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Perforations on different corrugated flute grades and their effect on packaging performance

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RISE Research Institutes of Sweden
~3200 employees, 130+ testbeds
Reduce overpacking
Replace plastics
Increased testing
Simulations?
The starting point

- In the industry, there is much knowledge of how perforations behave, but, most of it is not accessible in the literature.

- We have previously looked at how different cut/uncut ratios in perforations - cut on a cutting table - behave under different loading conditions.

- We have also looked at how laser cut perforations compare to the perforations cut in a cutting table for the same material.
Cutting table vs laser cutting
Conventional ECT cutter vs laser cutting
The strength of perforations

- Percentage of uncut frontside material left
- Strength ratio
- Laser cut data

- Ratio of uncut length to total sample width

- BK
- CW
- 1:1
Edge crush test

Effect of perforation type and placement on ECT test

Edge compression test comparison

- BK-Cutter
- Laser cut
To conclude the previous work

- Different liner materials and fluting types respond similarly to different kinds of perforations.
- Perforating using a cutting table leads to damages to the top layer which governs the measured behaviour of the perforation.
  - This is well in line with the industry experience.
- The cut/uncut ratio of the perforation has little influence on the “whole box” mechanics, since
  - Stiffness remains unaffected, and
  - Measured ECT shows an equal strength drop for all ratios.
- The cut/uncut ratio has, as was expected, a large influence on the strength of the perforation.
- Using a laser cutter for sample preparation increases the precision of the samples, and simplifies data analysis.
Method Die-cut
In the present study a E-flute corrugated was used.
Directions

- The material was cut in 4 directions:
Strength
Comparing perforation method, ratio and direction
Observations

• The strength is dependent on the amount of material, i.e. the cut/uncut ratio of the perforation.

• The direction of the perforation influences the strength of the perforation.

• The laser cut and die cut samples behaved similarly and had approximately the same strength. With the exception of the 4/1 perforation that was weaker for the die cut samples.
Let’s have look at the cuts

Top

Die-cut

Bottom

Laser-cut
Side view

Die-cut

Laser-cut
Observations

• In this case some damage, that can be attributed to the cutting blade, could be observed.

• The laser leaves the structure intact and has softer “ends” of the cut area, but wider perforations, at least on the top side.
Torsional tear
Torsional tear

• Sample attached in two clamps with a small gap between which is aligned with the perforation. One edge of the sample is against the end of the clamps the other is aligned with the centreline.
• The top clamp rotates around the centreline.
• Torque is measured during the test.
Torsional tear

<table>
<thead>
<tr>
<th>Cut/uncut</th>
<th>4/4</th>
<th>4/3</th>
<th>4/2</th>
<th>4/1</th>
</tr>
</thead>
<tbody>
<tr>
<td>MD</td>
<td>35.8</td>
<td>21.0</td>
<td>15.2</td>
<td>12.1</td>
</tr>
<tr>
<td>CD</td>
<td>26.7</td>
<td>33.0</td>
<td>27.8</td>
<td>12.5</td>
</tr>
</tbody>
</table>
Observations

• The moment required to break the perforation goes up with the amount of uncut material.

• The standard deviation of the required torque also increases with the amount of uncut material.
  – This is probably due to a combination of a larger damage zone, and variation in the moment arm.

• The CD perforations are weaker, but this effect is reduced with the amount of uncut material.
Based on these observations, and previous data, it seems that much of the discrepancy seen between perforations cut on the cutting table vs. die-cut perforations can be attributed to the cutting blade rather than the rubbers.

The tensile strength of the perforation is highly dependent on its orientation.

This is, however, not necessarily reflected in the opening behavior, especially for large cut/uncut ratios.
Thank you!