Z-SPAN TESTING FOR BETTER PAPERMAKING QUALITY PULP

Authors:

Joffrey Cowan, President
Lori Balint, Technical Sales Manager

Pulmac Instruments
HCR 34 Box 50
Montpelier, VT 05602
USA

INTRODUCTION

Zero span tensile testing, discussed almost 75 years ago by Hoffman-Jacobsen (1), has been available to the industry for over 50 years (2-Check Clark Book). Zero and short span tensile testing has been obtainable for more than 25 years. (3) Over the years Zero and short span tensile testing, as a primary predictor of the strength of pulp, has remained a curiosity which has seen its popularity fall and rise a number of times within the research community beginning in earnest from work by Van dan Akker (4).

Interest in zero-span tensile testing has again risen with the explosion of new, environmentally driven, pulping and bleaching application. However, until recently zero and short span tensile testing (5) has been associated with the same limitations as beater curve hand sheet testing. The test method requirements for pulp preparation and hand sheet production have limited its use in a production environment. However new advances in performing zero and short span test (6) have allowed the test to migrate from research labs into mills.

Zero and short span tensile testing generates data that is sensitive to changes in the strength, length and bonding of the fibers that are the building block of paper strength. (7) This paper will discuss the one system capable of making these primary measurements on a shift basis, within the production environment, and how this measuring system has been implemented in three mills.

Z-SPAN TESTING - MEANINGFUL, RAPID AND REPEATABLE

Third Generation Z-Span Testing System

The usefulness of a production pulp strength test is dependent on its ability to reliably indicate changes that predict end use quality. It is not good enough that a test has theoretical importance. The practical nature of a test method is even more important when used in a production setting.

The first generation zero-span testing equipment were attachments to a conventional tensile tester. The second generation zero and short span testing equipment was a stand-alone bench top device. The Zero Span 3000 is a third generation zero and short span tensile testing system that has made possible the practical and successful application of zero and short span tensile testing in the mill operations environment by addressing past sample preparation limitations, and an automated testing system.

Preparing pulp and the production of hand sheets has traditionally been a slow and tedious procedure that had to be performed in the lab. Also, tests had to be run one at a time. A third generation approach to zero and short span tensile testing includes the quick determination of basis weight by either dilution or de-watering and weighing, and a tester that is capable of performing multiple tests. On pulp samples, a five-minute "blending" treatment stabilizes the fiber shape to enhance repeatability. (This treatment is not performed on pulp samples taken from stock preparation) The stabilized pulp is then fed to an automatic sheet former. Within five minutes uniform test sheets with random orientation are available for testing. Performing many replicates is important to the repeatability of zero and short span tensile testing. A third generation Z-span tester can generate 24 individual tests within 5 minutes that can be all or any combination of wet, re-wet, and/or dry zero and or short span tensile tests.

Z-Span Numbers

The zero-span tensile test (8) measures the average strength of fibers that are clamped by both jaws at failure. The Newtons per centimeter force number is sensitive to changes in the average strength of fibers. Replicate testing is important to achieving good repeatability.

FS number (N/cm) = Avg. >10 wet zero-span tensile tests normalized to 60 grams per square meter.

A length factor (9) is derived by comparing the load tensile bearing capability of a test sheet in the short span (most commonly 0.40mm) to the zero-span test result.

L number (%) = Avg. >10 re-wet short span tensile tests / Avg. >10 re-wet zero span tensile tests

The bonding factor (9) is derived by comparing the load bearing capability of the fiber network at short span (also typically 0.40 mm) in the dry versus the wet condition.

B number (%) = Avg. 10 dry short span tensile tests / Avg. 10 re-wet short span tensile tests.

NORTHERN BLEACH KRAFT SOFTWOOD MARKET PULP

This softwood market pulp mill installed a Zero Span 3000 testing system as a replacement to viscosity. (10) The purchase was justified as a more reliable disposition of pulp strength than viscosity for their Just -In-Time delivery. It was also important that this test was more rapid than beater curve testing, as pulp strength had to be tested on an hourly basis, prior to warehousing or delivery. The mill is an ECF operation with continuous digesters, single stage O2 delignification, and a four-stage bleach plant. The mill produces a number of grades of baled dry lap pulp.

After two months of overlapping the viscosity and zero-span tests on an around the clock shift testing basis, the viscosity test was discontinued. The ease of getting production buy-in to replace the viscosity test was attributable to the much clearer picture the z-span test data provided. It was sensitive to many operational adjustments that the viscosity test hadn't been able to detect. Conversely, the z-span numbers didn't inexplicably move, unlike the experience this mill had with the viscosity test. This combination of sensitivity and stability is what quickly built up the required confidence in the data generated by this 3rd generation testing system.

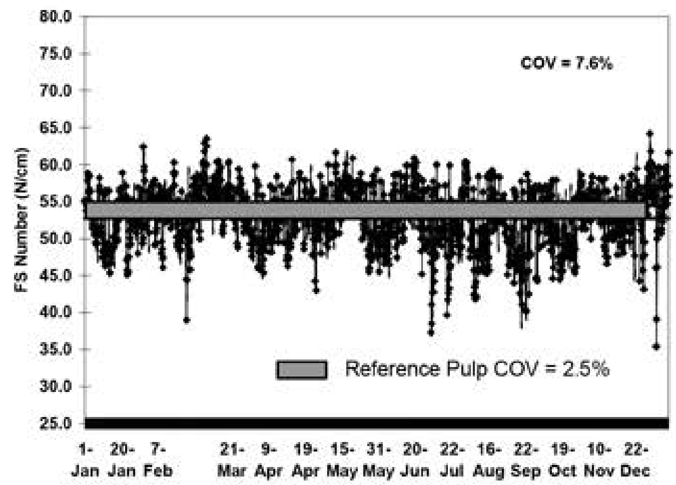

Figure 1: Data, with a COV of 7.6%, associated with FS number variation for one final product grade. (A standard deviation of Reference pulp is superimposed.)

The dispositioning of pulp lots, by measuring z-span strength of representative dry lap pulp at the grading station, was the first step in adopting the language of z-span numbers. Now a reliable measure of strength was available for all unit processes, not just at the end of the pulp drier. Baselines for strength loss and variability were generated at the brown stock washer, after to O2 Delignification stage and after each stage in bleaching as well as graded dry lap pulp. Ultimately the mill settled on testing z-span strength at four process locations: After the digester, after O2 delignification, the two final bleaching stages, and the dry lap pulp from the grading station.

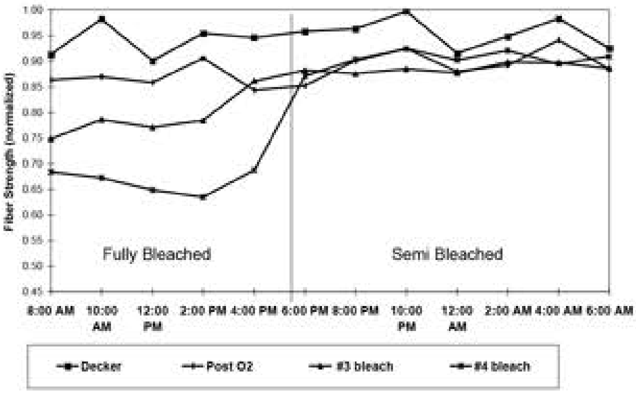

Figure 2: Stage by stage FS number (normalized) loss

This process-monitoring program has had a major role in reducing variability and thereby increasing the pulp quality. Transition pulp from chip to sawdust is reliably tracked for operational decision-making using the L number. (10) Transitions from fully to semi-bleached pulp are also being quickly and reliably tracked for strength implication throughout the pulp mill. (10)

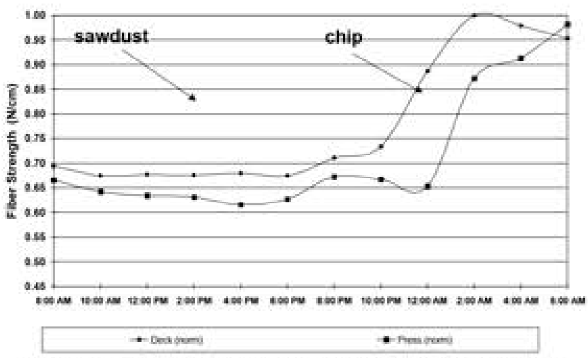

Figure 3: Transition from sawdust to chip, as shown by the FS Number.

Cost Savings

The mill has enjoyed many benefits from using this third generation testing system. The simplification of logistics associated with holding pulp in limited warehouse space for beater curve strength evaluation. The optimization of the O2 delignification process to reduce bleaching chemical costs, with information that was more meaningful than viscosity. There has been increased quality based upon higher average strength with lower variability.

INTEGRATED FINE PAPER MILL

This integrated fully bleached pulp mill with two fine paper machines, installed a Z-Span 3000 testing system to ensure stability in pulp quality during the transition to ECF bleaching. They are an ECF operation with a digester, a four-stage bleach plant, purchased NBK softwood, purchased secondary fiber, and purchased broke supplying two papermachines. They can produce wet lap hardwood for inventory and later use.

This mill had been monitoring viscosity, residual alkali, and sulphidity every two hours. They also made frequent measurements of kappa, brightness and dirt. Even with all this testing, the pulp mill management was not confident that they were predicting the papermaking quality of the pulp in terms of runnability, formation, and end machine strength requirements. This concern was heightened with the planned conversion to ECF bleaching. With encouragement from papermachine personnel, the pulp mill invested in a third generation z-span testing system. During the first three months they generated enough data throughout their pulp mill to provide baseline data for each pulp mill unit process and understand their overall variability. Also during that three-month period confidence in the reliability and credibility of the z-span data justified dropping the testing of viscosity.

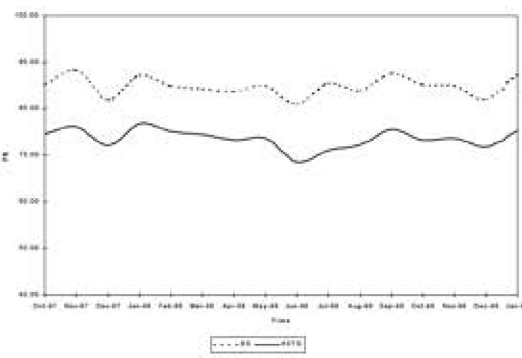

Figure 4: Monthly average of daily composite pulp mill FS numbers for brown stock washer and the last bleach stage washer.

As the pulp mill successfully reduced the variation in fiber quality being sent to the two papermachines two initiatives were made possible. The first was a project to reduce the costly requirement to add titanium dioxide. Both pulp and paper groups worked together towards this goal. The pulp mill was able to increase brightness 2 points from 88 to 90 and allowing the paper-side was then able to totally substitute PCC for titanium dioxide. Before having the z-span data, the pulp side would have been fearful that strength loss when increasing brightness would not have been an acceptable compromise for the papemachines. In another initiative a team from one of the papermachines was able to reduce, by 10%, the amount of softwood in a grade with a strength reel strength specification. The previous strategy was to keep softwood content high to accommodate for instances when hardwood quality was not good enough. With a more stable hardwood and credible data to track the pulp strength, this safety margin was no longer needed.

With ongoing credible feedback from the Z-Span testing system, the pulp mill was able to reduce its strength variation, from above 5% to less than 3%

Table 1: Coefficient of Variation for 45 days of 3 shift daily composites.

Sample Point	Average			Coef. of Variation		
	FS	L	B	FS	L	B
Brown Stock Washer	86.0	0.34	1.84	4.14%	3.69%	3.34%
Is t Stge BL Was her	85.0	0.33	1.81	5.04%	4.78%	5.95%
2nd Stge BL Washer	78.0	0.32	2.02	5.02%	4.85%	6.81%
3rd Stge BL Was her	76.0	0.30	2.14	4.40%	4.76%	5.71%
4th Stge BL Was her	74.0	0.30	2.13	4.31%	4.59%	4.97%
5PM Couch Trim	69.8	0.37	2.61	6.34%	4.21%	9.03%
4PM Couch Trim	65.7	0.31	2.99	4.63%	3.47%	4.75%

Prior to installing this 3rd generation z-span testing system this mill measured viscosity, sulphidity, and active alkali every 2 hours around the clock. A consensus emerged, in response to a cost cutting initiative, that this amount of testing was no longer needed because of the information provided by the z-span testing system. "If the z-span numbers are in line, then the whole pulp mill is running well!"

Cost Savings

Implementation of the 3rd generation z-span testing system resulted in the elimination of four shift-testing positions. The pulp mill was able to support the substitution of PCC for titanium dioxide for a cost saving of $1.5 million. Softwood content by 10% in a grade of paper. Main drier breaks and press blows have been reduced. Reducing hardwood FS variability from a COV of 5% to a COV of 2.9% has increased Millwide stability.

INTEGRATED CORRUGATING MEDIUM MILL

This integrated Medium mill installed a 3rd generation Z-Span testing system to optimize the pulp's contribution to medium strength. They are an NSSC, OCC and BC (Bottle Carrier) pulp mill supplying a high strength medium board machine. The pulp mill is responsible for the 2 DD NSSC refiners, the 2 Sprout refiners on the BC fiber line and the DD refiner for the OCC fiber line.

Pinpointing pulp quality variation was both complex and necessary at this mill. This mill had been unsuccessfully measuring the concorra and ring crush strength of handsheets to optimize the pulp's contribution to faster machine speeds at target strength. They purchased and installed the Z-Span 3000 testing equipment after assuring themselves of the correlation between the z-span numbers and the ring crush and concorra of oriented handsheets.

They generated baseline data for each of their unit processes starting from their NSSC de-shive refiners and then going through the whole stock delivery refining system.

Table 2: OCC, NSSC, BC variation averaged over several months.

Furnish	Avg	Avg	Avg	Co-efficient of Variati		
	FS	FL	FB	FS	FL	FB
OCC	65.3	0.56	1.61	3.2%	4.3%	4.0%
NSSC	49.9	0.43	1.93	4.3%	5.6%	6.1%
BC	63.5	0.55	1.76	9.7%	9.3%	22.1%

Once the baseline was established they were able to track the causes of pulp related slowdown of the medium machine. Confidence was built up by locating the root cause of a large percent of machine slow downs. Clashed or worn refiner plates, contaminated OCC, or too high of a yield coming from the NSSC pulping operation were normally the causes of slow downs. Many trials were performed at the pulp mill to optimize pulping conditions.