



# FROM FOAM TECHNOLOGY TO FORMALDEHYDE REDUCTION: *PURSUIITS TOWARD SAFER AND BETTER TEXTILE CHEMISTRY*

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## 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!

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**Ken Greeson**

**Fresh Out of College!**



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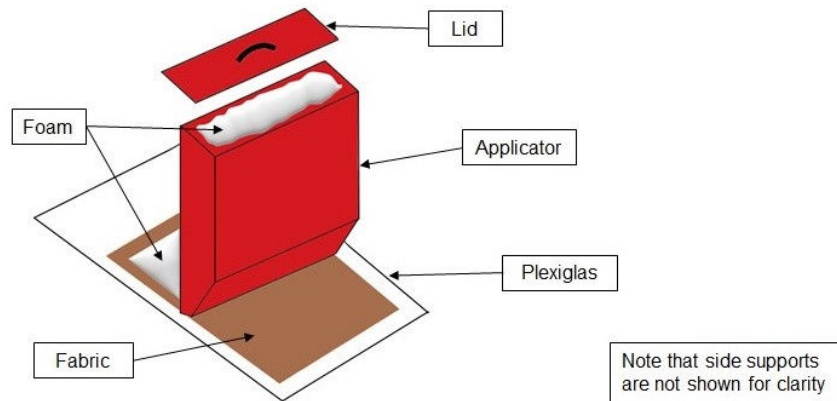
## **Foam Technology – Early Years**

- 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

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## My First Foam Applicator (circa 1981)



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## 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



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## 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

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## CFS® System from Gaston Systems: Lab Unit



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## **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

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## **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

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## 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)

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## 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!

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## 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)

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## 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: A Novel Approach to Durable Press Finishing", *AATCC Review*, March 2005, p. 13
  - "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

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## 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

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## 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)

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## Foam Eco-Care: Application Procedures

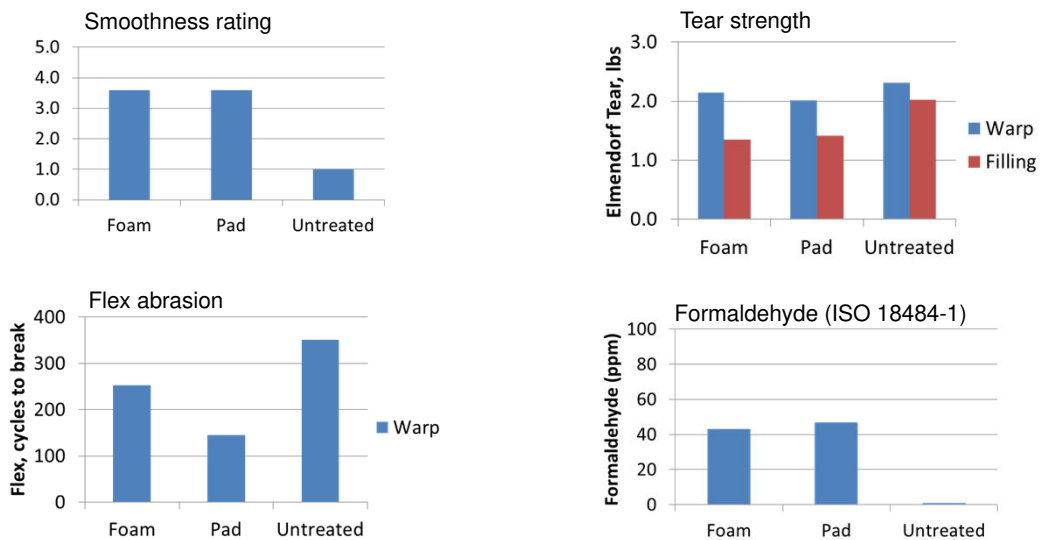
Chemical	Pad Application (Control)	Foam Application
Water	705 g	384 g
Ultra-low Formaldehyde DMDHEU	200 g	400 g
Catalyst for DMDHEU	50 g	100 g
Polyethylene softener	40 g	80 g
Aminofunctional silicone softener	20 g	40 g
Nonionic wetting agent	2 g	40 g
Wet pick-up, %	60	30
Drying time (110°C), seconds	80	60
Cure at 130°C, 3 minutes		

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## Foam Eco-Care: Results on Cotton Poplin

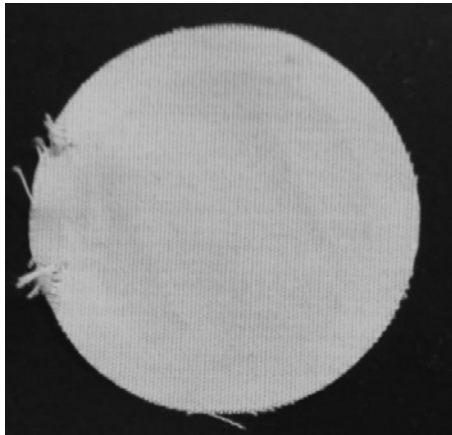


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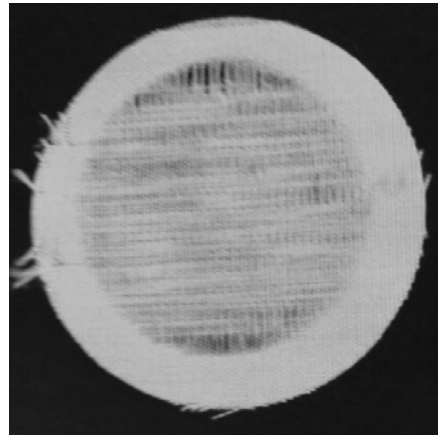
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## Foam Eco-Care: Martindale Abrasion Results on Cotton Poplin



*Foam*



*Pad*

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## 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

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## 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

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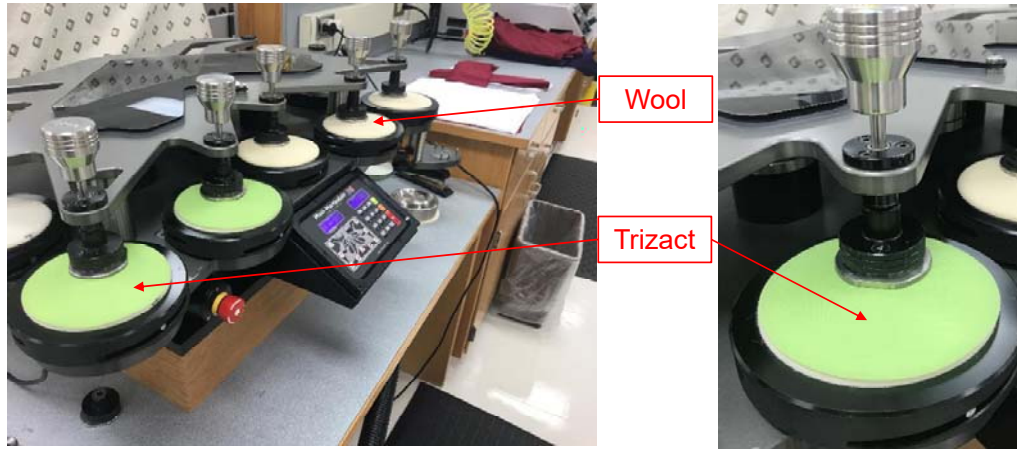
## TOUGH COTTON™ Technology for Knits

- 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!

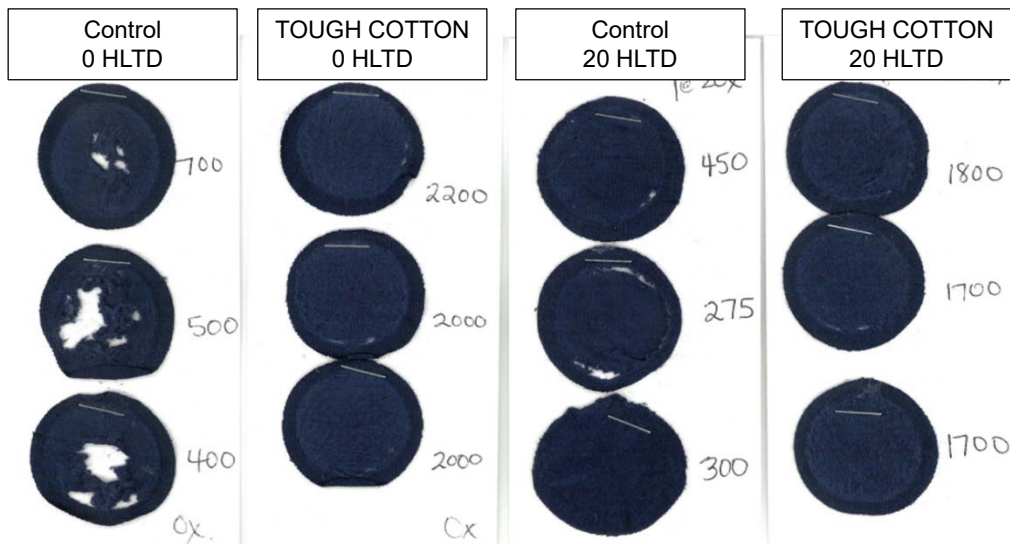
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## Martindale Abrasion with Trizact™ Abrasive



## Martindale Abrasion with Trizact™ on Knits





## PUREPRESS™ TECHNOLOGY for COTTON FABRICS



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## 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

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## 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

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## 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

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## PUREPRESS™ Technology: Abrasion Improvement on Post-Cured Cotton Twill Fabric



Martindale Abrasion Tester

Standard DP Finish    PUREPRESS™ Finish



## 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

	Smoothness Rating (HLTD)				Tensile (lbs.)		Tear (lbs.)		Flex Abrasion (cycles)	Formaldehyde (ppm)	
	3	5	10	20	Warp	Filling	Warp	Filling	3 HLTD	ISO 14184-1	AATCC TM112
<b>PUREPRESS™ Technology</b>	4.2	4.1	3.9	3.3	116	46	3.0	2.3	10433	8	4
<b>DMDHEU CONTROL</b>	4.3	3.2	3.8	3.7	47	40	3.0	1.8	2142	79	120

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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

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## 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?

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## 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.

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## 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!