Advanced Yankee Surface Management

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INTRODUCTION:

Management of the Yankee surface, or more specifically, the organic coating on the Yankee surface has a great impact on the operations and maintenance of the tissue machine. Tissue quality and machine productivity are both highly influenced by the composition and also adhesive and rheological properties of this surface. For example, a hard coating will make achievement of the bulk target difficult. Likewise, a lack of adhesion (also a by-product of hard coating in some cases) will give a drop in handfeel or softness. Hard coating at the Yankee edges can give rise to edge tears and web breaks, and a hard coating with poor release response makes achievement of a low crepe ratio difficult. Finally, we have the dreaded specter of chattermarks[1], blade-vibration induced CD scoring of the Yankee surface, causing sheet defects, slow running and ultimately a costly regrind or metallization of the Yankee surface. So clearly, correct management of this thin organic layer is of paramount importance to the majority of tissue makers who use light dry crepe technology.

MEASUREMENT OF THE COATING LAYER

It is an axiom of control technology that 'if you don't' measure it, how can you control it?' So, how to measure such a thin and largely unobservable but also dynamic phenomenon as a Yankee coating? Subjective measurements such as visual observation and even listening to the coating are a good starting point. Some classifcations are possible, for example:

Table 1 Yankee coating classification by observation

Observation	Status of Yankee surface
Even, translucent grey. Quiet. Sheet tight	Good soft coating coverage, adequate adhesion
White but even coating, noisier, sheet tight	Some fibre/fines contaminaton of coating, but OK
White and dusty, distinct noise, often with sheet flying	Highly contaminated coating
Streaky white coating, high pitch noise	Contaminated coating and poor moisture profile
Shiny Yankee, high pitch noise	No or little coating, wet sheet or cool Yankee

Many process engineers and operators will have their own classifcation, and with practice this can be quite discriminating, especially in combination with other less subjective methods.

An objective measure to add to this is to measure the amount of coating sprayed onto the Yankee. This is extremely useful, but still requires the engineer to make some assumptions. Typically, we start with a flow rate of the various chemicals, which can include a base coating, release, sometimes a modifier and sometimes phosphate additive. Best practice is to define this flow rate as a total solids add-on per unit area, normally expressed in mg/m^2 of coating. This requires knowledge of the concentration of the chemicals, their specific gravity and of course sprayed width and Yankee speed. However, this can only measure the chemicals as dispensed; what attaches to the Yankee will be somewhat lower due to misting of the applied spray, boundary air layer effects and so on. Eighty percent (80%) chemical stick-on versus dispensed chemical is a good rule of thumb for a correctly designed spraybar operating at 3-4 bar pressure. Whilst a very useful benchmark, add-on calculation does not take into affect coating rheology or adhesion (this requires some knowledge about the proprietary features of the chemistry) nor does it take ito account so-called natural coating, which we deal with in a later section.

Direct measurement of the coating thickness has some promise, but is not widely applied yet. Amongst the techniques proposed is a subtractive measurement using first an eddy current probe to determine the distance onto the metallic surface in tandem with a reflective EMR measurement to determine distance to the organic layer. Thus we can have total coating thickness including natural coating , but still not adhesive or rheological information.

Crepe blade vibration measurement is very commonly used across the tissue industry now, initially to alarm for high vibration and protect the Yankee from chattermark damage. However, a more detailed examination of vibration trends and spectra can reveal much about the Yankee surface and coating.

Working on the assumption that vibration can be caused by hard coating, and that a blade change will refesh the coating layer and allow softer coating to predominate, we can easily see this effect in Figure 1 below.

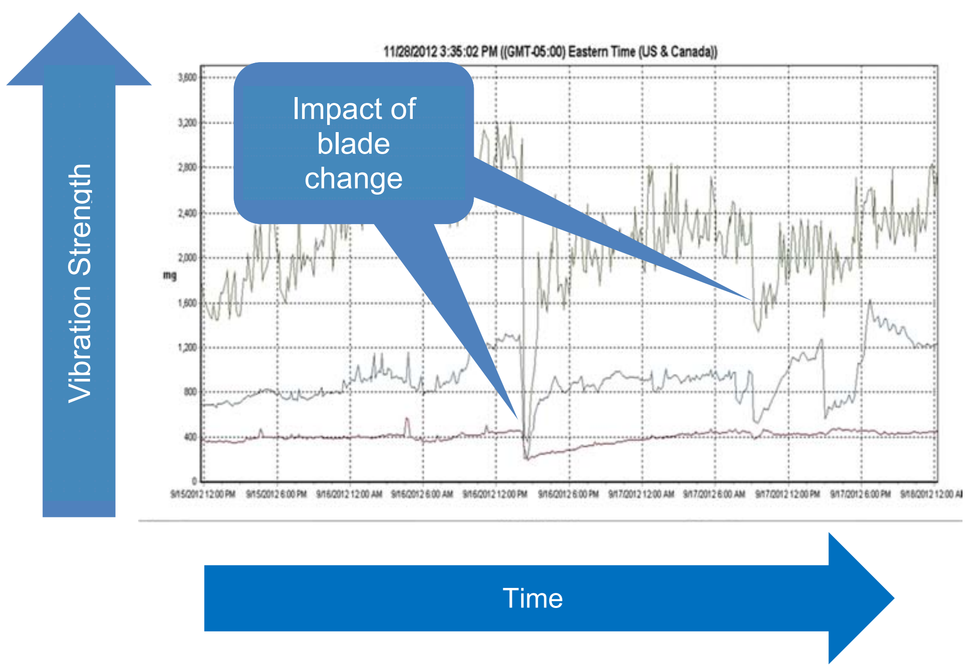


Figure 1: Vibration trend from crepe blade showing blade change response

Looking at the vibartion spectra shows a similar impact, but now we can start to discriminate at which *frequency* the hard coating (assumed to be stripped away after blade change) cause vibration:

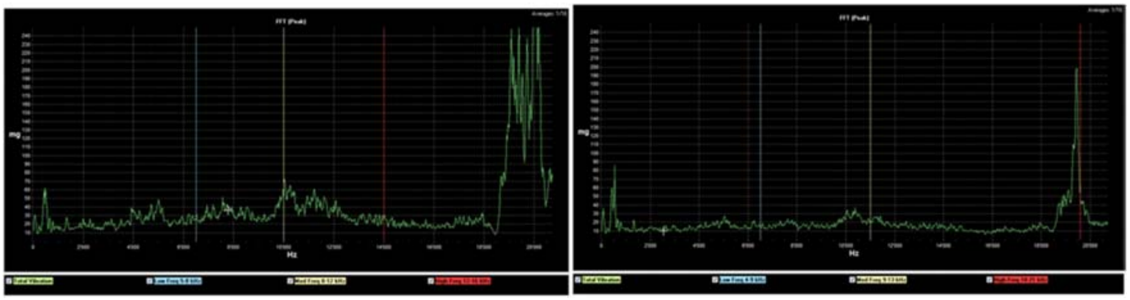


Figure 2: FFT spectrum of crepe blade vibration showing blade change response

So for this machine, illustrated in Figure 2 above, we can see the hard coating pre-blade change induces a high frequency vibration at around 19kHz. Taking this forward is extremely useful troubleshooting information.

It's ulimate expression is to map various frequencies to known and observed Yankee surface phenomenae, as per this example in Figure 3 below.

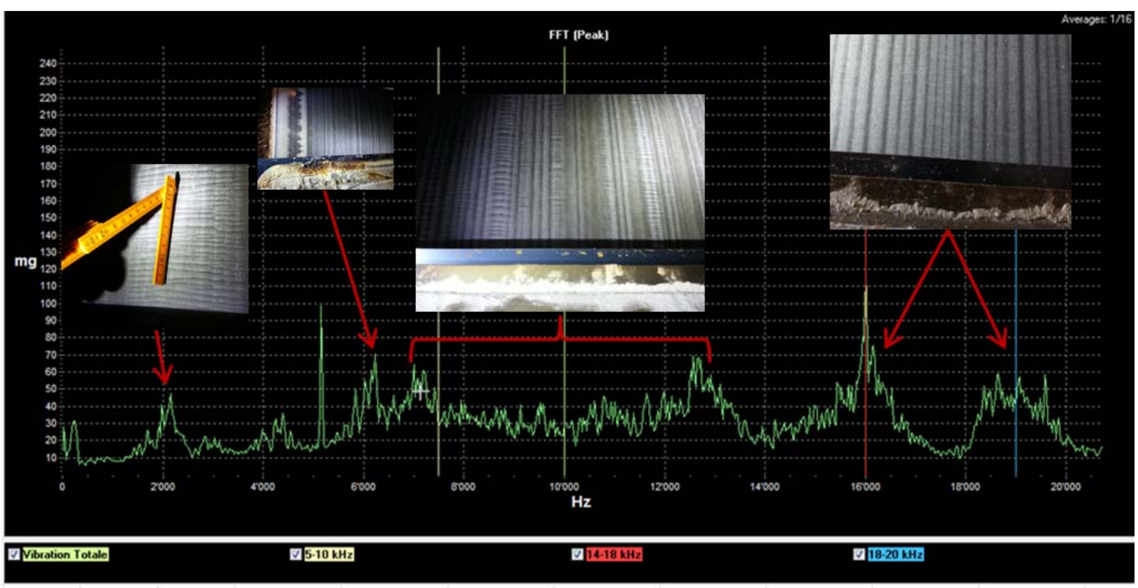


Figure 3: Frequency mapping of Yankee surface defects to blade vibration spectrum

In this case, the edge build up and chatter associated with it gives a lower frequency of vibration. This is determined by measuring actual Yankee marks on a shutdown and comparing them with the spectrum. Thus, in the future, we know that a high vibration at 6 kHz is likely caused by Yankee edge contamination. Higher frequency vibration is generally harder coating in the sheeted area, and consequently may have quality or crepe ratio implications.

In summary, the skilled process engineer will use a range of techniques to make judgments about the quality of their Yankee coating. The next question, having measured it, often is 'why is my coating hard', which we address in the next section.

IMPACT OF TISSUE MACHINE WET END UPON COATING LAYER

The applied Yankee coating chemicals are only part of the story on our Yankee surface. Practically everything else in the tissue machine stock and process water system has the potential to end up on the Yankee surface. Some researchers put the applied coating add on at less than 1% of the total Yankee organic layer.[2] The contaminants can include celluose short fibre and fines, hemicellulose, lignins, starch, other polymeric dry strength additive, wet strength resin and others, such as inorganic ash. The influence of chemical parameters such as pH, ionic charge demand, temperature, water hardness and system conductivity, as well as Yankee heat flux and other operational parameters can all impact how these behave on the Yankee surface. In this section we will focus on the fines, fibre and ash.

Short fibre, such as eucalyptus or inappropriately refined fibre can be easily incorporated into the catonic Yankee coating. Fines and ash may be added to the tissue process at various points, and in somes cases (e.g. inappropriate refining) they will be created in the system. In addition, the short and long water loops will continuously recycle these materials. A stable equilibrium is eventually reached on the tissue machine system. Thus, the net addition of fines plus fines generated must equal what is incorporated in the sheet exiting the machine system plus losses to sewer and sludge disposal; or what ends up on the Yankee, causing the issues decribed earlier.

The fines circulation loops can be depicted using a Sankey Diagram as shown in figure 5:

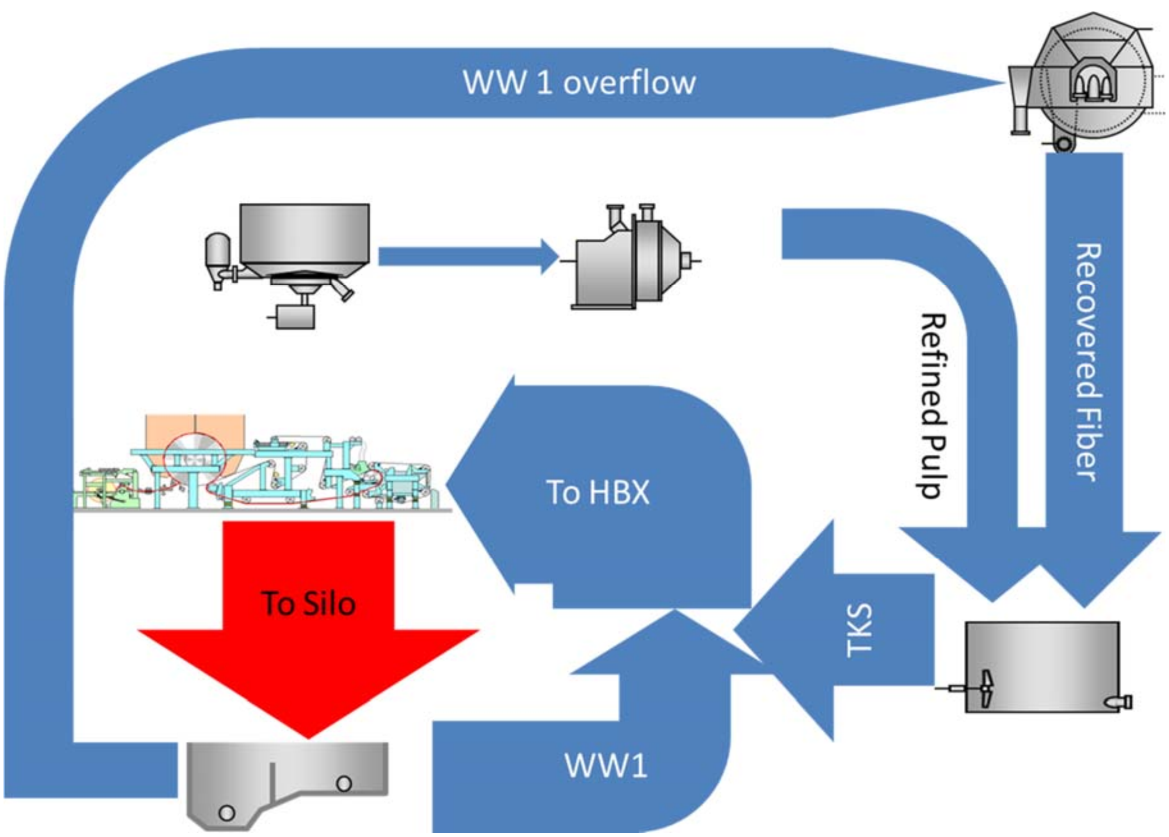


Figure 5: Simplified Sankey diagram of fines recirculation on a tissue machine

The Sankey diagram allows us to visualise the quantity of fines, ash and short fibre as they circulate around the system. One key point for us to understand in the context of this article is how much of this material ends up in the silo loop. This is important as any material here ends up diluting the forward flow of thickstock and will be present in the wet sheet as it is transferred from the press felt to the Yankee. Any anionic material here is pressed into a hot, cationic polymer plasma on the Yankee and thus the anionic material, if unfixed and mobile, readily transfers into the coating.

We need to be aware of a secondary factor as well, the Dreshfield effect.[3] This describes how particulate matter in the wet sheet matrix will migrate to the sheet surfaces when it is heated. This further exacerbates the fines and ash incorporation into the coating film.

Realising that the Sankey diagram can vizualise this equilibrium, the next step is to quantify it by making suitable measurements. Depending upon the time available, various techniques can be used from a simple total solids through to lab instruments for accurate fines determination of the various samples. The relative merits of the different techniques have been described elsewhere [4], now let us turn to how we use these measurements.

One approach, shown here in Figure 6, is to develop some generic indices which we can use to benchmark one system against another.

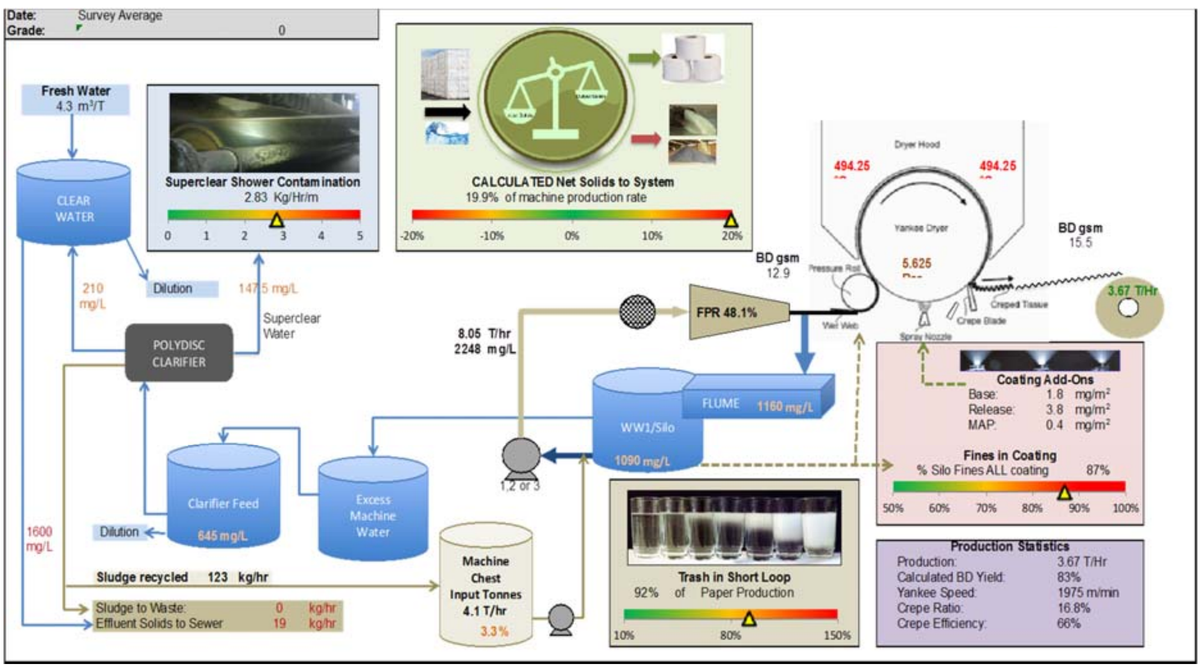


Figure 6: Typical tissue machine fines and ash audit

The 4 indices described in this study are as follows:

- Calculated net solids addition to system as percent of production
- Solids in clarfied water shower, kg/hr/m
- Percent trash in short loop
- Percent silo fines in coating

Please note that these are arbitrary indices, not necessarily absolute values to be interpreted rigidly per machine. However, the indices do allow machine to machine comparison, and thus some patterns start to emerge.

This study was carried out over a 12 month period in the EMEA area. The results are summarized in Table 2 below.

Table 2: Comparison of fines audit KPI's over 5 European tissue machines

BTG tr-ASH RUNNABILITY INDEX	TARGET	North EU Branded Luxury		North EU Economy and Luxury		East EU Soft Toipa and HHT		East EU Soft Toipa and HHT		Central EU Toipa and HHT	
		Following & Blistering		Chatter & High CR		Low C/E & Chatter		Low C/E and Hard Coating		Low C/E & Productivity	
		Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
1. NET Solids to System, % of Prod Rate	<8%	1.1%	0.9%	Consistency Transmitter Accuracy Issues		Consistency Transmitter Accuracy Issues		Consistency Transmitter Accuracy Issues		29.0%	15.5%
2. Solids to Shower Loop, Kg/Hr/m	<2.5 or Machine Manual	5.21	1.14	2.42	1.96	9.80	1.30	3.73	0.64	3.30	2.30
3. % Silo Fines - All Coating	<80%	61.4%	60.6%	84.2%	68.1%	97.2%	86.7%	93.2%	88.9%	91.3%	83.7%
4. % Trash in Shortloop vs Prod Rate	<45%	10.4%	9.6%	51.4%	22.5%	122.0%	58.1%	141.7%	94.1%	101.3%	74.2%

Values highlighted in red may be considered out of range. In the context of this article, machines exhibiting a high percent silo fines in coating, what we may term as a 'Yankee Coating Contamination Factor' or YCCF had poor runnability, characterised by high crepe ratio or low crepe efficiency plus in some cases chatter.

The relationship between hard coating and crepe blade vibration was explored in a study, over a 4 month period for the 'North EU economy and luxury' producing machine, second from left in the above table. What became apparent when we transformed the YCCF data via cusum calculation is that an upward change in YCCF correlated well with increases in crepe blade vibration, Figure 7 below. We speculate, that as the Yankee/Coating/blade dynamic may be in a stable equilibrium until a change in coating hardness triggers an increase in coating friction, this making the blade unstable and vibrating. As is well known, unmitigated blade vibration will propogate both in extent and amplitude until chatter occurs, as was the case for this reference.

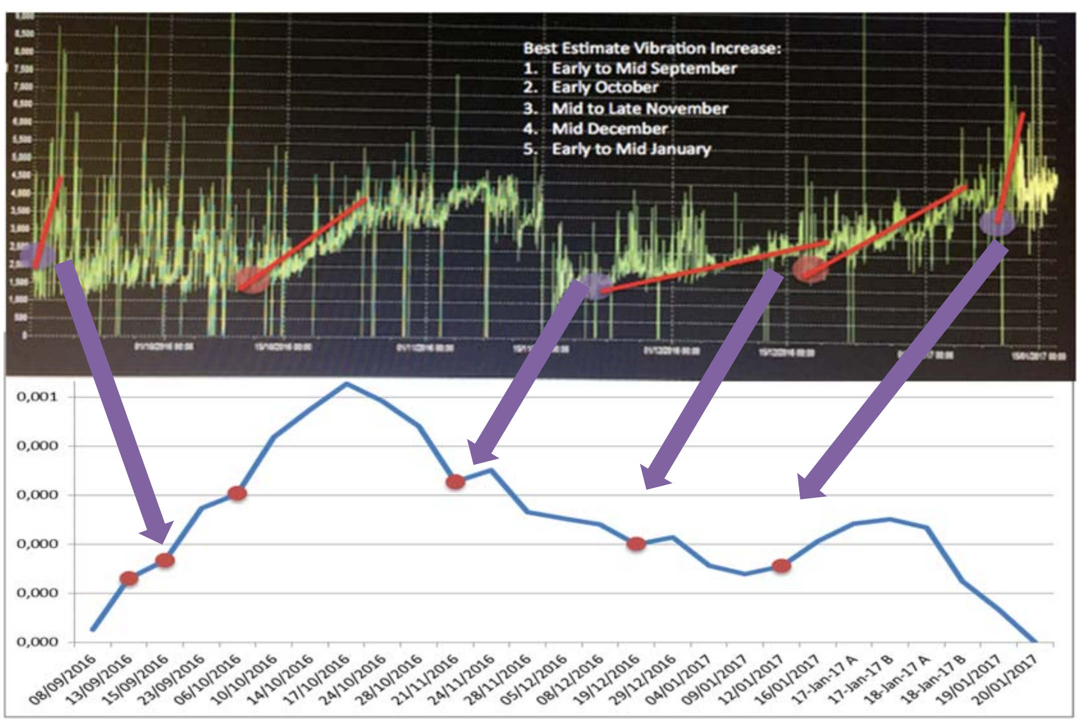


Figure 7: crepe blade vibration trend compared with YCCF cusum

CONTROL

So far we have established that a number of techniques can be used to characterise the organic coating layer on a Yankee, but amonst these, vibration can be a useful guide to the coating rheology. Moreover, with a knowledge of the add-on and the fines recirculation in the system and other parameters, an index for the contamination factor of the coating can be deterimnined, which correlates well to vibration. Thus, the process engineer could determine the potential for an issue and some of the causes. But what may be done to control them?

One obvious solution, and a good one, is to better control the tissue machine wet end. Having determined the problems points with the kind of audit shown above, repeated over different grades and times, we can propose solutions. These may include:

- Selection of low fines furnish
- Correct refiner plate design and refining strategy to avoid excessive fibre-cutting SEL
- Good polymer treatment for any DAF unit
- Appropriate disposal or reuse of DAF sludge
- Consideration of fines impact of polydic recovered fibre usage
- Awareness of fine equilibrium consequences of water closure
- Use of controlled short loop retention aid or better fines fixative.

The latter solution has worked particularly well when there have been other system constraints, fibre yield and water closure for example.

However, some trash will nearly always end up on the Yankee, so let us turn our attention to the much neglected cleaning blade. This is a potentially very powerful aid for the tissue maker in the field of Yankee surface management.

Any doctor blade will wear against the Yankee surface, faster for a steel doctor, slower for a high performance (normally ceramic) version. However, once the sliding surface wear area reaches say 200µm, the specific pressure (force per unit area) exerted by the blade is substantially lower then when the new blade was loaded, and thus coating refreshment, which depends upon the removal of the older hard coating, becomes less effective. This explains the exponential increase in vibration at the end of a blade life on a hard-coated machine. Thus, a frequently changed cleaning blade will help keep the coating fresh, with all its attendant benefits.

However, there is an argument against the steel cleaning blade.

1) On a metallized Yankee surface there is the possibility of adhesive blade-Yankee wear if the coating is in any way compromised. [1]
2) On any Yankee surface, the steel cleaner will wear first against the hardest coating, and with wear rates of over (sometimes much over) 50µm/100km of machine travel, the steel cleaner soon has too great a sliding surface in localised spots for effective cleaning. The blade with the smallest sliding surface against the Yankee will of course do most of the cleaning work, thus with a high performance creper and steel cleaner, it is often the creper doing most of the work on the Yankee, compromising its lifetime and quality output.

Good results have been obtained by using a high performance cleaning blade, with a design optimised for the cleaning position.

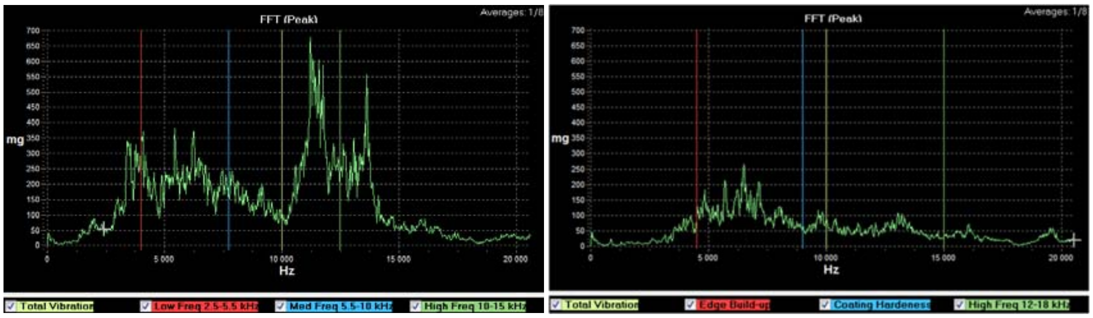


Figure 8: Impact of high performance cleaning blade installation on crepe blade vibration

In this case, the machine runs a 80° high performance crepe blade. In Figure 8 above, on the left is the FFT spectrum with the intermittent steel cleaner and on the right with a continuous ceramic cleaning blade. Over an extended period, overall vibration was reduced by 47% and the machine was able to break free of a two (2) month regrind cycle.

In a second case, after an extended trial, these benefits were confirmed for a modern high speed tissue machine using both state-of the art wet end fines control and high performance ceramic cleaning blades:

- Consistent shut-to-shut Yankee surface roughness: no adhesive wear
- 50% crepe blade vibration reduction
- 30% longer crepe balde life (changed for quality)
- Better bulk consistency
- Fewer cleaning blade changes, a safety benefit

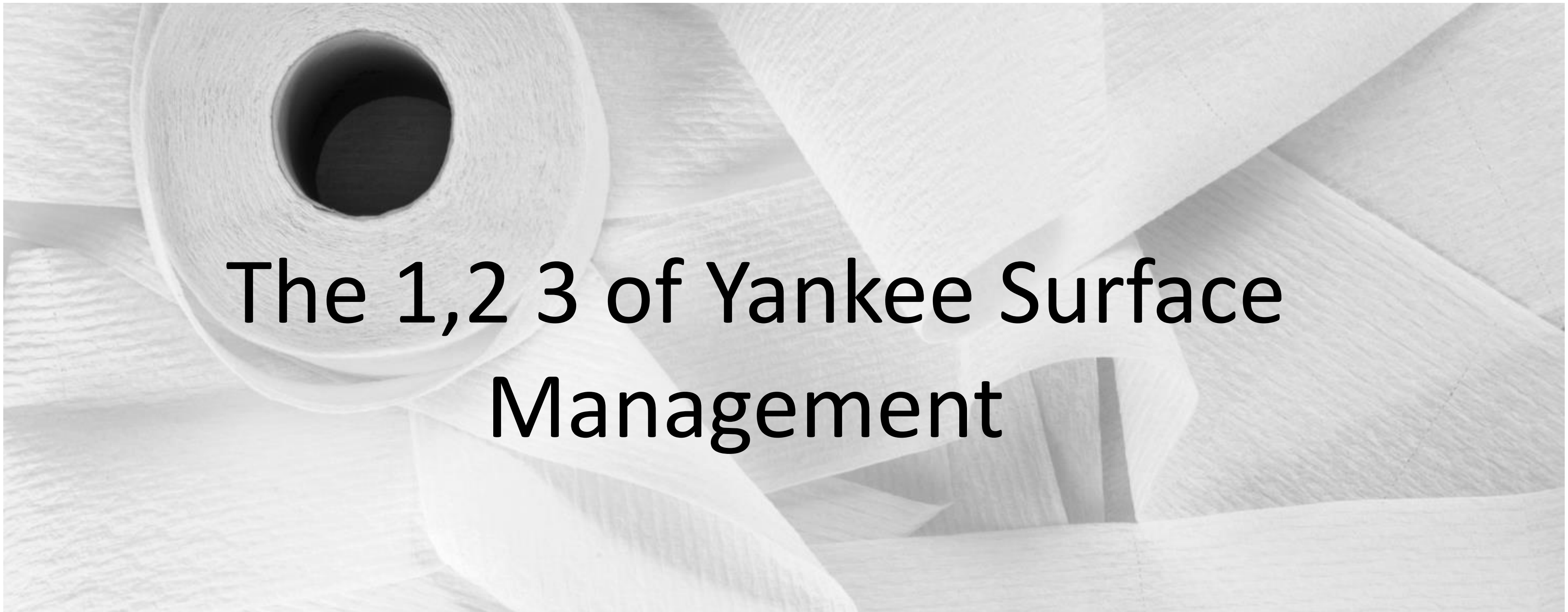
CONCLUSION

Attention to Yankee Surface Management as an holistic concept will repay the tissue machine process engineer with improved quality, more production and enhanced asset protection. The key steps are:

1) Implement an objective way to measure and track the organic Yankee surface condition, including classified visual observation, add-on measurement, vibration measurement and the more novel techniques as they come of age.
2) Understand and mitigate the wet end and natural coating influnces on the Yankee surface.
3) Implement active control measures to suit the circumstances
    a. A wet end management system
    b. Use of a high performnce cleaning blade strategy

REFERENCES:

1) Paczkowski, M. “Material Interactions and the Effect of Doctor Blades on the Yankee Surface,” Tissue World 2009 Conference, Nice, France, March 23-26, 2009.
2) Archer, S., Furman, G. and Von Drasek, W. “Yankee Surface Chatter – Mechanics, Monitoring and Methods to Minimize Impact,” Tissue World, Nice, France, March 28-31, 2011.
3) Dreshfield, A. C. A Study of Transverse Moisture Distribution and Movement During Hot-Surface Drying of Paper. Ph.D. Thesis, The Institute of Paper Chemistry (1956).
4) Devilliers,J., Padley, I. “Fines measurement for tissue machines”: Paper Technology, March 2014



The 1,2 3 of Yankee Surface Management

A Methodology for Quality, Productivity and Asset Protection

capstone technology corporation

BTG RAISING YOUR PRODUCTIVITY

Overview: The Yankee Surface

Creping: critical operation

- Quality - softness and bulk
- Productivity - crepe ratio and web breaks
- Asset protection- adhesive and abrasive wear and blade vibration

Understanding Yankee surface behavior is key to improved performance

3 Steps to a good Yankee surface

1. Objectively measure Yankee coating parameters

2. Understand influences on coating

3. Implement control measures

1. Measurement

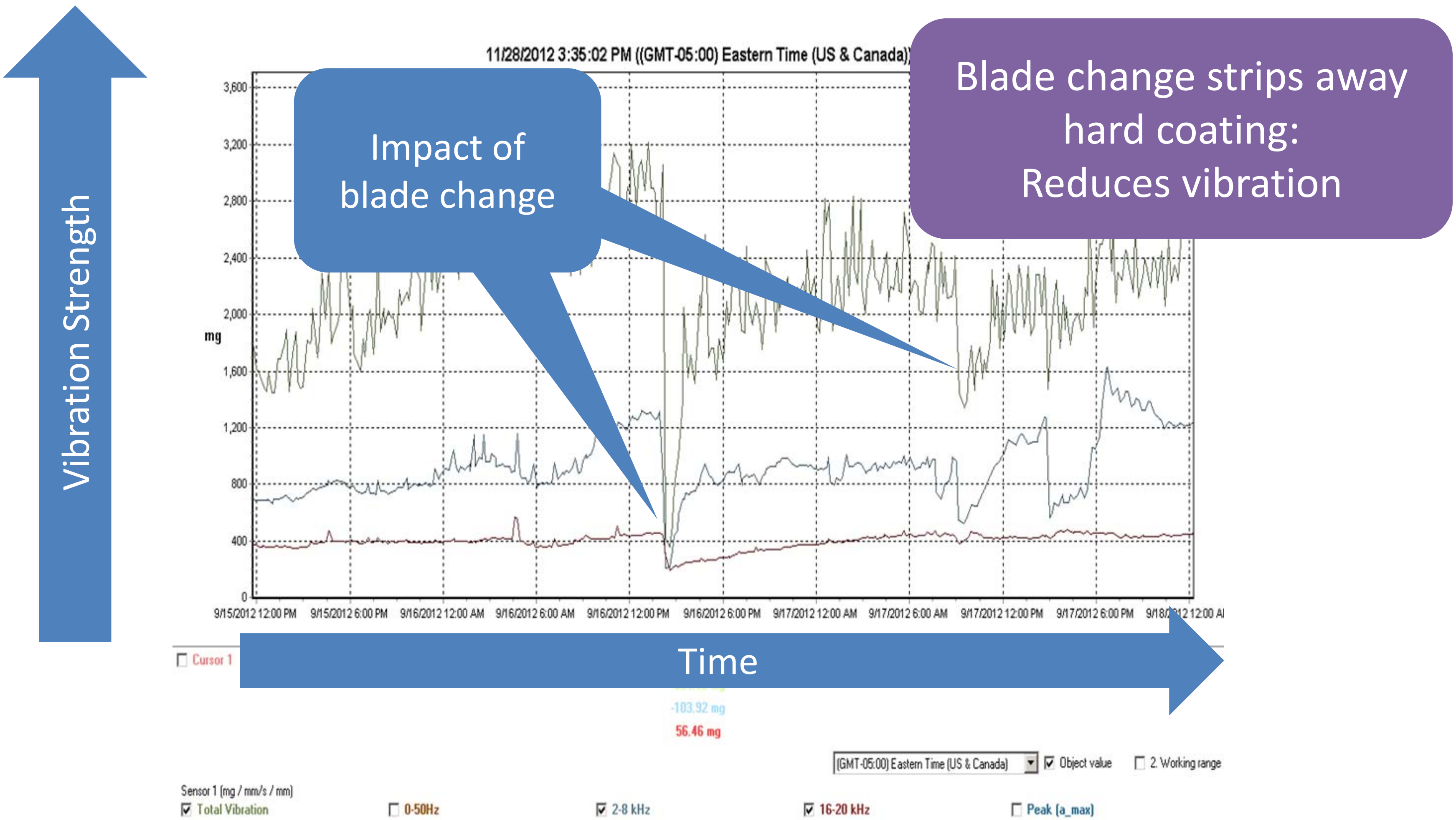
Some common ways to 'measure' the coating

Add-on:
Chemical flow or more accurately mg/m^2 of chemical coverage. A guide, but does not take account of wet end additives and contaminants.

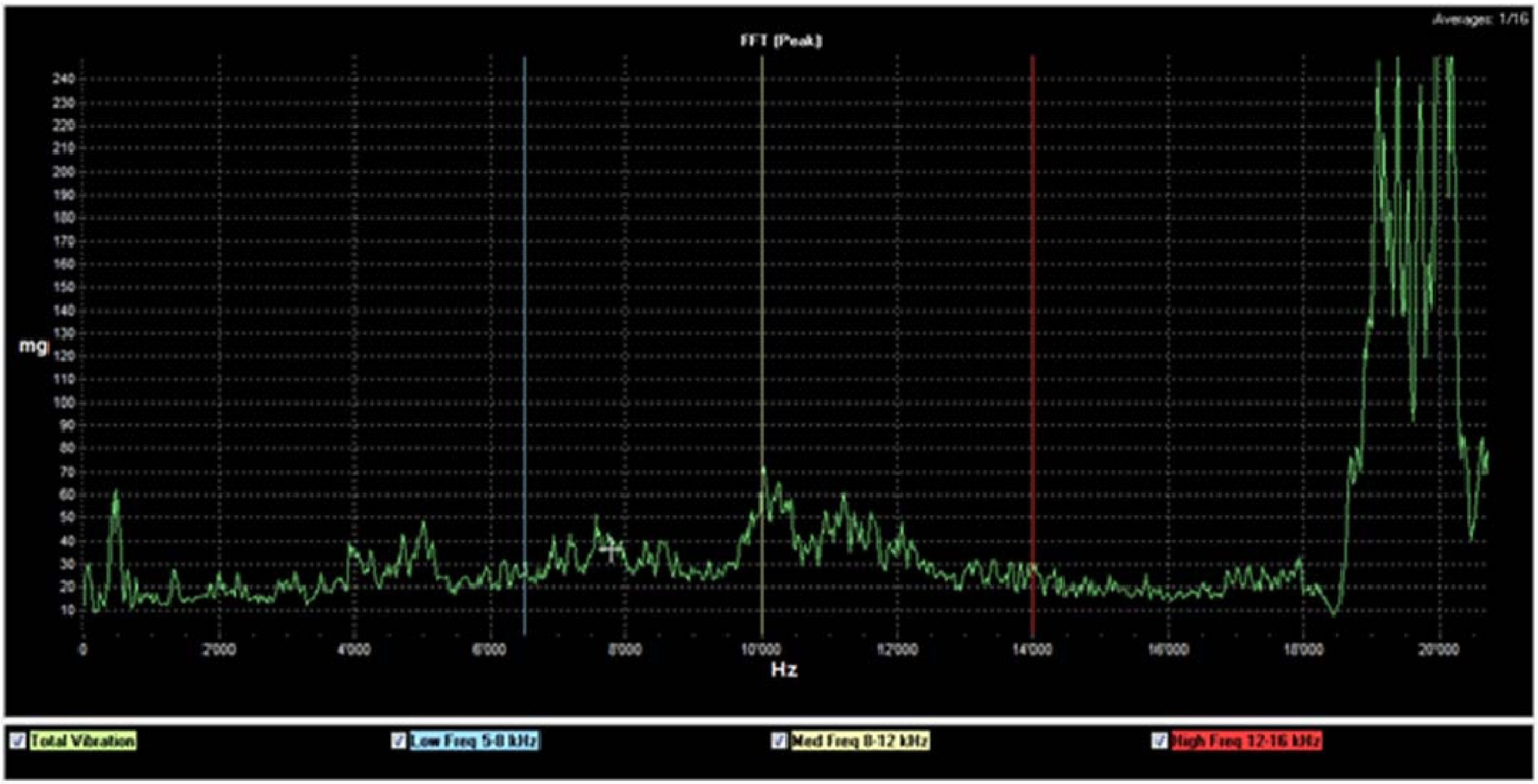
Thickness:
Promising techniques using laser/eddy current/other EMR. When reliable, good to know the thickness. Adhesive/ rheology properties not measured.

Vibration (Crepe blade):
Doesn't directly measure the amount of coating but gives a great guide to its rheology and Yankee surface protection. Widely used across the industry.

Blade Vibration trend measurement

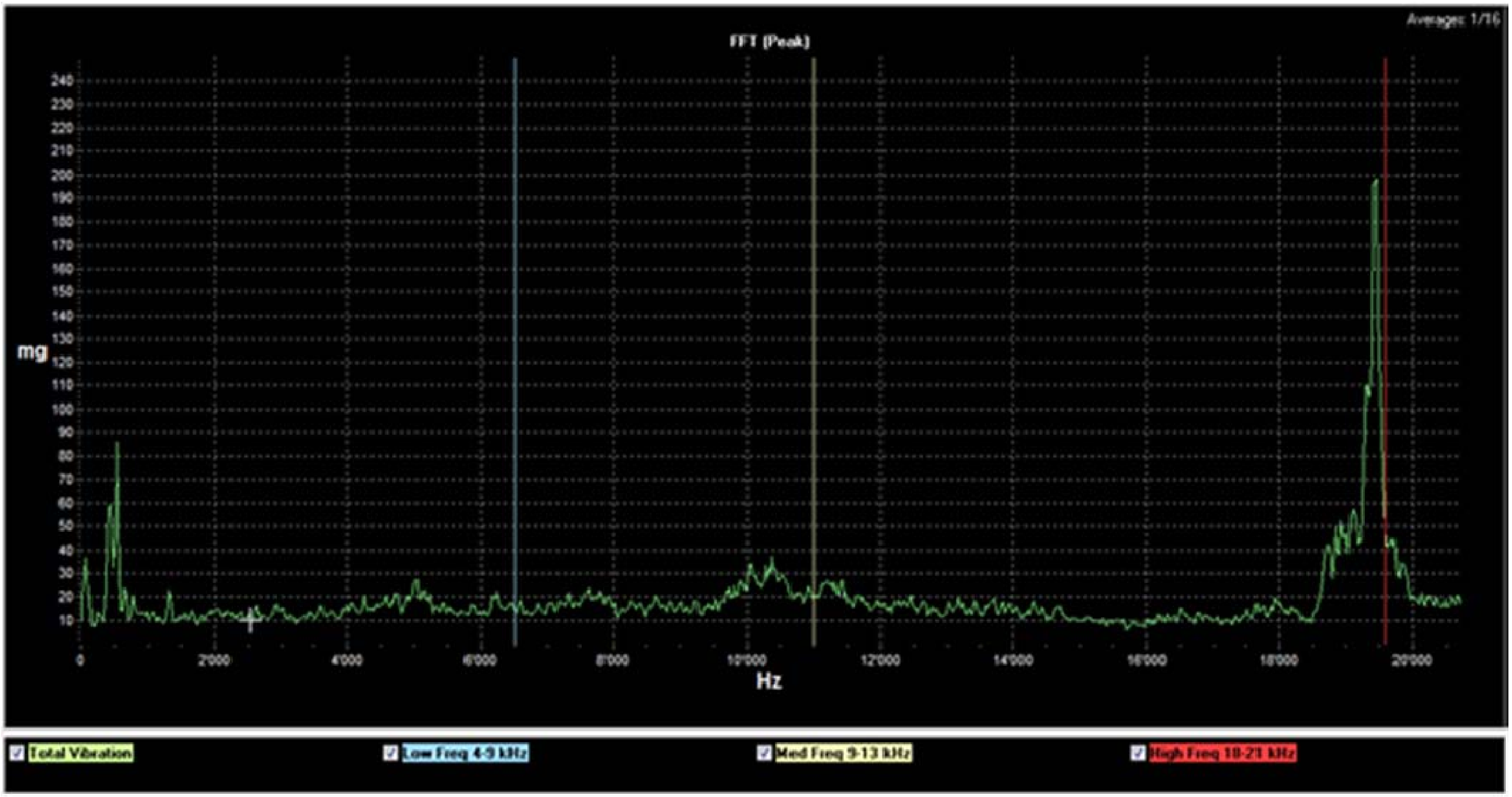


Vibration Spectrum Measurement



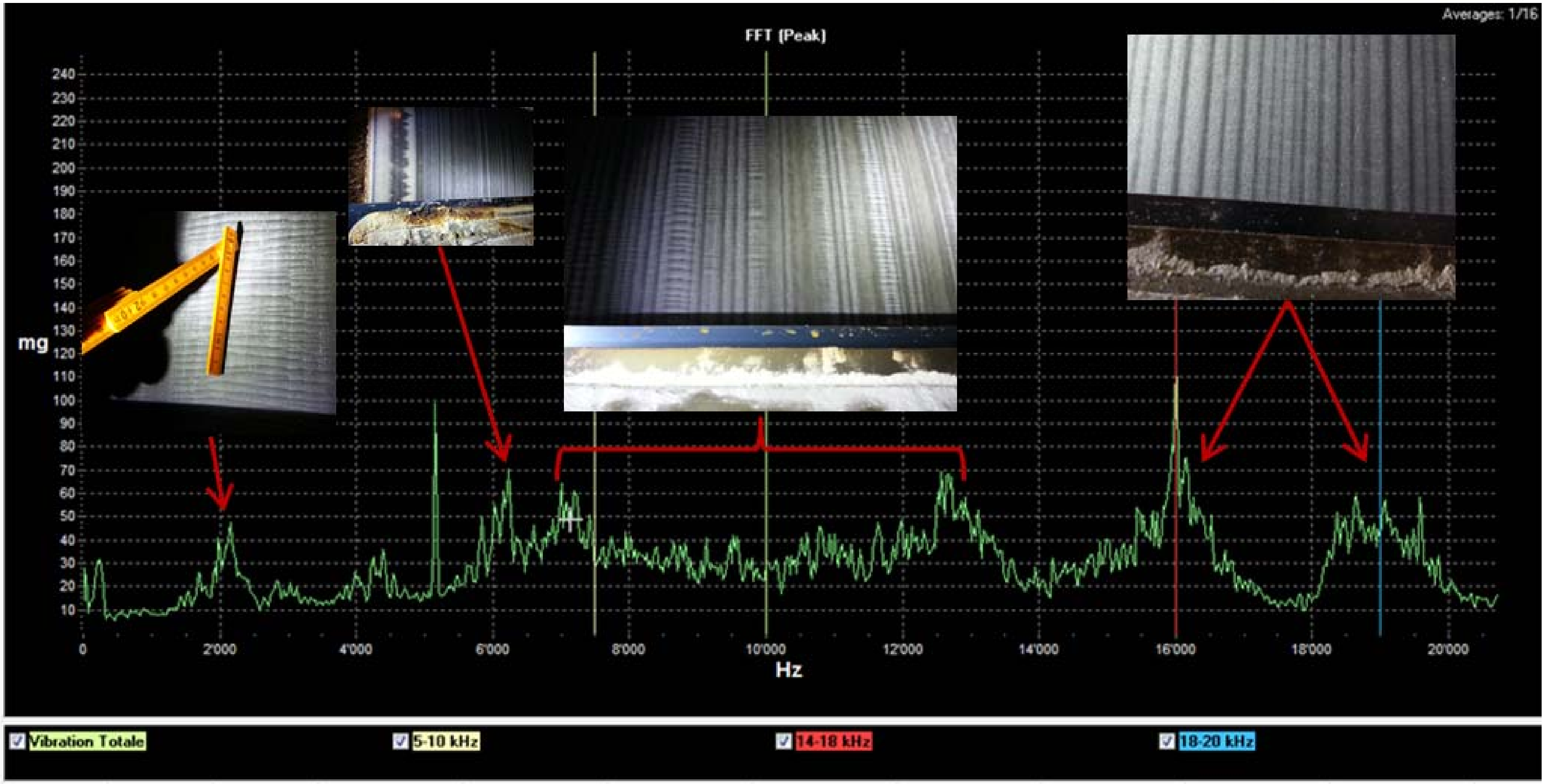
Before Blade change

Vibration Spectrum Measurement



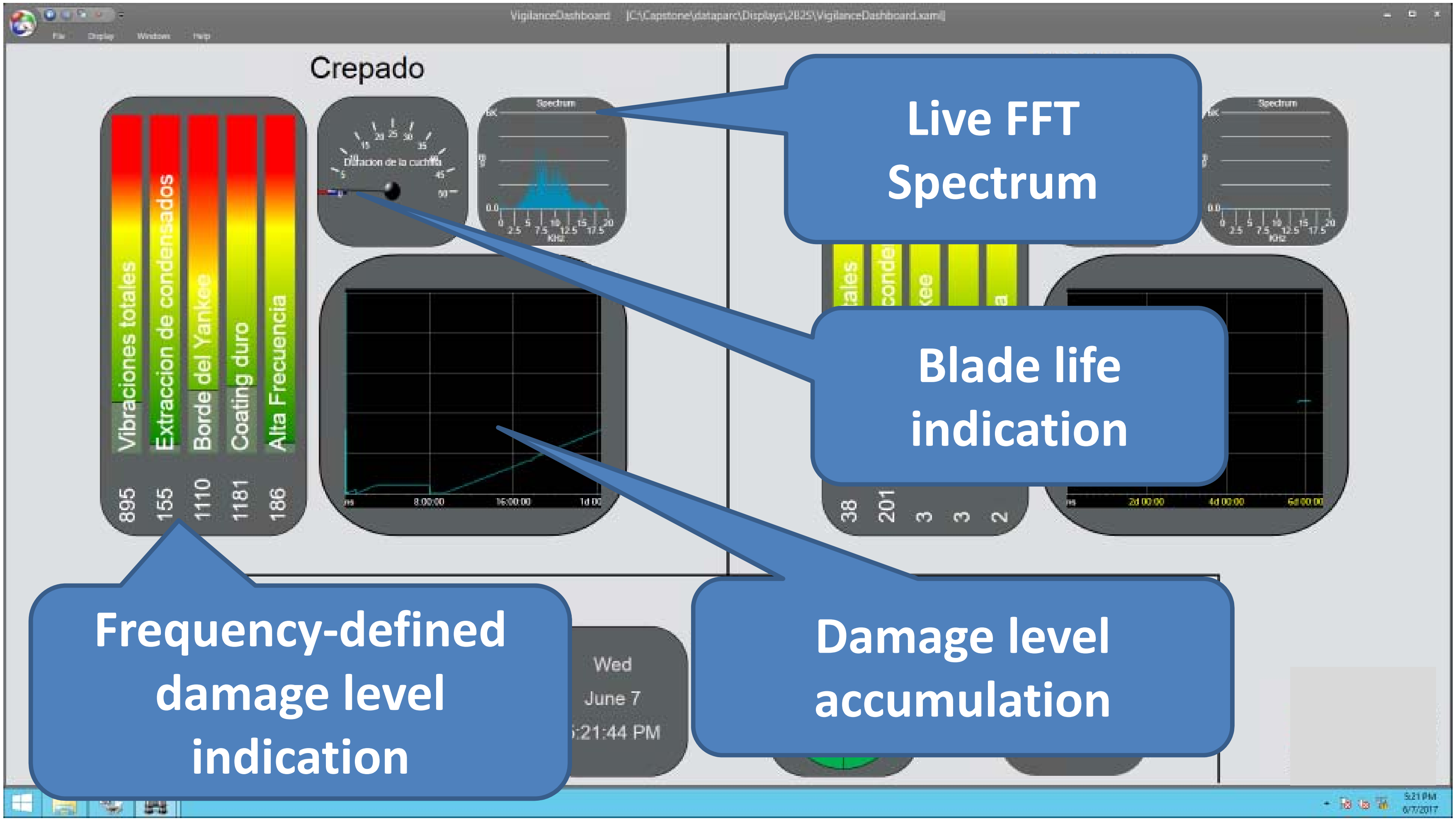
After Blade change

Map FFT frequency events to specific Yankee



Yankee damage matched to Vibration FFT spectrum by BTG Experts

Tissue machine blade vibration monitoring system example



2. Understanding Coating Composition

What's in your coating?

Coating Polymer?

Release?

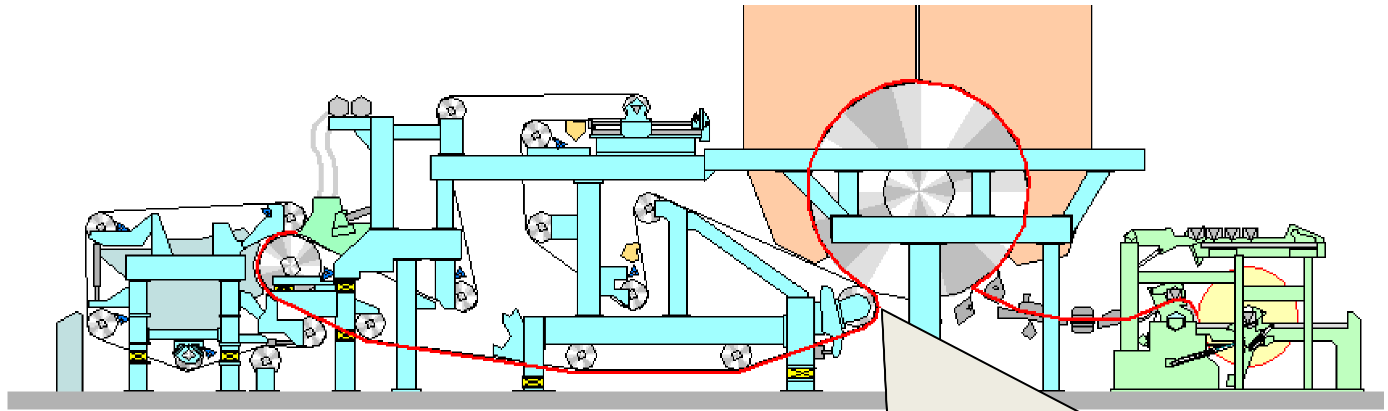
Phosphate?

Hemicellulose And Lignin

Fibre and fines

In fact as little as 0.5 to 1.0% of the coating is the applied polymer and release (Boudreau, 2009) Control of this is critical, but what about the other components?

Special concern for fines on the Yankee



Tissue machine first pass retention is 50-85%.
Many unretained fines will be in the water phase at the suction press

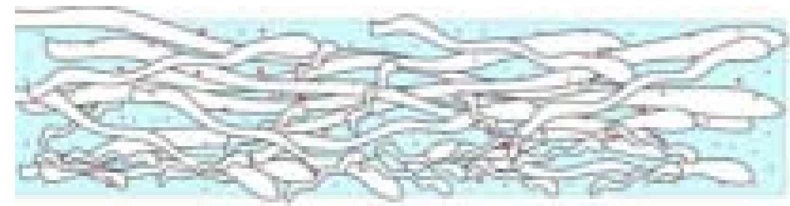
The fines-rich water is in **direct contact** with the Yankee coating.
The anionic fines will have a natural affinity for the cationic Yankee coating

Dreshfield Effect

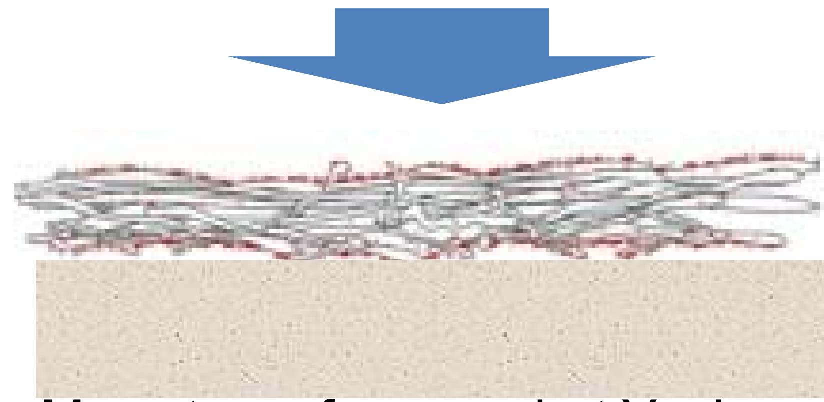
- This is the name give to the effect which happens when the wet sheet is dried on the hot Yankee

- The small fines, ash and other particles move to the surfaces of the sheet to make hard and dusty coating

- Most of these particles are anionic and easily combine with cationic Yankee coating



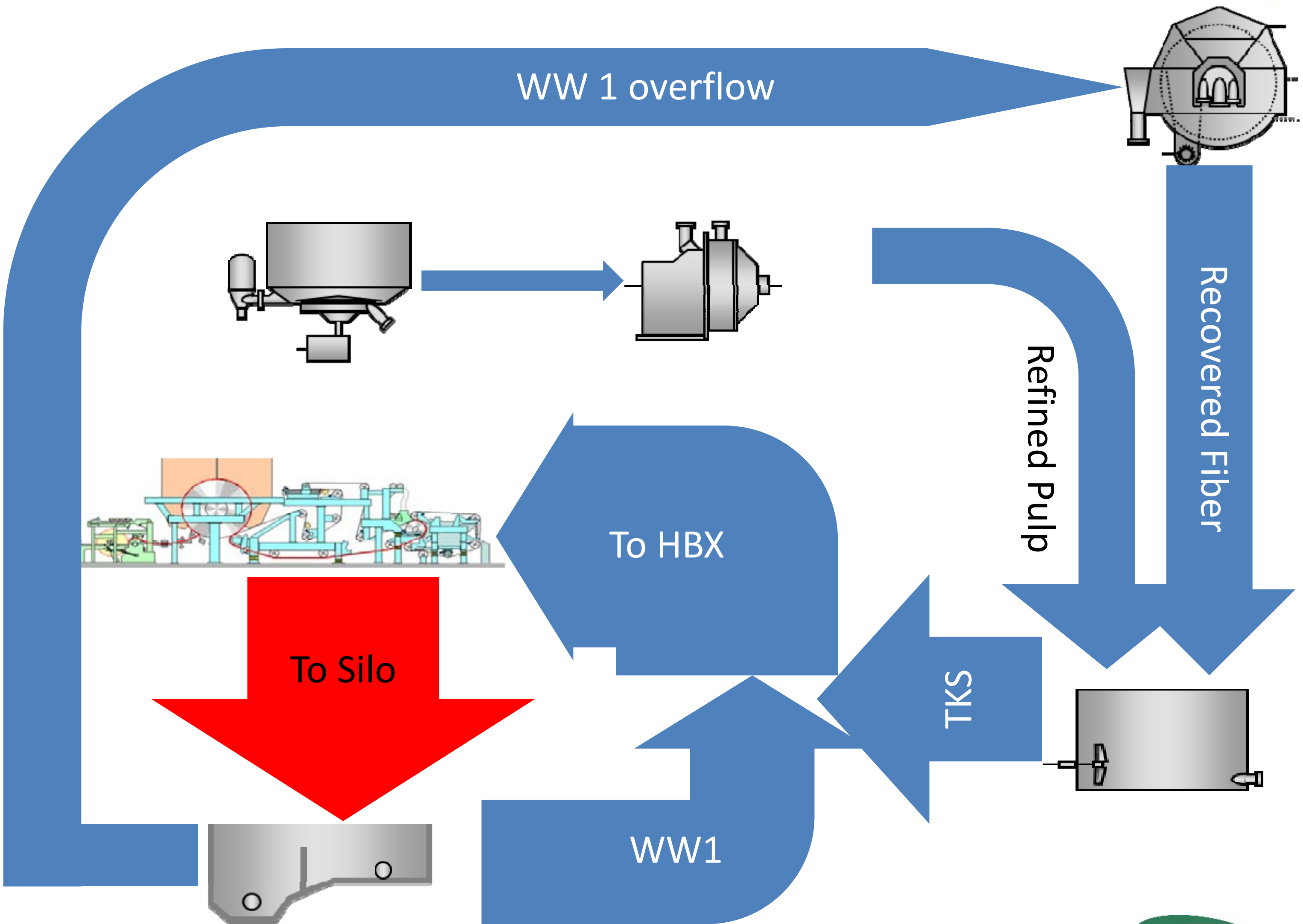
Wet sheet: particles dispersed



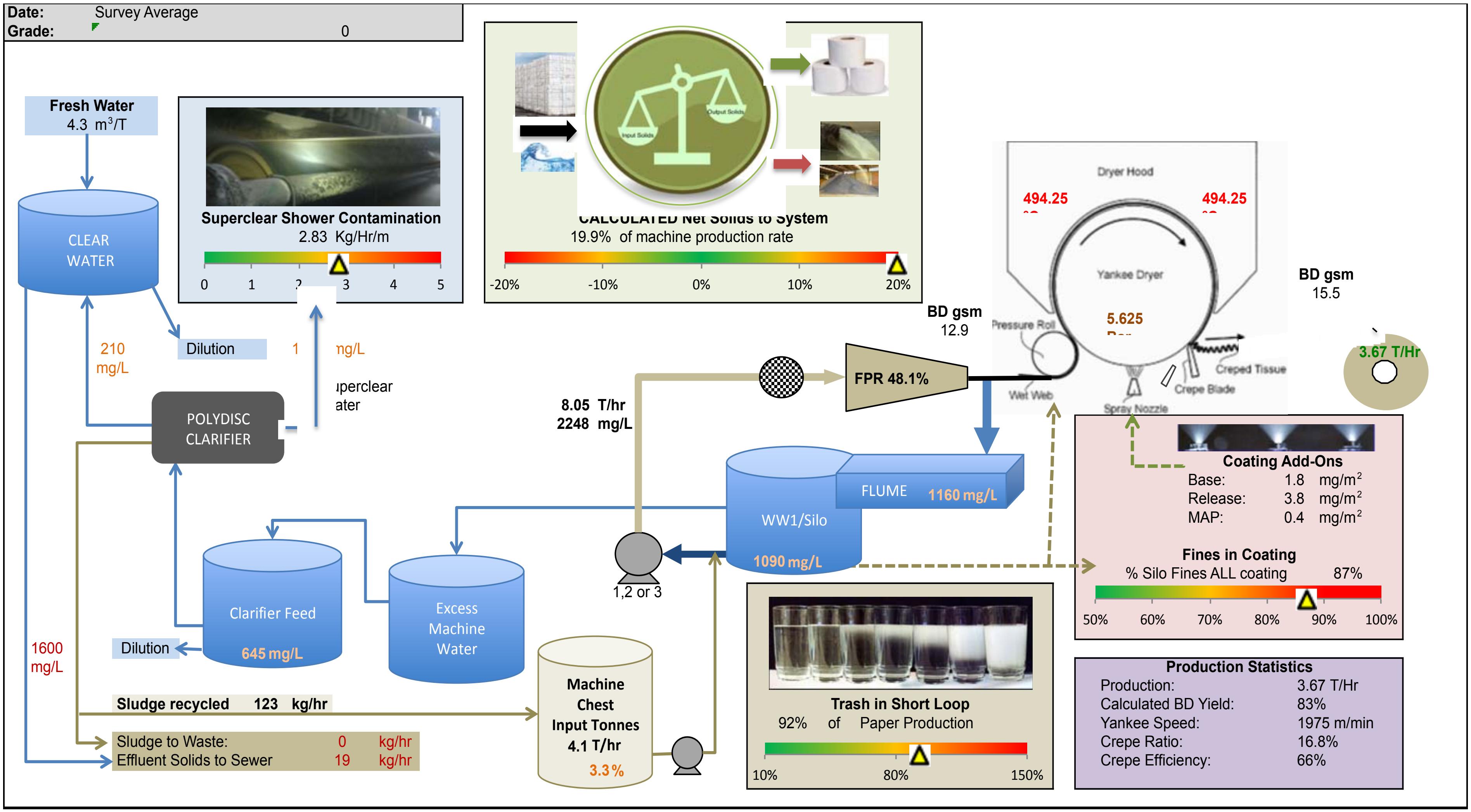
Move to surfaces on hot Yankee

Dreshfield, A. C. A Study of Transverse Moisture Distribution and Movement during Hot-Surface Drying of Paper. Ph.D. Thesis, The Institute of Paper Chemistry (1956).

Need to understand fines loops

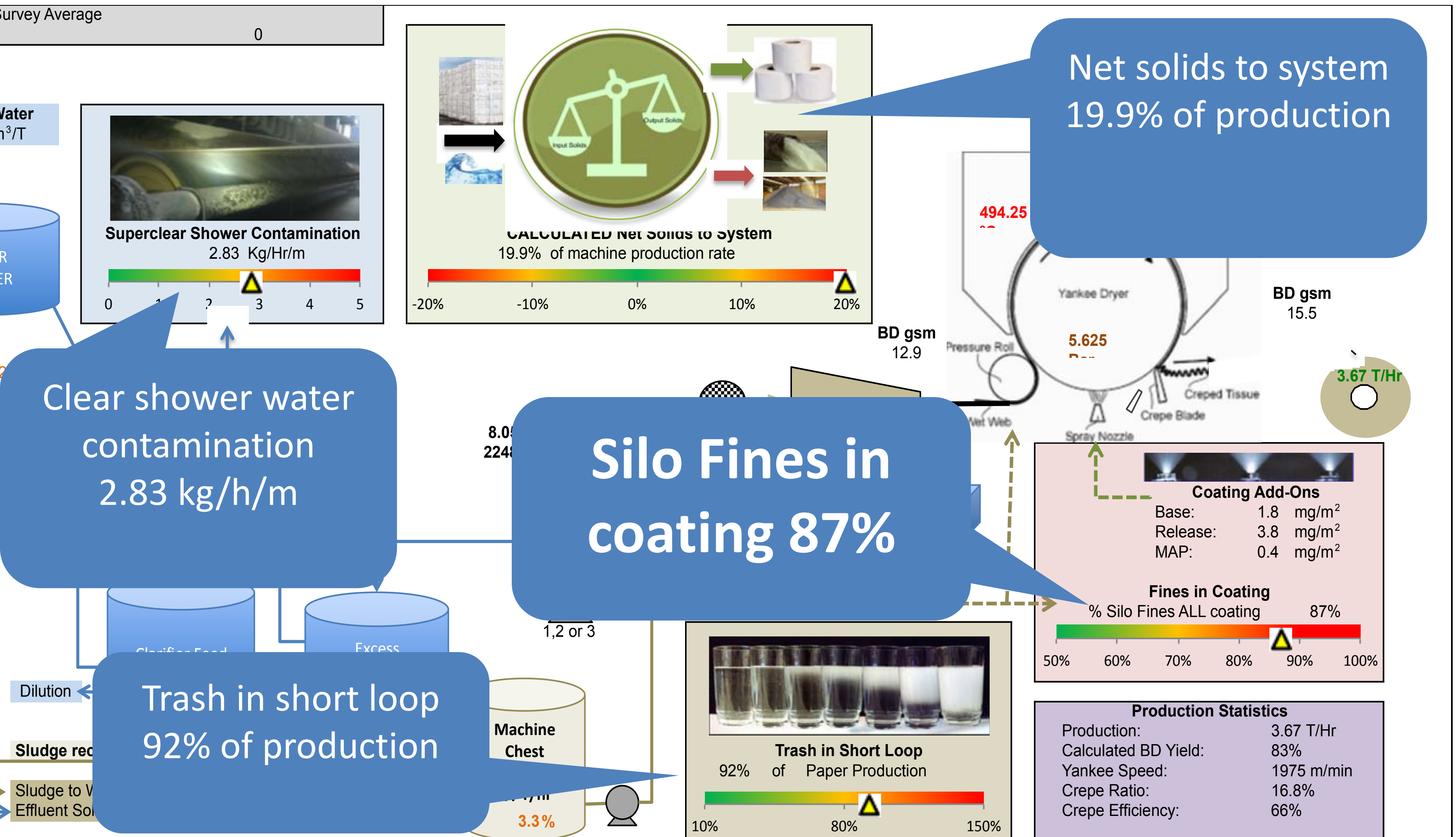


How: multipoint fines audit of whole system



key indices determined…

e, indices for comparison, not absolute values)



Comparative audits using these indices

-ASH RUNNABILITY INDEX	TARGET	North EU Branded Luxury		North EU Economy and Luxury		East EU Soft Toipa and HHT		East EU Soft Toipa and HHT		Central EU Toipa and HHT	
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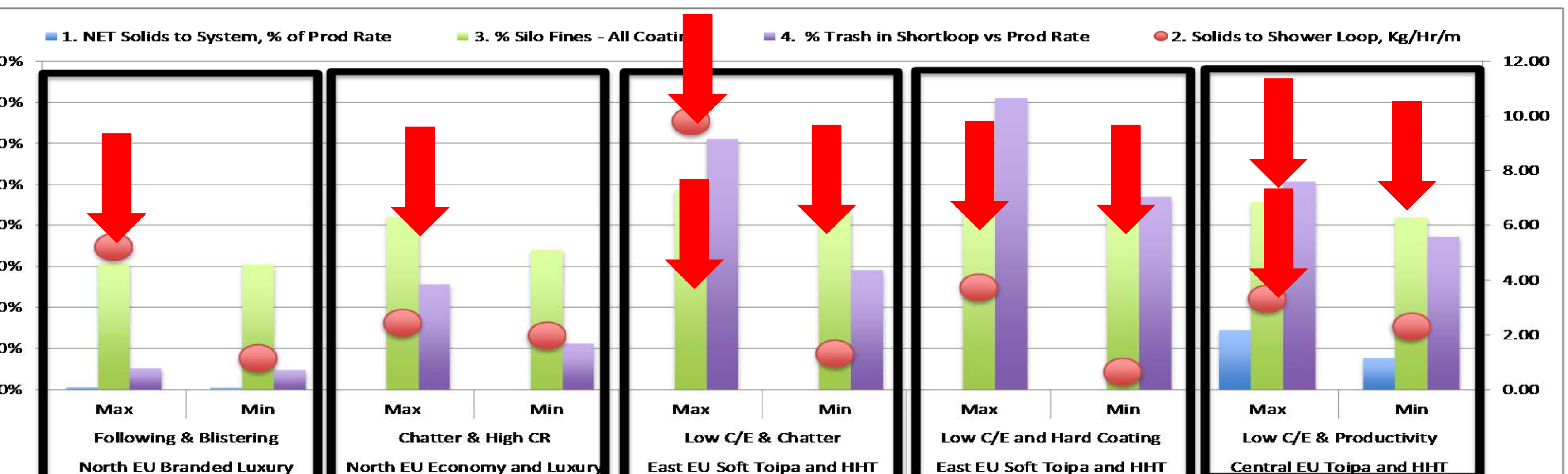
		Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
Solids to System, % of Prod	<8%	1.1%	0.9%	Consistency Transmitter Accuracy Issues		Consistency Transmitter Accuracy Issues		Consistency Transmitter Accuracy Issues		29.0%	15.5%
ds to Shower Loop, /m	<2.5 or Machine Manual	5.21	1.14	2.42	1.96	9.80	1.30	3.73	0.64	3.30	2.30
lo Fines - All Coating	<80%	61.4%	60.6%	84.2%	68.1%	97.2%	86.7%	93.2%	88.9%	91.3%	83.7%
rash in Shortloop vs Prod	<45%	10.4%	9.6%	51.4%	22.5%	122.0%	58.1%	141.7%	94.1%	101.3%	74.2%



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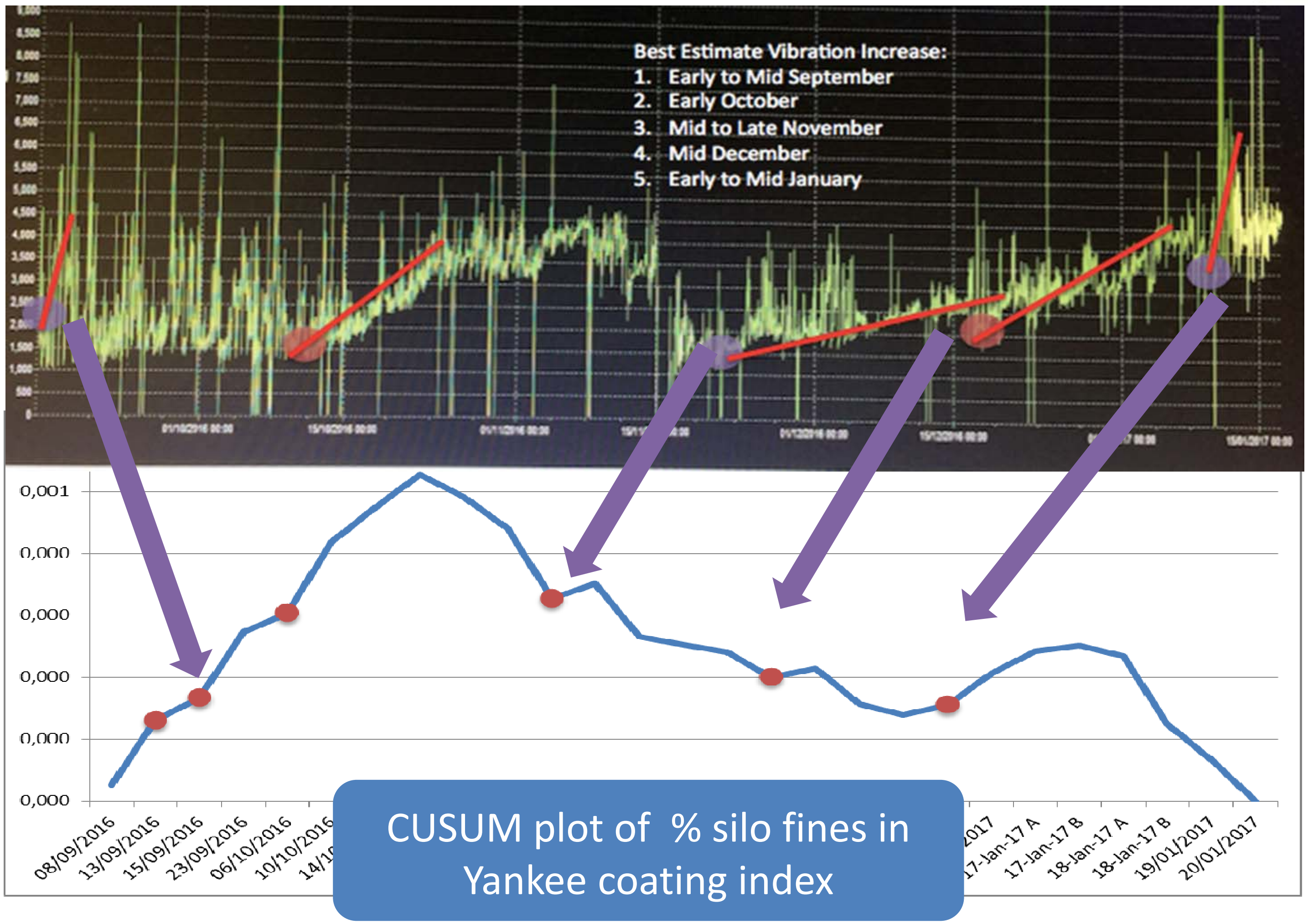
ltiple issues across these machines:
atter, observed hard coating, low crepe efficiency are all
own coating contamination issues corresponding with a high
ntamination index

Vibration versus coating contamination



3. What are my control measures?

ligh Vibration can indicate compromised coating

se of *controlled* wet end
kative/retention technology

Use of *high performance*
cleaning blade

o: Archer, Furman, Van Dresek:

ssue World Nice, March 2011

evilliers, Padley:

Cleaning blade to control coating

o better **control coating** and stabilize machine runability
vhen process is compromised (poor moisture profile,
ard coating due fines contamination)

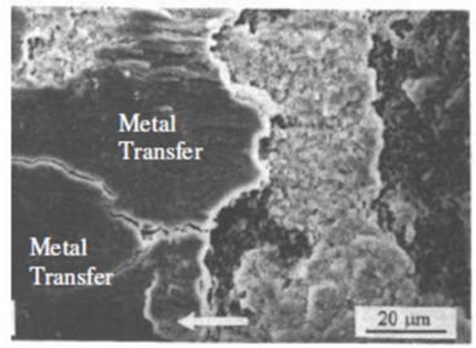
o **improve creping** blade performance, especially when
fetime and/or tissue quality is the issue (softness, bulk).

educe blade vibrations and chatter risks

Why should we use a ceramic cleaner?

To avoid **adhesive wear**

on metallized surfaces

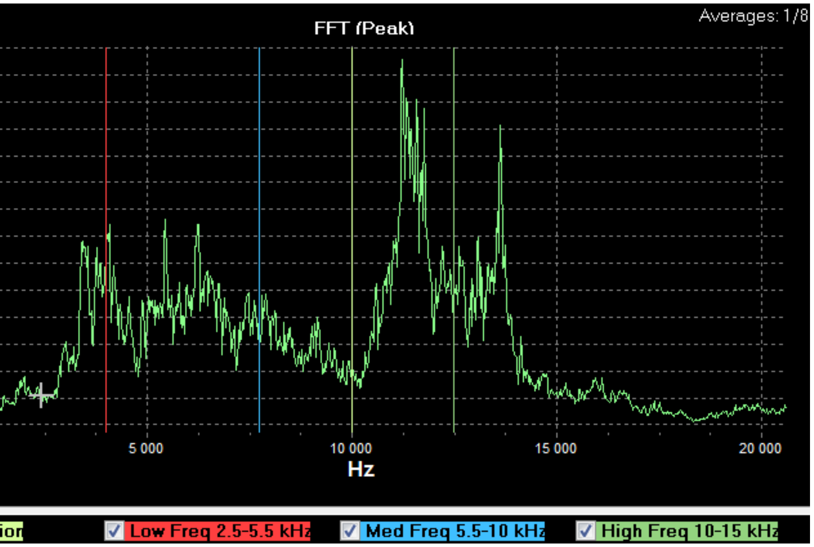


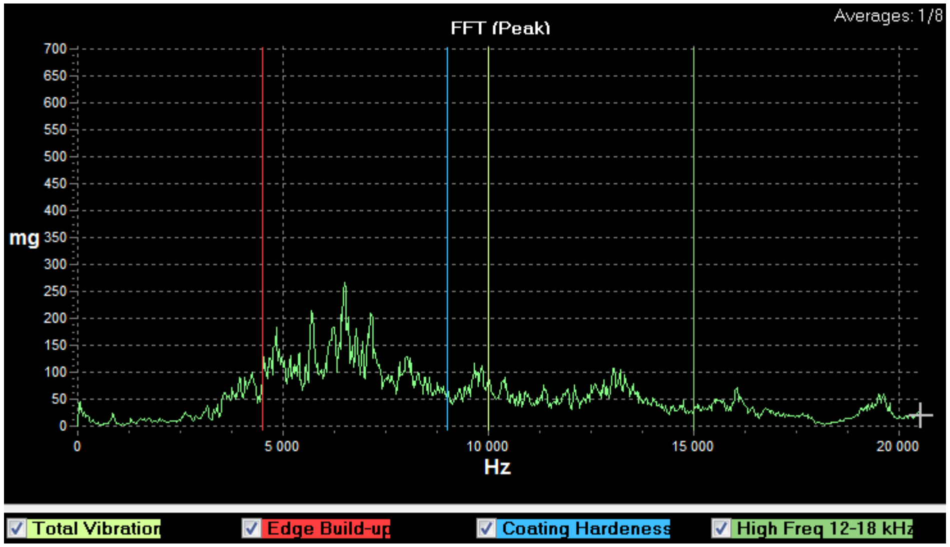
To avoid localised rapid wear which happened with steel to give non uniform coating in 15 minutes in some cases.

→ Steel cleaning blades will only adapt to local wear conditions across the Yankee and not clean the surface

→ The real cleaning is done by the creping blade, hence compromising tissue quality and blade life

Case history 1:
East Europe





High Performance Ceramic Crepe,
l cleaning blade loaded and
ged randomly

80° High Performance Ceramic crepe,
HP Ceramic cleaning blade in use continuously

utcomes:

- 47% less CR vibrations, mostly correlated with hard coating (friction)
- Lower grinding frequency (every 2 months → ???)

Benefits: Modern EU Tissue Mill case 2

Vith high performance ceramic cleaner usage
***nd* wet end fines control:**

- Improved Yankee surface condition (consistent roughness, no adhesive wear)
- -50% creping blade vibrations
- +30% creping blade life
- Consistent tissue quality (bulk)
- Less cleaning blade changes (Safety)

Summary: Yankee Surface Management