Serendipity

- As a young college graduate, I had no idea that I would spend much of my career toward making textiles more “sustainable”
- Call it serendipity, fortune, Lady Luck, or whatever… as I stumbled along, it always came back the same things:
  - Developing low wet pick-up technologies (especially foam!) for reducing water and energy consumption
  - Reducing and eliminating hazardous chemicals, especially formaldehyde
- At first, it seemed that I was forced to do these things
  - And then, I found out I really enjoyed them!
Ken Greeson

Fresh Out of College!

Foam Technology – Early Years

• 1981: My journey in the textile industry begins with research into low wet pick-up technologies
• First lab experiences with foam dyeing and foam finishing:
  • Foam dyeing acid dyes onto nylon carpet
  • Foam finishing
    • Wet-on-wet foam application of napping aid/softener to warp knits for bathrobes
    • Foam application of fluorocarbons to upholstery fabrics
My First Foam Applicator (circa 1981)

- First attempt was a home-built foam applicator with neoprene flaps at the entry and exit.
- Things DID NOT go as anticipated! (i.e., Disaster!)

Early Foam Production Trials

- Scale-up of wet-on-wet application of napping aid/softener to warp knitted fabric
- Round 1
  - First attempt was a home-built foam applicator with neoprene flaps at the entry and exit.
  - Things DID NOT go as anticipated! (i.e., Disaster!)
- Round 2
  - Second attempt was thought out better.
  - The foam applicator was Gaston County’s FFT system.
  - Initially, trials went well but foaming was inconsistent during longer production runs.
Foam Technology: Moving Forward to 2002

• Upon my arrival at Cotton Incorporated in 2002, a brand-new Gaston Systems CFS® application system had just been installed on the pilot tenter frame
  • The Gaston CFS has an improved applicator design as compared to the older FFT technology
• A smaller Gaston CFS lab unit was added later with multiple foam heads
• Several successful trials have been conducted on the lab and pilot units at Cotton Incorporated

CFS® System from Gaston Systems: Lab Unit
Interlude: TOUGH COTTON™ technology for Abrasion Resistance

• Originally developed by Dr. John Turner at Cotton Incorporated
• Optimized application of polyethylene emulsion with selected cross-linking agent to provide durable abrasion resistance to cotton fabrics
• See “Improving the Performance of Non-Durable Press Cotton Garments”, AATCC Review, September 2003, p. 47

Foam Trials:
TOUGH COTTON™ for Abrasion Resistance

• Trial A: Foam application of TOUGH COTTON™ to cotton denim fabrics
  • Allowed for simultaneous drying and curing on heavy-weight fabrics
  • Highly improved abrasion resistance, even at 50 laundering cycles
• Trial B: Dual-side foam application on cotton twill fabrics
  • TOUGH COTTON™ finish on the face to reduce abrasion
  • Post-cure resin finish on the back to provide durable crease
  • Much less crease edge abrasion than normal post-cure finishes
Other Foam Trials at Cotton Incorporated

- Foam application of finishes to provide one-way moisture transport to cotton knits
- Foam application of moist cure finishes for durable press performance to cotton shirting fabrics
- Foam application of various flame-retardant finishes to cotton fabrics
- Foam dyeing trials (assisting Len Farias)

Durable Press Finishing: My Early Years

1982: Another journey begins – this time into the world of durable press finishes and formaldehyde

- It started in a small piece dyeing plant on 65/35 polyester/rayon uniform fabrics
- Large quantities of DMDHEU resin were applied to the fabrics for acceptable DP ratings
- Old, uncapped (non-etherified) DMDHEU resins were used
  - Formaldehyde release was high, to say the least!
- Trials were successfully conducted with a methylated DMDHEU resin
  - Formaldehyde release was cut in half
- At the same time, we installed a new vacuum finishing system that saved about 35% in chemical costs!
Durable Press Finishing: 1985-2002

• My first experiences began with non-formaldehyde systems
  • Plant trials with BTCA were successfully conducted in 1989 on a variety of woven cotton fabrics at a large continuous dyeing and finishing plant
  • However, finish cost and potential for negative impact on certain dyes was a big concern
  • Early trials with DMUG were conducted; at that time, odor and yellowing were issues

• DMDHEU optimization
  • At a large textile corporation, I screened many DMDHEU resins in a central testing program, thus learning a lot about the technology
  • I worked with with a team at a specialty chemical company that successfully developed high-performance low formaldehyde DMDHEU resins
    • Lower formaldehyde release
    • Non-methylated versions to decrease Hazardous Air Pollutants (HAP’s)

Durable Press Finishing at Cotton Incorporated

• After coming to Cotton Incorporated in 2002, I have been involved in many projects to improve durable press finishes for performance and formaldehyde reduction
  • Dr. John Turner worked with me as a consultant for several years

• Our team developed TOUGH COTTON™ technology for durable press applications to obtain improved strength and abrasion resistance of cotton fabrics and garments
  • “TOUGH COTTON Finish for Shirting”, AATCC Review, March 2009, p. 30

• Several practical methods were tested and developed for reducing formaldehyde of DMDHEU-containing durable press finishes to nondetectable levels
  • “Formaldehyde Reduction for Durable Press Cotton Fabrics”, AATCC Review, May 2012, p. 36
Foam Trial: TOUGH COTTON™ for Durable Press Performance

- Foam application of TOUGH COTTON™ durable press finish in conjunction with dual action (repellent/release) finishes on cotton twill fabrics
  - TOUGH COTTON technology on the back for improved strength and abrasion vs. typical DP resin finishes
  - Dual action stain repellent/soil release on the face
- Sustainable for three reasons
  - Less energy for drying when using foam
  - Less chemical usage by concentrating TOUGH COTTON™ finish on the back of the fabric
  - Increased wear life meant less frequent disposal to the landfill

Foam Eco-Care

- Foam application of “Premium LT Cure” non-iron finish from Clariant (now Archroma) to cotton fabrics using CFS technology from Gaston Systems
  - This was a true team effort!
- Capable of providing moist cure performance with foam-dry-cure application
  - Low temperature curing (at 130°C)
  - Ultralow formaldehyde release (<75 ppm by ISO 14184-1)
  - No need for afterwashing
  - Safer than moist curing for mill personnel and equipment (no strong acids needed)
Foam Eco-Care: Application Procedures

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Pad Application (Control)</th>
<th>Foam Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>705 g</td>
<td>384 g</td>
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<tr>
<td>Ultra-low Formaldehyde DMDHEU</td>
<td>200 g</td>
<td>400 g</td>
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<tr>
<td>Catalyst for DMDHEU</td>
<td>50 g</td>
<td>100 g</td>
</tr>
<tr>
<td>Polyethylene softener</td>
<td>40 g</td>
<td>80 g</td>
</tr>
<tr>
<td>Aminofunctional silicone softener</td>
<td>20 g</td>
<td>40 g</td>
</tr>
<tr>
<td>Nonionic wetting agent</td>
<td>2 g</td>
<td>40 g</td>
</tr>
</tbody>
</table>

- Wet pick-up, %: 60, 30
- Drying time (110°C), seconds: 80, 60
- Cure at 130°C, 3 minutes

Foam Eco-Care: Results on Cotton Poplin

- Smoothness rating
- Tear strength
- Flex abrasion
- Formaldehyde (ISO 18484-1)
Foam Eco-Care: Martindale Abrasion Results on Cotton Poplin

Benefits of Foam Eco Care Finishing versus Traditional Easy Care Finish

• Energy and water savings
  • Less energy consumption because of lower curing temperatures:
    • Traditional Easy Care: Cure at 170°C
    • Foam Eco Care: Cure at 130°C
  • Lower wet pickup of foam application compared to pad application
    (30% compared to 60%) allows for faster speed and reduced energy consumption in drying
  • Foam uses less water in the application

• Performance
  • Superior abrasion performance with foam as compared to pad application
  • More or less same smoothness ratings
  • Low formaldehyde (<75 ppm) even without afterwashing
Benefits of Foam Eco Care Finishing versus Traditional Non-iron Finish (Moist Cure)

• Energy and water savings
  • Far less complicated and far less energy consumption than moist crosslinking:
    • Moist cure: Pad/dry – batch – wash – dry – pad/dry
    • Foam Eco Care: Pad/dry - cure
  • Lower wet pickup of foam application compared to pad application (30% compared to 60%) allows for faster speed and reduced energy consumption in drying
  • Foam uses less water in the application

• Performance
  • More or less same smoothness ratings
  • Low formaldehyde (<75 ppm) even without afterwash
  • Due to low acidity less shade change

TOUGH COTTON™ Technology for Knits

• The original TOUGH COTTON™ finish for durable abrasion resistance was developed for woven cotton fabrics
• Our team at Cotton Incorporated began modification of the finish for knitted fabrics
  • The challenge was to develop a test method to measure the performance of the finish
  • Martindale abrasion with standard wool abrasive was not effective
  • Trizact™ abrasive from 3M™ was found to be effective on cotton knits for measuring abrasion resistance
• A sincere Thank You to Angela Massengill and Jimmy Rowe for introducing this methodology!
Martindale Abrasion with Trizact™ Abrasive

Martindale Abrasion with Trizact™ on Knits

<table>
<thead>
<tr>
<th>Control 0 HLTD</th>
<th>TOUGH COTTON 0 HLTD</th>
<th>Control 20 HLTD</th>
<th>TOUGH COTTON 20 HLTD</th>
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<td><img src="image2" alt="TOUGH COTTON 0 HLTD" /></td>
<td><img src="image3" alt="Control 20 HLTD" /></td>
<td><img src="image4" alt="TOUGH COTTON 20 HLTD" /></td>
</tr>
</tbody>
</table>
PUREPRESS™ Technology for Cotton Fabrics

• Developed by a team at Cotton Incorporated led by the author in 2018
• Patented technology for completely non-formaldehyde durable press finishing of cotton fabrics
• Uses practical, available chemicals and finishing techniques
• Does not have many of the drawbacks of other non-formaldehyde durable press concepts
  • Low yellowing/shade change
• Comparable durable press to DMDHEU resins with improved strength and abrasion resistance
What is PUREPRESS™ Technology?

- Patented by the author and a team at Cotton Incorporated for non-formaldehyde durable press finishing of cotton fabrics
- Provides wrinkle resistance to cotton fabrics that is comparable to typical resin finishes such as DMDHEU
- Based on commercially-available products with a long history of safe usage
- Unique because the finishing bath components and the curing conditions have all been carefully optimized
  - Lower cure conditions than many conventional systems (160°C for 30-60 seconds)
- Fewer drawbacks than other non-formaldehyde systems
  - Low yellowing
  - No excessive shade change with traditional cotton dyes
  - No bad odors associated with some non-formaldehyde systems

PUREPRESS™ Technology: Commercial Trials on Cotton Bottom-Weight Fabrics

- Commercial pre-cure trials on woven 3/1 twill bottom weight fabric
  - Comparable smoothness to conventional resin
  - Slightly higher tensile/tear vs. standard DP resin
  - 30% improvement in flex abrasion
- Commercial post-cure trials on woven 3/1 twill bottom weight fabric
  - Comparable smoothness and crease retention to conventional resin
  - Substantially higher tensile/tear as compared to conventional resin
  - 40% improvement in flex abrasion
  - Substantial improvements in Martindale abrasion
PUREPRESS™ Technology: Abrasion Improvement on Post-Cured Cotton Twill Fabric

- Standard DP Finish
- PUREPRESS™ Finish

Martindale Abrasion Tester

PUREPRESS™ Technology: Commercial Trials on Cotton Shirting Fabrics

- Commercial pre-cure trials on woven shirting fabrics
- Trials with both mercerized and liquid ammonia treated fabrics
- Multiple constructions
- Equal or better smoothness vs. standard DP resin (DMDHEU)
- Improvements in tensile/tear strength as compared to conventional resin
- Very large improvements in flex abrasion
Trials on Cotton Shirting Weight Fabric
40/1 x 40/1 Poplin 1/1

<table>
<thead>
<tr>
<th>Smoothness Rating (HLTD)</th>
<th>Tensile (lbs.)</th>
<th>Tear (lbs.)</th>
<th>Flex Abrasion (cycles)</th>
<th>Formaldehyde (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 5 10 20</td>
<td>Warp Filling</td>
<td>Warp Filling</td>
<td>3 HLTD</td>
<td>ISO 14184-1</td>
</tr>
<tr>
<td>PUREPRESS™ Technology</td>
<td>4.2 4.1 3.9 3.3</td>
<td>116 46</td>
<td>3.0 2.3</td>
<td>10433</td>
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<tr>
<td>DMDHEU CONTROL</td>
<td>4.3 3.2 3.8 3.7</td>
<td>47 40</td>
<td>3.0 1.8</td>
<td>2142</td>
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</tbody>
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Summary: PUREPRESS™ Technology

- Versatile technology
  - Can be applied to a wide range of fabrics
  - Available in pre-cure and post-cure finishes
- Truly non-formaldehyde
  - Tested by both ISO (similar to Japanese LAW 112) as well as AATCC TM112 protocols
- Strength/abrasion improvements as compared to typical durable press resins
What’s Next?

• Low wet pick-up finishing with PUREPRESS™ technology
  • CFS foam application
  • Spray technology
• New applications with TOUGH COTTON™ for abrasion resistance
  • Yarn treatment
  • Metered addition
• The next generation of non-formaldehyde resins?

Parting Thoughts

• No matter what job or task awaits you, take it with enthusiasm and own it. It will go faster that way, and you may end up enjoying it. (Preston Aldridge, paraphrased)
• Looking back at my career so far, I am grateful for the things I learned well, no matter how trivial they seemed at the time. Life can be cyclic, and some of those things I did earlier came back again and again.
• Don't hold onto knowledge. I am never afraid of mentoring another employee or a student and then seeing them move into a superior job position.
• “Don’t give up. Don’t ever give up.” (Jim Valvano). These words helped me – not only in my job – but also when I dealt with a couple of life-changing experiences.
Thank You

• Thanks to AATCC for this distinguished honor and for allowing me to speak today
• Thanks to my wife, Ann Marie, for her love, support, and patience
• Thanks to everyone at Cotton Incorporated for their continued support
• Thanks to Dr. John Turner, my predecessor at Cotton Incorporated, for his work on TOUGH COTTON™ technology and for teaching me a lot about durable press finishing
• Thanks to Dr. Charles Tomasino, who mentored me at NCSU and inspired me to pass my knowledge along to others
• Thanks to all for attending this presentation!