Basic Techniques in the Creation of Felt Non-Woven Textile Material Regarding Wool Structure and Properties

Nikolay Tranchev, Margaret Sivova, Tanya Peneva

***Abstract* — The article examines the structural characteristics of wool fiber, its properties, and types of wool. Different technologies for the production of non-woven textile material by the method of wool felting are analyzed. The process of making a decorative panel using the "wet felting" technique is described in detail. The main stages, necessary materials, and manipulations to obtain the finished canvas are indicated.**

***Keywords* — Wool, felt, wet felting, non-woven fabrics, felt products.**

I. INTRODUCTION

[1]In recent years, worldwide, the textile and fashion industry has seen a trend of increasing consumer interest in products made from natural fibers through traditional crafts. Felting is a technique for making non-woven textile material that has been known for thousands of years. There are not any proven facts from a scientific point of view regarding when and where this ancient craft originated. The most common opinion is that it originated from the border between Europe and Asia, where the most ancient felt products were found.

Many scientists accept the domestication of sheep as an important factor for the emergence of the production of felt products, since the main raw material for their production is sheep's wool. It has unique properties and has been called the queen of textile materials. Thanks to their structure, wool fibers exhibit the property of stiffening, which is the basis of the felting process. Two main techniques are known - wet and dry felting, which differ from each other in the way of execution and the aids used. Wet felting originated at an earlier stage and it is safe to say that there is no people who have not used this technique to meet their textile needs for household use. This has led to various modifications to the process.

The purpose of the present article is to make an experimental sample using the wet felting method, according to a technique used since ancient times in the Bulgarian lands.

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II. CONSTRUCTION AND PROPERTIES OF WOOL FIBERS

Wool is a unique textile material that has become part of the culture and traditions of many peoples.

It was represented in the mythology of the ancient Greeks in the form of a golden fleece - a symbol of authority and royal rank. Entire countries, such as New Zealand, have embraced the wool as a national treasure and economic engine.

Wool – in the broadest sense of the worls – is called the fibrous covering of various animals, which protects them from injuries and from external atmospheric influences. It is formed from the skin of animals.

The X-ray and microscopic studies prove that the wool fiber has an extremely complex structure. It consists of three layers - outer flaky, intermediate cork and core (Fig. 1.).

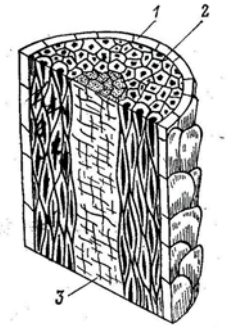

Fig.1. Construction of wool fiber

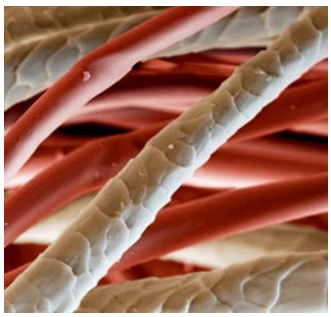

Fig.2. Microscopy of woolen fiber

The flaky layer 1 (Fig.1) forms the protective layer of the fiber. Flakes are cornified keratin cells directed towards the tip of the fiber. Their size depends on the type of fiber and the breed of sheep. Merino wool has the densest scaly structure. Cells are tiled, overlapping adjacent cells by about 1/3, with the apex of one cell overlapping the base of the other cell. At the point of contact, the upper cell forms a hook on its inner part, which enters the recess formed in the upper part of the lower cell. The coupling effect is very large. When stretching the fiber up to 50%, the cells at the stretched places remain connected to each other.

The luster of the fibers depends on the shape and arrangement of the flakes. The larger and less overlapped along the length of the fiber, the greater the shine and vice versa. There are about 40-50 flakes in 1mm length.

The flaky layer is stabilized by intercellular membranes that act as an adhesive. It has been shown that even when the membranes are removed, it is not possible to separate

cells from the outer layer.

Immediately below the outer flaky layer is the so-called intermediate membrane that plays an important role in the dyeing process of fibers. It is very thin, about 0,3 μm. There are conflicting opinions as to whether it should be considered as an independent layer or if it is part of the next layer [1].

Cork layer 2 is the main part of the fiber and represents 90% of its mass. It is located under the flaky layer. It consists of long spindle-shaped cells, the length of which reaches up to 80÷100μm (micro meter), and their thickness – up to 3÷10 μm. They are located along the length of the fibers, and the intercellular space is filled with a porous substance in which there is air. The cork layer has different thicknesses. In some fibers, its thickness is equal to the thickness of the fiber (disregarding the thickness of the flake layer), and in other fibers it depends on the thickness of the core layer. The cork layer determines all the mechanical properties of the fibers - strength, elasticity, extensibility, flexibility, etc.

The core layer 3 consists of loose, thin-walled cells filled with air. The coarser the fiber, the thicker this layer, as a result of which the relative strength is lower. Due to its loose nature, the heart-shaped layer does not tolerate any mechanical loads. It does not exist in the fibers of the fine wool.

In a cross-section of a wool fiber, it was found that the three layers are located in a ring shape (Fig. 1.). The wool fiber has an irregular circular shape - the thinner it is, the rounder it is. [2]

Thanks to their structure, wool fibers have the following properties: softness, high heat protection properties, wear resistance, hypoallergenicity; high elasticity. From the point of view of the felting process, the most important property is the stiffening property, which is a characteristic unity of the wool. This property is due to the surface flaky layer of the fibers. With the simultaneous interaction of moisture, heat and mechanical impact, especially in an alkaline environment, felting of the wool is observed, stiffening and felt is obtained. The reason for this phenomenon is the swelling of the fibers, as well as the difference in the coefficient of friction at the base and tip of the fibers. The migration of the fibers during crimping causes a change in the size of the article - shrinkage, which is different depending on the temperature, the alkalinity of the environment and the applied mechanical impact [2, 3].

III. Methods Of Wool Felting

In its essence, wool felting is a technique for making non-woven textiles, which enabled the ancient people without deep knowledge of chemistry, mechanics, etc. sciences to satisfy their needs. This unique material was used by many peoples, spanning the regions inhabited by Mongolian and Asian nomads to China and ancient Rome. This has made it the one craft that no nation can claim to have discovered, propagated and preserved.

There are two basic felting techniques: dry and wet. Historically, wet felting preceded dry felting.

Wet felting is done with water, soap and mechanical impact. This method is used in obtaining planar and form-resistant structures - carpets, clothes, shoes and others.

Dry felting is carried out with special needles. This technique is suitable for creating three-dimensional objects (jewelry, toys, plastics) or applying additional decorations on felt bases.

Regardless of the fact that the principles of the felting process are based on the property of wool to stiffen in an alkaline environment, soap and mechanical impact, each nation has brought something of its own and specific to the production of felt products.

The felt-making technique of the Slavic peoples is defined by some researchers as semi-felt. According to historical records, the Slavs have been making felt since the beginning of the 8th century. They spread a thin layer of woolen fibers evenly on a board, which they continuously watered with hot water. Two men stood facing each other at the end of the boards. They covered the wool with canvas and by moving their legs in opposite directions, they moved the canvas, as a result of which a thin layer of felt was obtained. They used wool in pastel natural colors as a raw material.

Our ancestors made wet felt, calling the process itself "felting" or "beating". They watered the spread wool repeatedly with hot water and exerted a mechanical impact through a series of blows with hands, sticks until a thickness of one or two centimeters was obtained. The felt is then turned over and beaten in the same way, or rolled into a tight roll and again beaten with hands, feet, sticks, etc. In the settlements where more felts were made, there were special devices made by stiffening the so-called an "odar" of boards that is placed over four stuck poles or on a "sled" to drain the water. The technique used for decorating is Iranian. In most areas, the color solution is mostly white and beige wool [2, 4].

IV. Making An Experimental Sample From Felt With Bulgarian Traditional Technique

Bulgarian folk technique described by the ethnographer Gina Krasteva [4] was used to make the experimental sample. Some of the necessary auxiliary materials have been replaced with modern means adapted for the purpose. The sample is an authentic carpet from the village of Dzhinovo (now the village of Zlati Voivoda), Sliven region, located in the "Dr. S. Tabakov" Ethnography of ROME Fund - Sliven - Fig. 3. The carpet was made around the 1920s.

Fig. 3. Authentic carpet from the village of Dzhinovo, Sliven region

The process of manually creating an article using the "wet felting" technique includes the following distinct stages, [5, 6]:

- laying the wool in different ways in a scale, as a result

of which a fiber web with a certain structure is formed (the set orientation of the fibers in the canvas is called "scale scheme");

- felting of the wool into a uniform fabric („prefelt“) by mechanical impact the fiber canvas preliminary treated with aqueous solution with special composition;
- shrinkage of the prefelt through a special treatment to increase strength and add texture;
- rinsing the finished product in water to remove the soapy solution;
- finishing treatment depending on the product and design.

The method of performing each of the listed stages affects the quality and properties of the finished non-woven fabric.

In making a mini-replica of the authentic felt carpet from the village of Dzhinovo, 100% merino-like wool on a 27 micron (micron) strip was used. The classic two-layer orthogonal scheme (Fig. 4) of wool fiber placement is applied.

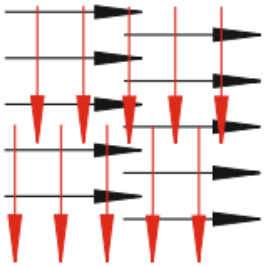

Fig. 4. Orthogonal scheme [7]

According to the scheme, when laying in the scale, the fibers of each layer are arranged in parallel rows with a slight overlap of each subsequent row to the previous one. The second layer of wool is placed perpendicular to the first. To create material of uniform thickness when repeating the first pair, each subsequent pair is offset from 1 to 3 cm to the right and down. In this way, a canvas with a uniform thickness and very low stretch is obtained.

The following materials were used to make the experimental panel (Fig. 5):

1.Wool in two colours;
2. Liquid soap, warm water;
3. Substrate of natural material;
4. Water shower for the soap solution;
5. Nylon pads

The description of the technological stages of creating the panel and their visual presentation are demonstrated in TABLE I.

Fig. 5

TABLE I

Stage / Description	Preview
1. Spreading the wool	
1.1. Spreading the first layer of wool – on the substrate, tearing off small bundles from the tape, a layer of wool is laid successively in one direction. The fibers are applied parallel, overlapping slightly.	 Fig. 6
1.2. Laying the second layer of colored wool - on top of the first layer, tearing off small bundles from the tape, a second layer is applied perpendicularly to the first, again with a slight overlap of the fibers.	 Fig. 7
2. Felting the canvas	
2.1. Wetting with a warm soapy solution - the formed workpiece is abundantly sprayed using the water shower, while the wool is carefully pressed by hand. The wool should be wetted evenly so that it is soaked completely.	 Fig. 8
2.2. Carrying out the felting process by applying mechanical force - rolling and pressing. The workpiece is covered with a second layer of nylon backing. The resulting "sandwich" is rolled into a roll and rolled for several minutes with an even distribution of pressure - first in one direction (Fig. 9), then rolled in a direction perpendicular to the first (Fig. 10), and again rolled and pressed. The process is repeated on all four sides of the "sandwich".	 Fig. 9  Fig. 10
3. Making of decorative ornaments	
3.1. Laying the ornaments according to designer's decision	 Fig. 11

3.2. Wrap the blank into a roll and repeat point 2.2.	

Fig. 12

4. Rinse in clean cool water, towel dry, dry at room temperature on a flat pad

Fig. 13 Experimental sample

V. CONCLUSION

The production of non-woven fabrics by felting is one of the oldest methods of producing textile materials. The most durable and dense fabrics are obtained from wool fibers - the only type of fiber that has the necessary properties for this: elasticity, stiffness and difference in the coefficient of friction at the base and tip of the fibers.

During the making of the experimental panel, the traditional wool felting technique, widespread in the Bulgarian lands, was practically demonstrated. The technological stages described in the article represent an adaptation of the "wet felting" method using modern auxiliary materials without changing the essence of the wool felting technique.

Historically, felting has given way to modern techniques for creating textiles. At the moment, a new trend is being observed - felting is becoming a decorative method that is reviving both as a therapeutic technique and as an interesting way to create unique products.

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