

CENTRE OF COMPETENCE PAPER AND BOARD

WAGENINGEN UR
For quality of life

Improved Level and Control of Stiffness

A joint action of 18 mills, converters and suppliers supported by Wageningen UR Paper and Board

Paper and Board International Conference
Beekbergen, The Netherlands
2004, April 6th and 7th

Introduction

- Welcome
- Contents
- Introduction of speakers
 - Annita Westenbroek Centre of Competence Paper and Board
 - Robin Sinke Wageningen UR Paper and Board
 - Geert Landlust Kappa Graphic Board
 - Jeannette van Leersum Papierfabriek Doetinchem

Kappa Graphic Board
Papierfabriek Doetinchem

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Contents

- Introduction and motivation
- Background, requirements and co-operation
- Chain integration and optimisation
- Optimisation of stiffness and humidity influences
- Case: Stiffness measurements, conditions and applications
- Case: Laminating paper for solid board stiffness
- Conclusions

Kappa Graphic Board
Papierfabriek Doetinchem

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Motivation

- Stiffness is one of the most important quality parameters for a lot of paper and board applications
- Workshop and discussions with industry 2001
 - Miscommunication about stiffness
 - Great variety in analysis methods, norms and standards
 - Significant influence of climate conditions
 - How to optimise and control stiffness?

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Background: what is stiffness?

- Differences between strength and other properties
 - stiffness vs. strength
 - stiffness: resistance against deformation
 - strength: maximum force until breaking (e.g. SCT is strength property)

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Background: what is stiffness?

- Stiffness is a construction property, e.g. multilayer board, box
- The way and kind of load on construction determines the material specifications:
 - modulus of Elasticity, E
 - thickness, d
- Important to distinguish between different kinds of stiffness
 - Bending stiffness $\sim E \cdot d^3$
 - Tensile stiffness / Compression stiffness $\sim E \cdot d$
 - Torsion stiffness

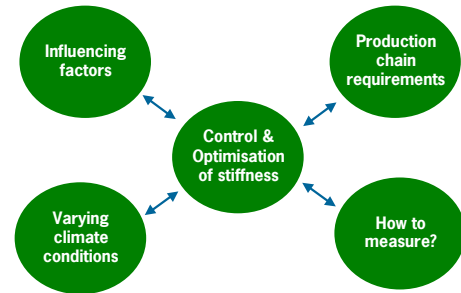
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Requirements

- Application determines specifications:
 - processability
 - practical use
 - use in construction, possibility of stacking etc.
- Often compromise between stiffness, strength and optical properties
- Requirements in daily practice
 - customer wants 'fit for purpose'
- Climate conditions (temperature and humidity influences)
 - practical climate conditions: -20 - 70°C (or higher), 10 - 95% R.H. (transport, storage and user conditions)
 - standard measurements at 23°C, 50% R.H.

Requirements

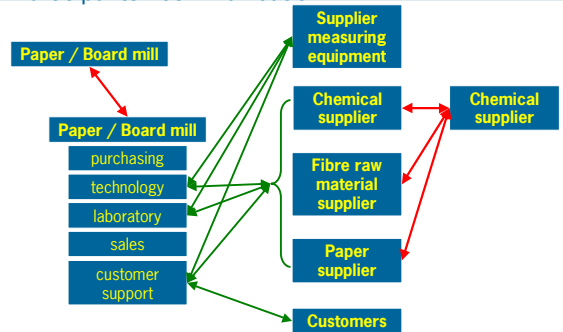


Participants

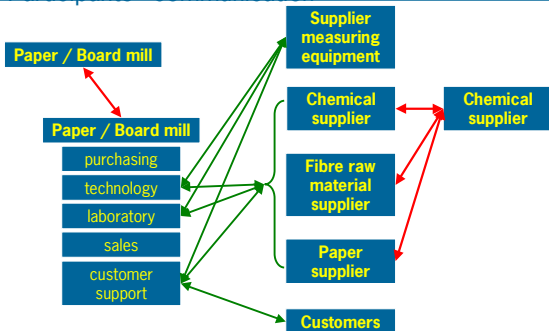
- Paper and board mills and customers
- Suppliers of chemicals, fibre raw materials, measuring equipment and paper
- Wageningen UR Paper and Board
- Dutch Centre of Competence Paper and Board



Participants - communication

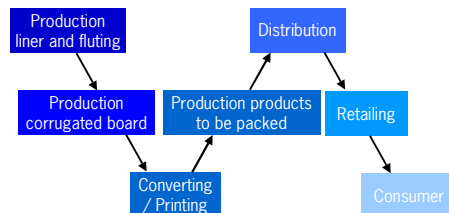


Participants - communication



Chain optimisation

- The production chain of board material to end product use
- Example: corrugated board chain



Chain optimisation

- Challenges in chain optimisation
 - different viewpoints from producers and customers
- Examples from daily practice
 - customers define strength requirements, but for their application stiffness is required
 - customers use average values for different board types, which results in over- and underspecification
 - discussions between producers and customers about board quality at lower basis weight
- Most important issue: communication with customers

Chain optimisation - discussions

- Many different players in the production chain
- Different, but inter-related chains for corrugated board, solid board and folding box board
- Different requirements at different stages in the production chain
 - paper supplier, paper producer, converter, printing company, producer of packed goods, transporter, retailer and consumer



Chain optimisation - outcome

- Results of discussions
 - customers should define product specifications instead of material specifications
 - producer should give advices on best material
- Start for better communication and further optimisation in the production chain in the future



Chain optimisation - cooperation

- Cooperation with customers
 - customers are willing to cooperate
 - organise (combined) meetings with your customers to inform them about material properties and measurements
 - stimulate communication further down the production chain
 - exchange of (laboratory) personnel within and between companies
 - good internal communication between R&D and sales department
 - active policy on providing information between producers and customers
 - stimulate standardisation in the production chain

Optimisation of Stiffness

- Differences issues for board industry vs. graphic paper industry

board: stiffness primary issue
(increasing importance due to deteriorating raw material and higher demands)



graphic paper: stiffness side issue
(with tolerance value range)
(strength and surface properties more important)



Optimisation of Stiffness - issues

- Optimisation research - topics
 - stiffness improvement
 - (partly: thickness improvement)
 - stiffness at high humidity conditions
- by
- use of starch / chemicals / glues
 - use of filler materials
 - construction of multilayer board
 - improved selection of fibre raw materials

Optimisation of Stiffness - influence of humidity

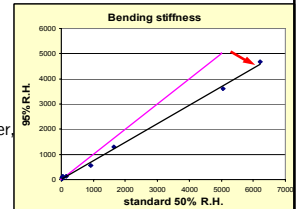
- Relevance
 - daily use of packaging in different climate conditions
 - variations from 10 - 95% R.H.
 - bad performance resulting in high product losses
- Todays practice
 - higher strength and stiffness at standard climate conditions
through
 - higher grammage, increased use of starch, stronger cover papers etc.
resulting in
 - higher costs, increased tonnage of packaging material

Optimisation of Stiffness - influence of humidity

- *Higher initial stiffness* \Rightarrow *higher stiffness at high humidity*
- Example
 - decrease of bending stiffness to 73%
 - of original value from 50% R.H. to 95% R.H.

comparable results for
tensile strength and SCT

Regardless of the type of paper!
(70 - 1000 grams, single-/multilayer,
virgin/recovered fibres)



Optimisation of Stiffness - outcome

- Results other subprojects
 - starch reology modifiers for improved starch efficiency
 - chemicals for improved stiffness / strength at high humidity
 - use of alternative glues for improved stiffness of multilayer board
 - optimised raw material choice for improved stiffness, strength and roughness of graphic paper

Optimisation of Stiffness - outcome

- Introduction of two cases
 - Stiffness: methods, conditions and applications



- Determining aspects of laminating paper



Laminating machine at Coldenhove Papier

Stiffness – methods, conditions and application

Stiffness,
unintentional uncomprehending

Programme

- Introduction
- Experimental approach
- Methods
- Measurement and environmental conditions
- Application

Introduction

- The three W-questions
 - Which methods
 - Where do they differ from each other
 - What are the possible relations

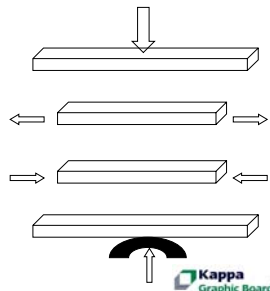
Experimental design

- Participants
- Materials
 - Different types and thicknesses
 - Broad range of paper and board
- Investigations
- Evaluation and report

Stiffness methods

- Principles

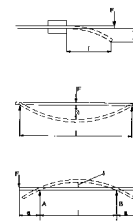
- Bending
- Tensile
- Compression
- Burst



Bending stiffness

- Static methods

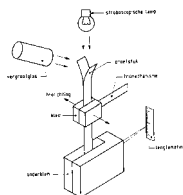
- 2 Point
- 3-Point
- 4-Point



Bending stiffness

- Dynamic method

- Resonance



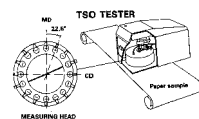
Tensile stiffness

- Static method

- Tensile strength

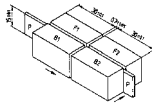
- Dynamic method

- TSO/TSI Ultrasonic

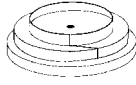


Compression stiffness

- SCT



- RCT

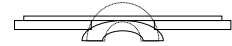


L2 16a RCT method

Bursting strength

- Burst is a combination of

- Tensile
- Bending
- Tearing



Correlations

- Gurley and 2 point bending stiffness (15°)
- Taber and 2 point bending stiffness
- 2 point bending stiffness at 15° and 5°
- 2 point bending stiffness at 15° and 7.5°

Correlations

- 3 point and 4 point bending stiffness
- Static and dynamic tensile stiffness
- 2 point static and dynamic resonance stiffness
- Bursting strength and tensile strength

Correlations

- Correlations which are **not** significant
 - E-modules of all methods
 - SCT and RCT with all other methods
- Kodak Pathé dynamic resonance stiffness with 3 and 4 point static bending stiffness
 - Correlation is significant
 - Results are increased with factor 1.6

Impossibilities

- 2 point bending at 15°/7.5° for weights over 1000 g/m²
- 3 point bending for weights lower than 220 g/m²
- 4 point bending for weights lower than 400 g/m²
- Static tensile for weights over 1000 g/m²
- SCT and RCT for weights over 600 g/m²

Measurement and environmental conditions

- Measurement conditions
 - Measurements performed according to ISO standards
 - Personal influence may be affecting results
- Environmental conditions
 - Laboratory condition 23°C/50 % RH
 - Moisture is affecting all strength properties



Measurement and environmental conditions

- Condition 23°C/95 % RH
 - 2 points bending decreases 25 %
 - Tensile strength decreases 15 %
 - Stretch increases 45 %
 - SCT decreases 45 %



Measurement and environmental conditions

- Kappa's Practice learns:
 - 2 % **Absolute** Moisture increase gives
 - 15 % stiffness decrease



Applicability

Awareness of different stiffness measuring methods will lead to:

- Better communication
- Fitness for use
- Recalculation of indicative stiffness levels for different measuring methods



Summary

- When strength is needed, stiffness may be measured
- Best results with method simulating expected forces
- Available stiffness measurement may be correlated to a variety of stiffness methods
- Be aware of moisture content and other environmental conditions



Stiffness – methods, conditions and application

Stiffness,
a clear concept



Case

Determining aspects of laminating paper

ON

Bending stiffness of laminated board

Jeannette van Leersum



Table of Contents

- Paper mill Doetinchem
- Requirements of Laminating Paper
- The case
- Conclusions
- Model used on 50 g/m² Laminating paper
- Pros and Cons



Paper mill Doetinchem

- More than 30 years supplier of laminating papers
- 100% recycled fibers

MISSION

Lowest paper costs in the end product of the client



Requirements of Laminating Paper

- Optical
 - Brightness
 - Shades
 - Opacity
 - Dot count
- Processing
 - Friction coefficient
 - Dennison wax test
 - Porosity
 - Water absorption
 - Tensile strength
- End product (Box)
 - Box Compression Test
 - ?



The Case

- Theoretical bending stiffness for a symmetrical 3-layer model

$$S_{\text{endproduct}} = f(E_{\text{bending, board}}; d_{\text{board}}; E_{\text{tensile, paper}}; d_{\text{endproduct}})$$

- Questions:
 - Is there a relation between the theoretical bending stiffness and measured in practiceIf so:
 - Which testing methods predict the best
 - Which aspects have the greatest influence
 - Which are determining aspects of laminating paper and board
 - How can these aspects be optimised



The Case

- Experiment
 - 13 laminating papers tested
 - Varying grammage and properties
 - Each paper laminated on both sides of a standard board (400 g/m²)
 - On a full industrial laminating machine with constant speed and sizing
 - Papers, board and laminated board tested on different properties with several testing methods



Laminating machine at Coldenhove Paper
coldenhove papier
verfresk, boordend



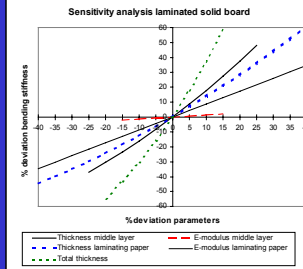
Conclusions 1

- Relation theoretical bending stiffness and practice?
YES, the theoretical formula gives a good description of the practice
- Limiting conditions e.g.:*
 - Laminating papers should be less than 50% of the weight of the board
 - Depending on the kind of paper a fixed percentage should be added to the outcome of the theoretical model
- Which testing methods give the best prediction?
 - E-modulus bending of the board → 2 points or Kodak Pathé
 - E-modulus tensile of the laminated paper → Tensile test



Conclusions 2

- Which aspects have the greatest influence



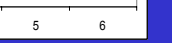
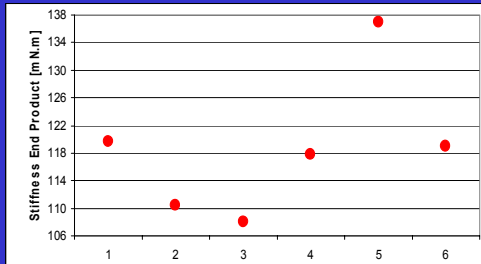
Conclusions 3

- Determining aspects of laminating paper and board and how to optimise
 - Laminating Paper : E-modulus tensile and thickness
A paper with high tensile strength and low elastic stretch
 - Board: Thickness



Model used on 50 g/m² Laminating paper

- Which dot is the Laminating paper from Papermill Doetinchem?



Pros and Cons

CONS

- Risky case. Co-operation with clients and competitors
- Model is simply to fill in, without right precaution wrong conclusions might be drawn
- The model gives the possibility to determine price / quality ratio.
 - Depending on the kind of paper a fixed percentage should be added to the outcome of the theoretical model
 - This is not taken into account in the price / quality model

PROS

- Took the discussion to a higher level
- Closer to delivering the right quality at the end of the chain in a good price / quality ratio



General conclusions

- Innovations in process- and product optimisation by:
 - multidisciplinary approach: exchange of expertise
 - co-operation with customers
 - co-operation with and between suppliers
 - activities performed by all participants
 - outsourced co-ordination
- Integral approach leads to a relatively cheap way of actual optimisation and control of process and product



General conclusions

- Results
 - increased level of knowledge on mechanical paper properties
 - awareness of applicability of stiffness measurement methods
 - decreased amount of stiffness measurements
 - step towards improved chain communication
 - possibilities, impossibilities and requirements for stiffness control
 - improved stiffness control of solid board
 - insight in significance of humidity influences

Questions?

Thank you for your attention

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