

Aliasing performance of variable-speed scanning in cross-direction control of paper web Seyhan Nuyan and Calvin Fu



Aliasing performance of variable-speed scanning in cross-direction control of paper web





What is aliasing? Why do we care?

MD signal aliasing *



If a signal is sampled too slowly, it may appear like a signal varying with a lower frequency. This is a false representation of the original signal, hence an alias.

* Figiel, Kerry. "Alias Impact on Control Profiles", *TAPPI PaperCon*, Indianapolis, IN, May 5-8, 2019.

Measuring CD properties of a web moving in MD with a scanning system is equivalent to sampling a 2D web too slowly. This creates a false profile, hence an alias.

MD/CD Aliasing *

3 sec MD in a 30 sec (single) scan profile



A good example from a Canadian mill shows rocking profiles when there is no such variability in CD. This is entirely caused by MD cycles of the retention aid dilution flow valve (stiction)

Filtered profiles from mill

Hanson, Ake & Idon Gladh, *Tvärsprofilstyrning - SPCI & STFI*, Karlstad, Nov. 15-16, 1983

Fu, Calvin & Seyhan Nuyan, "Mill experiences on cross-direction troubleshooting" *TAPPI Paper Summit 2002*, Atlanta, GA, Mar 3-6, 2002



MD / CD Aliasing from mill data capture



Validating aliasing hypothesis



Research work on aliasing

Some methods to reduce the impact

- By varying the end-of-scanner delay time
- By varying the scanner speed (VSS)
- Utilizing fixed-point measurement in combination with a scanning measurement
- Kalman Filtering
- Removal Techniques (Time Synchronous Averaging or Frequency Analysis)

This paper explores the aliasing performance of variablespeed scanning (VSS) in cross-direction control of paper web



Simulation Design Base data: 36,000 MD x 300 CD positions

- No CD, diagonal, or other variation except
- MD and random noise variation only
- 150 scenarios with MD variability from 1 to 150 seconds at 1 second intervals

10% of one hour Production with 300 points in CD Blue: 30-sec CSS --- Magenta: Random VSS - RSS



Aliasing Spectrum with Constant Speed Scanning (CSS)

Scan speeds of 30 and 36 seconds; In both cases, 100% aliasing of MD at distinct wavelengths





Aliasing Spectrum of CSS & Variable Speed Scanning (VSS) CSS = 30 sec., VSS=24 & 36 seconds alternating between reverse and forward

100% Aliasing of MD at the same wavelengths





Aliasing Spectrum of CSS & Variable Speed Scanning (VSS)

CSS = 30 sec., VSS=randomly selected between 24 & 36 seconds;





CSS = 30 sec., VSS_{4-s} =40, 25, 20, 35 sec. - VSS_{8-s} = 40, 25, 20, 32.1, 36, 37.3, 21.9, 37.6 sec.

VSS with 4 speeds compared to CSS (30 sec.)

VSS with 8 speeds compared to CSS (30 sec.)



- As the number of speeds are increased, VSS is less likely to pick up 100% MD aliasing
- At some wavelengths MD Aliasing may still be close to 100%
- VSS with eight speeds alternating in a fixed pattern already shows reasonable immunity to aliasing.
- If the pattern for the 8 speeds are randomized, VSS has better immunity



CSS versus VSS with random selection of speeds

CSS = 30 sec., VSS_{random} within upper and lower bonds with the expected value of 30 seconds





Conclusions

- Both CSS and VSS with two speeds alternating btw. forward & reverse scans pick up some MD aliasing wavelengths at 100%.
- VSS with two speeds shows better immunity if the 2speed pattern chosen randomly
- As the # of speeds increased, VSS less likely to pick up 100% MD aliasing.
- If speeds are selected randomly within upper & lower limits with fixed expected value (RSS), the average CD profiles do not pick up any significant frequency.
- RSS exhibits significantly improved performance compared to CSS.







Q & A

