**Motivations**

- "Stickies" is a broad term for all tacky components in Paper for Recycling
- During pulping, adhesives are disintegrated to
  - Macrostickies
  - Microstickies
  - Potential secondary stickies
- Why are they problematic?
  - Disturbance in the papermaking process
    - Paper quality reduction: holes, specks
    - Productivity reduction: deposits, breaks during papermaking but also during converting
  - Necessity to implement removal step, responsible for losses
Overview: sticky measurement methods

**quantitative (How much?)**
- macrostickies
  - INGEDE Method 4 standard updated, 04/13
  - TAPPI T277 (Voith method) standard
  - macrosticky staining in the sheet by CTP, PTS, ...
  - extraction (DCM, DMF, THF) by CTP, PTS, ...

**qualitative (What?)**
- IR spectroscopy
- gas chromatography
- solubility tests
- microscopy
- staining tests

**potential secondary stickies**
- extraction (DCM, DMF, THF) by CTP, PTS, ...
- precipitation (INGEDE Method 6)
- plugging on the wire test (CTP)
- UCM deposition test (UCM)
- C/SB
- Δ TOC
- cationic demand (PCD)

**Motivations**

- **According to Doshi (2009), a sticky measurement method should give access to**
  - Quality of the furnish
  - Efficiency of removal processes
  - Deposit control on paper machines
  - Performance improvement of recycled paper products

- **A new method would be**
  - Quantitative results (mm² of stickies per kg of pulp)
  - Qualitative information (chemical nature of the stickies, tackiness)
    - No deformation
    - on-line measurement possibility

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New lab measurement device:

3D-Stick

Sample preparation

- Screening (100 µm)
- Deposit on filter paper
- Pressing, drying, dying, white powder
  - Image analysis
  - INGEDE Method 4: Stickies surface distribution
- Air drying
  - 3D-Stick analysis
  - 3D-Stick results: 3D morphology + chemical nature
Main steps of 3D-Stick: workflow

1st prototype

Max. surface meas. = 250x250 mm²
For 125x125 mm² with approx. 300 contaminants
meas. time = 20 min

NIR spectro meter
optical fibre
high precision axes

NIR head
laser

Profile reconstruction
Visible image reconstruction
3D objects extraction
Contaminants classification

NIR
spectrometer

NIR
head

Laser scan
Local NIR scan
Contaminants classification

3D objects list
Move to each object
Acquire NIR spectrum
Modelling
Identification of contaminants

3D morphology of contaminants + Classification + Others

<table>
<thead>
<tr>
<th>Length</th>
<th>Width</th>
<th>Thick</th>
<th>Image</th>
</tr>
</thead>
<tbody>
<tr>
<td>1100</td>
<td>295</td>
<td>50</td>
<td>yes</td>
</tr>
<tr>
<td>1150</td>
<td>320</td>
<td>80</td>
<td>yes</td>
</tr>
<tr>
<td>1200</td>
<td>200</td>
<td>30</td>
<td>no</td>
</tr>
</tbody>
</table>
Step 1: **laser triangulation**

Identification of objects + 3D morphology

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**Profil scan**

**Altitude map**

Resolution: \(dx = 20\mu m\)
\(\) \(dy = 20\mu m\)
\(\) \(dz = 3\mu m\)

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**Step 1: laser triangulation**

3D morphology

**Industrial stickies**

\(\approx 1100 \times 250 \times 50 \mu m^3\)

\(n=819\) stickies

\[\begin{align*}
L_{avg.} (\mu m) &= 1086 \\
W_{avg.} (\mu m) &= 273 \\
T_{avg.} (\mu m) &= 49
\end{align*}\]

\(\rightarrow\) stickies were characterised in their 3 dimensions
Step 2: NIR analysis
Classification of contaminants

- Local NIR is moving to each object and analysis performed to determine their chemical nature

\[ X(\lambda) = wR(\lambda) + (1 - w) C(\lambda) \]

Find \( R \) which correlates best with database references

Comparison with existing methods
INGEDE Method 4 vs 3D-Stick results

deformation of stickies by INGEDE Method 4
Comparison with existing methods
INGEDE Methode 4 vs 3D-Stick results

**• Correct measurement of contaminants by laser scan**

**• Correct identification of stickies by NIR**

Conclusion on 3D-Stick sensor

**• New sensor to characterize macrostickies**
  - 3D morphology of contaminants
  - Stickies’ chemical nature

**• Advantages**
  - Quantitative and qualitative method
  - Fully automated
  - Fast measurement (20 min for ~300 objects)
  - Non contact method (no deformation)
  - (no black ink on your hands anymore…)

**• Sensor**
  - Awards: ATIP Palme d’Or de l’innovation (2014) and TAPPI Wayne Carr Best Paper Award (2016)
  - Commercialized now by Techpap
## Toward on-line measurement

### PI-Stick

#### PI-Stick workflow

<table>
<thead>
<tr>
<th>PART</th>
<th>ACTION</th>
<th>RESULT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampler</td>
<td>Collection of pulp sample</td>
<td>Pulp collection</td>
</tr>
<tr>
<td>PIC</td>
<td>Adjustment of pulp consistency</td>
<td>Weight of pulp screened</td>
</tr>
<tr>
<td>Screen</td>
<td>Contaminant screening</td>
<td>Fibre removal and contaminant separation</td>
</tr>
<tr>
<td>Formation bowl</td>
<td>Contaminant deposition, draining and drying on filter</td>
<td>Contaminant collection and sample preparation</td>
</tr>
<tr>
<td>3D-Stick</td>
<td>Contaminant analysis</td>
<td>Nature, size, number, 3D morphology, surface, volume</td>
</tr>
</tbody>
</table>

Pulp weight + contaminant analysis → Contamination expressed per kg of pulp
On-line sensor prototype

- After automatization of all the elements, they were installed in a container
  - For easy change of the organisation of the different elements
  - For easier and fast carriage into industrial sites for a «plug and play» trial
  - Standard connection requested:
    - Electricity
    - Air
    - Water
    - Pulp to the container

On-line sensor prototype

- After automatization of all the elements, they were installed in a container
- Main change implemented:
  - Automatization of a Somerville device performed with success
  - However, plugging was observed after 2–3 days of analysis
  - Decision to move to another concept
  - Development of home-made screening device (tested and implemented during the 3rd industrial trial)
On-line measurements (after coarse screening) – Example

- 400 objects measured (non-cellulosic)

<table>
<thead>
<tr>
<th>Material</th>
<th>Length (µm)</th>
<th>Width (µm)</th>
<th>Thickness (µm)</th>
<th>L x w (mm²)</th>
<th>L x w x t (mm³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSA</td>
<td>1786</td>
<td>558</td>
<td>57.6</td>
<td>0.996</td>
<td>0.057</td>
</tr>
<tr>
<td>PVA</td>
<td>1932</td>
<td>637</td>
<td>58.9</td>
<td>1.231</td>
<td>0.072</td>
</tr>
<tr>
<td>Hot-melt</td>
<td>2021</td>
<td>604</td>
<td>68.2</td>
<td>1.221</td>
<td>0.830</td>
</tr>
<tr>
<td>All stickies</td>
<td>1900</td>
<td>607</td>
<td>60.8</td>
<td>1.157</td>
<td>0.070</td>
</tr>
</tbody>
</table>

Average value

- PSA
  * The smallest particles in average
On-line measurements

Initial contamination (after coarse screening) – Results

<table>
<thead>
<tr>
<th>Mill A</th>
<th>Mill B</th>
<th>Mill C</th>
<th>Asia 1*</th>
<th>Asia 2*</th>
<th>US*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw material</td>
<td>Rich in OMG</td>
<td>Wood free Packaging</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>PVA</td>
<td>84</td>
<td>54</td>
<td>80</td>
<td>81</td>
<td>98</td>
</tr>
<tr>
<td>Hotmelt</td>
<td>8</td>
<td>2</td>
<td>18</td>
<td>19</td>
<td>2</td>
</tr>
</tbody>
</table>

Stickies nature (%) for different mills

- European and Asian investigated mills: PVA glues are widely present (not the case in the US)
- Very different PSA amounts (mainly in the US) → hence very different sticky management to be implemented!

* Not involved in on-line measurement, only one-shot analysis on sample

Results obtained with the PI-Stick
Examples
First results

• Sampling, screening, deposition, drying and analysis of the contaminants on the filter were running well

One weekend sampling

~10m

First results

• Even if not quantified: already discussion within the mill staff (pulp stock preparation and papermaking) on sticky issues!
• Both with automatic and manual analysis in the meantime, 3 mills learn a lot of things (and change their thinking also)
  • Their sticky method measurements (if performed in the mills)
  • Think about what they are thinking and take time to discuss on the potential improvement and have corresponding data!
Examples of results
Variability of sticky contamination

• How can be estimate the efficiency of an action based on short analysis?
• Already variability on inlet contamination…
• But on-line measurement can be an indicator on storm event and action to be implemented!

Examples of results
Do we need final fine screening?

• One of the mill was questioning the presence of LC fine screening:
  * Measurements were made for «one shot» analysis
  * All the people have their own feelings (and their own data)…
  * What is the true?
Examples of results
Do we need final fine screening?

• One of the mill was questioning the presence of LC fine screening:
  • Measurements were made for «one shot» analysis
  • All the people have their own feelings (and their own data)...
  • What is the true? Yes and No

Final LC fine screenings are not decontaminating extensively
But they are levelling down sticky contamination (mainly when pulp is highly contaminated)
Examples of results
What can be done with fine screening?

• Among the question of the mill
  • Parallel process efficiency depending on slot and/or rotor design?
  • What about accept handling of each step?

Examples of results
What can be done with fine screening?

• Accepted pulp of the 2nd stage are bringing back PSA, Hotmelt and PVA
• Accepted pulp from 4th stage are bringing many PVA, PSA and Hotmelt
• Very acceptable contamination of the acc. 3rd stage
Conclusions

- Fully automated sensor to determine the morphology and nature of contaminants has been developed: 3D-Stick
  - Quantitative and qualitative method
  - Fast measurement
  - Non-contact method
  - Now sold by
- Integrated in on-line sensor including automated screen allowing 48 to 72 measurements per day (depends on contamination): PI-Stick
  - Tested in 3 different mills (wood containing, wood free and packaging lines) with up to 6 samplers
  - On-line follow-up of sticky contamination at several process points
  - Detection of sticky storm
  - Possibility to use it in manual mode → extensive investigation can be performed (that was not done in the mills due to lack of resources)
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