The Influence of Filler Content and Process Additives on Wet Web Strength and Runnability

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Introduction

- Paper machine runnability is negatively impacted when filler content increases
- Point of greatest concern on most machines is the draw between the press and dryer sections
- Generally accepted that wet web strength decreases with increasing filler content due to breaks but difficult to directly observe
- Some evidence from literature that specific wet end additives can increase wet web tensile
  - Chitosan
  - Enzymes (can help or hurt)

Factors Affecting Wet Web Strength

- Paper machine runnability between the press and dryer sections is influenced by three factors that combine to influence the draw or speed differential requirement
- Web cohesion or wet strength
  - Documented influence of solids content, pulp characteristics, temperature, some wet end chemistry
  - Effect of increased filler generally accepted but no data on magnitude
  - This is “never-dried wet strength”, not re-wet
- Web adhesion to the press center roll
  - Capillary forces, surface energy, surface cleanliness
  - Very important but not considered in this study
- Paper machine speed

Objectives

- Develop a laboratory test to measure never-dried wet web strength using standard equipment
- Determine the magnitude of wet web strength loss with an increase in filler content
- Determine whether polymeric wet end additives can mitigate the expected loss in wet web strength

Experimental Approach

- Uncoated freesheet – copy paper model
- Noble and Wood handsheets – non-directional
- Increased basis weight required ~145 gsm
  - Eases handling of wet webs
  - Produces wet tensile strength results in measurable range
- Produce PCC-containing laboratory furnish at varying filler content
- Apply wet end additives to furnish ~ 1% consistency under high shear (Britt Jar mixer)
  - Perform ® SP retention system
  - Polymeric dry strength additives
- Dilute stock in sheet mold and form sheet

Experimental Approach

- Press sheet under controlled conditions using roll press with saturated felt
  - Pressure/solids control is critical
- Peel and encase wet pressed sheet in rigid low caliper plastic
- Cut 1-inch (2.5-cm) strips encased in the plastic using paper cutter for tensile testing – trim and discard rough edges
- Perform tensile testing immediately using standard Instron (or equivalent) and low capacity load cell
  - Run at least five replicates per condition
  - Collect tensile strength, stretch, TEA data
- Form and press second sheet under identical conditions
  - Collect press solids, basis weight, and ash content data from this sheet using standard methods

Results

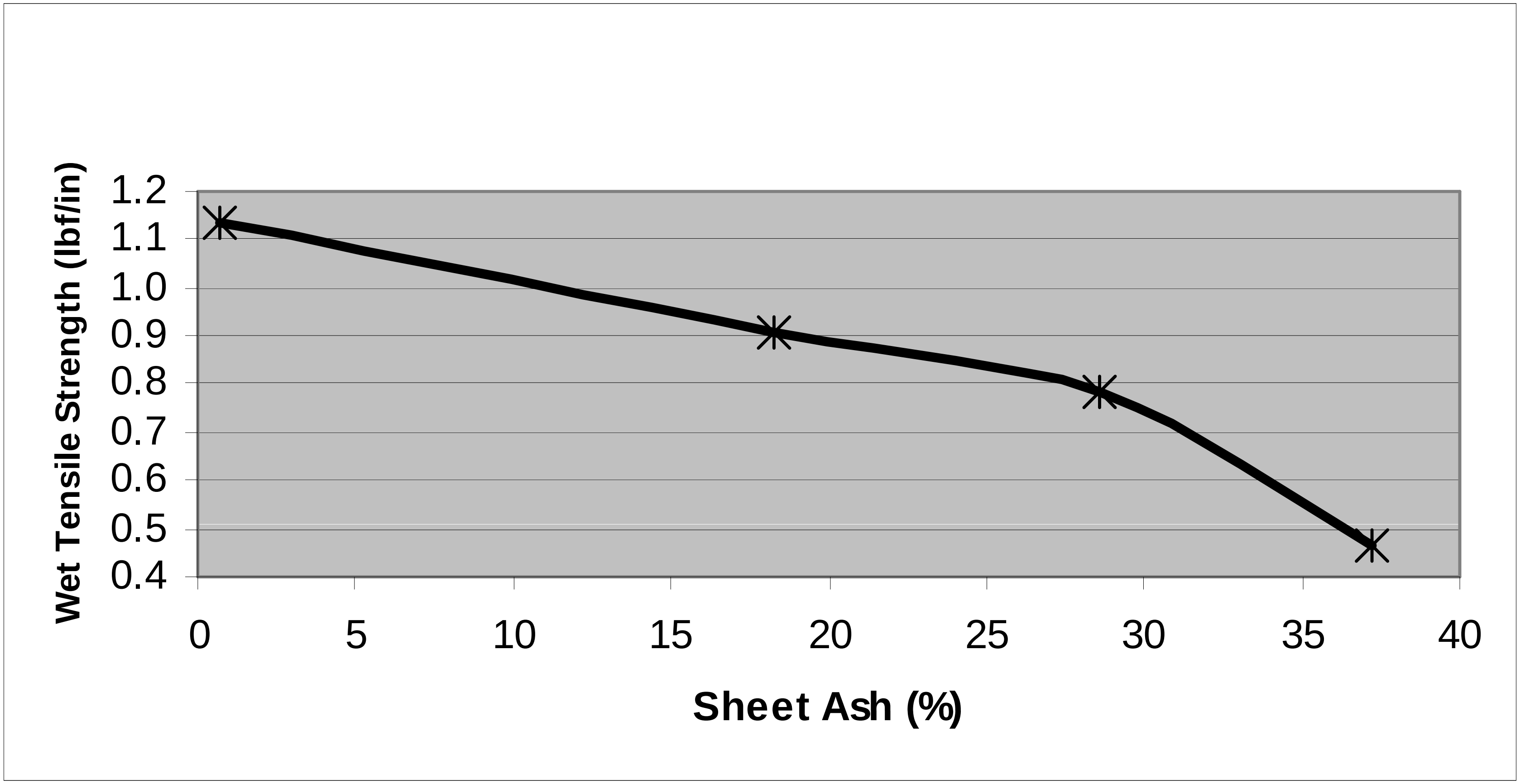
Test Precision

- With five replicates per condition, test repeatability

Test	Relative Precision	Absolute Precision
Tensile strength	~10% of mean	~0.08 lbf/in
Stretch	~14% of mean	~0.45%
TEA	~24% of mean	~0.56 in-lbf/ft2

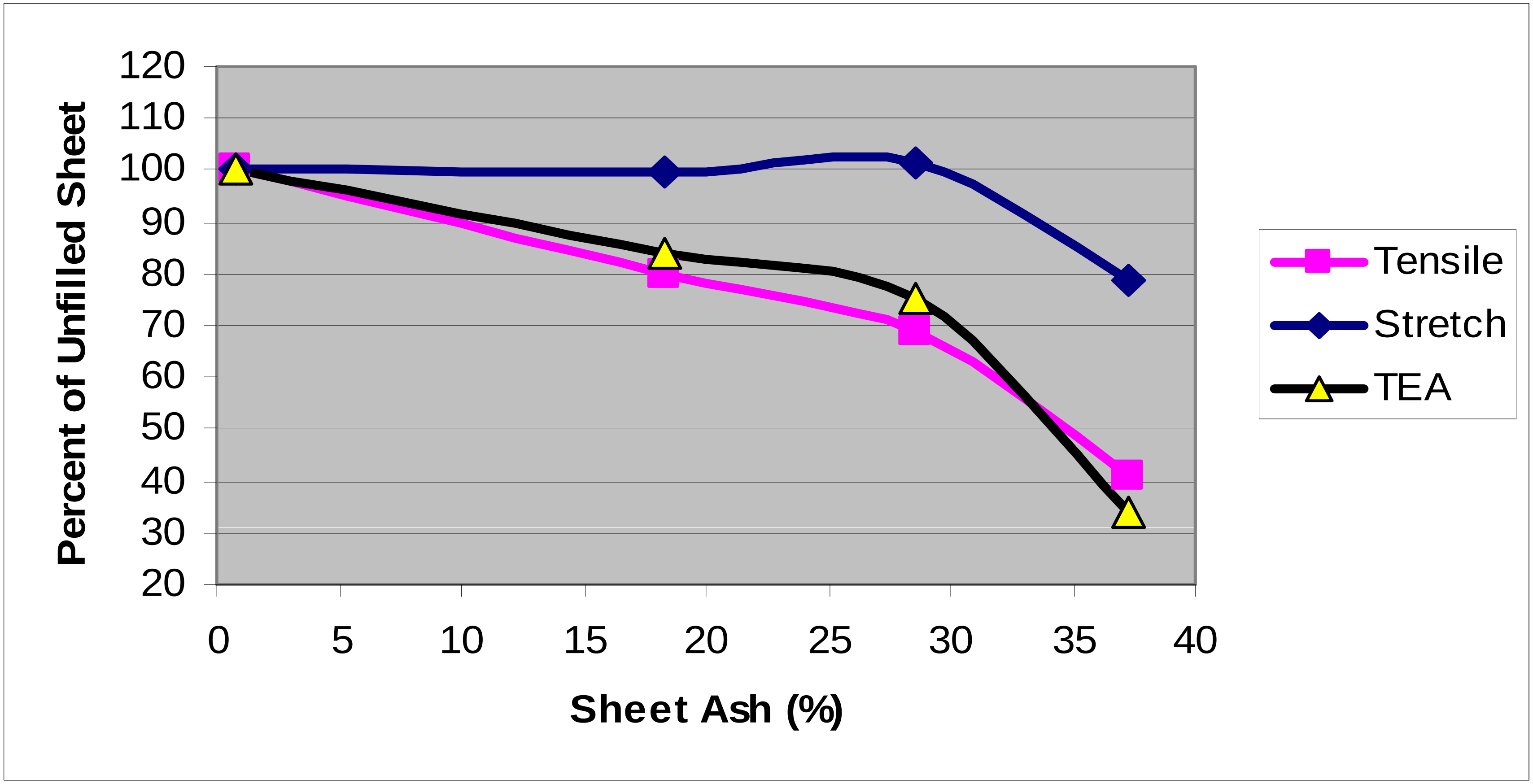
Tensile strength data will be the easiest to interpret

Effect Of Filler Content On Wet Web Strength



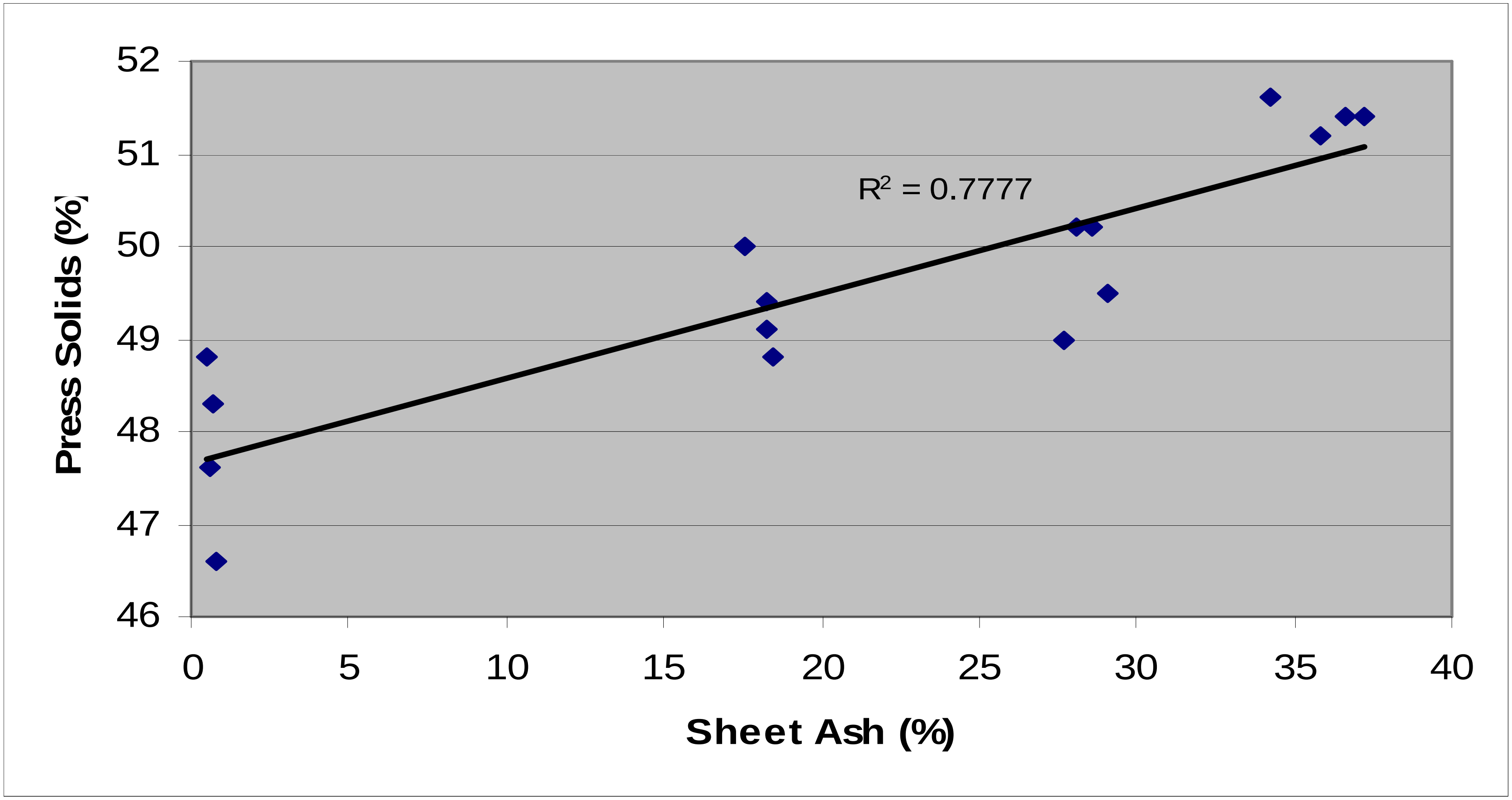
Surprisingly modest drop of about 30% between 0 and 28% sheet ash. Steeper decline thereafter. Limitation: These are non-directional handsheets.   Absolute MD strength on a paper machine would be higher at this basis weight.

Effect Of Filler Content On Wet Web Strength



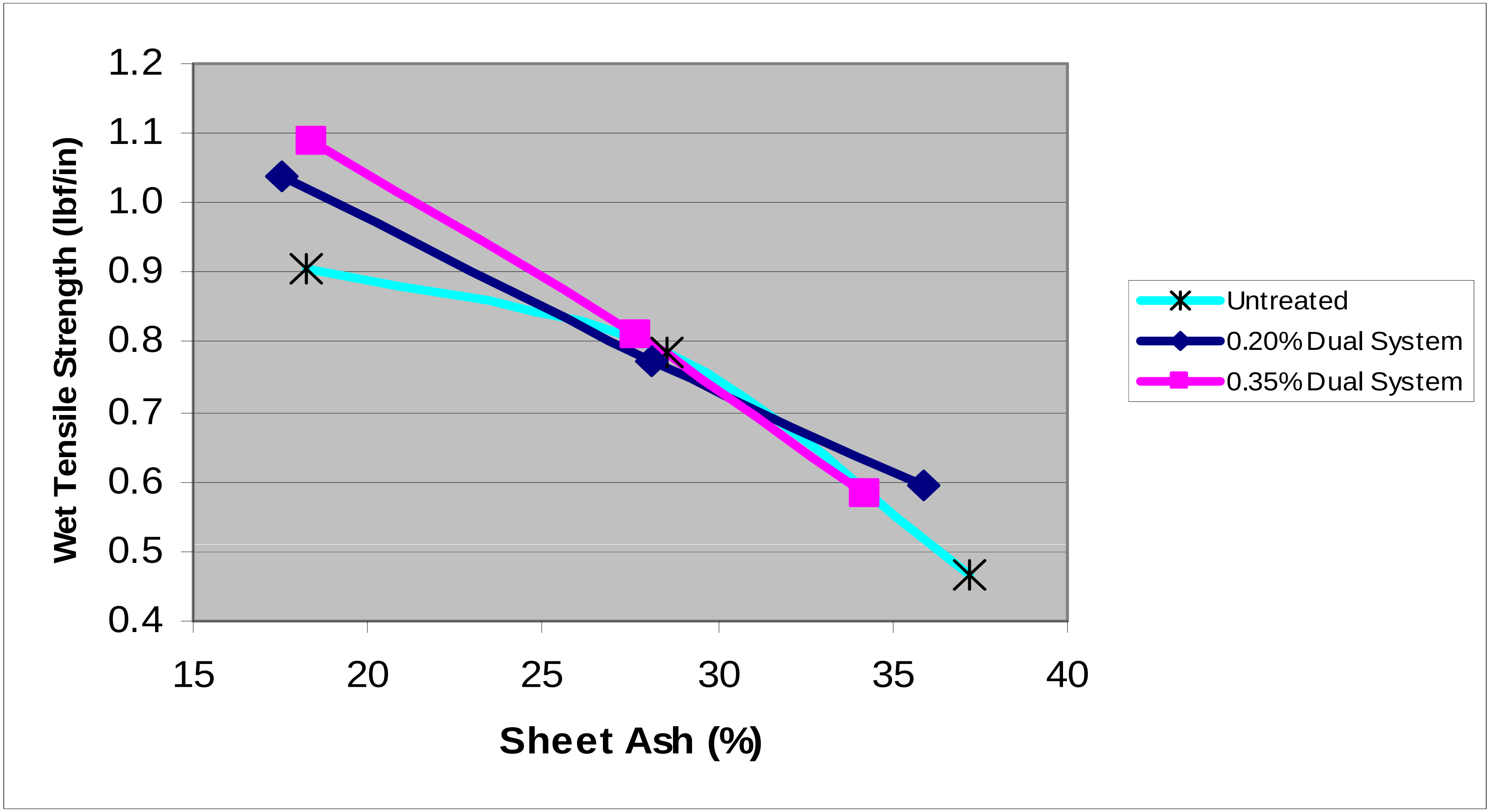
Tensile and TEA show the same trend. Stretch was surprisingly unaffected by sheet ash up to almost 30% filler content. Stretch-to-rupture at press consistency was ~2x that of dry paper.

Effect Of Filler Content On Press Solids



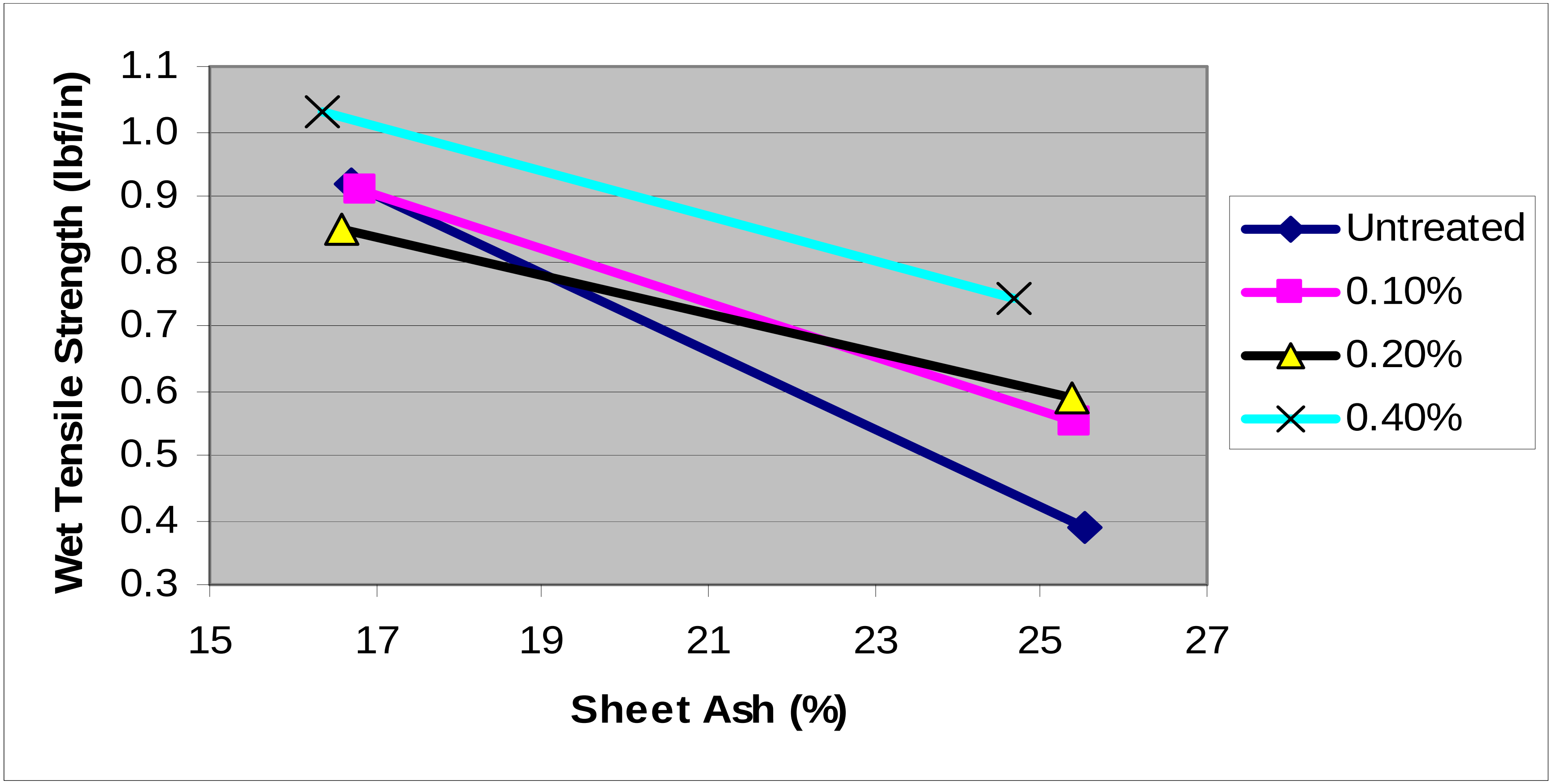
How well were press solids controlled in the previous experiment? Press solids increase with higher sheet ash, and scatter decreases. Increased solids could be partially responsible for lower magnitude impact than expected.

Effect Of Dual Polymeric System On Wet Web Strength



Application of a dual cationic / anionic polyacrylamide strength resin system appeared to have some positive effect upon tensile strength at lower filler content. There was no effect at 28-35% sheet ash.

Effect Of Novel Polymeric System On Wet Web Strength



Application of novel amphoteric polymer Hercobond ® HA5305 mitigated two-thirds of the tensile loss due to increasing filler content at the highest dosage. The untreated tensile loss was greater than observed in previous experiments.

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Discussion – Potential Mechanisms

- Micro-level
  - Improve filler distribution in web
    - Coarse fibers, fine filler particles
    - More uniform and smaller pore distribution increases capillary pressure
    - Related to filler distribution in sheet (homo- vs. hetero-flocculation)
  - Increase frictional forces
    - Increase inter-particle attraction due to entanglement
- Macro-level
  - Improve sheet formation
    - Fewer light spots in sheet prone to breakage
    - Some evidence from formation data (lab and commercial trials)

Commercial Application

- Three component approach
  - Retention system
  - Filler particle modification
  - Novel polymeric strength additive
- Numerous commercial trials run on world class fine paper machines
- Commercial application dosage 0.5 – 1.5 kg/tonne
- Maintained paper machine runnability and finished sheet properties with increases in filler content from 5-8%
- Some indication that the novel dry strength additive is maintaining runnability by improving sheet formation
- Retention system helps both with formation and filler particle distribution in the web

Conclusions

- Simple laboratory method developed to quantify never-dried wet tensile effects of increased filler content and wet end additives
- Wet tensile strength was the best response variable to demonstrate these effects
- Between 2-6% of wet tensile strength was lost with each 1% increase in sheet filler content
- Conventional anionic/cationic polyacrylamide dry strength resins had a minor positive effect increasing wet tensile strength at lower ash content but the effects disappeared under high ash conditions
- A novel amphoteric dry strength resin mitigated up to 70% of the wet tensile strength loss due to increasing sheet ash from 17 to 26%.

Acknowledgements

- Tom Parmenter – laboratory evaluations
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Questions?