

Enhanced Energy Savings in Papermaking

GA TIP3 Project Review

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Advantages of Using Filler in Paper

- Improve paper optical properties (brightness, opacity, printing quality)
- Reduce the papermaking cost
- Increase water drainage rate
- Increase solid content of paper web
- Substitution of fiber will reduce the carbon footprint

Problems of Using Filler in Paper

- Reduces the paper strengths
- Reduce the bulk
- Some effects on the wet-end operation
 - retention
 - sizing reversion (PCC filler)
 - water clarification
 - two-sidedness
 - dense paper
 - linting and dusting

Agenda 2020: Aggressive goals for cost reduction

R&D Focus Areas	Steam and Electrical Savings		Cost Savings (\$/ton)
	Million Btu/ton	Trillion Btu/ year	
Pulping/ Bleaching	1	80	\$37
Black Liquor Concentration	2	100	\$10
Causticizing	2	100	\$17
Dewatering/ Drying	2.5	250	\$12
Increased Filler/ Sustainable, Cost-Effective Pigments	3.6	75	\$35
Sheet Property Development	1	50	\$18

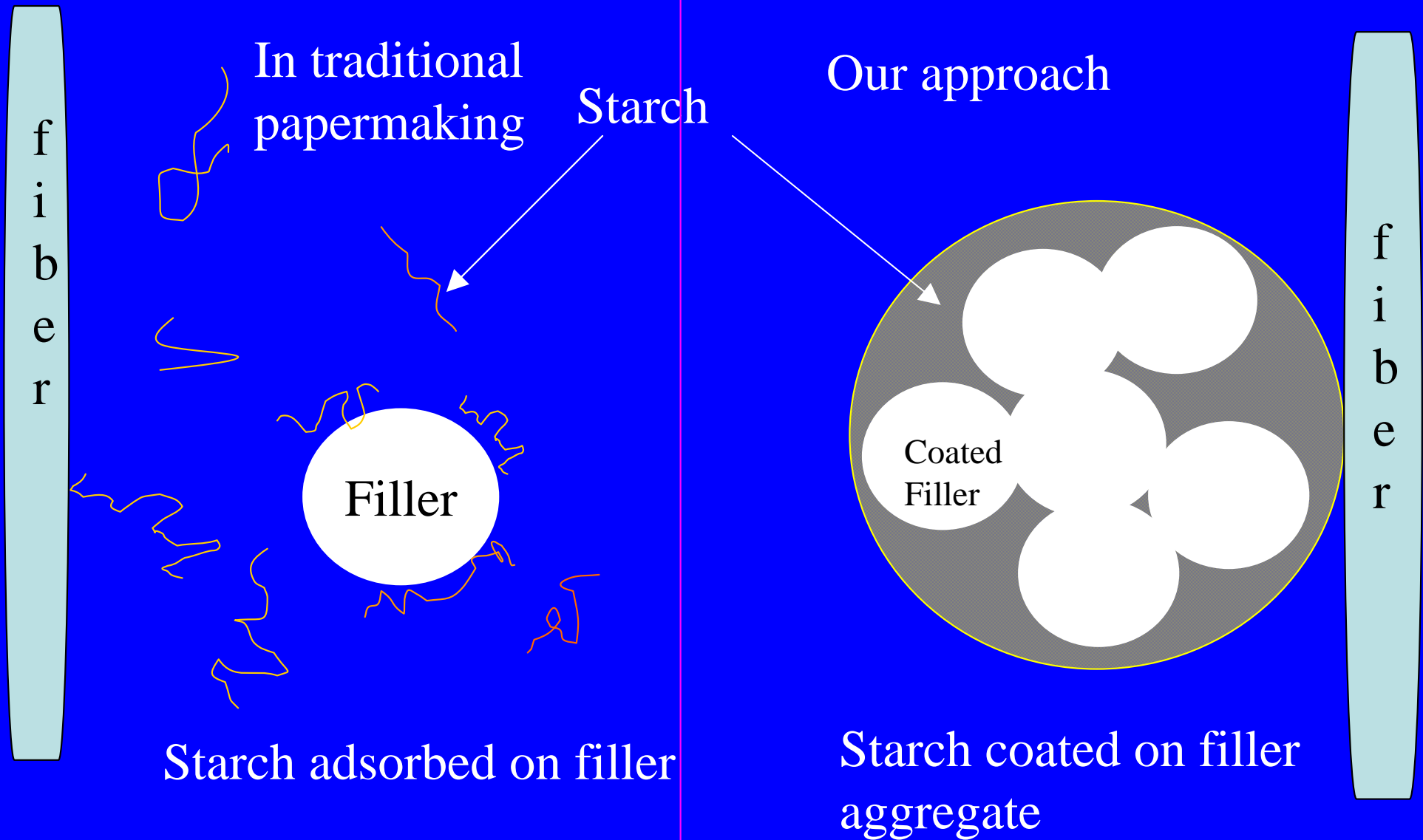
Objectives (from original proposal)

- Modify the technology for starch-coated clay and use the novel engineering filler to GA SW bleached kraft, bleached board, folding carton, and newsprint. Provide 5-10 % filler in newsprint and 10-20% filler for bleached board. Quantify laboratory dewatering, pressing and drying for high modified filler sheets
- Provide papermakers a predictive relationship between modified filler content and dewatering and drying properties for GA's linerboard, newsprint, and print grades
- Techno-energy-economic evaluation of clay bonding particles, sheet and drying properties.

Key findings to-date

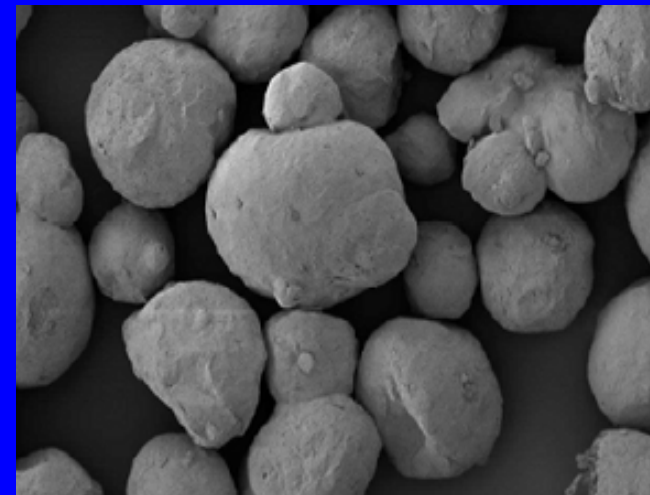
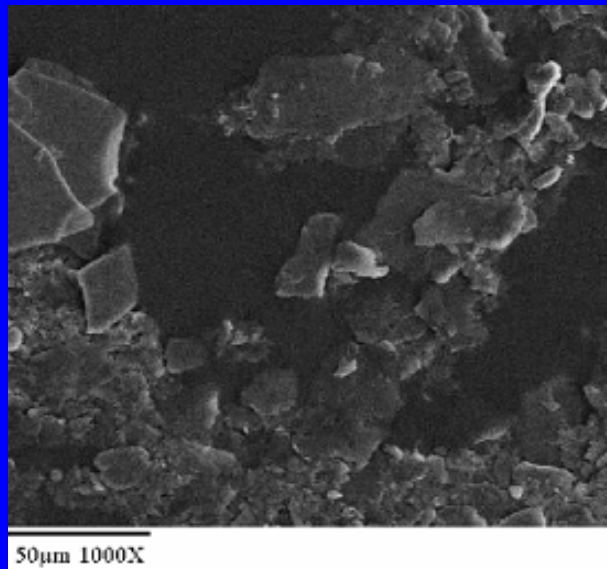
- Adding our starch coated clay to linerboards
 - improve water drainage rate
 - increase machine runnability
 - increase solid content by 3-5 absolute point
 - Saving drying energy by >10%
- Starch coated filler does not detrimentally impact linerboard sheet strength up to filler content of 8%
- The starch coated filler shows higher strength properties than adding filler and starch separately in wet end.
- The starch modified filler can also be used to improve newsprint properties
- Two modification methods (wet and spray drying) have been developed
- Our techniques can be used for both PCC and clay
- Both Starch and CMC have been used in filler surface coating
- Several mill trials have been done, and the longest trial is 11 days. All trials run very well and no break associated to the trials.
- Workshop in January 9th at IPST on the filler engineering technique we developed.
 - +8 companies (including two international participants from Japan and Sweden) participated the workshop.

Our Approach: Filler Treatment Using Starch



Filler Modification with Starch Coating

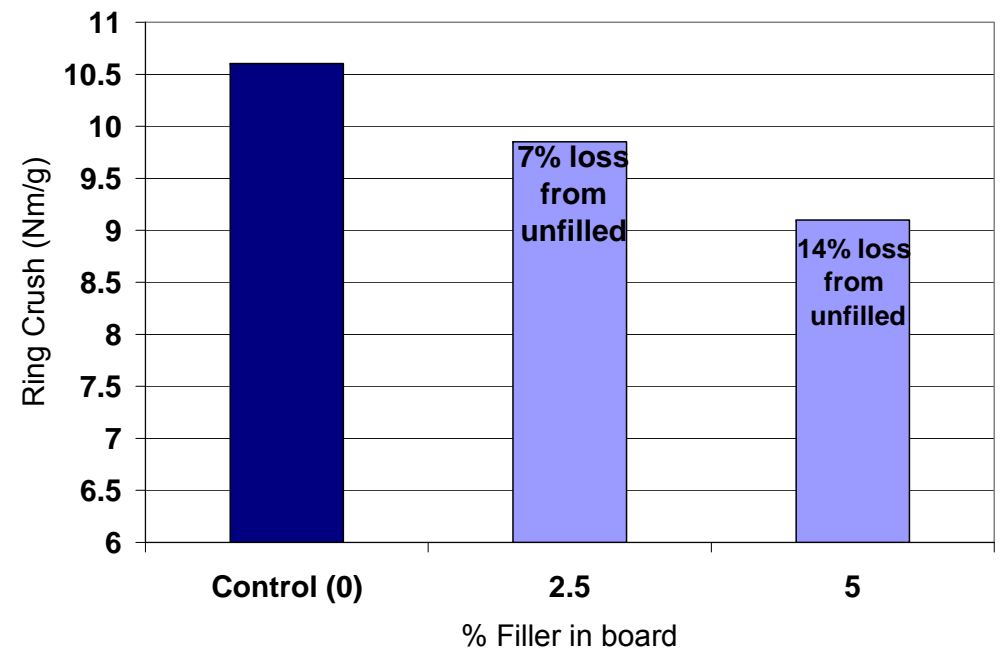
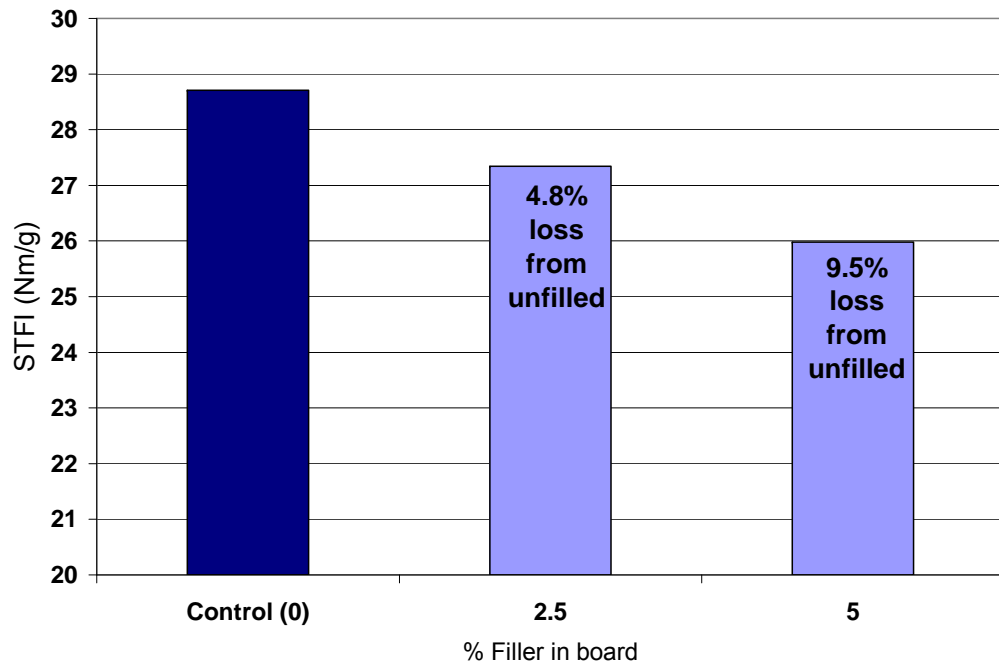
- Spray drying method (*Mill trialed, linerboard applications*)
- Wet slurry method (*Lab study for newsprint application*)
- CMC precipitation method
- *The best method depends on your paper grade, location (transportation cost), and fillers (PCC, Clay)*



Mill Trials

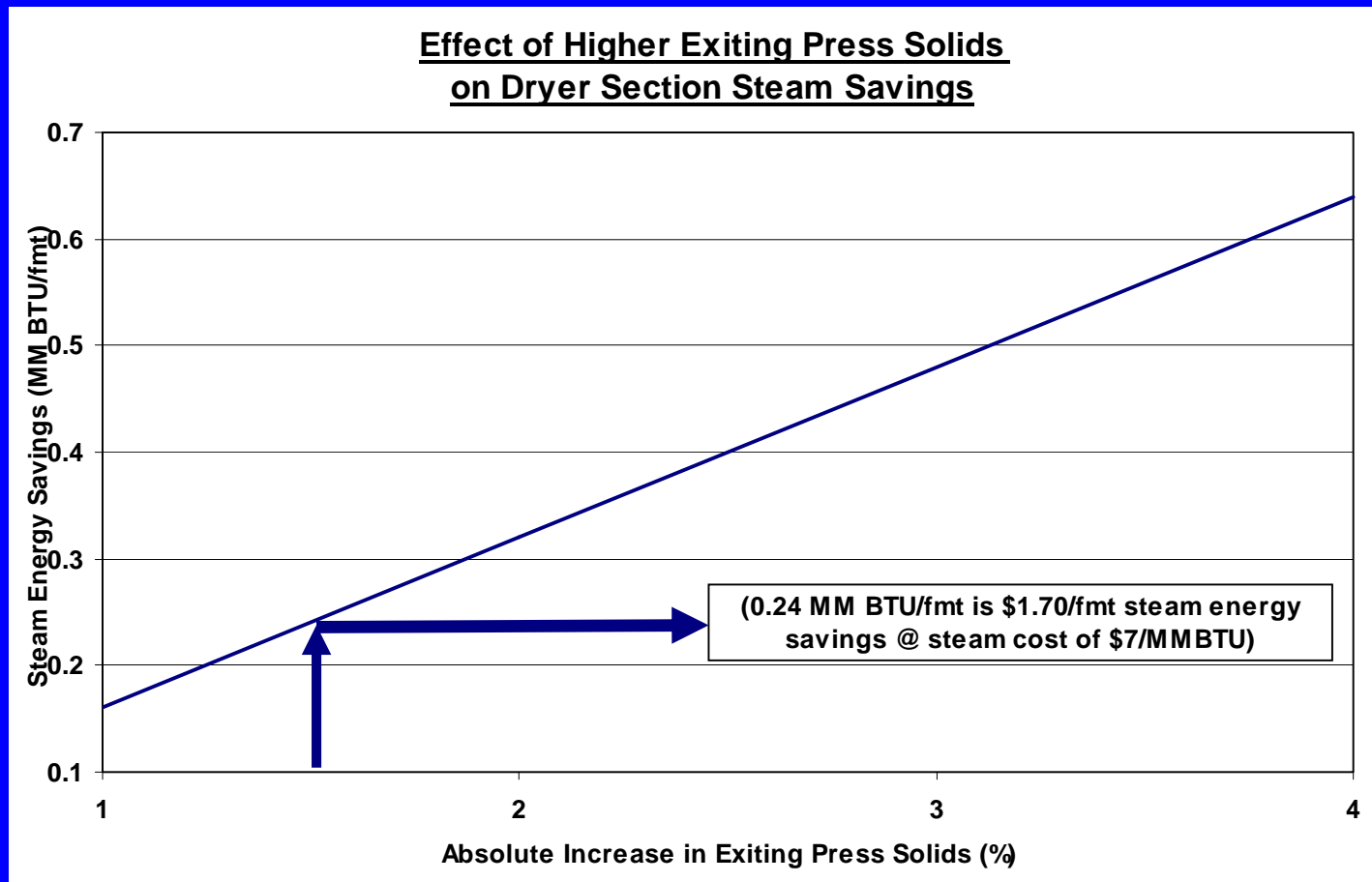
- 4 mill trials have been done by Imerys at different mills
- Linerboard and starch coated filler made by spray drying was used

Impact of Traditional Filler in Linerboard Using unmodified Clay Filler



4 mill trials have been done by Imerys at different mills
Linerboard and starch coated filler made by spray drying was used

Economic Impact of Reduced Steam Demand



Results - Dryer Section Energy Benefit

Constant Production: 1.5% press solids increase results in about \$1.70/t liner energy savings

Increased Production: 1.5% press solids increase on dryer-limited PM provides 6% speed increase giving net profitability increase of \$ 4 MM/yr

– 930 tpd mill at an incremental return of \$200/ton

Commercial Trial History Using SEK (Starch Encapsulated Kaolin Clay)

- March 2007: 8 hour trial on 55lb (268 g/m²) High Performance Liner
 - Speed kept constant
 - 10% reduction in steam demand seen at 4% in base ply
- October 2007: 24 hour trial on same grade as previous
 - Machine speed gains of 10-13 m/min were achieved
 - Old Corrugated Containerboard (OCC/recycled) flow was interrupted, which allowed an unexpected evaluation of OCC versus SEK
 - SEK appeared to have more impact on machine speed at lower levels than OCC
- March 2008: 72 hour trial encompassing a range of grades
 - Addition rates up to 5.5% were run successfully
 - Significant gains in productivity (up to 6%) were achieved relative to typical run rates (speed increases >30 m/min on some grades)

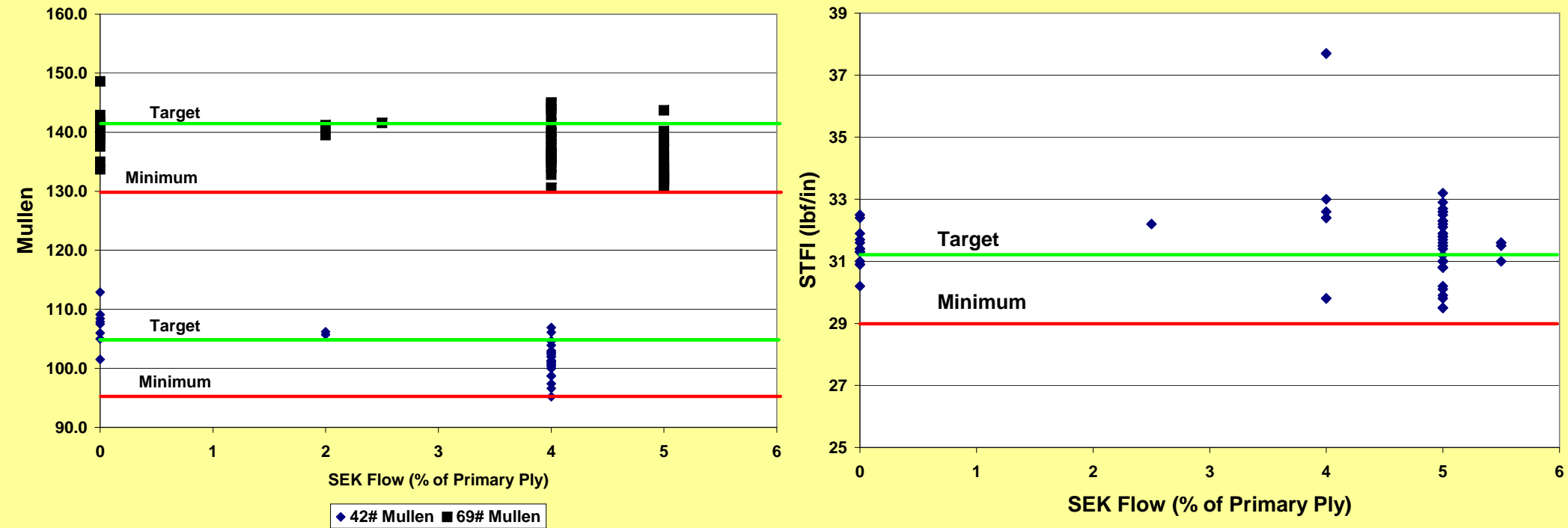
In all trials:

- **No paper was lost to breaks**
- **Strength levels were within specification**
- **Runnability was excellent**

Commercial Trial 3: Productivity Summary

Grade	42# Mullen (205g/m ² Standard)	69# Mullen (336g/m ² Standard)	55# STFI (268g/m ² High Performance)
Average SEK addition	3.90%	4.50%	4.80%
Target Speed (m/min)	750	506	584
Trial Speed (m/min)	774	522	601
Target Production Rate (stph)	43.9	48.7	44.8
Trial Production Rate (stph)	45.3	50.3	46.1
Max Speed (m/min)	779	534	618
Max Trial Production Rate (stph)	45.6	51.3	47.4

Commercial Trial 3: Impact on Strength



No correlation between critical strength tests and SEK dosage rates within trial ranges.

Value Proposition for SEK in Linerboard

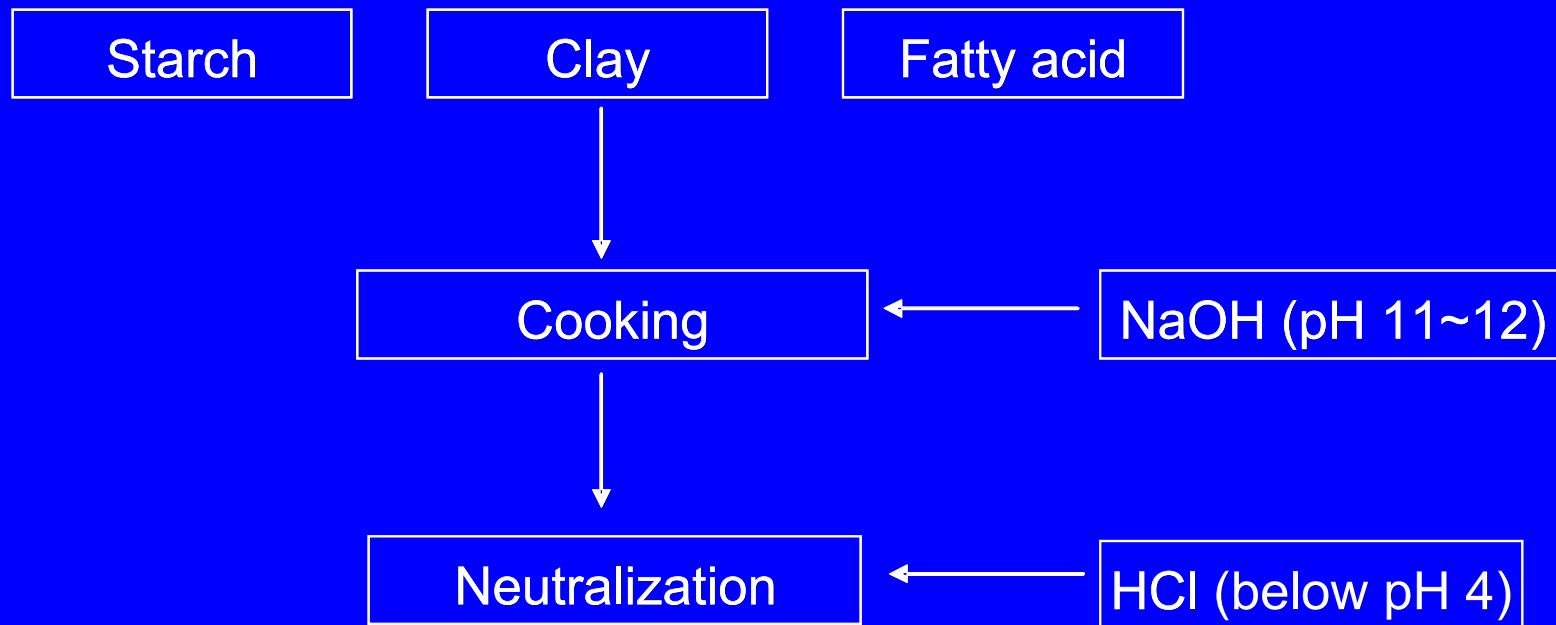
4 -5% SEK in linerboard results in the following benefits:

- Fiber replacement or extender
- Can substitute or extend OCC and Virgin fiber
- No statistical impact on strength and slide angle
- Faster drainage and drying
- Reduced steam demand - 10%
- Potential for speed increase - ~ 100 fpm
- Production rate increase of up to 3tph on 55lb liner

Laboratory Study: New Developments in FY08-09

- **Filler Modification methods:**
 - **Wet Slurry Method for starch coating: Starch-clay Composite with Fatty Acid**
 - **Wet Slurry Method for starch coating: Starch-PCC Composite with Fatty Acid**
 - **Wet Slurry Method Using CMC Coated PCC**
- **Paper Grades**
 - **Newsprint**
 - **Linerboard**
 - **Copy papers**
- **Energy Saving by Adding Fillers**

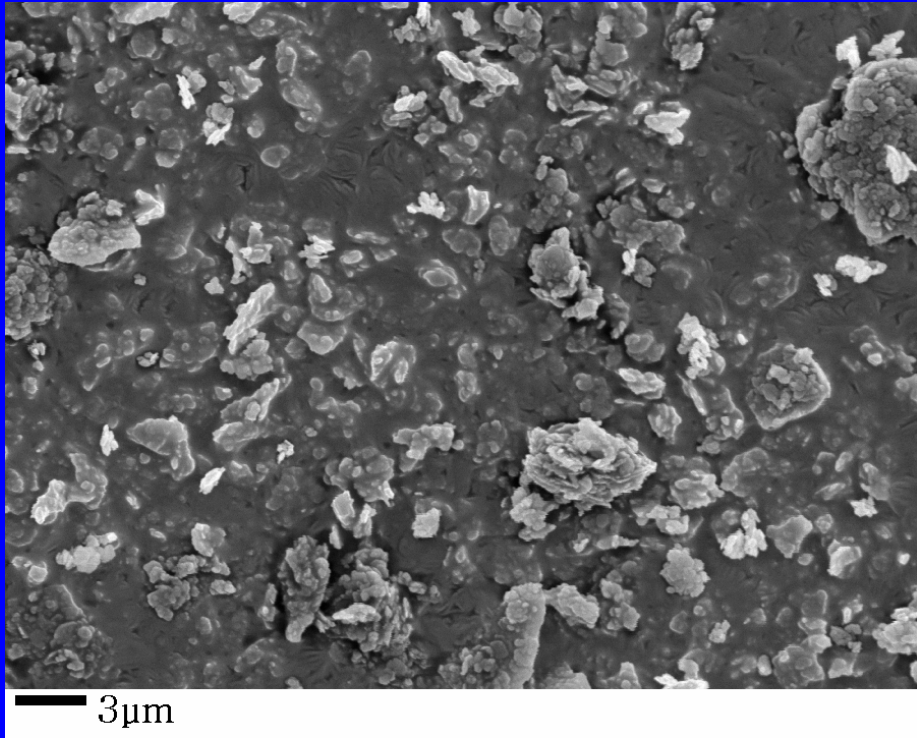
Wet Slurry Method for starch coating: Starch-clay Composite with Fatty Acid



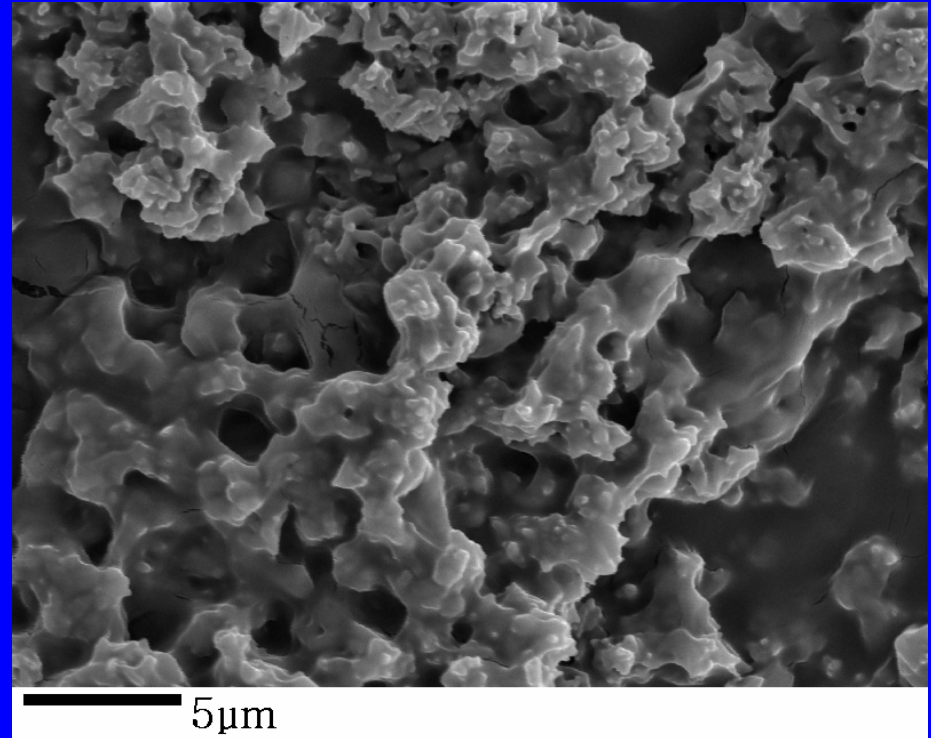
Unmodified corn starch and palmitic acid (or stearic acid sodium salt)

The mechanism of starch-filler composite is due to the formation of starch-fatty acid complex which is water insoluble at low pH

Morphology (SEM) and solubility



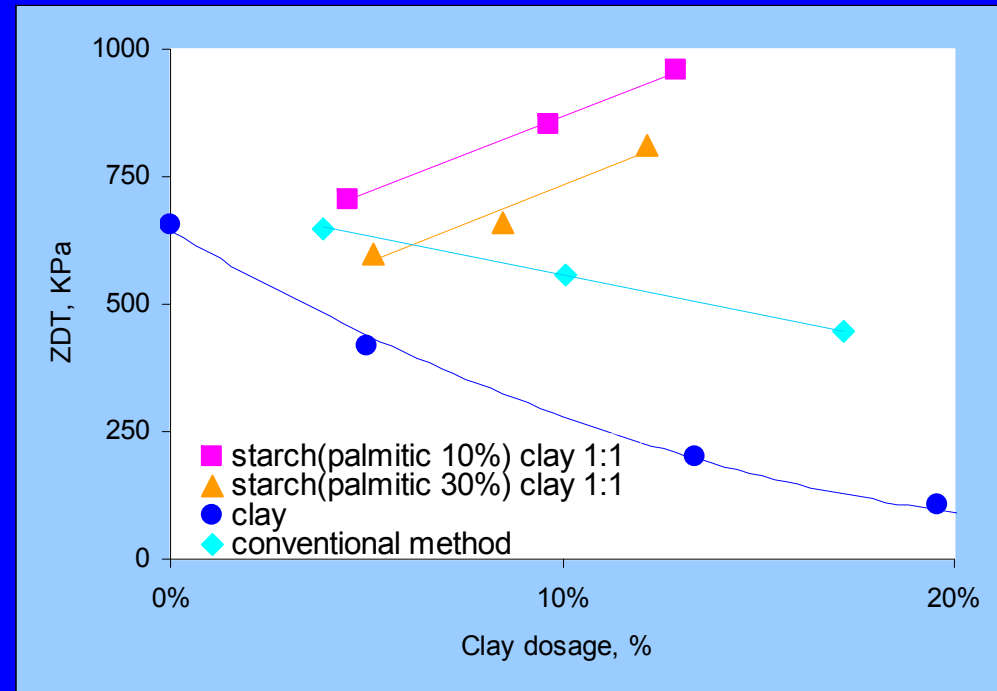
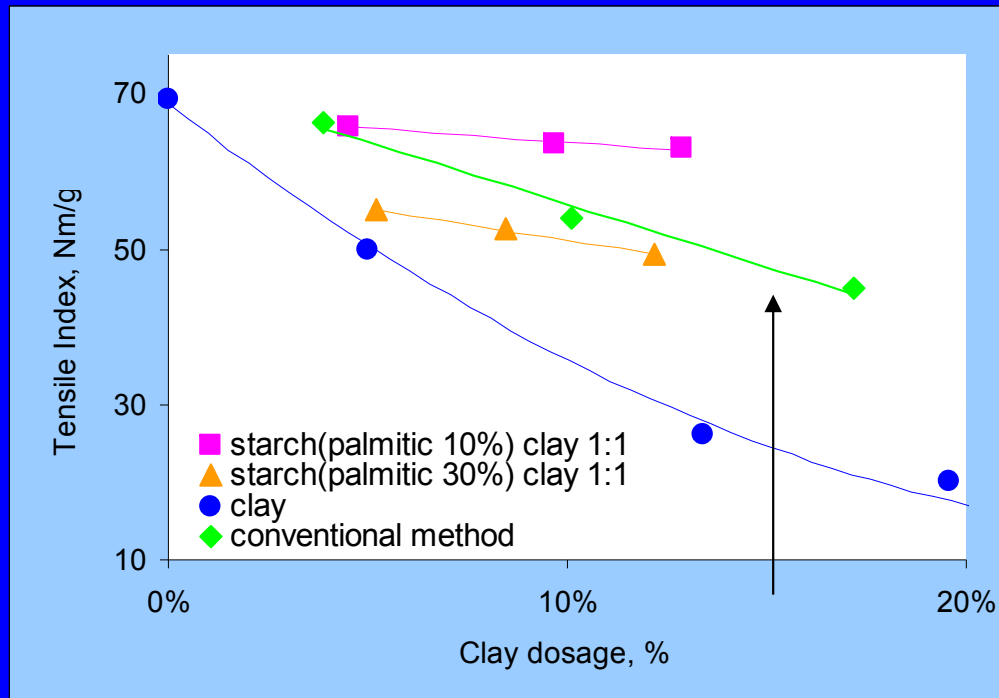
Clay



Clay-starch composite

Copy Paper

Physical properties

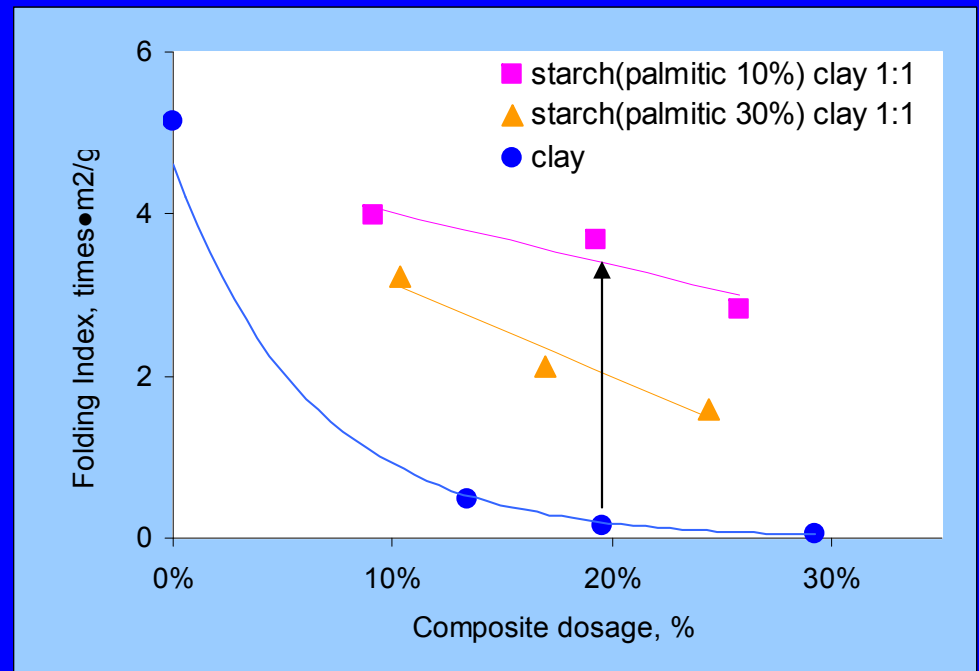
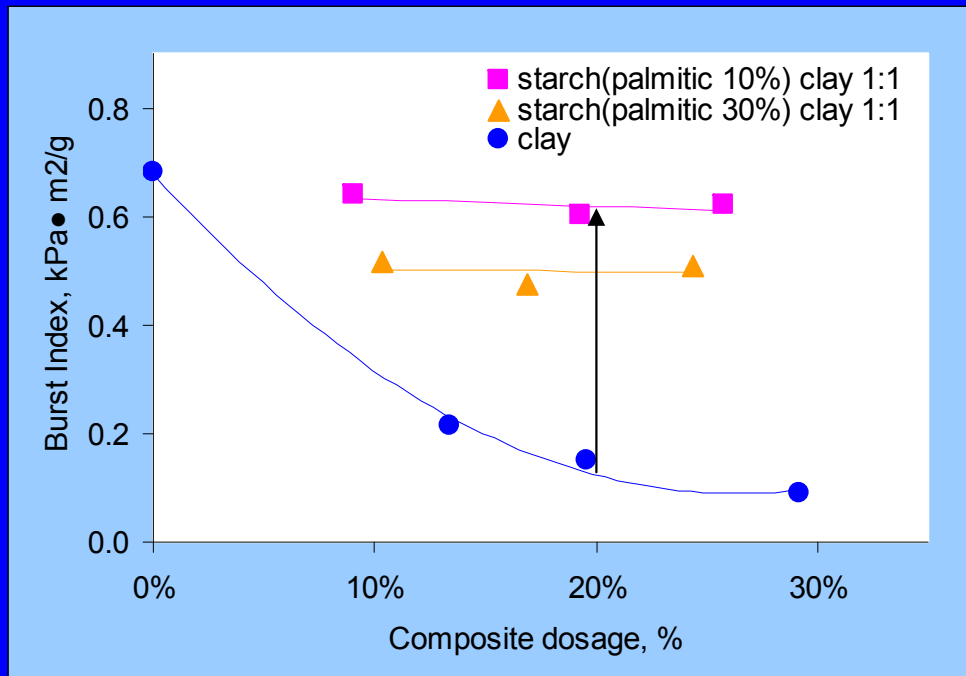


~120% increase comparing to clay-fiber only

~ 60% increase comparing to cationic starch (conventional method) method

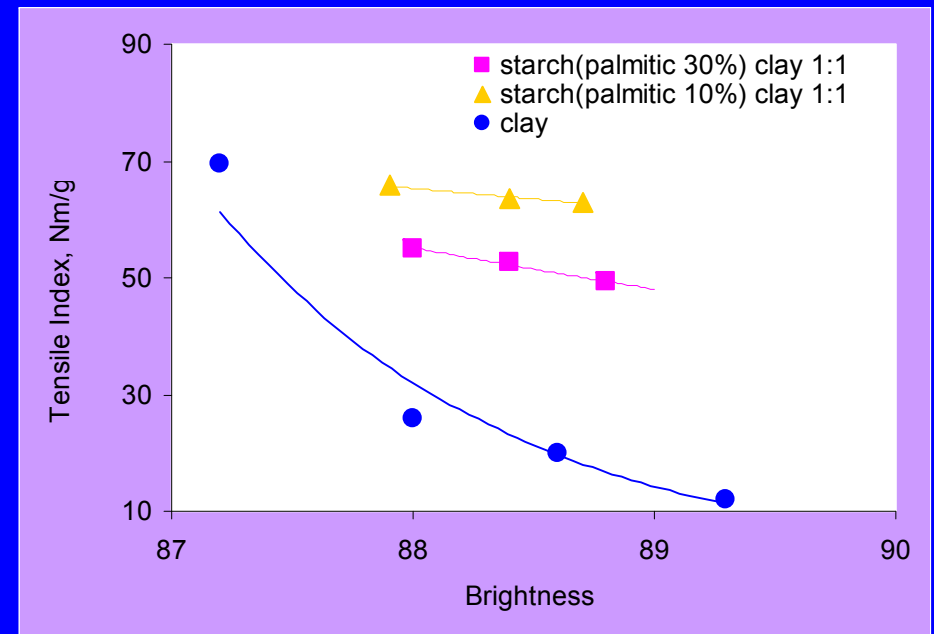
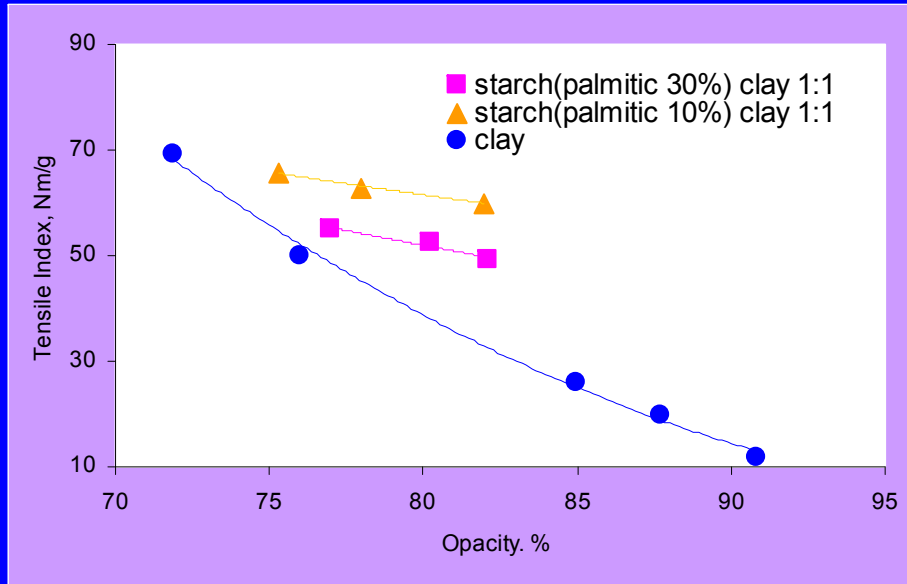
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Physical properties (cont.)



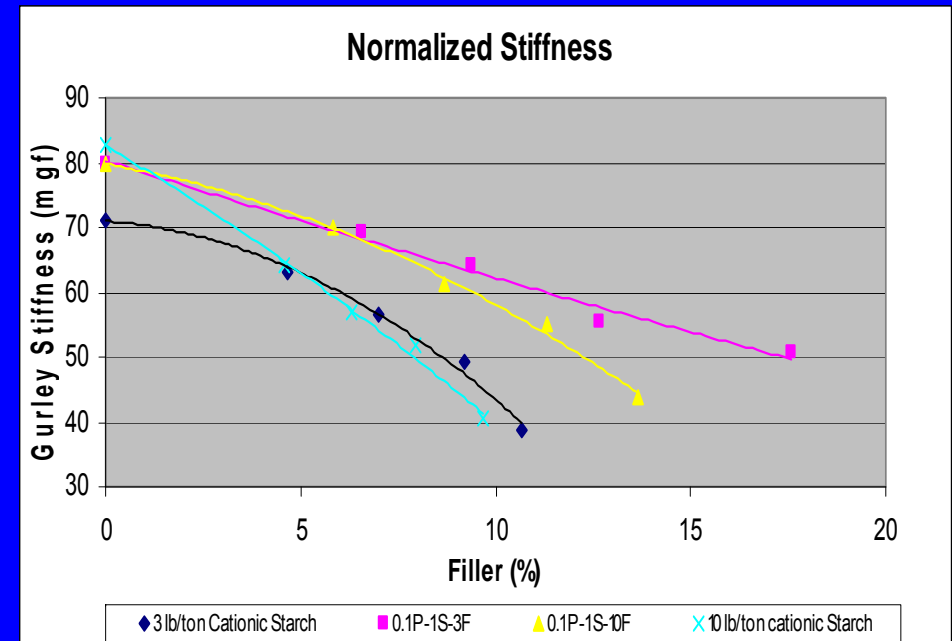
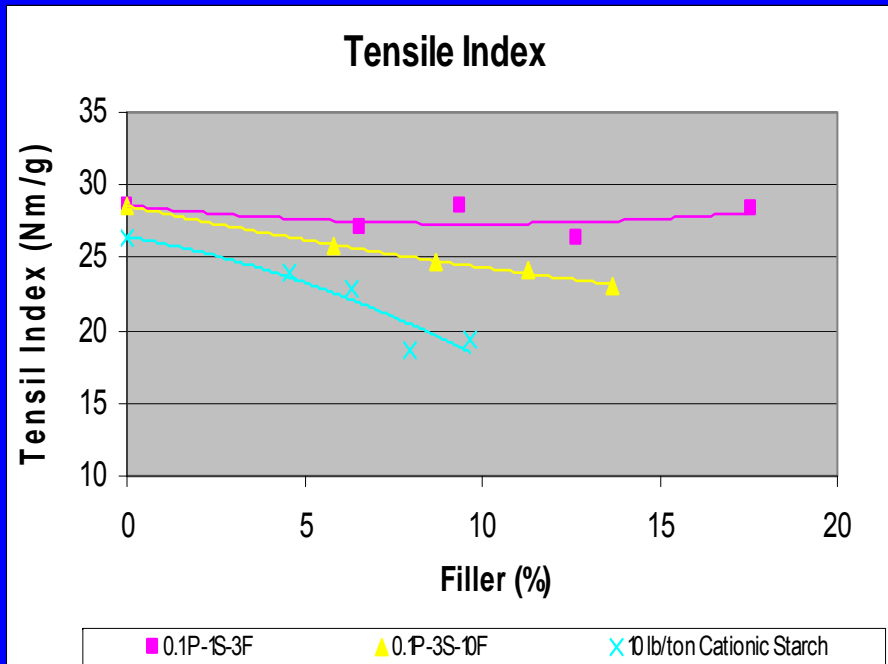
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Optical properties



Newsprint (wet method):

Effects of Different Starch Addition Methods on Physical Properties



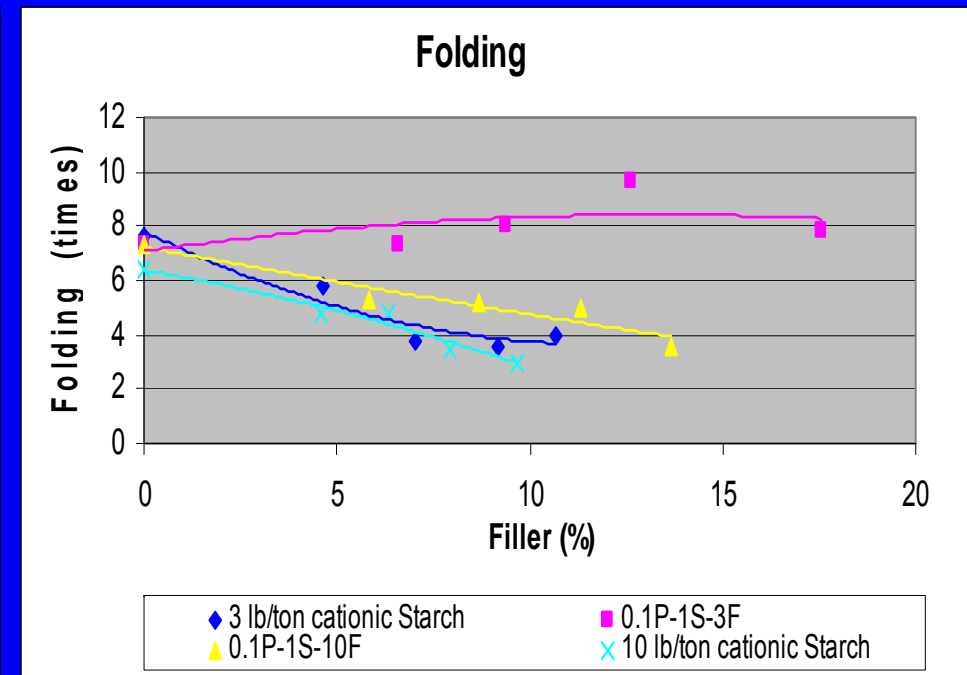
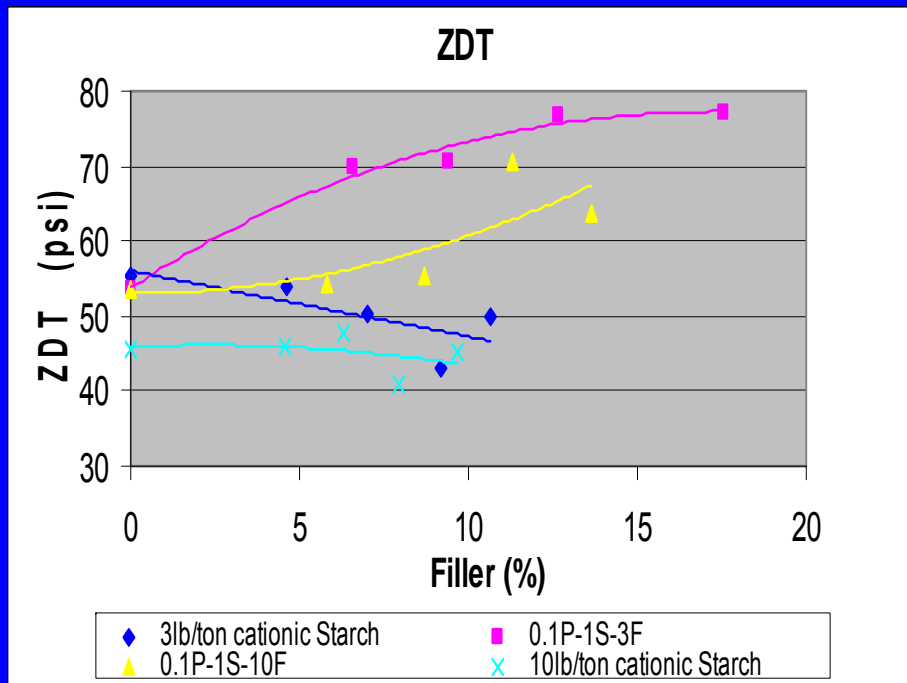
0.1P-1S-3F donates:

0.05 part of palmitic acid,
1 part of starch
3 parts of filler

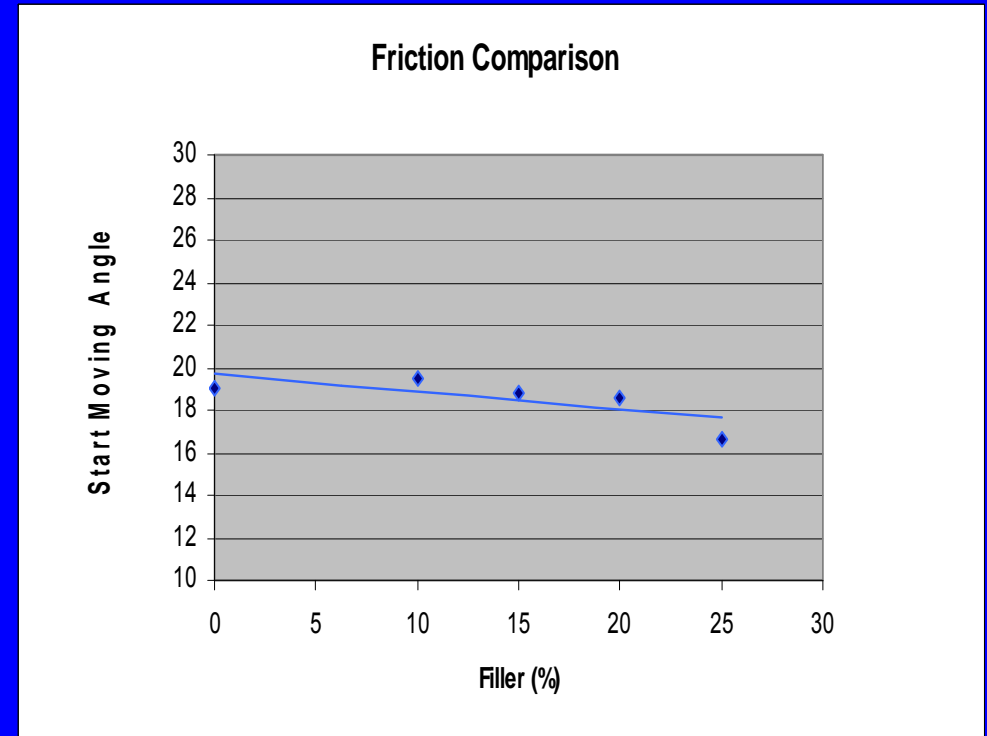
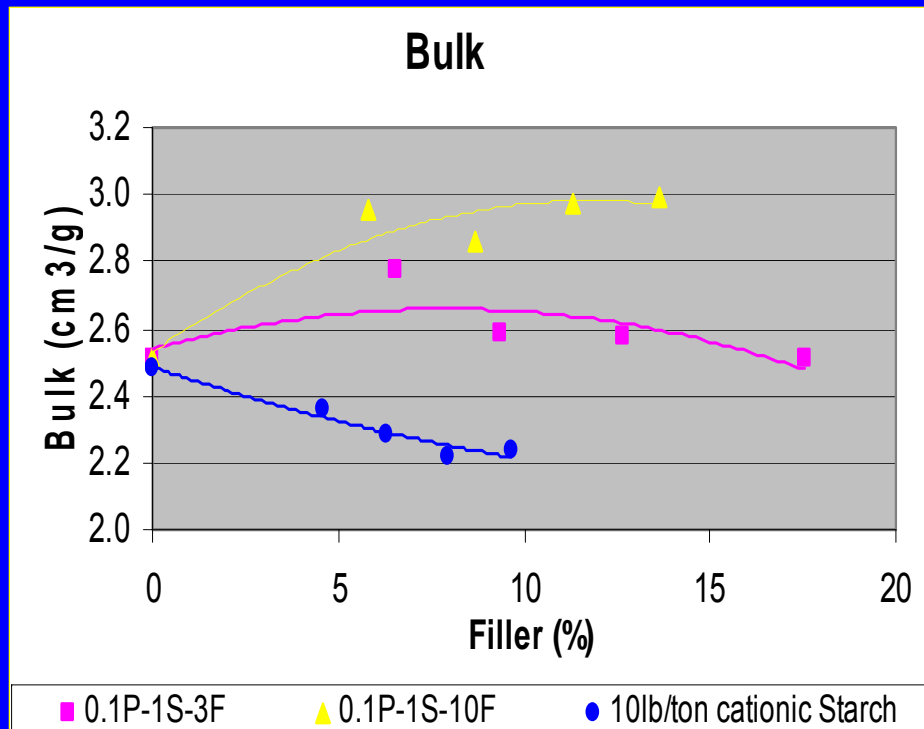
0.1P-1S-3F donates:

0.1 part of palmitic acid,
1 parts of starch
3 parts of filler

Effects of Different Starch Addition Methods on Physical Properties



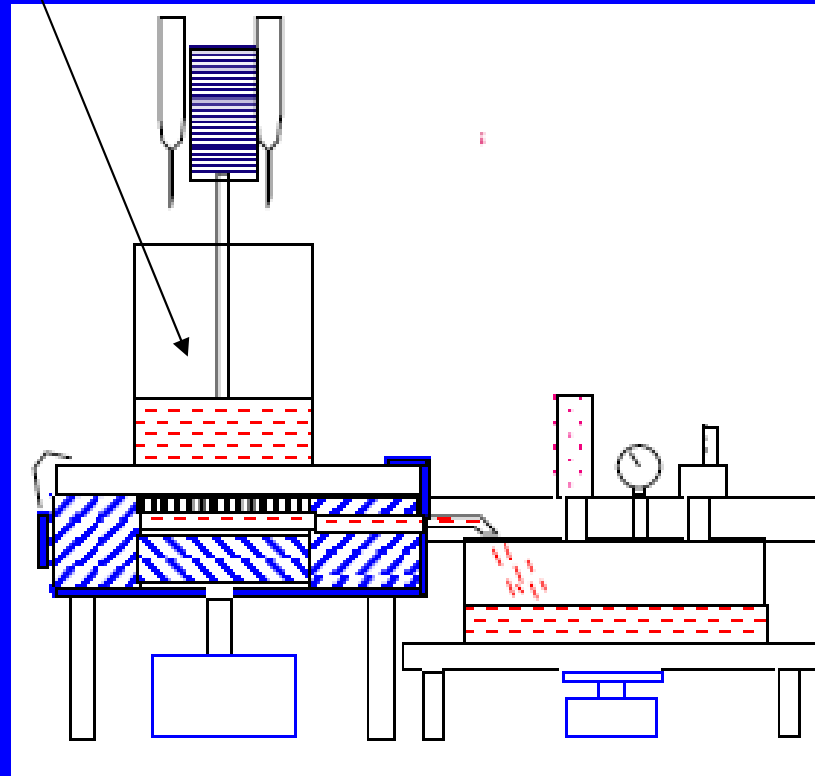
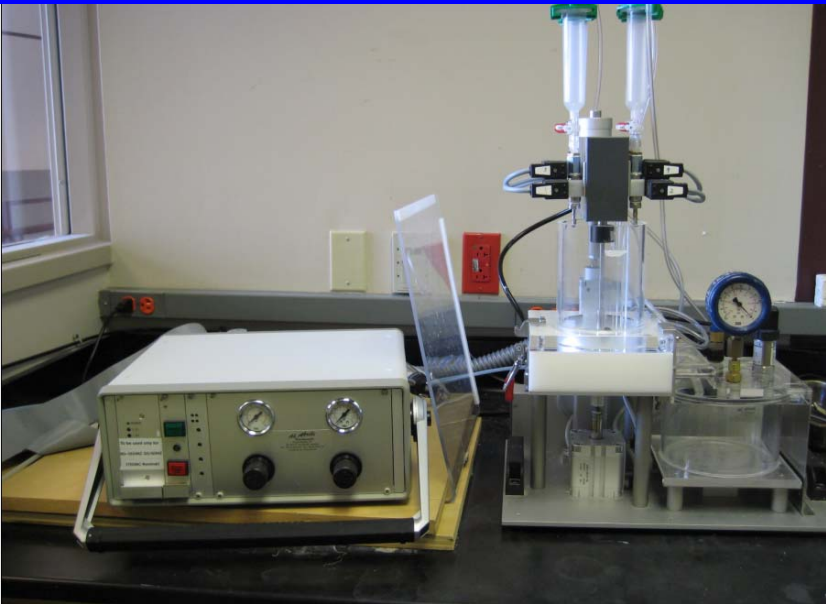
Effects of the Fatty Acid on Physical Properties



Energy Saving

DDA drainage unit

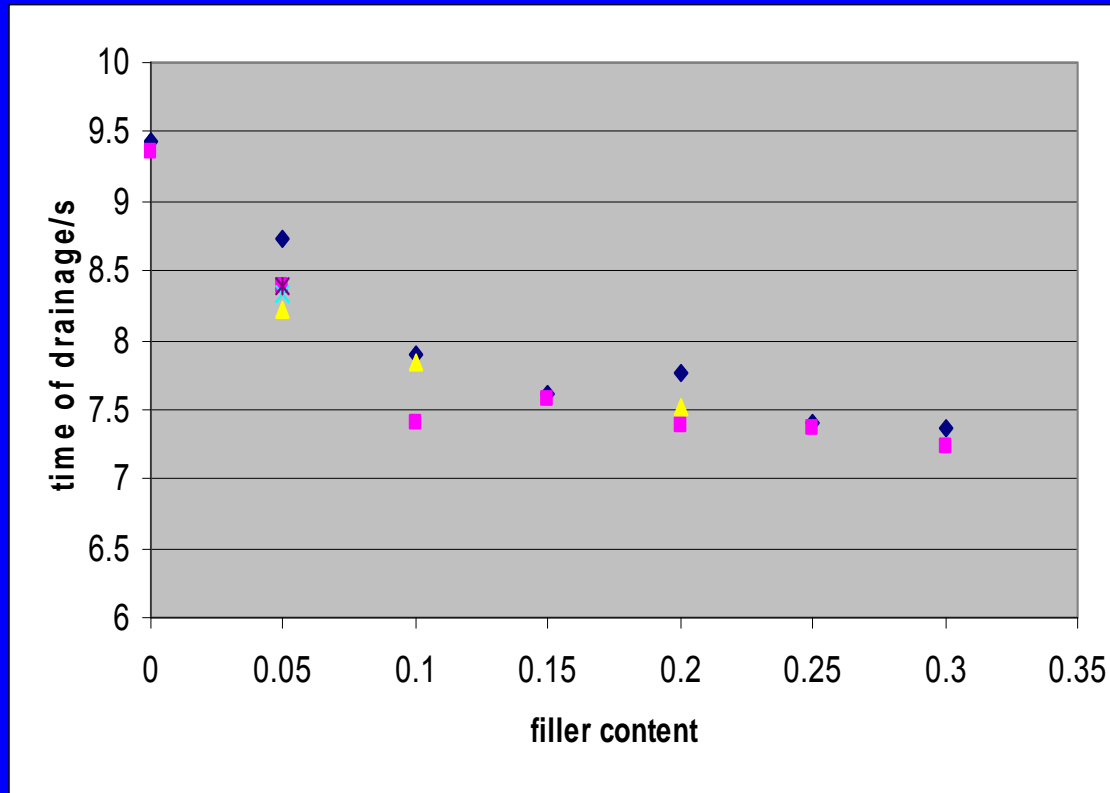
Stirrer (800rpm)



Vacuum vessel
(0.2 bar)

Drainage is measured as the time from the start of run until air start being sucked through the sheet.

Effect of filler content on the drainage rate

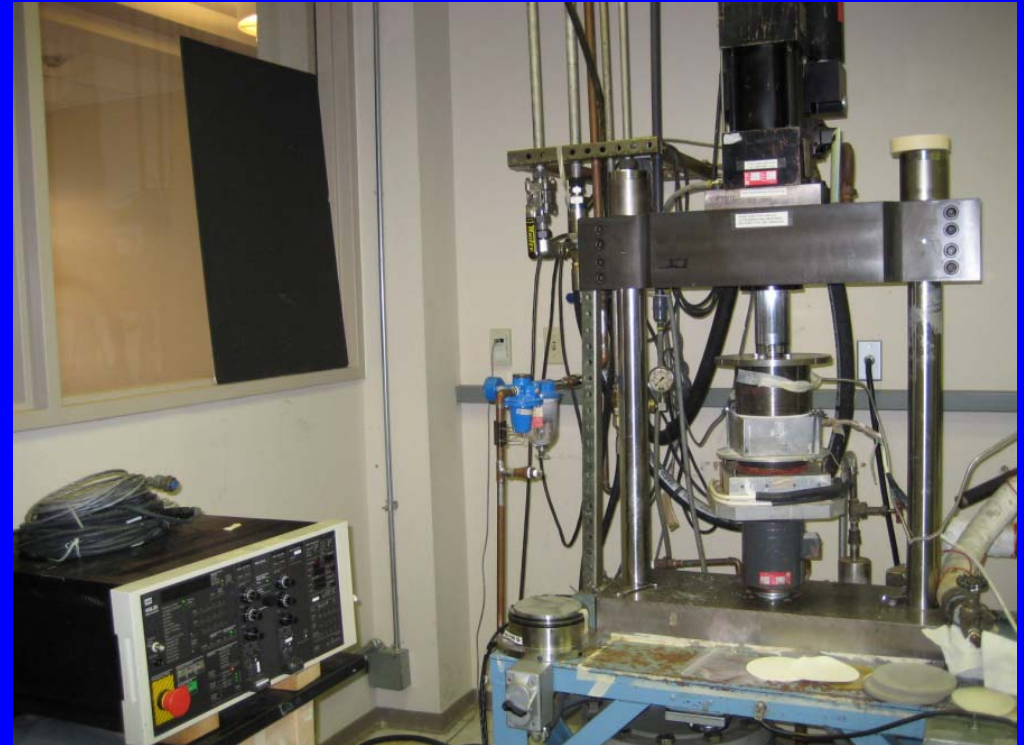


Clay filler; C-PAM retention aid at 2lb/ton; linerboard

Drainage rate was increased (or drainage time decreased) >20% by adding 20% fillers

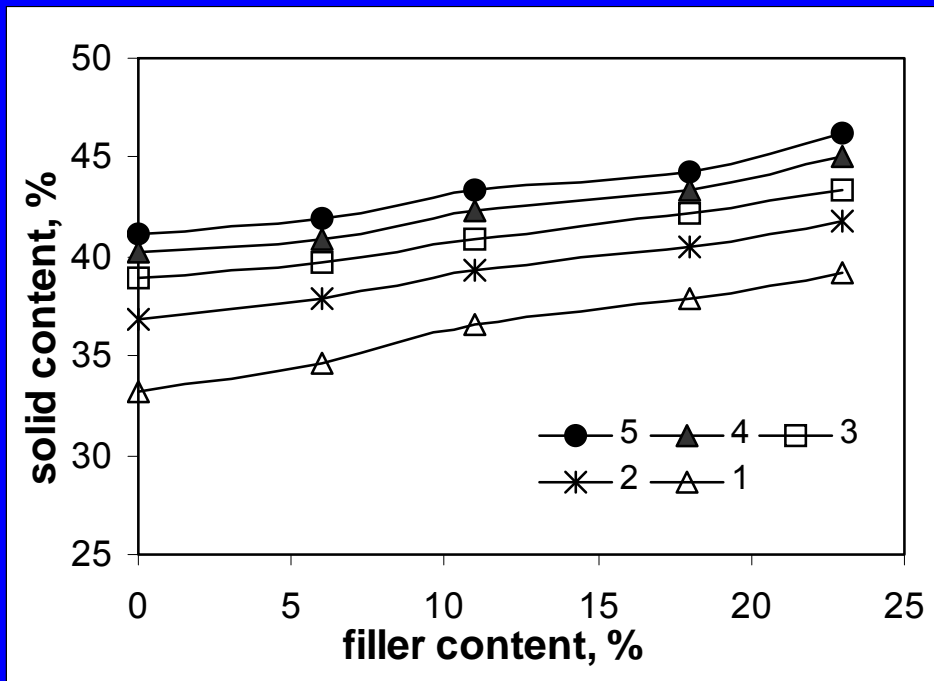
Wet pressing test

- The testing system used was the MTS Testing Machine controlled by a MTS 458.20 Micro Console.
- Handsheets were cut to a suitable size for the MTS press. The weights of the samples before and after press (600psi) were both measured immediately.



•MTS 458.20 Micro Console.

Web solid content as a function of press cycles at 600psi



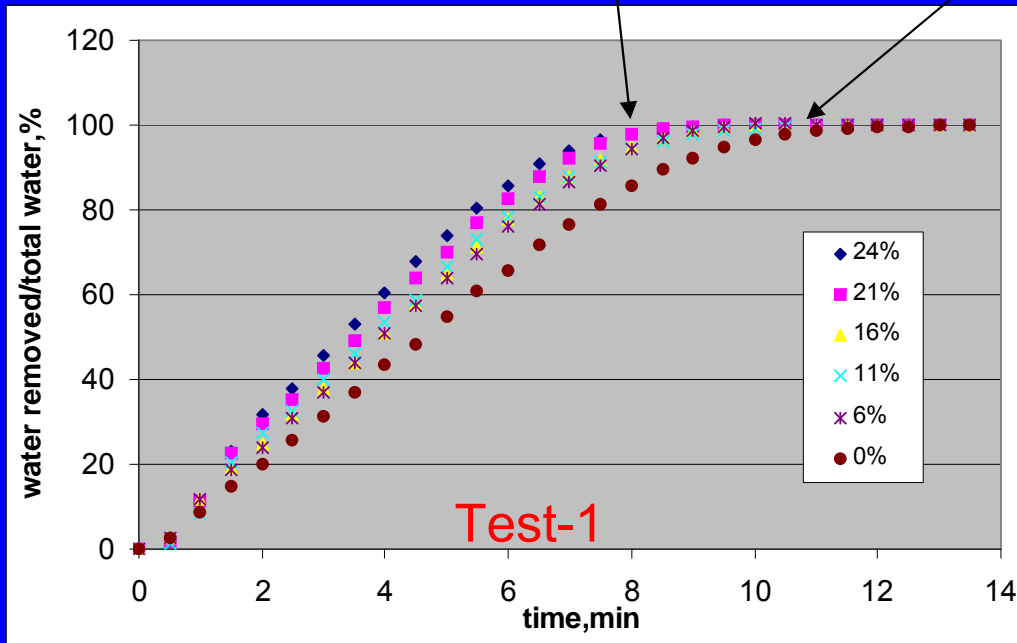
Solid content increased by 5 weight percents by adding 23% filler.

For every 1% increase in exiting press solids, an approximate 4% increase in machine speed can be projected on a dryer-limited machine. 5% increase in solid content will result in 20% improvement in the machine speed.

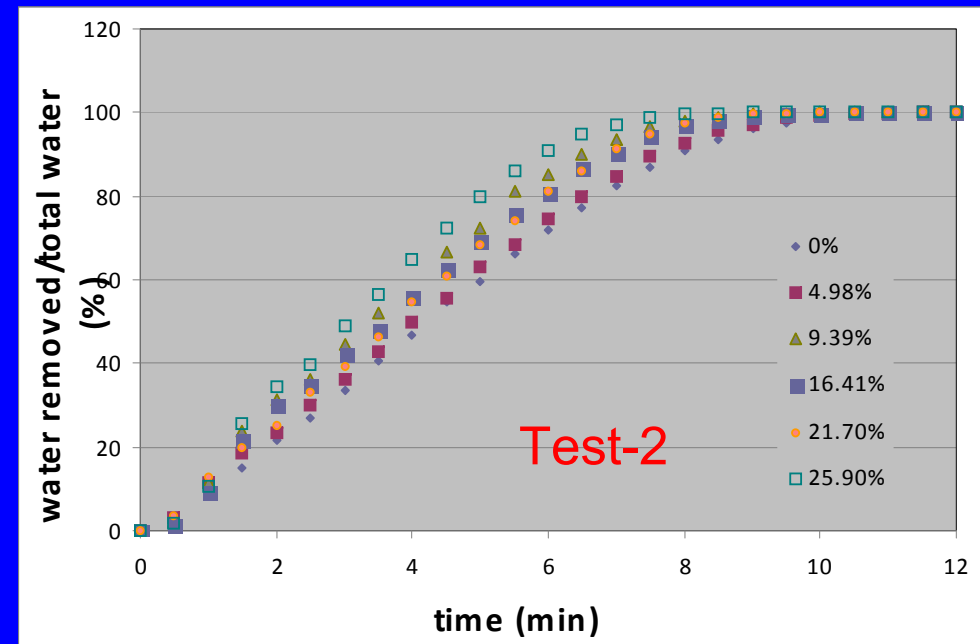
Different cycles at 600 psi

Effect of filler addition on the drying rate

Drying time (8min) with 24% filler



Drying time (10min) with 0% filler



Two figures were generated from two independent tests

The water drying time decreased from 10 minutes to 8 minutes, which saving drying energy by 20%.

Future Works

- Extend the work to multiple paper grades
 - Wet slurry method for linerboard application (Previous work using starch-clay composite, the future work will test CMC-clay composite)
 - Incorporate 5-10 % modified filler into newsprint and 10-20% modified filler for bleached board. Quantify laboratory dewatering, pressing and drying for sheets having high modified filler content
- Develop a wet starch-precipitation method for onsite PCC filler modification at paper mills (previous work was focused clay only)
- Techno-energy-economic evaluation of starch coated PCC, sheet and drying properties
- Carbon Footprint Reduction by Filler Additions
 - Data collection
 - Modeling development

Thank You for your
Attention!