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
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Introduction

- Welcome
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- 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

Contents

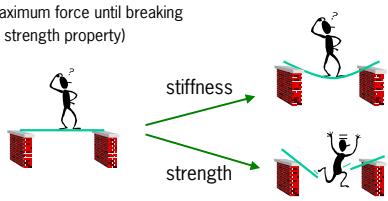
- Introduction and motivation
- Background, requirements and co-operation
- Chain integration and optimisation
- Optimisation of stiffness and humidity influences
- Case: Stiffness measurements, conditions and applications
- Case: Laminating paper for solid board stiffness
- Conclusions

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?

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)



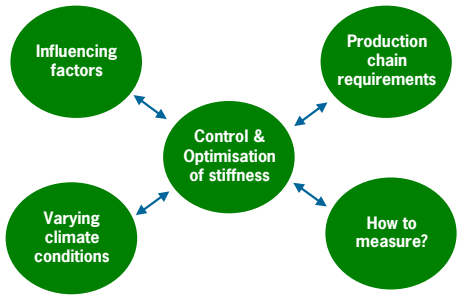
Background: what is stiffness?

- 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 ~ $E \cdot d^3$
  - Tensile stiffness / Compression stiffness ~ $E \cdot d$
  - Torsion stiffness

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.

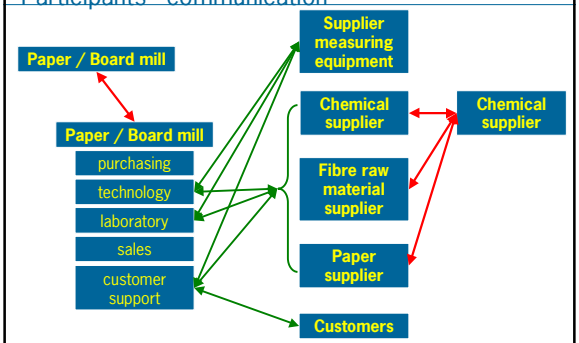
Requirements



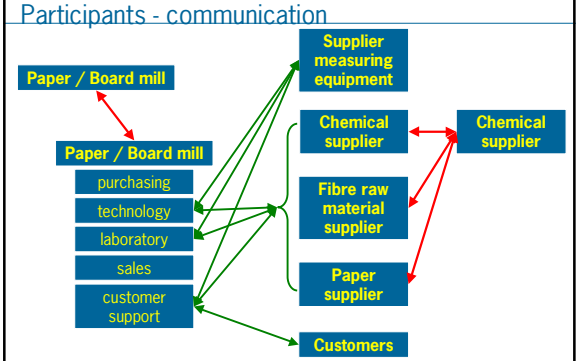
Participants

- 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

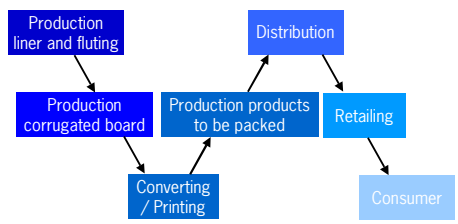


Participants - communication



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 differerent stages in the production chain
  - paper supplier, paper producer, converter, printing company, producer of packed goods, transporter, retailer and consumer

  and requirements on processability



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

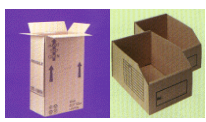
Chain optimisation - cooperation

- 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

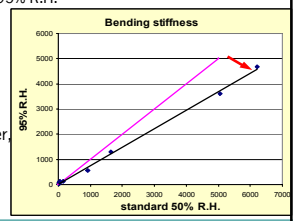
- Relevance
  - daily use of packaging in different climate conditions
  - variations from 10 - 95% R.H.
  - bad performance resulting in high product losses
- Todays practice
  higher strength and stiffness at standard climate conditions
  through
  higher grammage, increased use of starch, stronger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

Optimisation of Stiffness - influence of humidity

- *Higher initial stiffness ⇒ 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
    Geert Landlust
    Kappa Graphic Board

  - Determining aspects of laminating paper
    Jeannette van Leersum
    Papierfabriek Doetinchem

Laminating machine at Coldenhove Papier

Stiffness – methods, conditions and application

Stiffness,

unintentional uncomprehending

Kappa Graphic Board

Programme

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

Kappa Graphic Board

Introduction

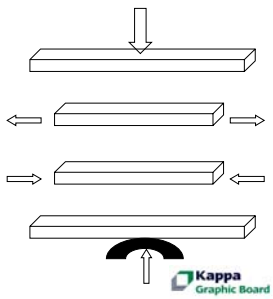
- The three W-questions
  - Which methods
  - Where do they differ from each other
  - What are the possible relations

Experimental design

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

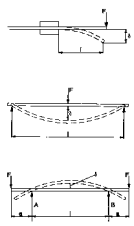
Stiffness methods

- Principles
  - Bending
  - Tensile
  - Compression
  - Burst



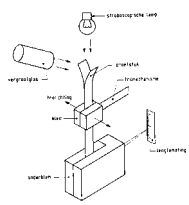
Bending stiffness

- Static methods
  - 2 Point
  - 3-Point
  - 4-Point



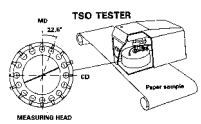
Bending stiffness

- Dynamic method
  - Resonance



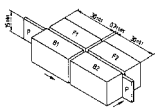
Tensile stiffness

- Static method
  - Tensile strength
- Dynamic method
  - TSO/TSI Ultrasonic

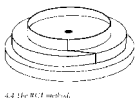


Compression stiffness

- SCT



- RCT



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

Papierfabriek Doetinchem

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- Paper mill Doetinchem
- Requirements of Laminating Paper
- The case
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- Pros and Cons

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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

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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
  - ?

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The Case

- Theoretical bending stiffness for a symmetrical 3-layer model

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

- Questions:
  - Is there a relation between the theoretical bending stiffness and measured in practice

  If 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

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The Case

- Experiment
  - 13 laminating papers tested

    Varying grammage and properties
  - Each paper laminated on both sides of a standard board (400 g/m^2)

    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 Papier

coldenhove papier eerbeek, holland

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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

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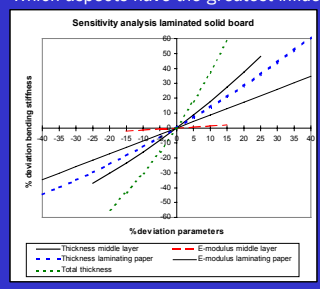
Conclusions 2

- Which aspects have the greatest influence



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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

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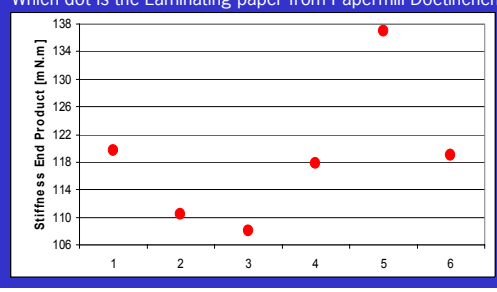
Model used on 50 g/m² Laminating paper

- 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

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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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