Critical evaluations of liquid absorption testing methods for package printing

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Background

- Topography + absorption ➔ print quality
- Appropriate and robust measurements ➔ predictable print quality

**How to measure the absorption properties ?**
- Total absorption
  - Cobb60 ?
  - Bristow wheel ?
  - IGT penetration tester ?
  - ...
- Absorption non-uniformity
  - Stain technique
Measurement methods

- Two relatively new methods have been evaluated
  - ASA – Automatic Scanning Absorptometer
  - ACT – Automatic Cobb Tester
- Both methods provide time-resolved absorbency measurements
  - To examine short or long time absorption characteristics
  - Capillary-driven absorption (no external pressure applied)
    \[ V(t) = V_0 + k\sqrt{t} \]
Paper boards

- Six pilot coated paper boards
  - Different top-coatings on the same pre-coated base
  - Similar surface roughness
  - But broad absorbency range

- Latex
  - Latex A: vinyl acetate acrylate (VAA)
  - Latex B: styrene butyl acrylate (SBA)

- Pigments
  - HC90=Hydrocarb® 90
  - SCHG=Setacarb® HG
  - Clay=Capim NP delaminated clay
  - CCN75 = Covercarb® 75, narrow PSD

<table>
<thead>
<tr>
<th>No.</th>
<th>Board notation</th>
<th>Coating compositions</th>
<th>Roughness, std. dev., height [µm]</th>
<th>Contact angle, H₂O</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>12.5 Latex A</td>
<td>12.5 pph VAA Latex A, 60 pph HC90 + 40 pph SCHG.</td>
<td>0.86</td>
<td>71.2</td>
</tr>
<tr>
<td>2</td>
<td>15 Latex A</td>
<td>15 pph VAA Latex A, Pigments as 1.</td>
<td>0.88</td>
<td>75.2</td>
</tr>
<tr>
<td>3</td>
<td>20 Latex A</td>
<td>20 pph VAA Latex A, Pigments as 1.</td>
<td>0.76</td>
<td>80.8</td>
</tr>
<tr>
<td>4</td>
<td>15 Latex B</td>
<td>15 pph SBA latex B, Pigments as 1.</td>
<td>0.89</td>
<td>84.4</td>
</tr>
<tr>
<td>5</td>
<td>40 Clay</td>
<td>15 pph VAA latex. Pigments; 60 pph HC90 + 40 clay</td>
<td>0.83</td>
<td>70.3</td>
</tr>
<tr>
<td>6</td>
<td>N75 GCC</td>
<td>15 pph VAA latex. 100 pph CCN75</td>
<td>0.87</td>
<td>73.4</td>
</tr>
<tr>
<td>-</td>
<td>Pre-coating</td>
<td>100 pph Hydrocarb® 60 and 13 pph of the VAA latex.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Measurements

Testing liquids

- ASA
  - 12% (volume) of the condensed blue liquid, methylene blue, diluted in deionized water.
  - 8.6 wt-% n-propanol in order to reduce the surface tension similar to flexographic inks. (38 mj/m2)

- ACT
  - water

Surface roughness

- OptiTopo
  - height standard deviation
  - wavelength interval 0.06-1 mm

- PPS

- Bendtsen
Print trial

- Print density of a solid cyan area was measured on five consecutive signatures.
  - Spectro-densitometer, SpectroDens (TECHKON GmbH, Königstein, Germany),
    - calibrated against the board white and with the following settings: D50 illumination, 2° observer, polarization filter and density filter ISO E.
Results -- ASA

- Boards of the same pigments but different amounts of latex A
  - Absorption rate decreases with increasing latex
- Different types of latexes A vs. B leads to different liquid absorption
  - Type B shows a wetting delay

![Graph showing water absorption over time for different latexes.](image)
The porosity of the coatings affect the liquid absorption
- Board (N75) having the most porous surface (GCC of narrow PSD)
- Board with 40% clay is less porous
- Board having GCC of broad PSD has the lowest porosity.
- The boards have similar contact angle
Results -- ACT

- The measurements show similar long-term trends as those from ASA

- Less reliable in short-term behaviour
  - More latex, higher absorption
  - Incorrect measurement at $t \rightarrow 0$
  - In contradictory to the ASA observations
Results -- ACT

- The measurements show similar long-term trends as those from ASA
  - For short term, it is less obvious with less information

- No wetting delay observed
Surface roughness vs. absorption at \( t \to 0 \)

- At \( t = 0 \), the liquid only fills the surface roughness.
- The intercept with the y-axis (\( t = 0 \)) is proportional to surface roughness.

\[
V(t) = V_0 + k \sqrt{t}
\]

\[\begin{array}{c|c|c|c}
\text{Surf. rough. Std. Dev [\( \mu m \)], Optitopo (0.06-1mm)} & \text{ACT} & \text{ASA} \\
\hline
R^2 = 0.01 & & \\
R^2 = 0.73 & & \\
\end{array}\]
Absorption rates
- Both methods reveal similar long-term trends
  - The absorption rates of ASA measurements are generally proportional to those of ACT
  - The board 15 Latex B is an exception
- Their short-term observations differs significantly
  - t< 1.0 s
  - ASA’s measurements is probably more reliable
    - makes more sense as it reveal surface topography
There are a clear correlation between the absorption rates of the boards and the respective print densities.
Industrial applications

- Being capable of predicting print quality from unprinted surfaces (paper/board) will help the producers to
  - supply substrates with properties demanded by converters and end-users.
  - develop products of preferred printing surfaces.
  - increase production efficiency and effectiveness by reliable in-house quality control.
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