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An Holistic Approach to Creping

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INTRODUCTION

In the manufacture of tissue webs creped from the surface of the Yankee dryer, certain tissue properties and characteristics are produced.

The highly desired properties of tissue stretch, bulk and handfeel depend upon many factors, the principle mechanism being the adhesion of the web to the Yankee dryer surface coupled with mechanical forces acting at the point of web release.

To achieve these goals through creping, we must find a balance between sheet cohesiveness (the forces holding the sheet together) and the adhesive force which resists detachment of the web from the Yankee surface when it impact the contacting edge of the doctor blade.

The adhesive force is often thought only to be the chemical mixture applied to the Yankee surface to hold the sheet in constant contact to the Yankee, but in fact, this force has many other components. Unfortunately, many process variables interfere with the above equilibrium and can create other issues that detract from the tissue makers goals.

To understand this, the process has to be broken down into segments or ‘process technology platforms’. These defined platforms allow the tissue maker a snapshot of his process and hopefully invites questions from them on what could be done to improve the process and achieve their goals.

PROCESS TECHNOLOGY PLATFORMS

The segments we review below form the quality chain which leads to good crepe and ultimately the best tissue quality with the desired consumer properties of handfeel, stretch, bulk and strength. Too often, we see attempts to improve softness for example completely focussed on dry end operations; creping chemicals or doctoring. The tissue making professional however will know that the upstream processes have to be optimised before working on the final crepe operation. An audit of factors influencing crepe might cover all of the following:

<table>
<thead>
<tr>
<th>Furnish</th>
<th>Jet wire ratio</th>
<th>Headbox stratification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formation</td>
<td>Wet end operations</td>
<td>Strength management</td>
</tr>
<tr>
<td>Softener/debonder chemical</td>
<td>Pressing</td>
<td>Stretch and crepe ratio</td>
</tr>
<tr>
<td>Drying</td>
<td>Creping platform</td>
<td>Pope reel equipment</td>
</tr>
</tbody>
</table>

Table 1 General factors in the process affecting creping

This is all on the tissue machine; converting can have an even greater impact upon tissue quality, but it remains true that the best tissue is converted from good parent roll base sheet.

In the following section, we briefly describe the science underpinning these quality impacts, in terms of how they influence creping.
FIBRE MANAGEMENT

YANKEE COATING EFFECTS

Chemical analysis of the ‘natural’ coating that develops on the Yankee surface shows it is composed mainly of hemicellulose, along with smaller fractions of lignin, Cellulose, pulp extracts and dispersed fibre fibrils.

The development and formation of this natural adhesive layer on the Yankee surface based on laboratory studies show there are three possible main mechanisms, these are:

When the natural/Yankee adhesive layer becomes greater than the cohesive force of the sheet, the sheet ‘picks out’ when the sheet is removed by the creping blade, therefore small fragments are removed from the web. If this layer is allowed to build and is exacerbated by none or infrequent cleaning blade changes or none fitment of a cleaning blade holder, the coating layer becomes more inconsistent and more uncontrollable, the end result is sheet breaks.

During the drying and evaporation phase on the Yankee surface, the fibres undergo thermo plastic transformation, therefore a thin layer of Hemi cellulose is transferred to the hot Yankee surface. Depending on the degree of heat flux of the Yankee surface, which may be high due to maximum steam usage (conduction), the fibre matrix containing organics/fines migrate to the hot Yankee surface (Dreshfield effect) providing a densely packed substrate ‘baked’ onto the Yankee surface. This densely packed layer is more difficult to break down at the creping blade thus low bulk and low creping efficiency are generally found.

White water: contains amounts of hemi cellulose which readily wets out on the hot metal surface upon sheet evaporation phase along with organics/fines.

Alkali extractives from wood pulp fibre during the sheet evaporation phase form a thin layer with very strong adhesive characteristics. This certain trait is very much dependent upon the dryness at the moment of impact is made between the Yankee surface and the suction roll, so sometimes we see lower adhesion at high dryness levels.

(This is one reason why a cleaning blade is required to keep in check/refresh the Yankee coating)

The three mechanisms above show there is a constant and continuous state of flux and a full understanding of pulps/pulping/bleaching etc. need to be understood along with Yankee coatings and procedures for the refreshment of coating are paramount to presenting a consistent sheet quality for creping aesthetics.

FIBRE TYPE

The fibre type, especially the fibre morphology, are fundamental to producing required tissue properties. The effects of fibre morphology, regardless of source are, applicable to any fibre type and it is these subtle effects that the tissue maker needs to understand.

The use of softwood to provide strength and short fibre to provide excellent tactile properties is still the steadfast way of producing premium grade tissue product. However todays trend is still for tissue with good quality handfeel but with reduced furnish costs, hence the increased amount of short fibre is utilised. This however has its own disadvantages and again should be recognised by the papermaker.

The best of softwood tissue making fibres come from Canada. The fibre produced is specific to their particular climatic conditions, producing softwood fibre with low fibre coarseness and appearance of long ribbon like strands with wide lumen and thin cell walls. This fibre easily collapses and provides a much wider or specific bonding site, generally termed Relative Bonding Area (RBA). It is this RBA that gives unrefined northern softwood kraft a higher breaking length of up to 2000 metres greater tensile index than an equivalent unrefined southern softwood fibre (small lumen and thicker cell wall) from the southern states of the USA.

The premier or class 1 softwood fibres are generally mixes of white and black spruces and possibly Cedar, with a fibre coarseness of 11 to 16 mg/100ms.
Class 2 softwood fibres which generally incorporate sulphite prepared fibres have a coarseness range of 16 to 20 mg/100m.

Class 3 fibres are generally the southern softwoods (Pines) and have a coarseness range of 20+ mg/100m. The best southern pine species is maybe Radiata pine from Chile, which has a coarseness value of around 20 mg/100 metre and very similar in properties to Douglas fir species.

Today the majority of the class one fibre is quickly purchased by the big North American tissue making corporations, leaving very little available on the open market especially Europe. Probably the best fibre available to Europe is from specialist Scandinavian producers, but a major Canadian based supplier now making more inroads into the European market.

The best European fibre generally has a class 2 type coarseness or around 16 mg/100metre produced from fast growing ‘fractionated’ Scandinavian spruce and blends of pine.

<table>
<thead>
<tr>
<th>Higher coarseness leads to lower quality</th>
<th>High density leads to lower quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>High stiffness</td>
<td>More resistance to bulking</td>
</tr>
<tr>
<td>Less flexibility</td>
<td>Less flexibility</td>
</tr>
<tr>
<td>Low bonding potential</td>
<td>Less specific volume</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Lower coarseness leads to higher quality</th>
<th>Lower density leads to higher quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improved handfeel</td>
<td>Improved bulk softness</td>
</tr>
</tbody>
</table>

Table 2 Quality impact of fibre coarseness and density

The general trend today however is to substitute the softwood fibre with forever increasing amounts of Eucalyptus or other hardwood species. Aesthetically, the sheet has good formation and tactile properties, generally a nice ‘surface’ feel, but loss in stretch, tensile and in some cases increased stiffness is the trade-off, which detract from the some of the fibres positives. Moreover, this increased hardwood trend brings other disadvantages if the tissue maker is unaware of his process of refiner treatment. This will be dealt with further in the next section.
REFINING

Refining along with fibre selection is important for setting tensile and the providing structure for a cohesive sheet. However, the path leading to correct refining is misunderstood and often neglected. Today’s trend is to utilise more short fibre in the tissue furnish, but correct refining practices do not follow suit.

The stock preparation system may have originally have been designed for a higher mass throughput of softwood, where the refiner plates would have been selected for such fibre processing. Once the decision has been made to utilise more short fibre, mill operations still often refine with the originally fitted long fibre plates.

The result is heavily cut fibre and high percentage of fines/debris, which ultimately result in even higher refining loads as strength criteria is not met.

The higher fines laded stock in the white water system creates havoc on the Yankee with heavily contaminated hard coating preventing good creping characteristics, loss of strength due to excessive fibre breakdown and increasing Yankee chatter risk through Yankee contaminated coating.

The use of enzymes can help in creating fibre bonding and reduction of refining energy, but early results show that it cannot completely substitute refining.

Finding the correct refining solution is the only way to go. The refining system and through put requires the system to be surveyed to establish suitable refining garniture fitment.

The refining energy is split into 2 energy equations, firstly, we have to determine how hard the fibre is hit or intensity (I). This is called SEL (specific edge load). This is measured in watt seconds or joules per metre.

The value for softwood is generally 1.25 to 4.0 joules/metre, however it has been established that to suitably ‘prepare’ softwood fibre for tissue making the intensity should not much exceed 2.0 J/m (squeezed/bruised fibre). Above 2.0 J/m is the onset of fibre cutting.

For preparing short fibre the specific edge load is usually found in the range of 0.4 to 1.2 J/m. Eucalyptus refining intensity however has a slightly lower intensity ceiling of 0.8 J/m.

The second energy equation is based on ‘how many times the fibre is hit’ denoted (E).

This is based on the mass throughput through the refiner divided by the net power of the refiner and the result is given in kW/hr/ton.

In principle the fibre should be subjected to multiple impacts (E) at very low intensity (I). The following table summarises the ideal refining ranges for common tissue pulps.

<table>
<thead>
<tr>
<th>Furnish</th>
<th>CSF drop per net kWh/t (ml)</th>
<th>Range of SEL J/m</th>
<th>Consistency range</th>
<th>Best SEL for tissue</th>
</tr>
</thead>
<tbody>
<tr>
<td>UBSWK</td>
<td>0.75-1.5</td>
<td>2.5-4.5</td>
<td>3.5-4.5</td>
<td>&gt;2.0</td>
</tr>
<tr>
<td>BSWK</td>
<td>1.25-3.0</td>
<td>1.5-2.5</td>
<td>3.5-5.0</td>
<td>&gt;2.0</td>
</tr>
<tr>
<td>BHWK</td>
<td>3.0-5.0</td>
<td>0.5-1.0</td>
<td>4.0-6.0</td>
<td>Lower is best</td>
</tr>
<tr>
<td>BHWK Euc</td>
<td>2.2-2.5</td>
<td>0.5-1.0</td>
<td>4.0-6.0</td>
<td>Lower is best</td>
</tr>
<tr>
<td>OCC</td>
<td>2.0-3.5</td>
<td>0.75-2.5</td>
<td>3.5-5.0</td>
<td>As low as possible</td>
</tr>
<tr>
<td>Mixed</td>
<td>2.5-3.5</td>
<td>0.75-1.5</td>
<td>4.0-6.0</td>
<td></td>
</tr>
<tr>
<td>News</td>
<td>1.0-1.8</td>
<td>&lt;1.0</td>
<td>3.5-6.0</td>
<td></td>
</tr>
</tbody>
</table>

Table 4 Refining parameters for tissue
FORMATION

Formation is one major asset that brings numerous benefits in terms of tissue aesthetics. A sheet with good formation is nearly always perceived as softer to the eye and touch. Good formation also improves tensile generation which ultimately can mean reduction of refining energy, thus increasing bulk and thereby reducing refiner impact energy on the fibre. This also reduces fines and debris generation which has a major effect in the white water system and natural Yankee coating layer.

In the pursuit of reduced energy consumption, the first thing the operator is inclined to do is to close the slice lip opening. A sample of several interactions then take place such as:

- Increased forming consistency (floculation)
- Increased fibre crowding ratio (again floculation but offset if higher amounts of short fibre are used)
- Poor or incorrect forming geometry
- Higher wire fibre bleed
- Retention changes
- Loss of tissue strength leading to increased refiner energy to 'crutch' the tensile loss.

So what can be done?

Firstly we must assess if the formation is wire or floc induced:

We require a forming fabric with high fibre support (fine mesh yarns) and good drainage characteristics.

A fabric that is well cleaned on a continuous basis ready to accept the slice jet.

Good formation from the headbox itself. This is dependent on type of headbox shear and de-floculating design i.e. diffuser board or tube bank. Headboxes fitted with internal lamellas inside the forming nozzle can be incorrectly dimensioned in length, creating high tip 'expansion profiles' that cause poor velocity profiles and intermixing of layers if not tuned to provide a good velocity profile, especially if the headbox is 2-layer, so reduction of the slice opening and changing to a shorter fibre matrix can also cause unexpected outcomes in the tuned length of the lamella.

If formation is deemed acceptable from the headbox, then it can be easily destroyed by poor forming geometry, that is the jet impacting incorrectly between the converging nips of roll and fabrics. It is recognised best geometry is when the top and bottom of the slice jet impacts on the intended impact surfaces simultaneously, this being the forming wire and the second wire or felt.

Below is an example of a very poor (incorrect) forming geometry with 100% jet impact into the forming roll (felt). As can be seen the jet impacts on the forming roll then is immediately 'exploding' upwards on impact before the wire captures the slice jet. This example gives rise to poor formation, tensile generation, poor drainage profile, high wire fibre bleed impacting on first pass and true retention and felt filling with fines/debris, holes, exacerbating in natural Yankee surface coating contamination development.
Figure 1 Poor forming geometry

- Breast roll
- Forming roll
- Angle between wire and slice jet too great
- 100% slice jet impact into the forming roll

Figure 2 Good forming geometry

- Breast roll
- Forming roll
- Angle between wire and slice jet too great
- 100% slice jet impact into the forming roll
Above with revised headbox geometry. Incline headbox upwards (A) and reducing the breast roll distance to the forming roll to capture the jet earlier (B). Breast roll to forming roll distance is based on the minimum and maximum headbox opening.

HEADBOX JET SPEED MANIPULATION
One area that is generally misunderstood is the jet/wire ratio and tensile index via refining relationship.

For example the MD tensile may be well above target values and the CD tensile is on target values for a particular product being produced but with low bulk. At this point no further refining adjustment is made by the operator, yet the level of refining may be at such an intensity that it is damaging the fibre and therefore reducing the bulking potential of the fibre matrix along with unnecessary freeness levels impacting on drainage and drying.

To try and correct this first we must establish the geometric mean tensile (GMT, $\sqrt{(MDT \times CDT)}$) or total tensile from the product specification and then apply the same method to the tensile values in production.

By doing this we can establish if a jet wire ratio change is needed or a refining change is needed or corrections to both.

So going back to the earlier example of high MD tensile and target CD tensile, once the GMT is found to be higher than specification, then it can be corrected as follows:

- We need to reduce MD tensile, but hold the CD tensile.
- Increase the total head by changing the jet wire ratio. This action will increase both the MD and CD tensile together, thus making the CD tensile higher than target.
- Reduce the refiner by 5 kWH/ton increment if running in SRE mode, or power by 10 kW if running in power mode only.

PRESSING AND IMPORTANCE OF FELT CONDITIONING
The function of the suction press roll is to transfer the sheet to the Yankee and simultaneously remove water via mechanisms of compression (press loading) and vacuum.

The major negative with the ‘roll’ type press is sheet re wetting, as vacuum breaks on the exit side of the nip and the felt / sheet expands allowing the rewet to occur by capillary action.

The exit felt angle is very important and ideally the sheet needs to separate immediately after the mid nip point.

Sheet consolidation during this pressing phase increases the hydrogen bonding of the sheet but reduces the sheet ‘bulking’ factor due to compression. Obviously this is exacerbated further if two presses are used.

To produce a sheet with more bulk, taking out the effects of fibre selection, we must reduce the compressional forces (press loading).

This can be achieved by shoe press technology or proprietary wet moulding technology such as Voith Atmos™ of Valmet NTT™.

To achieve soft bulky tissue on an LDC machine with a conventional press layout, the only way to go is with softer roll covers, single press and non- use of the steam box if fitted.

The benefit of soft roll coverings, especially rubber is the ability to improve the Yankee crown ‘fit’ thus increasing and improving sheet intimacy with the Yankee surface (thus improving performance of the creping process) and possibility of reducing the line loading of the press due to a wider nip foot print.

Today’s trend once again is very much energy reduction driven, therefore harder covers are generally order of the day along with new felt structures and polymeric fibres.
Polyurethane covers are increasingly popular with a differing hardness scale and improved void volume, which is very much where these covers come into their own.

Lastly, there is no point in realising good pressing performance characteristics if simple tasks are not addressed, these are:

- Correct setting of the vacuum box angle. (Energy saving).
- Is the angle of the ejected water from the suction roll even across the full width of the roll?
- To avoid suction roll rewetting is the doctor blade correctly set up on the roll? (Double doctor better, fitted with air wipe even better still).
- If an under roll rubber wiper is used is it correctly ‘set up’ against the roll?
- Is the saveall designed correctly for the ejected water volume and is it adequately ‘vented’ to remove large volumes of air to allow impeded drainage of water away from the roll?
- In hard water areas, is the suction roll periodically cleaned with acid? This also goes for the vacuum pumps. Energy savings should result.

Any mechanical issues such as vibration should be addressed immediately

FELT CONDITIONING

Felt conditioning is extremely important as we need to keep a continuous revolving belt with exceptional permeability on every fabric revolution with excellent intimacy with the suction roll and Yankee surface.

A well-conditioned felt can also reduce chatter risk by reducing the impact of contamination from wet end effect depositing on the Yankee surface bare edges, but most of all it has an extremely high synergy effect if a correctly designed felt structure is used in conjunction with a correctly chosen soft covered press roll.

To utilise this effect the mode of operation is based on total suction roll dewatering. If this is correctly employed there have been reports of post press solids increases of up to 1% being achieved and consequently, significant energy savings.

Theoretically the mechanics of suction roll nip dewatering is that it generates high hydraulic nip impulses that totally purge water out of the felt at the suction roll vacuum exit. Some theorists have even suggested that there is no need for uhle box dewatering and in some cases some mills have resorted to reducing vacuum at the uhle box or by increasing the uhle box slot openings well beyond the recommended openings.

However, we must understand that sheet dryness depends on the balance of dewatering and rewetting.

Rewetting is a process that can be related to many factors such as the surface batt structure of the felt but mostly is related to the fabric’s compressibility characteristics.

The compressibility is not just associated with the felt design but also includes suction roll(s) nip loading and loading profile

When a felt is too compressible, water flow out of the fabric is reduced and therefore sheet crushing occurs.

To provide the correct press fabric design it is necessary to understand the press nip impulse and other factors such as:
Factors

<table>
<thead>
<tr>
<th>The furnish and components</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basis weight range</td>
</tr>
<tr>
<td>Temperature of the sheet and system</td>
</tr>
<tr>
<td>Post press solids</td>
</tr>
<tr>
<td>Press roll nip loading</td>
</tr>
<tr>
<td>Pressure shape in the nip</td>
</tr>
<tr>
<td>Press roll diameter, roll cover hardness and thickness</td>
</tr>
<tr>
<td>Press configuration such as roll open area, geometry, suction box airflow</td>
</tr>
<tr>
<td>Other press type such as shoe press technology.</td>
</tr>
</tbody>
</table>

Table 5 Press Fabric Design Considerations

It is outside the scope of this article to give a detailed treatment of nip-dewatering felt conditioning, but as a rule of thumb, if the flooded nip show is delivering 60-70% of the felt water volume at around 150lpm/m width felt, and the HP needle shower is correctly positioned and used at the minimum pressure consistent with maintaining SPR vacuum, then the tissue maker is going in the right direction.

TISSUE DRYING

The mode of drying the sheet presented to the Yankee has such a tremendous impact on tissue aesthetics namely softness (drape) tactile properties, bulk.

However to achieve this requires the drying energy split to be moved from the Yankee (conductive heat transfer) and placed more biased towards the hoods (convective heat transfer).

However this drying mode is usually unacceptable to most papermakers as this requires more drying energy from the hood in terms of gas flow.

Understanding the drying energy impact and the final product aesthetics needs to be understood, especially when it comes to product development and degree of sheet ‘engineering’.

WHY INCREASED HOOD DRYING?

Yankee drying is a complex process of heat and mass heat transfer.

If the maximum allowable Yankee heat energy is utilised then capillary and surface tension forces draw water deeper into the web along with fibres/vessel fragments, fines and organics. The web becomes densely packed and heat sealed, thus high sheet density and a poor response to creping.

The ‘baked’ web natural coating components are responsible for Yankee coating contamination and have a very high contributory factor for Yankee chatter marking.
The mechanism of drying is as follows:

- As the wet sheet is pressed against the Yankee surface the conductivity of water dominates the drying process until water vapour is generated, driving heat into the web.
- As water vapour leaves from the closed surface (yankee) to the open surface, liquid water migrates towards the Yankee surface to fill the voids.
- Now if a new drying balance is established with lower steam pressure and more convective heat energy from the hood, the drying process is accelerated which affects the sheet structure. The increased hood convective drying more rapidly evaporates the webs surface water, thus drawing more interior sheet water to the exterior open surface.
- Air will then rapidly make the exchange and fill the voids left in the web and keep the surface more open, allowing water to readily evaporate and pass through the web from the Yankee surface. In this way the web is ‘fluffed up’

Figure 3 Steam dried sheet- densely packed

Figure 4 Steam and hood dried sheet, loosely packed
Bulk and softness properties are then further enhanced by the correct creping mechanisms employed.

**CREPING**

After bringing and tying together all the mentioned process platform stages, tissue sheet properties can be greatly further enhanced by manipulation of the final sheet moisture, creping chemistries including softners and debonders and creping mechanics.

Generally the lower the reel moisture, the more coating and creping blade frictional forces (creping energy) are generated to breakdown the internal fibre bonds and explode the sheet to produce a three dimensional structure.

The lower moisture increases sheet adhesion by coating contraction during the sheet drying phase, thus increasing adhesive strength.

The table below reflects the current reel moisture contents by grade

- Value tissue grades = 5.0% to 6.5%
- Premium tissue grades = 3.5% to 5.0%
- Super premium grades = 1.5% to 3.5%.

**YANKEE COATING**

The functions of the Yankee coating are as follows:

- To pick up the sheet at 60% moisture from the felt and stick it to the dryer
- To keep the sheet stuck to the dryer in the drying process
- To support the now 2-6% moisture sheet in the creping process
- To protect the Yankee surface and ensure acceptable blade wear.

This is diverse range of functions for any chemistry, but good solutions have evolved. However, it is important to note that only a small part of the ‘coating’ will be applied chemicals; the majority will be a mixture of other wet end chemicals (starch, wet strength), fines, filler, ash, and lignins and hemi-cellulose from the pulp, as referenced earlier. The function of the applied chemicals is to give control of the 4 main functions outlined above.
Discussion of various chemistry types is not within the scope of this paper, suffice it to say that the tissue maker has many options. But there are a few basic guidelines which can help:

Base Coat: This provides the adhesive power which defines the crepe, and much of the Yankee protection. The older polyamine-epichlorhydrin cross linking products can still provide good results for medium speed machines and 3-5% crepe moisture, with a good moisture profile. Higher speed (and higher temperature) machines demanded better products, so the non-crosslinking film forming types are preferred. The latest and most advanced products will be blends of various cross-linking and non-crosslinking polymers with plasticisers and modifiers, and work well even at the higher crepe moistures demanded by energy-cutting tissue mills today.

Release: The release should soften the coating, balance adhesion and lubricate the blade. It is worth spending time on the release, as the performance difference between good and bad ones is vast. Critical factors are dose response (the ability to increase stretch when the release is increased) and blade tip lubrication. BTG’s extensive experience is that vegetable oils and their synthetic analogues work very well with high performance ceramic or cermet crepe doctors. Some novel, non-oil chemistries have been launched which look very promising.

Phosphate. MAP or more complex phosphates should be used in soft water conditions, say below 150 ppm Ca hardness. Compatibility with base and release chemicals needs to be checked.

The best practice for using the chemicals are as important as the choice:

- Ideally, dose the chemicals in-line and use static mixers. Use water at around 150ppm Ca hardness and 40-50 °C to avoid microbiological growth.
- The chemical should be sprayed at 3-4 bar pressure through a spraybar with 60-70% spray overlap and an evaporative load (spray volume per dwell area spraybar-press nip) at around 85 to 115 kg/h/m2. A bar with 110001 tips at 200mm pitch and 200mm spray height normally achieves this.
- Base add on should be from 1.5 to 4.0 mg/m2, or sometimes even more, with higher add-ons favouring more premium products and normally longer blade life.
- Ideally set base coat add-on per grade and fine tune sheet properties (bulk, stretch) with the release. If there is no release dose response, then add more base. If there is still no response, then change the release chemical. Crepe control is not possible without a good release response.
- If phosphate is used, cap the add-on at 0.5 mg/m2

If these simple rules are used, and chemistry is well selected according to function (not by price or by following the latest supplier fashion) then a good platform is created for the final part of our creping story.

CREPING MECHANICS

SHEET AND YANKEE COATING

Firstly we need to understand that to produce a flexible sheet with high bulk and superior tactile properties the following concept is adhered to:

- In order to produce a de-densifying or exploding effect on the fibre when it impacts on the creping blade, it is necessary to have the sheet cohesive forces (Fc) lower than the Yankee adhesive force (Fa).
- Consideration that Fc is the force holding the sheet together and the adhesive force Fa is adhering the sheet to the Yankee.
- Therefore when Fa > Fc, the interfibre bonds are disrupted by the adhesion forces upon creping blade tip impact with such force that the number of interfibre bonds are reduced. Consequently, the flexibility of the tissue sheet is increased transforming the sheet into a tri dimensional structure.
CREPING BLADE AND GEOMETRY

Below is a pictorial representation of creping geometry and its effects.

The ‘Effective angle’ is basically the blade holder angle minus the blade grind angle. The resulting number is deducted from 90° to give the more established pocket angle.

<table>
<thead>
<tr>
<th>High effective angle (low pocket)</th>
<th>Low effective angle (high pocket)</th>
</tr>
</thead>
<tbody>
<tr>
<td>lower tensile</td>
<td>greater tensile generation</td>
</tr>
<tr>
<td>lower surface softness</td>
<td>greater creping efficiency</td>
</tr>
<tr>
<td>lower creping efficiency</td>
<td>greater levels of softness</td>
</tr>
<tr>
<td>Limited bulk gain</td>
<td>higher bulk gain from ‘explosive’ creping</td>
</tr>
<tr>
<td></td>
<td>reduced furnish costs</td>
</tr>
</tbody>
</table>

Table 6 Impact of effective angle

- Creping blade stick out usually between 10mm to a maximum 30 mm. Free blade height greater than 30 mm can induce unacceptable vibrations at the blade tip.
- The linear pressure of the creping blade is balanced between coating thickness, coating durability and deflection of the free height of the blade used.
- Running too deep into the coating layer will cause the layer to strip from the Yankee with total loss of the protective layer.
- Running the creping blade not too deep results in sheet picking, holes and high dust generation.
- How the blade runs is a function of:
  - Coating hardness
  - Blade loading pressure.
  - Blade free height (stick out).
  - The size of the wear pad of the blade (specific worn area of the blade tip).
  - Blade hardness/sharpness (steel or ceramic).
The holder angle and the creping blade bevel angle results in the creping pocket. Low creping pocket gives rise
to coarse crepe and poor hand feel. High pocket angles give fine crepe and a more tactile feeling sheet.
Ceramic blades maintain blade tip sharpness and are slower wearing, thus maintaining uniform continuous
creping operations and quality, and also fewer blade changes are required to maintain product quality.

**CREPING MECHANICS AND SHEET VELOCITY**

When the sheet is creped from the Yankee, we are effectively reducing its length and consequently, to maintain
the wire weight the same the wire weight reduces.

The property most related to creping ratio is bulk. The range at which bulk increase is achieved is quite large, as
can be seen from this chart:

![Figure 6 Impact of crepe ratio on bulk](image)

The maximum thickness increase occurs from 13 to 27% of crepe ratio \((Y - R / R)\)

However, we often see tissue makers running high crepe ratios, but trying at the same time to achieve very good
handle feel. In fact, at very high crepe ratios (backing in crepe) two processes are occurring which work against
good handlefeel and crepe explosion:

- The uncreped sheet weight on the wire will be at a minimum at high crepe ratio. This the papermaker will
tend to compensate for the inherently low tensile in the low fibre mass by over-refining, increasing sheet
consolidation and thus \(F_c\)
- High crepe ratio is often achieved by a high release add on, reducing the crepe adhesion of \(F_a\)

So, although it may seem counter-intuitive at the first glance, the best creping for soft and bulk tissue is often
achieved at a slightly lower crepe ratio. They key point is that once the basic machine set-up is correct, crepe
ratio, refining and GMT and Yankee coating add-on must work in harmony. The goal of the expert tissue maker
is to achieve this perfect balance.
CREPING SUMMARY

The most important factors governing the creping operations and process are:

- **Controlled adhesion**, dependant on the amount of accessible hemicellulose in the furnish and the use of applied chemical additives in the wet end and on the Yankee.
- **Uniform adhesion**, the precise control of all the process/systems variables, including dryer surface condition, the concentration of dissolved hemicellulose in the white water system and manipulation/adjustment of the creping and cleaning blade process to maintain a continuous smooth adhesive layer.
- **The doctor blade pocket angle**, the optimum value which depends upon web adhesion, the friction between the doctor blade tip and the creped sheet, fibre stiffness and finally the take off velocity of the sheet.
- **Cleaning doctor**, the operation of the cleaning doctor is very much misunderstood of just how important this blade position is. The cleaning blade influences the nature of the coating layer formed on the dryer and can control to a degree hard coating build up on the Yankee bare edges and help to reduce chatter mark incidences, therefore to optimise the creping functions outlined, correct adjustment and maintenance of both blades are critical. Sadly, the trend in removal of the cleaning blade positions has increased.

SUMMARY AND CONCLUSION

Building the correct process platform for good creping is a journey which only ends at the dry end of the machine. Working with the Yankee coating and creping blade should only be done after the upstream process platform has been correctly built.

Fibre choice and fibre management are critical, if not the critical determinates of quality. Fibre of the lowest possible coarseness and density will give the best result. Over refining that fibre will destroy the advantages and liberate unwanted hemicellulose by-products and fines into the Yankee coating.

Good formation is a must for good tissue, and once again, over refining is no substitute for poor formation. Low headbox consistency should always be favoured. Correct jet wire velocity and jet impingement can maximize strength properties for the minimum of refining. Attention to these details helps the tissue maker run at the low crepe ratios needed to drive the Fa>Fc concept which underpins good creping.

Sheet presentation to the Yankee, and sheet density and consolidation are largely determined by the pressing and felt conditioning strategy. Talk to your felt vendor about implementing true nip dewatering.

A bias to hood drying, whilst it may have some energy impact, it another driver for the best tissue quality.

Finally, we come to the creping process itself. This should never be considered in isolation but is in fact just the last part of the quality chain running from fibre selection. The coating should be appropriately chosen and applied correctly, with sufficient add-on to provide the Fa adhesive force, protect the Yankee and extend blade life. Set the base coating and use a good dose-responsive release to fine tune the stretch. Blade geometry with relatively low stickout and a slightly open pocket, combined with high adhesive forces and a low crepe ratio should achieve the holy grail of high softness, high bulk and good productivity. Adding high performance doctors into the mix further improves productivity as well as sustainability and sheet smoothness.

The new challenge is the pursuit of energy conservation, as modern trends are pushing moisture targets at the reel even higher, with values as high as of 7% being enforced.

With this trend sheet bulk and elongation is found to decrease substantially, for many mills outside their sheet parameters.

This problematic issue is then pushed towards certain dedicated mill suppliers of high-performance blade and the Yankee coating suppliers to provide ‘magic’ blades and chemical solutions to regain lost properties.

As can be appreciated this is a difficult task to even stabilize and enhance properties and often leads to the mill ‘re – engineering’ their products specification, with possible converting implications/losses. In fact, there is no
magic solution, and the process platform approach and attention to detail, along with realistic sourcing policies for essential raw materials and consumables remains the soundest strategy for the modern tissue maker to follow.

REFERENCE, SOURCE MATERIAL AND FURTHER READING:

- J F Oliver, TAPPI 1980