

WRINKLE FREE COTTON - AN OVERVIEW

Joe Don Long
Plains Cotton Cooperative Association
Lubbock, TX

Abstract

Many people have perceived the wrinkling associated with 100% woven cotton apparel as an annoying problem and one that lead them, as consumers, to purchase apparel made with blends of polyester and cotton. However, in the middle 1980's, a major manufacturer of men's casual pants introduced a 100% cotton product which claimed to be wrinkle free. This manufacturer applied older chemical technology with newer methods of process control and process regulation to impart a certain degree of wrinkle resistance (panel smoothness) and crease retention (the ability to hold a crease after washing and wearing) to men's casual pants that were 100% cotton. At first consumers did not understand the 100% cotton and wrinkle free tags on a pair of pants because they were thought of as mutually exclusive terms. However, after several years of successful marketing of the product, wrinkle free cotton apparel has exploded into the marketplace, especially in menswear casual pants, and has become not only a product enhancement, but is now an expected feature in a high quality men's casual pant.

Evolution Of Wrinkle Free

Before 1960, the words wrinkle free and cotton gave visions of one thing - an iron. At that time, it was widely accepted that having the comfort of cotton and a neat appearance could be accomplished only through pressing. During the 1960's and 1970's, with the invention and introduction of polyester into the apparel market, terms such as dura-press and perma-press were common. When cotton was blended with polyester, that annoying characteristic of wrinkling was eliminated. However, it came at the expense of a certain loss in comfort and other annoying characteristics like pilling. In the 1980's there was a strong movement in the apparel market away from synthetic fibers back to 100% cotton and consumers accepted the fact that cotton had to be ironed or one must live with the wrinkling associated with it. Now in the 1990's, 100% cotton wrinkle free apparel is available. But what does wrinkle free mean? Is a garment truly wrinkle free, or does it resist wrinkling to a much greater degree than a non-wrinkle free garment? To answer these questions we must first look at the chemistry and physics associated with the wrinkle free process.

Wrinkle Free Technology

Semi-Permanent

Cotton can be made wrinkle free simply by doing what has been done for years - pressing with a wet press rag. This process provides a garment which has a smooth surface appearance and retains creases where folds and pleats are intentionally, (or accidentally,) placed. By using the heat of an iron and the humidity associated with the press rag, there is a reaction which occurs known as hydrogen bonding. This hydrogen bonding is semi-permanent in the sense that it is not easily removed until additional heat and humidity are encountered which destroys the hydrogen bonds. Unfortunately, in apparel, additional heat and humidity are encountered simply in the wearing of the product resulting in creases and wrinkles being set in unwanted places.

Permanent

To make cotton permanently wrinkle free involves the addition of certain chemistry to the cotton while it is semi-permanently wrinkle free. This chemistry involves the use of a resin and catalyst system in the presence of heat to chemically modify the cotton. This reaction actually cross-links the cellulose molecules of cotton in a permanent fashion, thus making the cotton hold the shape it was in when the reaction occurred. Therefore, if the cotton has been placed in the desired shape using semi-permanent methods, (pressing with a press rag,) the desired shape can be maintained permanently through a cross-linking reaction of a resin and catalyst system with the cellulose molecules of the cotton.

The Resin And Catalyst System

As previously stated, cross-linking of cellulose molecules occurs in the presence of a resin and catalyst system. Formaldehyde, a cross-linking agent, was widely used in the perma-press technologies of the 1960's and 1970's as a resin. However, because of its undesirable environmental impact, the resins used in today's wrinkle free technology are typically very low in their formaldehyde content and some even have no formaldehyde at all. A low level formaldehyde resin (generically termed ultra-low formaldehyde) used in many of today's wrinkle free applications is referred to as DMDHEU which stands for *dimethyloldihydroxyethyleneurea*. The other part of the cross-linking system is the catalyst. Catalysts are chemicals which promote reactions, meaning they cause a chemical reaction to occur at a faster rate than normal. A common catalyst used in wrinkle free processing is an inorganic salt called *magnesium chloride* ($MgCl_2$). Other auxiliary chemicals are used in wrinkle free processing and may include wetting agents, buffers, and softeners, but they are not necessary for actually imparting wrinkle free properties to cotton.

Heat

After a resin and catalyst system has been added to the cotton, a reaction does begin to take place. This reaction is

governed by the activity of the catalyst and, because of the time delays associated with processing fabric into apparel (usually a minimum of several weeks), is necessarily very slow. The reaction is so slow and highly controlled that, under normal processing conditions, almost no cross-linking is accomplished before the appointed time in the apparel manufacturing process. This reaction needs to be extremely slow and highly controlled to prevent cross-linking from occurring while the product has unwanted wrinkles such as when it is being transported. Heat is the final ingredient which activates the catalyst to promote the cross-linking reaction between the cellulose molecules and the resin. Typically, a curing oven is used for this part of the process which is governed by a time and temperature relationship. Higher temperatures mean a shorter heating period is required to achieve cross-linking, while lower temperatures require a longer period. For apparel, common parameters used in wrinkle free processing today are a temperature of 300 °F with a dwell time of 15 minutes.

Manufacturing Wrinkle Free Garments

The previous discussion has centered around the actual chemical and physical relationships needed to impart wrinkle free characteristics to products manufactured with cotton. Now the discussion will focus on the apparel manufacturing processes for producing wrinkle free garments. There are three main types of processes: pre-cure, post-cure, and immersion; each process differs on exactly which stage of manufacturing the wrinkle free properties are imparted to the garment. Though each will result in a wrinkle free garment, the selection of which one to use is based on the requirements of the end product.

Pre-cure

The pre-cure process is a fabric treatment process and is the simplest of the three. It involves application of the resin and catalyst system and cross-linking of the resin with the cellulose molecules during the fabric finishing process at the textile mill. The resin and catalyst system is applied in a chemical pad to fabric that is in an open-width form. Water is removed from the fabric in a pre-drying process and the fabric passes through a curing chamber, which is frequently a tenter frame, where cross-linking occurs. The wrinkle free fabric is then manufactured into apparel which is ready to go to the consumer without any additional processing. The name pre-cure comes from the fact that the cross-linking is done pre-garment manufacturing. Of the three, this is the least expensive method of obtaining a wrinkle free garment. Pre-cure garments will have excellent panel smoothness, but will not maintain a permanent crease since the wrinkle free properties are imparted before garment manufacturing. Many wrinkle free shirts are manufactured in the pre-cure process. A typical process flow for the pre-cure wrinkle free process is given in Figure 1.

Post-cure

The post-cure process is a fabric/garment treatment process and is similar to pre-cure in that the resin and catalyst system are applied to the fabric during the finishing process at the textile mill. However, the cross-linking of the resin and the cellulose molecules is not done at the textile mill. Instead, the fabric is manufactured into apparel at which time it is pressed with a hard crease and cross-linked in a curing oven to impart the wrinkle free properties. At this point, an optional softening wash with a subsequent finishing press may be done on the product to soften the garment for aesthetic purposes. Since the cross-linking is done post-garment manufacturing it is called post-cure. A post-cured garment will have excellent fabric smoothness as well as a permanent crease. Much of men's wrinkle free casual pants are manufactured in the post-cure process. A typical process flow for the post-cure wrinkle free process is given in Figure 2.

Immersion

The immersion process, a garment treatment process, differs from the previous two processes in that after the fabric is manufactured, it goes directly to apparel manufacturing. The garment is then laundered to achieve a desired abraded look and immersed, (thus the name,) in a resin and catalyst system. After drying in such a manner to prevent cross-linking, the garment is handled much the same as a post-cure product in that it is pressed with a hard crease and cross-linked in a curing oven to impart the wrinkle free properties. Again, just like post-cured products, an optional softening wash and finish press may be done to achieve a desired feel of the garment. The advantages of the immersion process are the same as the post-cure process in that the product has excellent fabric smoothness as well as a permanent crease, with the added benefit of being able to give the garment a certain "look" before it is made wrinkle free. It is possible to give a post-cure product an abraded look but, since the resin and catalyst system applied at the textile mill is water soluble, it must be done after cross-linking. Therefore, since a post-cured garment has a permanent crease after cross-linking, a white line results on the ridge of the crease and is usually not a desired characteristic in the finished product. Because the immersion process is the most expensive of the three, it is not used as extensively as the post-cure process, however, it is used some in the manufacture of men's casual pants where a certain abraded look is desired. A typical process flow for the immersion wrinkle free process is given in Figure 3.

Results

Depending upon the type of wrinkle free process used, benefits to the consumer include improved seam appearance (for all but pre-cure), improved fabric smoothness, and improved crease retention (for all but pre-cure.) However, these benefits come at the expense of certain other

characteristics. Each process will reduce fabric strength by approximately 25% - 40%. Though there have not been any quantitative studies done regarding the effect of this on the life of an apparel product, one would have to be concerned about how much this reduced strength would shorten its useful life, especially in the children's pants market. Another compromised characteristic is the feeling of "softness" of the product. Though this can be partially offset through the use of softeners, wrinkle free garments tend to feel slightly harsher than those that are non-wrinkle free. Finally, products that are wrinkle free usually cost several dollars more than their non-wrinkle free counterparts.

The degree to which a consumer perceives the "wrinkle free" benefit to be truly wrinkle free is relative to the consumer and their expectations; thus, wrinkle free is more a marketing term than anything else. Regardless of the consumers expectations, garments which are processed as wrinkle free will definitely be easier to care for and will provide most consumers with a garment that has a greater utility than a non-wrinkle free one.

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1. Manufacture Fabric
 2. Pad On Resin And Catalyst System In Chemical Pad And Cross-link In Tenter Frame During Finishing Process At Textile Mill
 3. Cut And Sew Into Apparel
 4. Finished Garment Ready For Consumer
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Figure 1. The Pre-cure Wrinkle Free Process

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1. Manufacture Fabric
 2. Pad On Resin And Catalyst System In Chemical Pad During finishing Process At Textile Mill
 3. Cut And Sew Into Apparel
 4. Press With Hard Crease
 5. Cross-link In Curing Oven
 6. Wash For Softening (Optional)
 7. Finish Press (Only If Washed For Softening)
 8. Finished Garment Ready For Consumer
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Figure 2. The Post-cure Wrinkle Free Process

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1. Manufacture Fabric
 2. Cut And Sew Into Apparel
 3. Wash For "Look" (Optional, But Usually Done In Immersion Process)
 4. Immerse In Resin And Catalyst System
 5. Dry Without Cross-linking
 6. Press With Hard Crease
 7. Cross-link In Curing Oven
 8. Wash For Softening (Optional)
 9. Finish Press (Only If Washed For Softening)
 10. Finished Garment Ready For Consumer
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Figure 3. The Immersion Wrinkle Free Process