Pilling Effect Evaluation Through Fingerprinting Method

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To assess the effect of pilling due to the peculiarities of wool fabrics type where, after testin, the appearance of areas does not allow an objective assessment (visual counting of pilling differs significantly from one evaluator to another),there were proposed two original methods: fingerprinting method followed by scanning the fingerprint specimens after application and direct scan method and interpretation of the specimen required by digital image processing using the program CorelDRAW. Fabric appearance of a textile material is very important to the consumer. Pilling is recognized as major aesthetic attribute of a woven apparel fabric. Thus, fabric pilling is a key step in fabric pilling objective evaluation. Method of measurement, though laborious, makes an objective ranking of worsted yarn fabrics by resistance to pilling and highlights the determining factors being helpful in optimizing the structure of fabrics. The necessary of introducing of these methods is that a visual observer is subjective, tired and assigns differently the grades of investigated specimens. Fingerprinting method is a simple, accurate and easy to use one, especially when we compared colored fabrics or dark colors fabrics.

Keywords: fingerprinting method, resistance to pilling, elastomeric yarns, fabrics, number of cycles of friction

The effect of pilling is a typical manifestation of plane textile, consisting in the forming onto their surface of agglomerations of tight fibers, made up of three types of fibers: outer ends (fibers having one end attached to the backbone), outer loop (the both ends in backbone) and marginal/wild fibers (very little fixed at one end), as a result of the action of the friction forces, affecting their appearance.

A frequent complaint about the visual evaluation method is its inconsistency and inaccuracy [1]. Until recently, the inspection of fabric was made by operators on an inspection table with a maximum accuracy of only 80% [2-5]. In general, quality of a fabric is estimated by three criteria of physical properties, appearance and defects [4-6]. Most of the defects in a fabric are related to physical properties of the fabric. Consisted in this relation, occurrence of pilling defects in fabrics is related to the physical properties of fiber, yarn twist and fabric structure [5-8]. Existing methods of inspection of fabric vary from mill to mill. The inspectors view each fabric as it is drawn across the inspection table. This task of visual examination is extremely exhausting, and after a while, the sight can not be focused, and the chance of missing defects in the fabric becomes greater [9-11]. More reliable and subjective methods for pilling evaluation are desirable for the textile industry. Computer vision technology provides one of the best solutions for the objective evaluation of pilling. Researchers in various institutions have been exploring image analysis techniques effective for pill identification and characterization [10-12]. The pilling phenomenon is one of the most serious visual imperfections of textile fabric because it causes not only bad appearance but also a bad touch, both being especially important for fabrics are used in clothing [11-13]. It is generally recognized that pilling is more pronounced in fabrics made of synthetic fibers or blends of synthetic fibers and natural fibers [12-16].

Evaluating the pilling defects, we can assess these properties of fibers, yarns and fabrics and also the probability of problem occurrence in production line [14-18]. Computer vision technology provides one of the best solutions for the objective evaluation of pilling. Researchers in various institutions have been exploring 2D image analysis techniques effective for pill identification and characterization [15-19]. Also, orthogonal projections of the three-dimensional (3D) fabric images are used directly to virtually evaluate the pilling formation of the fabrics [18-23].

Experimental part

Materials and methods

The study was conducted on woven of worsted yarn used to manufacture garments, whose structural features are presented in table 1.

Table 1

THE STRUCTURAL CHARACTERISTICS OF THE STUDIED FABRICS

Article Code	Fibrous composition	Nm_{Warp}	Nm_{Weft}	The type of bonding
A	100%Wool	52/2	52/2	$D = \frac{2}{2}/$
B	45%Wool+55% Polyester			
C	44% Wool+50%Polyester+5% Dorlastan			
D	60%Polyester+40%Rayon			

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The dynamical evaluation of the pilling phenomenon was done through a series of trial experiments on a Rubtester-Metrimpex FF 25 machine, on samples of fixed dimensions set by the fixation device and tested for homogeneous friction on one side.

The technological parameters are: the pressing force adopted by the fabric mass in g/m^2 and the number of cycles of friction.

Qualitative and quantitative analysis of the test results allows ranking assortments of fabrics made from worsted woolen yarn meant to manufacture outerwear products.

Quantitative analysis of the dynamics of pilling phenomenon is performed by determining the following indicators: change in mass of tested specimens; thickness variation of the specimen during the test and the dynamics of congestions of the fibers; the *pills* mass detached from the unit area: the amount thereof, to obtain the number/ mass *pills* made to a specified number of cycles of abrasion.

Samples tested for wear,by friction, were scanned and processed in two ways:

- fingerprinting method followed by scanning the fingerprint of the specimens after application;
- direct scan method of required specimen.

Fingerprint is the negative replica of the relief structure or it is a pattern of grooves on the surface of the test material. The uniqueness of fingerprint feature is exclusively determined by local notches.

Fingerprinting is a set of methods and techniques that achieves this replication. Typically, fingerprinting is carried out using plastic materials in plastic state-called impression materials.

The initial degree of deformability of the impression materials is defined by the fluidity or plasticity. The impression materials fluidity influences directly proportional the playback capability of details but it is inversely proportional to the ease of handling the impression material.

After a period of preparation, the impression materials lose their plastic state, passing in a stable form and, in this way, maintain the form of the structures that have been in contact.

The materials from which there are made the footprints must satisfy a number of conditions imposed by the fingerprinting technique used, such as:

- plasticity or fluidity of the material should provide the capability of being deformed and shaped under a minimum pressure with recording all the details, but without distorting its reliefs;
- the size of the particles included in the composition of the material must be low enough to reproduce the finest details of the surface of the fabric;
- the degree of elasticity must allow the full footprint desinsertion without the existence of any retentive areas on the footprint surface;
- mechanical strength of the materials must be high enough not to be broken during desinsertion or during the subsequent stages (transportation, storage, pouring of the model);
- good dimensional stability to ensure maintenance of accurate negative image of the surface of the fabric, under normal temperature and humidity.

Results and discussions

Pilling is a typical manifestation of plane textiles which results in the formation of some fiber agglomerations at the textile surface as a result of friction. The pilling phenomenon is one of the most serious visual imperfections of textile fabric because it causes not only bad appearance but also a bad touch, both being especially important for fabrics are used in clothing. It is generally recognized that pilling is more pronounced in fabrics made of synthetic fibers or blends of synthetic fibers and natural fibers. At the same time, open flexible textile structures like knitted fabrics are more prone to pilling which is caused in this case by fiber emergence and the persistence of the generated fiber agglomerations.

Figure 1 presents the experimental data regarding the quantitative analysis for four woven articles and indicates the differentiation of woven materials by the variation of the number of formed fiber agglomerations/surface unit and the number of formed and detached fiber agglomerations/surface unit, depending on the number of abrasion cycles and pressure force (P = 20 N).

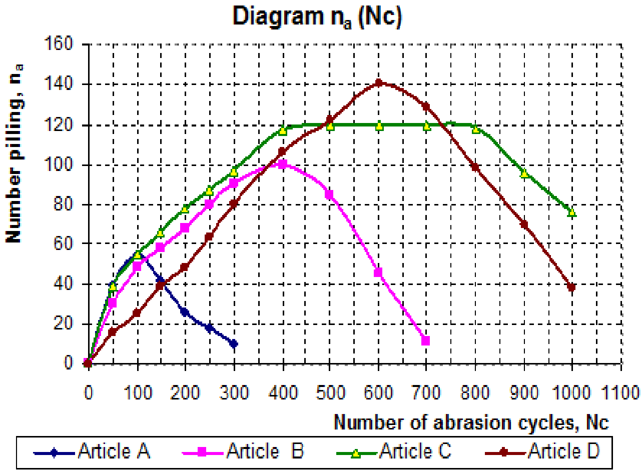

Fig.1. The variation graph of the number of formed and detached clusters of fibers/mass unit, n_a

From the graph of variation of the number of clusters of fibers/mass unit can be drawn the following issues:

- at A article, made of 100% wool, the number of clusters of fibers reaches the maximum value at Nc = 100, due to the length and fineness of fibers. They tend to migrate outwards so that after a small number of cycles of abrasion they are detached from the fabric surface;
- the B article, made of 45% Wool + 55% Polyester, the number of clusters of fibers increases by a greater number of cycles of rubbing, reaching a peak in the range from 300-400 cycle and they remain, on the surface of the fabric, in this range due to the strength of polyester fibers;
- at C article, made of 44% Wool + 50% Polyester + 5% Dorlastan, the maximum number of clusters of fibers appears at a number of cycles Nc = 400 and held on the surface up to Nc = 800. This is justified by the presence of Dorlastan filament, due to its characteristics; the fiber clusters formed are caught in wire structure hindering their detachment;
- at D article, made of 60% Polyester + 40% rayon, the agglomerations number of fibers reaches the maximum value at Nc = 600 and are detached from the surface of the fabric.

Also, it is noted that there is a significant difference between Pilling formed in the first period of using the fabric and that one made by a large number of cycles of stress. For example, at the article C , the pilling is maintained on the surface for the duration of the increased number of cycles of abrasion from Nc = 500 to Nc = 800; at the article B, pilling from Nc = 300 to Nc = 450, at the article D, from Nc = 575 to Nc= 650, and at the A article, pilling is to be held on the surface in a range of 35 rubbing cycles (from Nc =75 to Nc = 110).

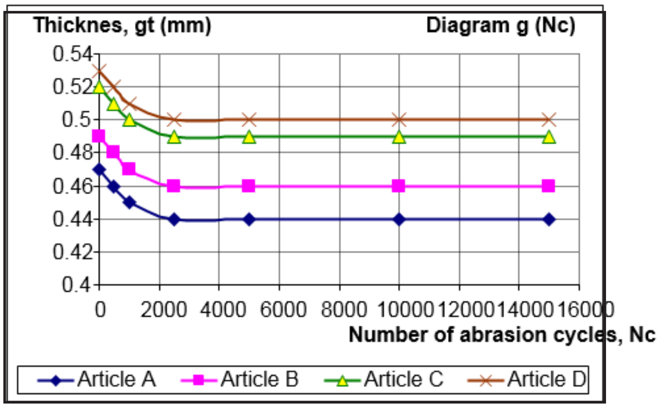

Fig. 2. The variation of fabric thickness, analyzed by the number of cycles of friction

A part of the fiber agglomerations is eliminated from the surface due to breaking of the fibers that connect them and the wire or because of fiber slippage between them.

From this point of view, because the fabrics made of 100% wool have a tendency of forming the pilling effect, this is lost after a reduced number of cycles of rubbing in comparision with the fabric made of 44% Wool + 50% Polyester + 5% Dorlastan where the pilling effect is persistent. This can be an advantage for products with a longer duration of use.

The experimental results relating to the analysis of the four items of fabric illustrating the intensity of the pilling effect by the variation of the thickness are shown in figure 2 of which it is observed that:

- at A article, the thickness reduction after 15000 cycles of friction is 3.4%, occurs quickly at the beginning of the process of friction, up to Nc = 1000, after the thickness variation occurs in a slower process. This can be explained by the position of the fibers in the yarn structure;
- at B article, the reduction in thickness is 3%, the thickness variation occurs in a slow process due to the presence of polyester fibers in the yarn structure;
- at C article, the thickness reduction is 2.4%, due to the presence of Dorlastan filament in yarn structure;
- at D article, in the early cycles of rubbing, the fibers break themselves and are detached from the surface so that after 15 000 cycles of friction, the reducing of the thickness is 2.6%.

In this study, fingerprinting was performed in the sequence of the following steps:

- *selecting the material for fingerprint and fingerprint-art*: the material used for fingerprint was plaster and for portfingerprint, it was a device made according to the size of the head sample of the wear testing machine.
- *preparation of fabric samples to fingerprint them*: the samples (n = 5) were tested in a number of different cycles and different bias friction; diameter of samples Φ = 100 mm and the wear area has the diameter = 50 mm.
- *fingerprinting*: fabric samples are placed on a perfectly flat surface, because the obtained fingerprint data has to restore only bumps gatherings of fiber (Pilling); The realization time of the fingerprint is only 3-4 min.
- *fingerprint conservation*: after about 15-20 min when fingerprint is perfectly a dry ink powder is deposited on a surface so that the pores/voids of gatherings of fiber to be fully covered.
- *assessment of-pilling effec*t: include counting of blackheads on the surface of fingerprint, either visually or using a software using CorelDRAW programs because the visual evaluation is less objective.

To achieve a top quality fingerprinting is imposed to apply the following conditions:

- fingerprint should be achieved in a short time in order not to strengthen before being placed on the test friction specimen;
- for making fingerprints can be used many types of materials (plaster, special resins, special silicones).

The essential role of fingerprint is transferring *the morphological information* regarding fingerprinted structures, materialized as a positive copy called model.

To obtain digital images it's used a scanner that quickly inserts graphics and alphanumeric information in computer, directly taken from the sample of fabric or the fingerprint. Image processing quality is assessed through two features: fidelity and intelligibility.

By the second method of evaluating the effect of pilling, namely scanning method and image processing, aims to transform it into another enhanced image or extraction of information leading to an interpretation as it was intended. Methods to improve the image processing are not based on increasing the information content, but the increase in the dynamic of the chosen characteristics to be more easily analyzed.

In a more general way, *a picture* is a description of the change in a parameter on a surface. For example, the images (in the classical sense) are simple result of variation of the change of light intensity in a two-dimensional plane. Image is a concept with informational character. People get visually the most information which their sensory system acquires it. Acquired images can be displayed as the synthesis images for to be viewed and analyzed by a human observer. If you want to determine what contains the acquired image without recourse to a human observer when there is a new problem, interpretation or understanding images using artificial intelligence techniques.

Solving this problem involves the addition of a new stage after acquisition and processing of the image. New stage performs a decoding of the information contained in an image and can be associated with the generic term of image recognition. Identification of objects in the operating area, seen as regions/parts in images, is a process of estimating similarity by measuring distances between shapes, seen as vectors of features and associated with points in multidimensional spaces. This shaping of the images enables counting of the pilling, which results on friction surface, to be done directly on the monitor so that errors are very small. When we compared colored or dark shades fabrics, it is recommended the fingerprint method. Image processing by Corel Draw program, that uses vector graphics where the images are formed from objects (groups of lines, straight or curved) described by mathematical formulas that determine their size, position and orientation.

These drawings can be resized and rotated without losing any quality, because they are regenerated at any size and in any position by mathematical formulas that they have been described. Their main disadvantage is that, being composed by the objects described with mathematical formulas; both the number and complexity of these items are limited, depending on the library of mathematical formulas used by drawing program.

The processing is performed in the following steps:

- fabric specimens that have been undergone to wear or fingerprint process are scanned (fig.3) and imported into the program CorelDRAW (fig. 4);
- it converts the scanned image in black/white (fig. 5);
- it is used the filtering Trace bitmp command a high-pass filter for highlighting the contours (fig. 6);
- displays the number of objects and their contour consists of a network of nodes (fig. 7)

Article C Martor | Article C (Nc = 350, P = 10 N)

Fig. 3. Scanned images

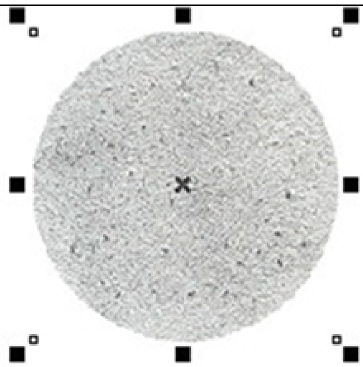

Fig. 4. Scanned image (fingerprint) Art. C (Nc = 350, P = 20 N)

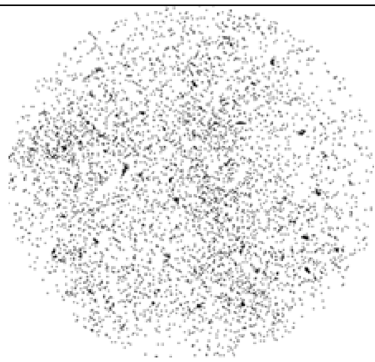

Fig. 5. Black-white converted image

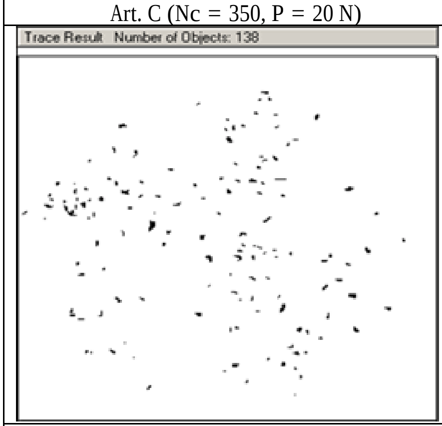

Fig. 6. Highlighting/Display the contours by trace bitman command

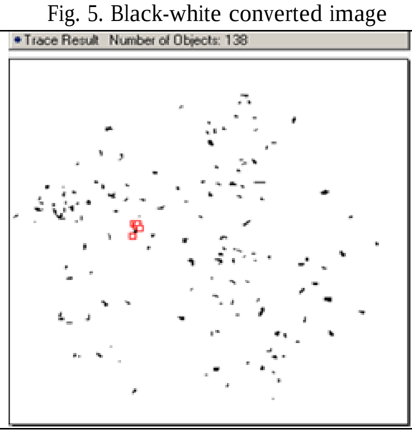

Fig. 7. Objects contours made by a network of nodes

Conclusions

Samples tested for wear, by friction, were scanned and processed in two ways:

- fingerprinting method followed by scanning the fingerprint of the specimens after application;
- direct scan method of required specimen.

The experimental results were synthesized by digital manipulation of images using CorelDRAW.

Direct scan method of specimens can not be applied to dark colored fabrics, this was the reason I proposed fingerprinting method.

CorelDRAW image processing program is a way of working fast, accurate and easy to use but requires conducting fingerprints, transforming in a white-black image and it ends by counting and displaying the existing pores / voids on the surface.

Method of measurement, though laborious, makes an objective ranking of the textiles based of pillng resistance and highlights the main determinants being useful in optimizing the structure of fabrics.

Pilling resistance selects textiles both in the initial stage and advanced stage of abrasion; higher initial resistance materials can generate more persistent pilling.

Pilling phenomenon is more pronounced in the products made of synthetic fibers or blends of natural and synthetic fibers, open textile structures and flexible fibers caused by the emergence of fibres and persistence of generated clusters.

Pilling resistance is influenced by the position of the fiber in yarn which is reflected in the look and appearance of the finished product, being determined by the participation shares of the components of the mixture, so by the process of used spinning. Distribution fiber in yarn can be changed by using high shrinkage mixed fibers.

The link highlights best the pilling resistance of the fabrics, being in line with the other basic parameters-smoothness and technological density of yarns as well as test conditions, because it determines the appearance of the yarn system at the contact surface of the fabric exposed to friction efforts and provides positional stability of yarns and the technological density maintain this stability.

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