CHAPTER 12

OTHER FINISHES

I. ANTIPILL FABRIC FINISHING

Pilling is a condition exhibited by certain fabrics made from spun yarns. Balls of lint are firmly attached to the fabric's surface and when the condition is severe, the fabric becomes visually unappealing and irritating to the touch. Spun fabrics made from 100% synthetics fibers, i.e. acrylics and polyesters, or blends of polyester/cotton are prone to pill. The pill in a polyester/ cotton blend is made up of twisted, loose fibers still attached to the parent yarn by one or more anchor fibers. Usually the anchor fibers are polyester filaments that have partially worked their way out of the spun yarn. Pill formation is a function of rubbing against the fabric so pills are mostly found in garment areas where rubbing is most prevalent, i.e. areas near pockets, collars and cuffs.

The .most common laboratory test method for predicting a fabric's pilling tendency is the Random Tumble Pill Rating method. Squares of fabric are tumbled against a cork lining in an accelerator for specified periods of time. The squares are visually rated against photographic standards, see table 1. The number and severity of pills still attached to the surface determine the pill rating. While the method has deficiencies, it will differentiate good fabrics from bad.

A. Mechanism of Pilling

The propensity of a fabric to be classified as bad for pilling involves the equilibrium established between two ongoing actions. The first action creates fuzz balls on the fabric's surface whereas the second action breaks them off. If the rate of creation is greater than wear-off, the fabrics develops the unsightly pilled condition. However if break-off rate is greater than the formation rate, the fabric will appear to be pill-free.

1. Pill Formation

When the surface of a fabric is rubbed, pills develop because abrasion cause fibers to twist into fuzz balls. Fabric surface hairiness is a condition brought about by hairy yarns. Yarn hairiness is related to ease with which fibers migrate out of a spun yarn with one surface fiber end still firmly attached within the yarn structure.

2. Pill Build-up

Pill build-up depends on the ease with which the fuzz ball break off. If the rate of break-off is equal to the rate of formation, the fabric will appear to be pill free. However, if the rate of break-off is less than the rate of formation then the fabric will exhibit noticeable pilling.

B. Factors Affecting Pill Formation

Experience has shown that most 100% cotton fabrics are not prone to develop objectionable pilling. Some cotton fabrics will become hairy and some pills will form, however, the rate of pill break-off is greater than the rate of formation leaving the surface void of pills. The reason for this is because cotton anchor fibers are relatively weak. Experience has also shown that some fabric constructions made with polyester/cotton yarns will exhibit severe pilling. When these pills are magnified, the anchor fibers are seen to be polyester filaments. The strong polyester anchor fibers do not break off easily so pills continue to build up and not wear away.

1. Fiber Variables

a. Denier of Synthetic Fiber

Yarns made from fine denier synthetic filaments (1.5 dpf or finer) pill worse than yarns made from course filaments (2.5 dpf or higher). The reason for this is because yarn twist imparts greater cohesive forces onto larger diameter fibers than finer fibers. As the filiment denier decreases, the total number of synthetic filaments in any given weight percentage of a blend increases. This creates many more fiber ends that serve as anchor fibers. Finer fibers, because they are more limber, will move more easily through a yarn assembly than will stiff, thicker fibers.

b. Fiber Tenacity

Fiber tenacity is a major contributor to fabric pilling because fabrics made from weaker synthetic fibers pill less than fabrics made from their stronger counterparts. Synthetic fiber producers offer pill resistant varieties which are based on lower molecular weight polymers which result in lower tenacity and flex life. Low flex life alone is not enough to produce pill-free fabrics, fiber migration must also be controlled.

2. Yarn Variables

a. Yarn Twist

Yarns with low twist will pill worse than yarns with high twist. The degree of twist will influence the ability of fibers to migrate to the surface. The lower the twist, the easier it is for fibers to migrate.

b. Hairy Yarns

Hairy yarns pill worse than smooth yarns. Low twist contributes to yarn hairiness.

c. Yarn Spinning Methods

Open-end spun yarns pill worse than ring spun yarns because the yarn structure is more uneven allowing for greater fiber mobility. Air jet spun yarns with low flex life fibers result in relatively pill free fabrics. Air jet yarns have wrapper fibers holding the yarn assembly together. These act to keep the body fibers from migrating to the surface.

3. Fabric Construction

Tightly constructed knits and woven fabrics pill less than loosely constructed knits and wovens. Tighter constructions reduce the migration tendencies of the fibers within the yarns.

C. Preparation and Dyeing

Preparation and finishing will have a profound effect on fabric pilling. Some wet processes make pilling worse while others provide substantial improvement. Preparation and dyeing processes that overly work the fabric will cause excessive hairiness and lead to poor pill performance. Long preparation and dyeing cycles are especially bad. In some instances pills may be seen from just these processes alone. High temperature dyeing of fabrics containing low flex life, high shrinkage fibers improve pilling performance. Auxiliaries such as carriers also have a positive effect on these fibers.

D. Fabric Finishing

Finishing procedures have pronounced positive effect on fabric pilling. Many fabrics can be improved by selection of proper finishing conditions.

1. Film Forming Binders

Finishing with film-forming latexes will improve the pilling performance of nearly all fabrics. Whenever the final fabric hand will allow, these film-forming finishes may be considered the closest thing to a universal solution for fixing fabrics prone to pill. These finishes reduce fiber migration by bridging across filaments binding them together. About 1.5% solids deposited on the fabric is needed to do much good.

Latex binders applied to fabrics utilizing low flex life (pill resistant) fibers produce a dramatic improvement in pill ratings. Whereas the base fabric alone would be only marginally better than one made from conventional polyester fibers (still rated objectional), the latex finished fabric would be virtually pill-free. The latex finished conventional fiber fabric would be improved but not to the same degree and the low flex-life-fiber fabric.

2. Durable Press Reactants

Cellulose crosslinking resins applied to low flex-life fibers also produce dramatic improvement in pill rating. However, they have very little effect on conventional polyester fibers.

3. Fabric Softeners

Materials that reduce the coefficient of friction between fibers will make pilling worse. Fabric softeners will increase the pilling propensity of a given fabric. Those applied after dyeing and/or in the finish bath make matters worse. Laundry added softeners may also interfere with pill resistance. These materials operate on the fiber migration portion of the pilling mechanism making it easier for the filaments to move. Softeners co-applied with latexes tend to overcome the improvements noted with film-former. Those softeners that provide a soft hand (silicones, ditallow quats) are the worst offenders.

4. Singing and Shearing

Singeing and shearing are methods of reducing fabric hairiness. In many cases, pill ratings are improved because of the reduced hairiness. This improvement may last for some fabrics for many wash-dry cycles, however, for others, the onset of pilling is only temporarily postponed. Pills will start to form after several wear-wash cycles.

5. Heat-setting

Heat setting fabrics containing thermoplastic fibers is often beneficial in improving pilling performance. For some fabric constructions, the improvement may be temporary and deteriorate after multiple wash cycles. On the other hand, heat setting is a definite plus on those fabrics made with synthetic fibers having higher heat shrinkage. When high heat shrinkage is combined with low flex life, heat setting can enhance pilling performance to the point where the fabric appears to be pill-free.

E. Summary

Pill resistant fabrics need to be engineered from the ground up. Some improvement can be made on poor performing fabrics by combining elements of yarn twist, yarn spinning methods and proper dyeing and finishing procedures. However the best route to pill-free fabrics is to utilize low flex-life fibers with higher heat shrinkage characteristics and finish them with durable-press resins or latex film-forming binders. Also fiber lubricating softeners should be avoided whenever possible.

F. References

II. ANTISTATIC FINISHES

A. Causes of Static

Static is defined as the surface build-up of electrical charges whenever two unlike surfaces contact one another. Many charged particles reside on each surface. These particles may have resulted from previous treatments to the surfaces or from the presence of electrolytic impurities. When the surfaces are separated in air, a net charge transfer will occur depending on which surface attracts the charges more. If one of the surfaces is a conductor, there is an unlimited supply of electrons available to transfer to any other attractive surface. The transfer will continue until it is stopped, either by low initial concentration of ions or by the generation of a strong electric field. Rubbing the surfaces together generates heat and thermal agitation and causes an even greater separation of charges because the charged species tend to migrate away from heat. The direction of transfer, because of frictional heat, may not be in the same direction as the original transfer. For example, its been observed in some textile processes that an increase in speed or tension can actually reverse the polarity of the charged surfaces.

Materials that are non-conductors of electricity and have good electrical insulating properties are known as dielectric materials. Whenever charges build up on these surfaces, the magnitude of the charge will persist until some pathway forms to conduct away the charges. As the insulative property of a dielectric increases, the charge potential it can build up also increases exacerbating problems associated with static.

B. Problems Caused by Static Electricity

Almost all of the fiber polymers can be classified as dielectric materials. This is especially true of the synthetic fibers, e.g. nylon, polyester, polyolefins, acrylics etc. Many textile processes require that fibers and fabrics be moved rapidly over stationary objects so all the elements needed to generate static electricity exist in every phase of manufacturing as well as where consumers use textile products. For example, fibers and yarns may balloon and flare away from each other by repulsion of similarly charged surfaces. Excessive drag tension can be created when the surfaces develop opposite charges. This can cause fibers and yarns to stretch or break. Static can cause problems in the proper folding of long lengths of fabrics in the dye house. Dust can be attracted from the atmosphere to soil the textile. Static can cause garments to cling to the body, an aggravating consumer problem. Lint or other unwanted materials can be attracted to socks and pant legs from carpets and dusty floors.

These static problems are related to charge build-up potentials below the threshold electric discharge potential. However, if the built-up charge potential exceeds the threshhold potential, an electric discharge (a spark) can occur. The spark is the result of rapid ionization of the surrounding atmosphere and is identical to what happens when lightning bolts flash through the sky. For atmospheric lighting to occur, electrical charges continue to build up on water droplets in clouds until the potential is high enough for electrons to ionize surrounding air molecules. The bolt striking the ground is a pathway of ionic species for electrons to follow to earth thus restoring electrical neutrality to the environment.

Examples of static electrical discharges are the zap that occurs when one walks across a carpet on a dry, cold day and touches the metal door knob and the snap, crackleand pop that occurs when clothes are taken out of a dryer while they are still warm. While the actual shock is not life threatening unless it occurs in an explosive atmosphere (gasoline/air mixtures, hospital operating rooms, etc.), involuntary reaction to the unexpected shock can cause accidents.

D. Mechanism of Control

Methods for controlling static build-up rely either on preventing the build-up of static charges or increasing the rate of charge dissipation. One way of reducing charge build-up is to reduce friction. Certain fiber lubricants help in this respect. Another way of reducing charge build-up is to blend fibers which have the potential of developing opposite charges. The tribo-electric series is an attempt to classify fibers as to the sign and magnitude of the charge they will develop. This process has shown limited success due to the inability to accurately predict the specific compositions of materials which will produce opposite charges of the same magnitude, and due to the variation in charge produced by individual processes.

1. Static Eliminators

Since preventing static build-up is difficult if not impossible, successful antistatic control relies on increasing the rate of dissipation of the static charges. One way to do this is to "ground" the material by having it come in contact with grounding bars, metallic foil (copper or aluminum) connected by a wire lead to earth. Another way is to use static eliminators, devices that increase the electrical conductivity of the surrounding air as a means of providing sufficient opposite charges to neutralize the charges on the textile. High voltage wires or low level ionizing radioactive materials have been somewhat effective in this application. These methods have limited utility since static can again build-up as soon as the textile rubs over the next surface it come in contact with.

2. Antistatic Agents

Increasing the conductivity of the textile fiber has been a highly successful way of increasing the rate of dissipation. A wide varity of antistatic finishes have been developed which function to increase the conductivity of the fiber. Nearly all of these materials rely on water as the medium to transport the charged species and therefore their usefullness is dependant on atmospheric humidity. They are very effective in moist atmospheres but their effectness decreases as relative humidity decreases. Common reagents include hydrophylic surfactants, poly-electrolytes, long chain quaternary ammonium salts, polyethoxylated polymers and any other hydroscopic material that can be left on the surface of the fiber. Most of these agents are not permanent since they may wash or wear away. Structure/property relationships will be discussed in sections to follow. Reagents of this nature are applied to fibers by kiss rolls, spray or immersion as they are being manufactured. They are can be applied to yarns and fabrics in similar fashions. Fabric softeners that also function as antistats can be exhausted from the rinse cycle of a dyeing procedure or padded on as an ingredient in the fabric finish formulation. Consumers can add similar types of agents in the rinse bath after the wash cycle during home laundering. Dryer - added softener sheets afford the same type of static protection.

3. Fiber Polymer Modifications

Approaches not relying on moisture to provide electrical conductivity have also met with some success. The use of good electrical conductors, e.g. metals and graphite, have been successfully incorporated in some applications. For example, very fine stainless steel fibers have been blended into nylon carpet yarns. When enough steel wire is incorporated to give electrical continuity, a conductive pathway is available to dissipate the charges as they build up, keeping them below the annoyance values. Another approach is to coat fibers with a metallic coating (silver) or graphite. These coating are subject to abrasive disruptions and have limited utility. Newer developments involved the formation of bicomponent fibers where one component contains the conductive material. Graphite containing carpet fibers are available that effectively reduce static problems.

In carpets, the lack of humidity on cold dry days render the the hydroscopic antistatic agents ineffective. These materials tend to become oily or gummy and entrap foot borne soils. Therefore carpets quickly develop a heavily soiled condition and need to be shampooed more often. Vacuum cleaning is ineffective in removing the composite gummy soil.

E. Non-Durable Antistatic Agents

Many of the commercial chemical auxiliary products that function as antistats can also be classified as surfactants. Most of them have limited durability to washing and abrasion so their main use will be as temporary processing aids to overcome static problems encountered in textile manufacturing process. It is not uncommon to apply new materials along the manufacturing chain to replace those that have been removed by downstream processes. Once the textile is in consumer product form, static problems in general are nuisances and opportunities exist where antistats can be reapplied in laundering and dry cleaning. In general non-durable antistatic agents, like surfactants, belong in one of the following classes: cationic, anionic and non-ionic. Structures representative of these classes have been discussed in the chapter on Surfactants and the chapter on Softeners and will not be repeated here. The reader is reminded of ancillary problems such as smoke point, color, odor and color bleed that are associated with these compounds. What follows is a brief discussion pertaining to structure/antistatic properties of the various classes.

1. Cationic Materials

Nitrogen containing materials such as fatty amines, amides, imadazolines, and quaternary ammonium salts make up the types of materials that function as antistats. These materials exhaust and orient onto the textile surface. The ionic nature of the quats render them excellent antistatic agents. They provide good lubricating properties which is a plus in reducing the charge build-up, are somewhat hygroscopic and thus attract water molecules which provide charge dissipation and have mobile counter ions which also improve water's ability to conduct electricity. Ditallowdimethyl ammonium chloride is an effective antistat.

2. Non-Ionic Materials

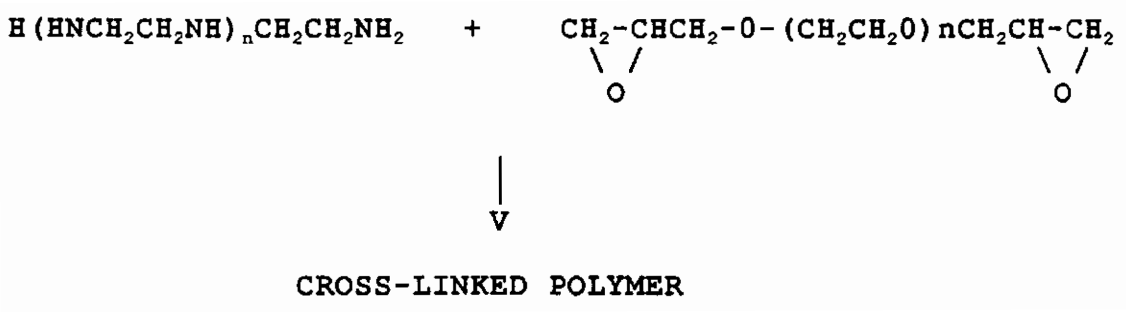
Non-ionic materials such as polyethylene glycols, ethoxylated fatty acids ethoxylated fatty alcohols and sorbitan fatty acid esters fall under the catagory of non-ionic antistats. These materials are also hygroscopic and thus function to dissipate the charge build-up. Often they are blended with the cationics as the blend has superior properties than either alone. It is believed that the non-ionic improves the water absorption while the quat provides the ionic species that improve the electrical conductivity of the surface.

F. Durable Antistatic Finishes

The basic principle behind durable antistat finishes is the formation of a cross-linked polymer network containing hydrophilic sites. To be effective, the cured properties of the resulting surface coating must be carefully controlled. As the number of hygroscopic units increase, moisture absorption increases and antistatic performances increases. However at higher levels of moisture absorption, the coating tends to swell and the resulting material becomes susceptible to abrasion during laundering. Insufficient number of hygroscopic units or over cross-linking reduces the moisture pick-up thereby reducing the effectiveness of the finish. Additionally, if the film is gummy, it will attract and hold on to carpet soil, a serious deficiency. Cationic materials also tend to interfere with the laundering process, they make soil release worse. Because of the deficiencies listed above, the use of durable antistat finishes is limited. Whenever a static problem arises, the first approach is to try a non-durable finish before attempting durable finishes. Where durability is must, blending in good conductors or modifying the fiber polymer are better choices.

1. Composition

The basis for most of the durable finishes is polyamines, polyoxyethylene and some means of crosslinking them.



$$H(HNCH_2CH_2NH)_nCH_2CH_2NH_2 + CH_2{-}CHCH_2{-}O{-}(CH_2CH_2O)nCH_2CH{-}CH_2 \longrightarrow \text{CROSS-LINKED POLYMER}$$

G. References