

How to deal with the effects of recycling?

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Wageningen UR Paper and Board

- Wageningen University and Research Centre
 - Fundamental, strategic and applied research
 - 7000 employees, 5600 students
 - Divided in 5 Science Groups, a.o.
Agrotechnology & Food Sciences

Pulp, paper, board and packaging research

Paper and board: research themes

Fibre Raw Materials: focus on quality and choice related to processing and end product requirements

Fibre Processing: focus on reduced energy consumption during fibre processing and in the total paper production line

Papermaking Chemistry: synthesis of new or more effective chemicals based on natural raw materials

End Product Quality: insight in product requirements based on converting and consumer demands / enhancing end product performance

By-stream Processing: creating commercial value for solid by-streams from pulp and paper production process

Project

'Fibre Raw Material Technology for Sustainable Paper and Board Production'

Goal

- closure of the fibre cycle
- more effective use of fibre raw materials
- improved control and efficiency of fibre processing
- improved product quality
- strengthening knowledge infrastructure of the Dutch Paper and Board Industry

Project consortium

Project consortium:

- *co-ordination:* Dutch Competence Centre Paper and Board
- *paper and board producers:* Kappa, Sappi
- *industry suppliers:* Södra, Voith, Novozymes, Buckman, DSM
- *universities:* Twente, Eindhoven, Wageningen
- *research institutes:* Wageningen UR Paper and Board, TNO



Topics

- Recycling effects on fibre properties
- Recycling effects on pulp properties: fines, ash and other contaminants in recovered paper
- Effects on processing and paper properties
- Requirements for upgrading technologies

Analysis techniques (1)

Fibre / pulp analyses

- chemical / morphological analyses, flexibility, RBA (Cyberflex[®])
- surface area fibres / fines (DAS Jar[®])



Analysis techniques (2)

Other fibres / pulp analyses

- drainability, water retention, chemical / morphological analyses
- surface characterisation: XPS, ATR-IR, E-SEM, AFM
- (surface) charge analysis: titration methods (potentiometric, pH Stat, Böhm, polyelectrolyte), cationic demand
- surface adsorption polyDADMAC



Analysis techniques (3)

Paper analyses

- tensile index
- shrinkage
- internal bond strength
- scattering coefficient
- porosity



Effects of recycling

Effects of recycling on fibres

(= repeated wetting and drying)

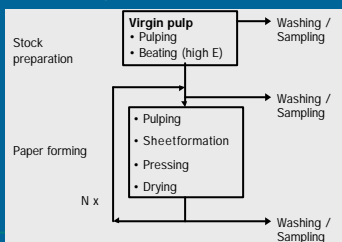
Effects of recycling on pulp

(= repeated wetting and drying of fibres and accumulation of fines, fillers, contaminants)

Recycling procedure

Simulation recycling on laboratory scale

Focus on fibres only
(fines removal)



Repeated wetting and drying

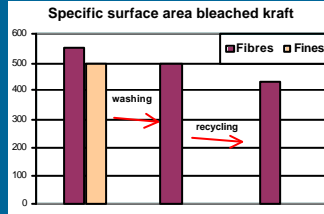
Effects of repeated wetting and drying on fibres:

- Effect of first time recycling is significantly larger than successive recycling steps
- Fibre shortening: minor influence

Effects of recycling: fibre damage

Creation and accumulation of fines
Decrease in fibre surface area
(DAS-Jar®)

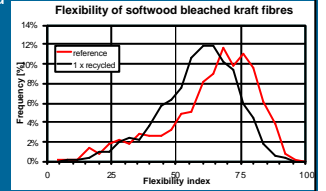
No significant changes
in cellulose properties



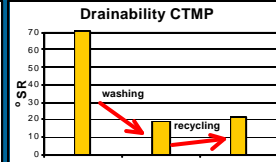
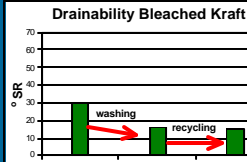
Effects of recycling: physical properties

Fibre flexibility and relative bonded area (Cyberflex®):

- increase with beating
- decrease with repeated wetting and drying

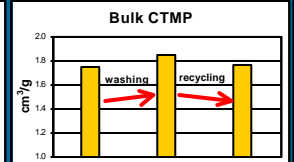
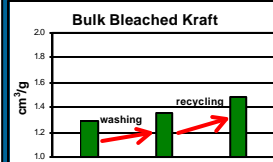


Effects of washing and recycling



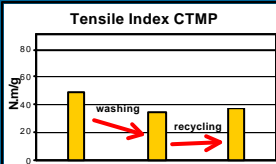
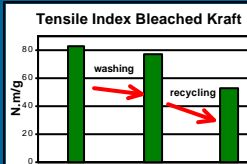
- Fibre changes hardly effect drainability
- Large effect of *fines* on drainability

Effects of washing and recycling



- Bulk increases due to loss of fines
- Fibres are less conformable due to recycling
- Recycling increases conformability of CTMP fibres

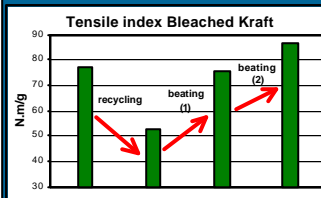
Effects of washing and recycling



- Fines contribute little to paper strength
- Recycling reduces bonding possibilities on fibres

'Fibre potential' after recycling

Beating of recycled fibres improves mechanical properties of fibres



Fibres still have enough 'potential' after recycling!!

Effects of recycling: surface properties

Surface extractives and surface charge

Changes occur due to

- beating
- repeated wetting and drying
- accumulation of paper additives.

Most important effects

- reduced swelling
- reduced additive efficiency
(little influence on bond strength)

Fines and ash

Ash

- appears to have negative effect on paper strength
- no effect on drainability



Fines and ash

Ash

Fines: mono fibrils ('live fines')

- increase binding potential
- decrease dewatering rate
- decrease paper porosity



Fines and ash

Ash

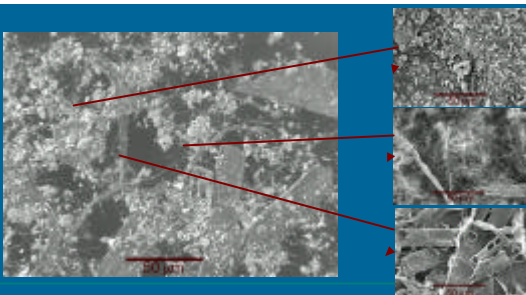
Fines: mono fibrils ('live fines')

Fines: fibre chunks ('dead fines')

- low binding ability
- hardly any influence on porosity and dewatering



Fines and ash in recovered paper



Effects of recycling: accumulation of additives

Effects of *pulp* recycling in practice:

- Accumulation of chemicals / additives on the surface
- Charge density:
 - recycled *pulps* higher than virgin pulps
 - recycled *fibres* slightly higher than virgin fibres
 - fines higher than fibres
- Additives react more easily with fines \Rightarrow decreased efficiency

Requirements for upgrading technologies (1)

Goal

To counteract on the fibre degrading effects due to processing.

Approach

Development of new technologies should focus on the improvement of the following pulp / fibre properties:

- fibre flexibility and relative bonded area
- fines content and morphology
- ash content
- surface charge

Requirements for upgrading technologies (2)

Prevention and restoring technologies:

- Prevention of unnecessary fibre damage in paper and pulp processing
- Restoring fibre /pulp potential
(mechanical, enzymatic, chemical)

P presentation Loud van Kessel

Dutch Competence Centre Paper and Board / Kappa Roermond Papier

Conclusions (1)

Fibre degradation is caused by fibre damage and accumulation of additives (fines, ash, chemicals)

Fibre damage can be (partly) reversed.

Effect of fines, fillers and contaminants is much higher.

Conclusions (2)

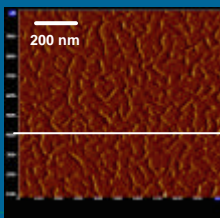
Upgrading by prevention or restoring technologies

Most important properties to focus on:

- fibre flexibility and relative bonded area
- fines content and morphology
- ash content
- surface charge

Further research

Fundamental studies on cellulose model surfaces (PhD)



Cellulose model surface, University of Eindhoven

Acknowledgements

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Thank you for your attention.

For more information about our research:

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