet delamination and same pressure is applied to the sample

(Absolute humidity = 6.45 g water/kg air)
Characterization of detached material

• We know that increasing humidity and pressure detaches more material from the sheet
  – What is the effect on material composition?

• Composite graph of all experimental conditions

• Constant proportions of fibers, fines and filler for all experimental conditions
  – 96±1%, 4±1% filler

• Different from the original sheet
  – 82% fibrous material, 18% filler
Method verification during pilot papermachine trial

- Linting potential measured on the felt and wire side of the sheet
  - Significant variations between lint reduction additives were detected
  - Cationic wax emulsion formed two-sided sheet
  - Phosphate ester emulsion was the most effective with a 41% reduction of linting on both sides of the sheet
Method verification (Pilot papermachine trial)

• However…
• These results should only be used to indicate trends in the linting propensity of the paper

Lint test result

41%

≠

Copies without problems

41%
Effect of surface roughness on lint test result

- One last point to consider
- Determine if the method
  - is really measuring the linting propensity of paper (Good)
  - or just changes in surface roughness (Bad)
- Composite graph of all pilot PM trial conditions
- There is not correlation between linting (% area) and surface roughness
- The lint test results could be used as a reliable way of predicting the relative efficiency of different lint reduction additives

\[
\text{% Area} = -0.2314(\text{PPS}) + 1.77
\]

\[R^2 = 0.0079\]
Conclusions

• Three important parameters of the pull-tape lint test were studied on a SCB paper
  – Pressure applied to the sample
  – Tape tack
  – Humidity level

• Effect of humidity
  – Non-linear increase on newsprint
  – Linear increase on SCB

• Effect of pressure
  – Significant increase
  – Linear effect

• Tape tack had no effect when
  – No delamination occurs
  – Same pressure is applied to the sample
Conclusions

• Reproducible results can be obtained for a SCB paper sample by performing the test at the same absolute humidity **AND** adequate conditioning

• Not necessary to use very low humidity levels like it is the case for newsprint to avoid large variations between measurements

• Pilot trial validation
  – Pull-tape lint test could be used as a fast and reliable way of predicting the relative efficiency of different lint reduction additives
  – Indicative of trends
  – Direct extrapolation to pressroom operations hazardous
Acknowledgments

• Financial support
  – Ciba Industrial Chair on Paper Chemicals

• Technical assistance
  – Josée Doucet
  – Olivier Riffard (Université Paul-Sabatier, Toulouse, France)

• Paper samples
  – Abitibi-Consolidated, Laurentide Division