Defining softness

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Defining softness

• Softness is often a very important parameter for tissue products

• Current markets continue to demand high quality products at a reasonable price

• Perceived “Value” is the key
Defining softness

• To measure, or improve, softness, first we need to understand it

• Softness is an indirect measurement – a combination of other, directly measurable parameters

• What is not clear is which parameters and in what weighting would give a definitive guide to “softness”
Defining Softness

- Complex characteristic
- Subjective and psycho-physical property
- What one person, at one time, believes are the most important characteristics for softness, will not be the same as someone else’s, or even their own in a different setting
Consider.....

• One person may consider a bulky, fluffy-surface TAD sheet to be “soft”
Consider.....

- One person may consider a bulky, fluffy-surface TAD sheet to be “soft”
- Another may deem a highly flexible (drapey), silky surfaced (calendared) sheet to be “soft”
Consider.....

• Weighting of parameters will depend upon:
  o Product purpose (towel, tissue)
  o Environmental conditions
  o Emotional state of tester
  o Personal preference
  o Advertising
  o And more!
Current thinking on Softness

• So, I am going to talk about some work that has been done by others on defining softness
Current thinking on Softness

• Tissue products have been developed to replace cloth items, which were soft and absorbent
Consensus – compound property

- Generally accepted that customers perceive softness based on three parameters:
  - Surface smoothness
  - Flexibility
  - Bulk softness (Cushioniness)
• And these three parameters – apply in differing ratios, for different people, different products, different times........etc.!
So, how is it measured?

Subjective panel measurement

Panel

Individual components measured – Softness calculated from weightings

Off-line

Automatically, test carried out off-line by technician, on one machine auto weighting of parameters

On-line

Automatically, online measurement

Weighted
Remember? Characterisation of tests

- Sensitivity
- Readability
- **Precision**
- Accuracy

**Precision**

Variation to be expected if same test carried out on same sample (replicate tests)

Think of Precision as “repeatability”
Panel test: How does it compare?

- There can be significant differences in the perception of softness by different people (*lack of Precision*)
- The softness of the reference samples is not stable over the time (*not repeatable over time*)
  - dependent on chemical specification and storage conditions
- It can be hard to find a strong correlation with any objective method (*comparing precise and imprecise*)
How do they compare?

• Many equations have been derived that describe softness as a function of certain physical properties.

• There is still much debate over how well these represent the consumer’s perception of softness.
Defining softness

- Flexibility
- Bulk Softness
- Surface Smoothness
Surface smoothness

- Surface softness is defined as the sensation of softness when *fingertips* are lightly brushed over the *surface* of a sheet under slight restraint.

- Related to the *size* and *distribution* of the irregularities on the surface.
Surface smoothness - characteristics

- Smoothness
- Fibre stiffness
- Micro-compressibility
- Texture
- Uniformity
Surface smoothness - relationships

- Wet-end control
- Uniform formation
- Yankee coating
- Creping blade
- Softeners and lotions
Defining softness

- Flexibility
- Bulk Softness
- Surface Smoothness
Bulk Softness

- Perceived softness obtained when tissue or towel is crumpled between the hands
- Bulk softness has been shown to be closely related to the flexibility, or the bending stiffness of the sheet
Bulk Softness - characteristics

• Stiffness (flexibility, drape)
• Cushioniness
• Creasability
• Macro-compressibility
Bulk Softness - relationships

- Creping
- Chemical de-bonders
  - Break fibre bonds
  - Block hydrogen bonding sites
Other factors in perception of softness

1.

2.

3.

4.
Relative Importance of parameters

• **Base tissue evaluation**
  - Mainly **surface softness** tested
  - Bulk softness has less influence on the handfeel test

• **Finished product evaluation**
  - Surface softness
  - Bulk softness
  - Sometimes thickness
Measurement implications

- The **directly measureable parameters** affecting the softness can be measured using different **existing** measuring methods.

- By using a **complex equation**, a certain value can be calculated which represents (more or less) the subjective softness, determined by a specific panel.
However........

• The equation weightings will not be the same between products

• These methods are very time-consuming and complex

• Therefore generally inappropriate for application in a paper mill or for the use by chemical supplier
A better way? – Automatic testing

• There are now some new methods, which can gather the most important parameters affecting the softness
  o With one instrument
  o Sometimes in one run
  o Combining the data in specific equations to give a softness number

• The basic idea of the new testing method is to try to simulate the human fingertips as much as possible
The next section will be about

Measuring Softness
Measuring softness

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Current measurement methods

- Sensory testing
- Tappi method
- Clarke’s Softness Tester
- Kawabata Evaluation System (KES)
- Neural Networks Models
**Sensory (panel)**

- The idea that a panellist can convert the intensity of softness perception to a number.
- Each panellist awards a figure based on the softness in relation to a standard.
Sensory (panel) Test

• Take a sample of each of the tissues and decide which is softest

• Now count that as “100”, what score do you give the other tissues?
Panel test vagueness - 1/2

• Specific sensitivity of the finger tops, nose, ears and eyes
  - Each human brain determines a softness, based on an individual “biological equation”

• Each member of a panel has their own idea of softness
  - Based on their country and region of origin
  - And Environmental influences like weather, actual feeling of the person, season, and others
  - The effect is exaggerated in Embossed Products
Panel test vagueness – 2/2

• No good for small differences
• Very costly, not very timely
Tappi Method – Slot Test 1/2

• Carried out on a Handle-O-Meter

• Force necessary to push the sample into a 6.35 mm slot, in grams

• Sensitive to surface characteristics
  
  o Crepe undulations
  
  o Embossing
  
  o Friction between the sheet and the metal surface
  
  o Bending characteristics
Tappi Method – Slot Test 2/2

• It gives an indication of the handle, smoothness and drape

• A **Lower** value indicates a **less stiff**, **smoother** sample and hence point toward **higher softness**
Clarke’s softness tester

- Based on **stiffness measurement** of the tissue paper
- The test does not consider the surface effects on softness and is purely a stiffness-based parameter
Kawabata Evaluation System

- The KES instruments (4 of them) measure the mechanical properties that correspond to the deformation of tissue in the hand.

- Tries to predict the qualities perceived by human touch by measuring:
  - Bending
  - Shearing
  - Tensile
  - Stiffness
  - Smoothness and frictional properties
Neural networks

• Infer softness from the process variables

• This methodology can be used online and provide operators with a prediction of the quality of the final tissue

• The specific process variables used are:
  - Yankee dryer speed
  - Fan pump speed
  - Yankee temperature
  - Headbox pressure
  - Refiner power
  - Basis weight valve position
Two additional methods

- Tissue Softness Analyser
  - Off-machine (laboratory) single testing machine

- CTP methodology
  - Online fibre analysis (MorFi analyser)
  - On-machine dry-end analysis (TSSA scanner)
Tissue Softness Analyser

• Measures a combination of parameters in one run

• Uses specific equations to automatically calculate softness numbers from a combination of parameters:
  - Surface smoothness
  - Plastic deformation
  - Elastic deformation
TSA components

- The measuring elements are:
  - Rotor
  - Vibration sensor
  - A few other sensors to gather additional data
TSA method

• The softness is calculated using a complex equation, based on parameters entered by the customer

• Up to 68 separate parameters can be entered

1. Rotor pressed onto sample
2. Rotor rotates
3. Vibration sensed and analysed
4. Complex computer evaluation
TSA adaptability

• Emtec can develop specific equations, to suit a variety of products
  o Provided there is a sufficient database of measurements of known hand feel numbers to work with

• The end user (e.g. tissue manufacturer) can create their own scale, using two reference samples
TSA flexibility

• There are other accessories available which enable the TSA to measure:
  o Elastic/viscoelastic/plastic properties
  o Burst resistance
  o Compressibility
  o “Crumple ability”
  o Basis weight
  o Thickness
TSA – recommended activities

1. Quality assurance in base tissue production (same grade comparisons)

2. Product optimization of base tissue, measurement of hand sheets

3. Quality assurance in the production of finished products of the same grade

4. Benchmarking of base tissue and un-embossed finished products

5. Benchmarking of embossed finished products
CTP research

• Designed to be an Online (almost) real time measurement

• Based on pulp properties AND final sheet properties

• MorFi analyser used for Pulp Properties
  o Laboratory
  o On Line

• Paper presented by Jean RUIZ of the CTP at IBC (Paris) – 2010
CTP - Predicting softness from pulp

• From the data from **pulp fibre analyses and panel assessments** (handsheets) a mathematical model was designed to predict the pulp softness potential

• Very good agreement achieved (~90%)
• The pulp fibre analysis model is based on mean kink angle, mean curl index, broken fibres content, fines content in area and fines content in length
  - Morphological properties of the fibres explains about 60% of the tissue softness
CTP Predicting softness from scanner

- The process impacts the tissue softness
- Develop a tissue surface characterisation to better assess the final softness
  - 34% is from the paper formation process

![Pie chart showing surface characterisation percentage]
CTP research

**MorFi**
Fibre Morphology Analysis (online scanner)

Morphological properties of fibres

Surface Characterisation

**TSSA**
Tissue Surface State Analysis (online scanner)

6% still unaccounted for... the “human angle”?!
CTP – on line softness assessment

- GSM & Machine Speed
- TSSA
- MorFi

Softness Database
Limitations of testing

• What none of the machine testing can do is to take into consideration the other parameters (unless they are constant), such as
  o Embossing
  o Brightness/colour/pattern
  o Smell

• But Panel testing has many of its own issues, such as repeatability and impact of external factors (and cost and timeliness)
Enhancing softness

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How can we improve softness?

1. Horses for courses – match the approach to the problem type (John Stitt)

2. Some common problems

3. Pulp Process

4. Wet End

5. Dry End Converting
Two types of decision making

Buying a House  Buying clothes  Buying cereal

Static  Dynamic

Machine manufacturer and configuration  Doctor blade loading angle  Paper machine running parameters
• Static decision making should be based on data Analysis
• The more (relevant) data available the better – as long as you interpret it correctly
• e.g. Deciding what route to take to avoid a road closure
• Dynamic decision making should be based on intuition

• The more experience the better your intuition
  o but it does not follow that everyone with a lot of experience will have fantastic intuition!

• e.g. Driving a car – responding to unexpected hazards
• Very dependant upon personality types
  o Individual
  o Company
However, it is important to use intuition to “sense check” static decisions based on analysis!
• Time, Cycle, Position (*Shainan*)

• Often *used informally* to diagnose machine problems

• e.g. Holes in the sheet:
  
  o How often do they repeat?
  
  o What process element does this correspond with?

  * Yankee circumference?
  * roll diameter?
  * felt length?
  * wire length?
J Stitt – intuitive dynamic situations

• **LOOK**
  
  o Uniform coating after shower/before blade?
  
  o Dust is “rolled”? – too much release
  
  o Blade wear
  
  o Formation, creping, holes?

• **LISTEN**

• **FEEL**
• LOOK

• LISTEN
  o A harsh grinding sound? - coating is too hard
  o Good creping has a hiss like an open air hose
  o Blade vibration that leads to chatter can be heard as a whine, or press roll bouncing, or erratic pump or consistency regulator operation

• FEEL
• LOOK

• LISTEN

• FEEL
  o Feel the sheet on the reel for static and an indication of moisture profile (humps in sheet)
  o Do you feel ticks on your hand as the reel runs past it (picking or holes)?
  o Do you feel ticks at the edge (edge cracking)?
  o Run a fingernail along the edge of an old blade to feel any defects
Some examples of problem areas – 1/3

• Basis weight (BW) variation
  o Consistency control issues
• Machine moisture variation
  o Especially showering related
• Condition (porosity) of the felt
• Pressing profile
Some examples of problem areas – 2/3

• Hood dampers

• Yankee profile

• Yankee surface issues
  
  o Stroboscopic examination of the Yankee dryer surface after the creping blade looking for uniformity, colour, and possible chatter

• Blade wear profile and history
Some examples of problem areas – 3/3

• Coating shower
  o Coating shower pressure and temperature
  o Nozzle condition

• Shower to pressure roll nip dwell time. Changing speed changes the dwell time and coating set

• Nature of the crepe viewed with magnification, for softness look for surface fibres in the Z-direction
Areas to improve softness

• Pulp Process
• Machine Wet End
• Machine Dry End
• Converting
To improve softness - Pulp Process

• Softwood and Deinked pulps worst for softness

• More tensile → lower softness

• Hardwoods good, especially Eucalyptus

• Tactile softness can be improved by using short hardwood fibres, such as eucalyptus, on the outer layers of the tissue (formation)

• The use of chemical debonders in the outer layers can help softness
To improve softness - Pulp properties

• In general, increasing fibre curl will increase softness

• Performing mechanical action, at high consistency (>10%) can introduce curl into chemical and recycled pulps
  ○ Even at lower consistencies changes in fibre morphology, brought on by refining, impacts tissue properties

• It is often necessary to reduce excessive fibre curl
  ○ In general, low intensity- low consistency (LC/LI) refining helps remove curl and kink from chemical pulps
To improve softness - Pulp Properties

- Basis Weight and Softness 1/3

- Increase in BW → Increase in softness

- Constant bonding
- Fixed refining
- Low BW product
To improve softness - Pulp Properties

• Basis Weight and Softness 2/3

High BW Product

Increase BW → increase Stiffness

Decrease Softness
To improve softness - Pulp Properties

- Basis Weight and Softness 3/3

Increase BW
→ lower bonding
→ Lower density

Constant tensile

Increase Softness
To improve softness - Pulp Properties

- **Formation** has a major impact on softness

  - Poor formation
  - Fibres not bonded well
  - Refine more / add strength additives
  - Sheet becomes more dense

  **Reduced Softness**
Areas to improve softness - Fabrics

• Fabrics specifically designed to **increase bulk and softness**

• Different fabric manufacturers have their own proprietary fabrics available

• Fabric choice dependant upon:
  - machine and process type
  - desired properties
  - furnish requirements
To improve softness - Voith - ATMOS

• TAD is a way to increase the BULK softness
  ○ But can fall down in terms of flexibility and surface smoothness
  ○ Very costly re-build and running costs

• Advanced Tissue Molding System (ATMOS)

• ATMOS is posited to achieve the same results -
  ○ Using 60% less energy
  ○ Fewer fibres
  ○ Up to 100% recycled or virgin fibres
To improve softness - Voith Nipcoflex

- Pressing technology that is advertised to enhance bulk and softness
- Extended Nip Press (ENP) technology
To improve softness – Coating set

Coating set illustration

Developing:
- Cross-linking
- Cohesive strength
- Film uniformity

Developing:
- Cohesive strength
- Coef. of Friction
- Film Hardness

Rehydration

Developing:
- Cross-linking
- Tack
To improve softness – Coating set

• What affects coating set? 1/2

Higher → slower set

Release quantity

Water % in coating

Longer → harder set

Dwell time

Higher → faster set

Coating temperature

Yankee surface temperature

pH of coating (crosslinked)

pH of stock
To improve softness – Coating set

• What affects coating set? 2/2

Doctoring  What the coating “sees”

Coating chemistry  Heat demand
To improve softness – Coating set

• For good creping the coating must set properly in the nip

• The point of maximum tack (set-point) should happen at the press roll nip
  o where the sheet first contacts the coating
To improve softness – Coating set

- For good creping the coating must set properly in the nip

- Sets too soon
  - “glasses over”
  - Does not adhere well

- Sets too late
  - Coating washes into felt
To improve softness – Coating set

Drying mostly from Hood → softer coating, slower set

Drying mostly from Yankee → Harder coating, Faster set
To improve softness - Coating chemistries

• Things to consider about coating chemistries
  o Interaction with water (solubility, rewet, moisture retention)
  o Film forming properties (uniformity, surface energy, interfacial adhesion)
  o Film rheology (Tg, shear modulus, cohesive strength)
To improve softness – Yankee coating

• Optimal coating set-up will depend on your parameters

More adhesion

Less release

Wetter sheet?
To improve softness – Yankee coating

- More Release

- Sheet
- Absorbency

- Coating
- Set Rate

- Coating bond
- strength

- Bulk
- Stretch
To improve softness – Yankee coating

• More adhesion
To improve softness – Yankee coating

- Most response curves are non-linear
- e.g:

```
Stretch %
```

```
Release addition rate
```
To improve softness - Converting options

- **Lotions** can improve the perceived softness of most products
- **Capital investment is low**, compared with fundamental papermaking process changes required to bring about the same improvement
- Fits with the market demand for perceived value
- Higher quality at reasonable price
To improve softness - Converting options

- Still many choices to make, in terms of lotions
- First, must ask “what does my customer want?”

<table>
<thead>
<tr>
<th>Drape</th>
<th>Smoothness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slickness</td>
<td>Silkiness</td>
</tr>
</tbody>
</table>
To improve softness - Converting options

• Then, what product to choose?

<table>
<thead>
<tr>
<th>Wax</th>
<th>Emulsion</th>
<th>Silicone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surfactant</td>
<td>Liquid</td>
<td>What solids?</td>
</tr>
</tbody>
</table>
To improve softness - Converting options

- Finally, how to apply?

<table>
<thead>
<tr>
<th>Roll</th>
<th>Spray</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blade</td>
<td>Bath</td>
</tr>
</tbody>
</table>
Conclusion

• There are very many ways to impact on softness
• They range from expensive to relatively low cost
• They range from static to dynamic
• They range from basic papermaking, to high-tech solutions
• Softness can be complex to define, measure and improve
Conclusion

• The key is to have a full understanding of YOUR situation
  o Brand
  o Product
  o Process
  o Limitations
  o etc.