Laser Ultrasonics Web Stiffness Sensor

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R&D Partners: IPST at Georgia Tech, LBNL

Industry Partners: ABB

The Laser Ultrasonics Web Stiffness Sensor (LUSS)

Prototype tested in mill environment

Technology Description

- Decrease the amount of energy, fibers, chemicals and water needed to produce paper on paper machines

Project Goal: The objective is to provide a sensor that uses non-contact laser ultrasonics to inspect the mechanical state of paper during the manufacturing process, so as to save raw materials and energy via improved process control.

Estimated Benefits: UnCoated free sheet case 2001

Grade is UnCoated Free Sheet; numbers from Jaakko Pöyry model at IPST		Base Case	Lower Basis Weight Cases (Equivalent strength)	
Basis weight	**(g/m²)**	**75.2**	74.4	**73.6**
% reduction in BW; same area: -->			-1.06%	**-2.13%**
Basis weight	(lb/3M sq. ft.)	46	45.5	45
Machine production rate	(met. ton/year)	175,000	173,098	171,196
Savings				
- Fiber (@ **$139/metric ton**)***	($000/y)	-	264	527
- Chemicals (@ **$103/met. ton**)***	($000/y)	-	195	391
- Energy ** (@ $40/metric ton)	**($000/y)**	**-**	76	**152**
- Total, fiber + chemicals + energy	**($000/y)**	**-**	535	**1,070**

**With: electricity: $0.05/ kWh $20/barrel oil ***2001 numbers

Est. Benefits: UnCoated free sheet case 2006 1/2

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Basis weight	(lb/3M sq. ft.)	46	45.5	45
Machine production rate	(met. ton/year)	175,000	173,098	171,196
Savings				
- Fiber (@ **$142/metric ton**)***	($000/y)	-	270	540
- Chemicals (@ **$108/met. ton**)***	($000/y)	-	205	411
- Energy ** (@ $93/metric ton)	**($000/y)**	**-**	177	**354**
- Total, fiber + chemicals + energy	**($000/y)**	**-**	652	**1,305**

**With: electricity: $0.08/ kWh $60/barrel oil ***2006 numbers

Est. Benefits: UnCoated free sheet case 2006 2/2

With: electricity: $0.08/ kWh $60/barrel oil		Base Case	Lower Off-Standard
Basis weight	(g/m^2)	75.2	75.2
Basis weight	(lb/3M sq. ft.)	46	46
Machine production rate *	(met. ton/year)	175,000	176,810
Machine Losses			
Shut-downs	(%)	3	3
Breaks	(%)	3	3
Total up-time	(%)	94	94
Off-standard	**(%)**	**6.2**	**5.2**
PM saleable efficiency	(%)	93.8	94.8
PM efficiency	**(%)**	**88.2**	**89.1**
Increase in net profit ##	**($000/y)**	**-**	**425**

UCFS selling price = $783/metric ton (for 50 Lb UCFS on January 24, 2006; source: Forestweb)

Estimated Benefits: Summary
(for a 175,000 metric tons per year UCFS machine)

- In 2001, total savings using sensor were estimated to be $1.45 million

- In 2006, total savings using sensor are estimated to be $1.73 million

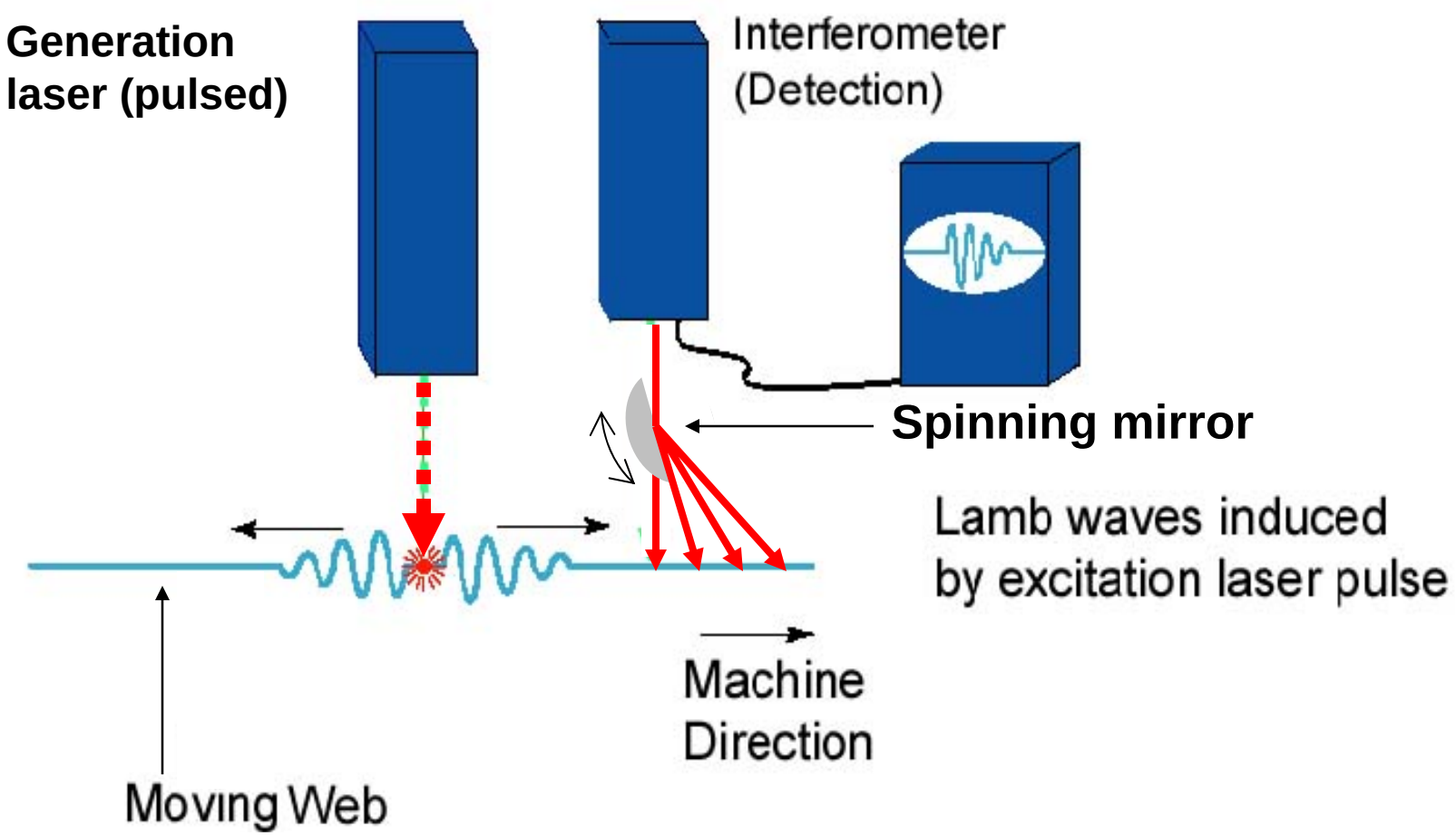
This is almost entirely due to increased energy costs:

- 2001 energy cost/ton of produced UCFS was $40/met. ton
- 2006 energy cost/ton of produced UCFS is $93/met. ton

The Laser Ultrasonic Stiffness Sensor (LUSS): Overview

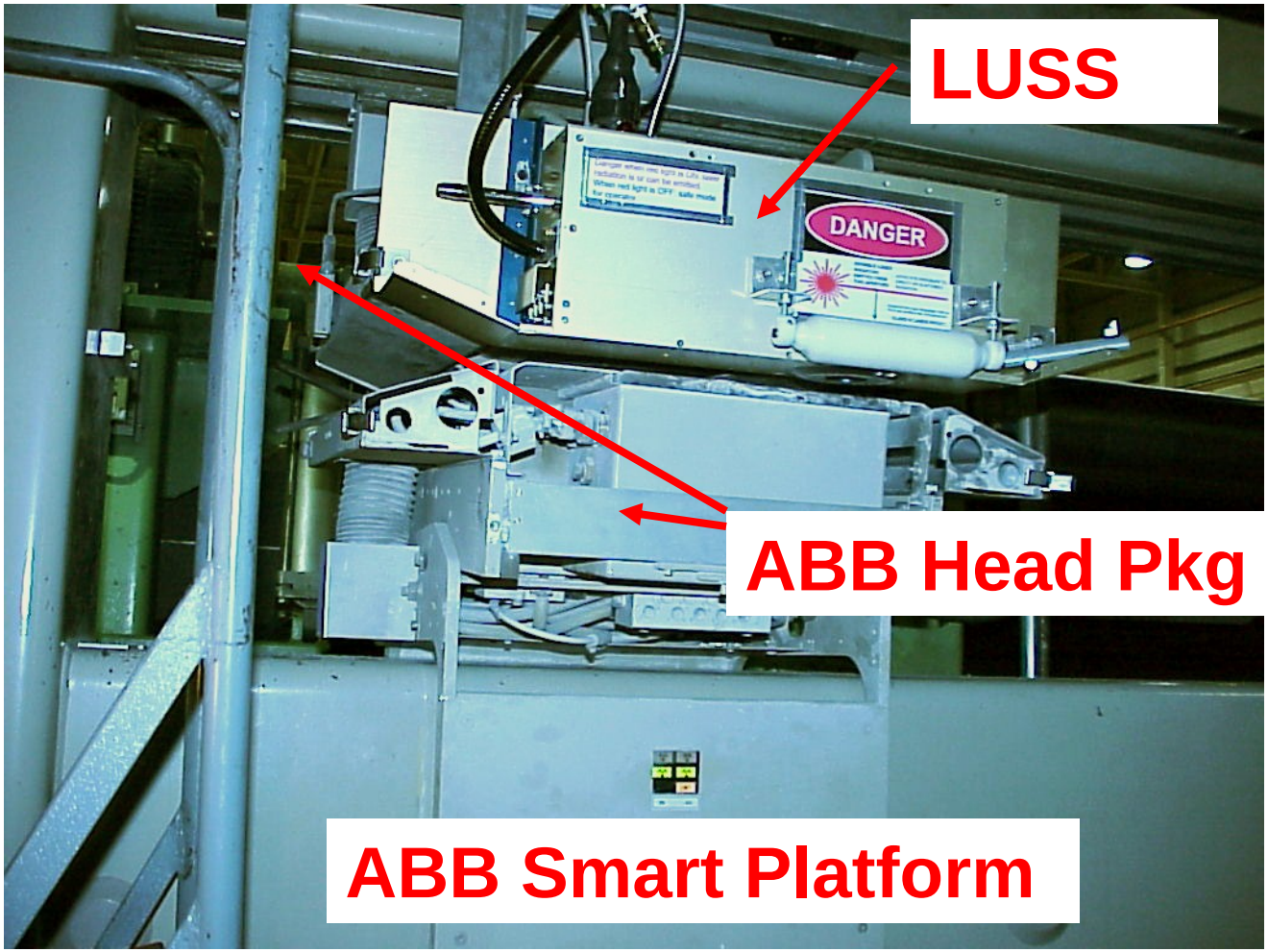
- Measures two fundamental mass specific mechanical properties of the paper: Flexural Rigidity (bending stiffness) and Out-of-plane Shear Rigidity
- Does not contact the moving paper
- Operates on-machine at speeds from 0 to 25 m/sec (~ 5000 fpm)
- Current sensor will work on paper or paperboard with basis weights from 35 to 205 g/m^2

LUSS Principles of operation



Edge View – Antisymmetric mode

Alpha trial of LUSS in 2005 - Installation on ABB Smart Platform at Boise Paper mill in Jackson, AL

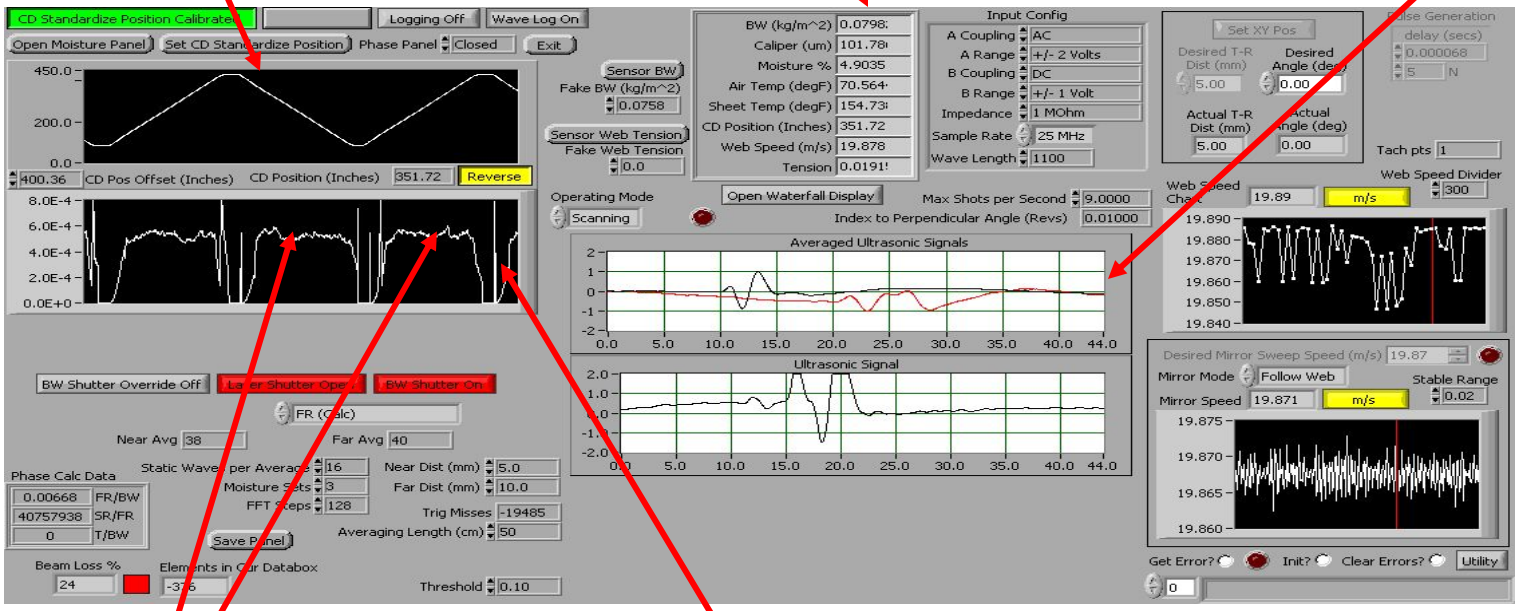


One of several display panels

Scanner position vs time

Current time data: basis weight, moisture content, etc.

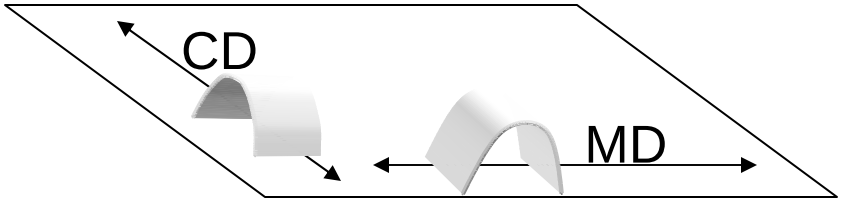
Averaged signals



CD profile of MD stiffness

Gap in measurements at the end of each scan across web

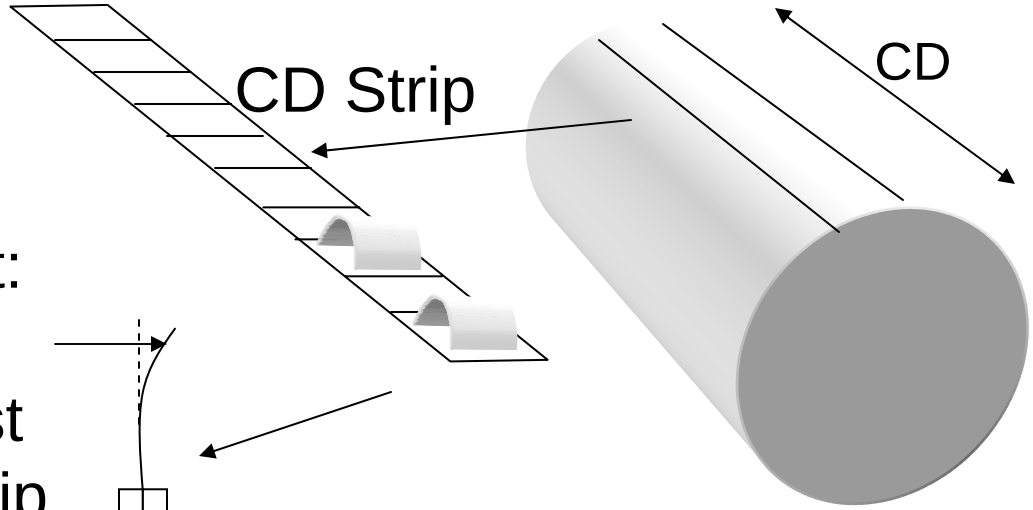
Other Alpha Trial Data



Does sensor measure bending stiffness accurately on the papermaking machine?

Comparison of sensor data with Gurley stiffness measurements on “CD strip” samples

CD Profile of CD stiffness



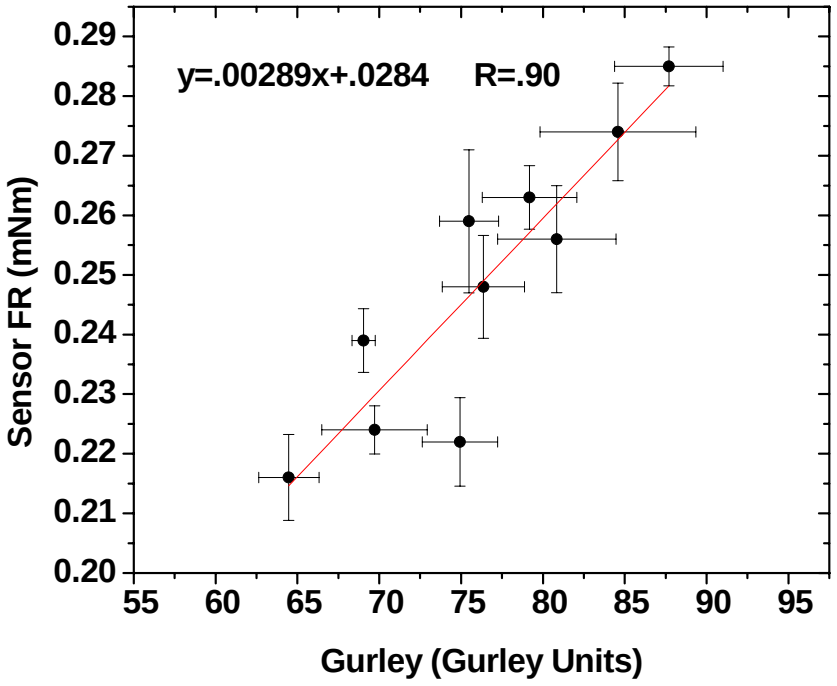
Gurley Test: Mechanical bending test of paper strip

Completed Paper Reel

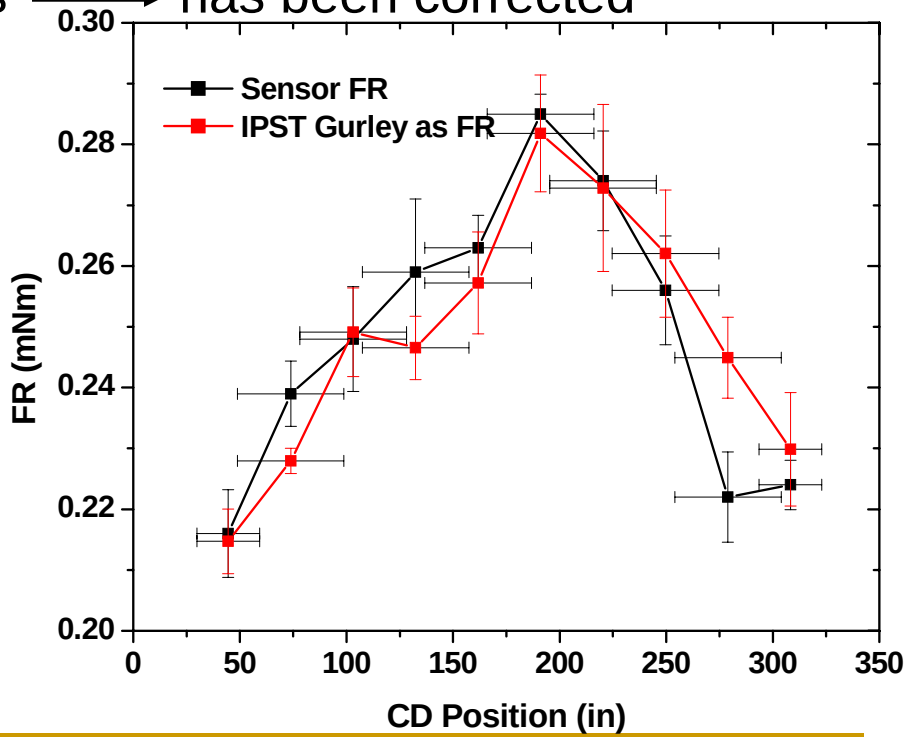
Mill Sensor vs. mechanical tests data on "CD Strip" Sample 1/2

Sensor data collected as "CD strip" passed under

Sensor FR *vs* Gurley Measurements: paper correction factor for CD stiffness



CD Profile of CD stiffness: Mostly agree once CD offset has been corrected

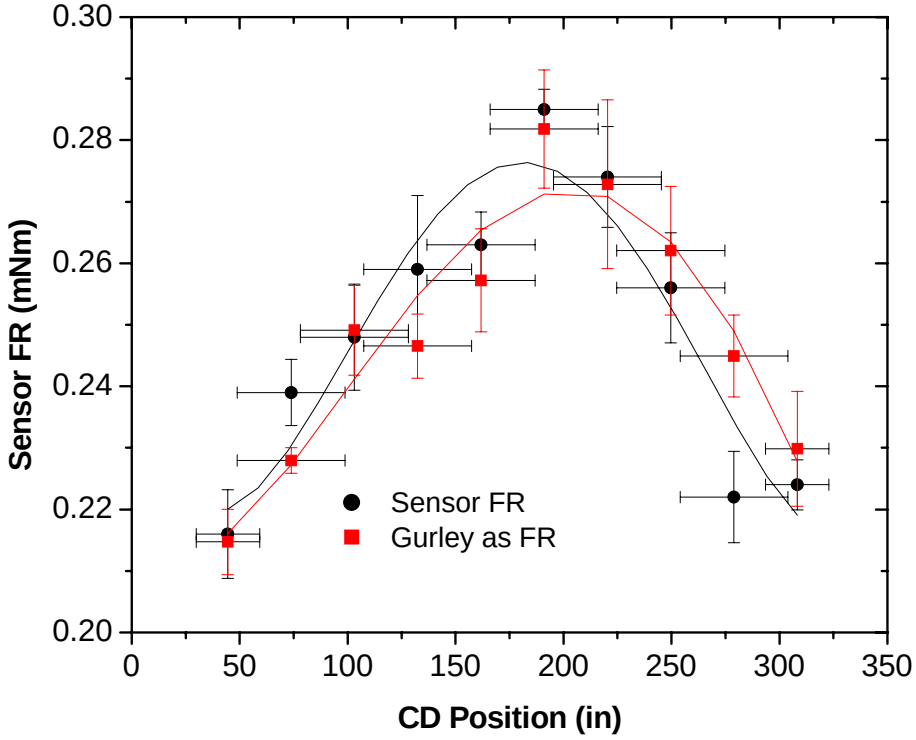


y error bars: std dev of mean
x error bars = CD averaging distance

Mill Sensor vs. mechanical tests data on "CD Strip" Sample 2/2

Sensor data collected as "CD strip" passed under

Another CD Profile of CD stiffness on a different day:



y error bars: std dev of mean
x error bars = CD averaging distance

Alpha trial conclusions

- LUSS performed very well during mill trials with excellent results
- LUSS remained on ABB Smart Platform for over two weeks without any major problems (but it was shut down at night)
- Mill trials enabled improvements in software
- Currently planning for a long term trial (Alpha+) for process control optimization

Major tasks for 2006-2007

- Alpha+ long term installation
  - Feeding sensor's stiffness numbers into mill's QCS for process control
  - Either at Jackson, AL or in Oregon/Washington mill
  - With LBNL's participation if North West Energy Efficiency Alliance supports LBNL
  - Single CD position non-scanning sensor for ease of installation
- Commercialization

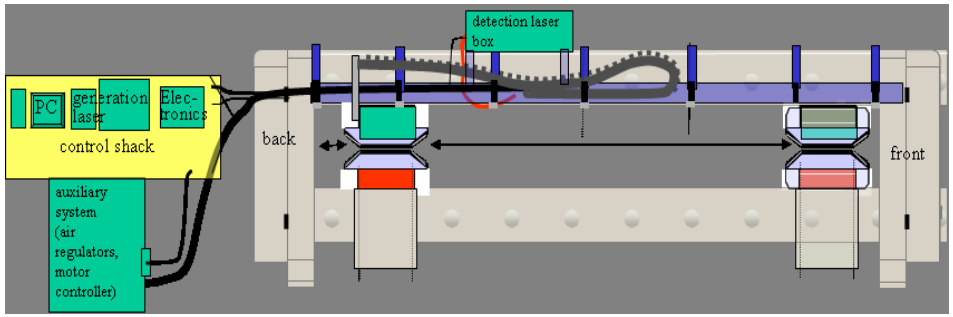
Commercialization Potential

- This is the only existing sensor for measuring stiffness on-line for light weight papers
- Non-contact characteristics have been a key to mill's acceptance:
  - No risk of tearing the web or downtime production
  - No wear, damage, drift, overheating of sensor caused by a hot and abrasive web (pb. of many contact sensors)
- According to ABB, scanning sensors market size is 10 scanning sensors sold per year worldwide

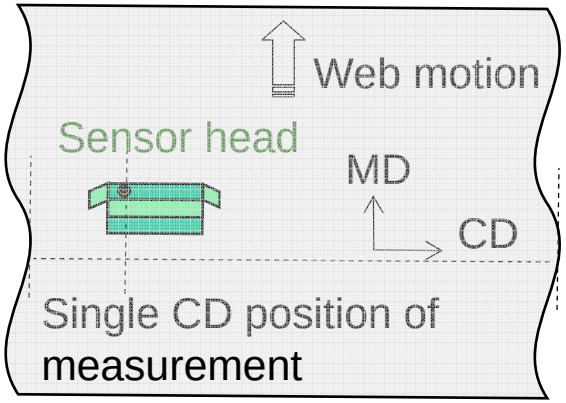
Commercialization Plan

Using same technique (laser ultrasonics with spinning mirror) : 2 paths

Scanning sensor mounted on scanning platform



Single CD position sensor



Commercialization Plan

- ABB is the industrial partner for a scanning sensor
- ABB considering a Beta trial of scanning sensor for mid-2007 but is limited by available time of its engineers
- Vibrant Sensors LLC formed in January 2006 to quickly commercialize a single CD position version of sensor
- Licensing agreement for spinning mirror U.S. patent #6,356,846 signed in March 2006 between GTRC and Vibrant Sensors for non-scanning use only
- Scanning Mirror Patent available for licensing of scanning sensors with ABB or other platform manufacturer

LUSS' advantages for the paper mill

- Continuous monitoring of flexural rigidity and out-of-plane shear rigidity during reel construction
- These measurements will enable automatic or manual process control such that:
  - Energy consumption can be decreased
  - Product uniformity (especially CD) can be improved
  - Waste from off-spec product can be reduced
- Certain mills may be able to realize additional cost savings or benefits, e.g., by being able to reduce fiber content while maintaining specs or by making a "super stiff" grade

Acknowledgements

- Boise Cascade
- Jackson mill personnel
- ABB Inc.
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Thank you!