



Assessment of Terry Towels Strength

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Abstract. In the work presented theoretical formulation, analytical solutions, algorithm implementation of numerical experiments, and analysis of the results of numerical experiments. Based on the theoretical and experimental analysis of the yarns of the ground, the conclusions about the fabric of the toweling were made. Based on the results of the studies on the assessment of fabric strength, calculations were made and cross-analysis was carried out. It has been theoretically proven that the tension of ground warp yarns of arbitrary cross-section is not equal to each other. Based on the law of distribution of external force effect of yarns on the ground warp of the towel fabric, it has been proven that the increase in the number of passes of the yarns along the weft leads to a decrease in the level of external force effect distribution.

From the results obtained above for a single warp yarn, general conclusions can be drawn regarding the terry toweling fabric. The effect of the force decreases as the fabric specimen is as it gets further away from the section $x=0$ where the shearing force is applied. From the point of view of mechanics, if all weft yarns in the stretching sample are considered to be of equal strength, its dangerous cross-section will be in an infinitesimal circumference of the cross-section on which the external force is applied.

In the above studies, the law of distribution of external force along the warp yarns of the terry toweling fabric, where the warp yarns alternately pass two and three weft yarns, was studied. From the obtained results, it is possible to draw a general conclusion that if the number of half-cycles of warp and weft yarns in the fabric increases, the degree of dispersion of the external force along the warp yarns in such fabric decreases.

Keywords: terry fabric, toweling fabric, ground weft yarn, warp yarn, strength, tensile strength.

1 Introduction

It is known that in the conditions of the market economy, among all textile materials, there are important requirements for terry fabrics. These include the strength, design, water absorption (speed, volume), thickness, etc. of the towel fabric.

Scientific-methodical analyzes of theoretical and practical methods of evaluating the strength of various fabrics, especially terry fabrics, can be found in the works presented in the list of literature. In work [1], presented different types of terry fabrics have been studied for effect of washing on some properties. Towels have been subjected to different washing cycles. After each cycle, the rate of water absorption, total amount of water absorbed, surface and compression characteristics have been assessed by gravimetric absorbency testing system, image analysis methods, and KES-FB 3 system respectively. Different theories and mechanisms of water absorption have been reviewed along with the key factors to improve the water absorption. Both dynamic and static water absorbency along with the initial time lag immerse are found to be the equally important attributes of the water absorbency performance of terry fabrics. The influence of some structural characteristics of terry fabrics on the rate of sorption have been studied.

Among the indicators that determine the strength of terry towels, one can include the physico-mechanical and technological properties of the yarns, the method of weaving, the density of the fabric, the friction and impact forces between the yarns, and several other conditions. For example, in work [2], it was noted that it is necessary to determine the coefficient of yarn strength in weffe cloth strength in order to determine the tensile strength of warp and weft yarns in the designed wafer fabric in certain parameters. A new method of determining the coefficient of yarn strength is proposed in the assessment of fabrics strength. This method depends on the frictional force of the two systems, depending on the mutual opposition of the yarns and the angles of coverage of each other.

1.1 Analysis of Terry Fabric Characteristics.

As they study terry fabrics, they learn more efficient ways to improve their processing efficiency, which leads to an increase in demand for terry fabrics in the middle of the production process. In this regard, in [3] work, the water absorption, surface properties, and abrasion resistance of terry towel fabrics made of cotton fibers with different structural parameters were studied. The pile height and density of the terry towels chosen to be the most suitable option that can withstand the maximum number of washing cycles. The water absorbency, abrasion resistance and surface properties of terry towels of different towel fabrics produced from the same yarn under industrial conditions were analyzed over 10 washing cycles. In order to optimize the terry towel fabric, the terry towel fabric with different pile density, different height was compared, and in the first sample obtained, after the 8th washing cycle, the water absorption rate of the terry towel fabric, the total amount of absorbed water was found to be worse. A terry toweling fabric with maximum density and pile height of 15 - 17 mm was found to perform well after 10 wash cycles.

In the process of interaction of yarns in fabric production, the bending resistance of the yarns evaluates the resistance to tension under the influence of gravity. Methods for estimating bending deformation indicators from the values of the beginning time of bending of the yarn, the length of the bending part, the shear force and the bending moment in cross-sections have been proposed [4]. The force of friction also determines the degree of strength of the yarns in the fabric, thereby increasing the strength of the yarns in the fabric. In turn, the friction force depends on the angle of coverage of one system yarn with another system yarn.

2 Scientific Analysis and Improvement

The results of scientific-methodical researches on terry towels, including weffe terry towel and their improvement, for example, works [1, 3] and the literature cited in them, are analyzed. In particular, it is based on the possibility of creating a towel fabric with positive evaluation of all parameters by improving the methods of location of pile yarns on the towel base woven by placing the pile warp yarns as shown in Figure 1. Also, when talking about terry fabrics, factors affecting pile strength, including pile yarn structure, are important. In addition, the influence of the pile yarn on the water absorption properties of the towel fabric was considered in works [5,6]. The water absorption property of towel fabric shows different indicators before and after it is washed [7]. Therefore, consumers are advised to wash it in warm water before use and then use it.

The structure of the fabric in the direction of the warp and the weft, as well as the condition of the resulting pile, also have an effect on its surface density. The balance between pile density and pile height increases the quality of the toweling fabric [8]. Another factor that increases the quality of towel fabric depends on the fiber composition and structure of the yarn that makes up the fabric [9].

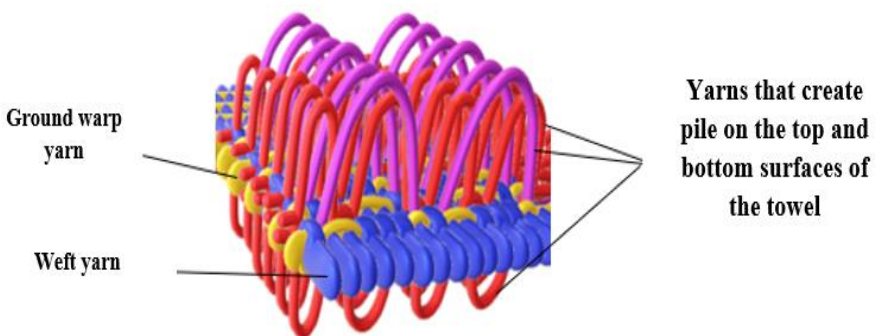


Fig. 1. Appearance of improved toweling fabric before cutting pile yarns

[1, 2] shows an example of a towel material developed in the work (Fig. 1). This material differs from the previous ones in that the methods of weaving the warp, a half-circle (Fig. 2).

Figure 2 shows the cross-sections of the improved fabric cut along the i and $i + 1$ weft yarn.

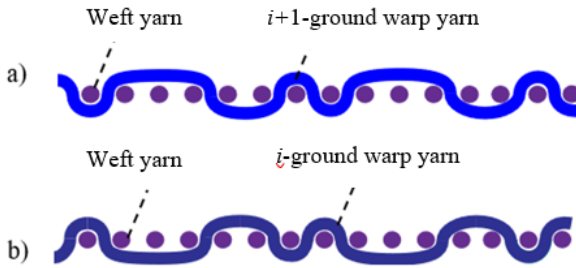


Fig. 2. A system of placing ground warp yarns in an improved fabric

The strength of the towel fabric is primarily related to the method of warp and weft yarns weaving the base fabric. Below are the results of studies on the strength evaluation of the improved toweling fabric.

3 Theoretical Considerations of Terry Fabrics.

Usually, the strength of any terry is done by testing a sample taken from it using drawing frame. A conditional diagram of tensile force P and absolute elongation Δl is constructed by monotonically increasing the force until the sample breaks and P_{\max} is the value of the force P that causes the sample to crack.

The resistance to stretch of the fabric depends primarily on the properties of the yarns and the method of weaving the fabric. That's why there are many difficulties in using the methods of evaluating the mechanical strength of solid bodies to the evaluation of the tensile strength of fabric. For example, if a stergen metal located along the horizontal x axis and fixed at one end is stretched centrally, the amount of internal longitudinal force N_x in its arbitrary cross section will not depend on the x coordinate. Likewise, if a homogeneous metal plate located in the (x,y) plane is stretched by a uniformly distributed force, the amount of internal stretching force in its cross section will be equal to the amount of external force.

When a fabric sample is stretched as shown in Figure 3, the amount of internal longitudinal force in its cross-section is variable. When such a sample is stretched with a monotonically increasing force evenly distributed along the width (z axis), the position of the yarns in the fabric, the bond forces between them and the interaction surfaces and directions of movement, etc. parameters that determine the current stress state of the material change. For this reason, the limits of fabrics similar to those of pitch-bound reed, such as the limits of elasticity, plasticity, viscosity, etc., are not evaluated.

Let's assume that the value of the external force P is evenly distributed over the width of the sample $0 \leq z \leq b$, i.e. the distance b , and the total number of warp yarns in this interval is n . As mentioned above, each ground warp yarn in the sample has different characteristics (start length, tension, distance of contact with weft threads, the number of twisting of yarns, mechanical properties of the fabric). Therefore, the effect

of the external force is not distributed uniformly along the n ground warp yarn, namely $x=0$ in the cross section

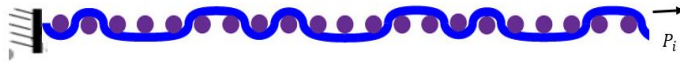


Fig. 3. Sample P_i - loading of ground warp yarn

$$P = \sum_{i=1}^n p_i \tag{1}$$

the equality is valid, where p_i is the internal longitudinal force generated in the cross section of the ground warp yarn i at the section $x = 0$ of the sample. In particular, if all ground warp yarns in the sample are of equal strength, expression (1) can be written in the following form

$$P = n p_i. \tag{2}$$

Since ground warp yarn are not equally strong, the magnitudes of longitudinal forces N_{xi} in their arbitrary cross sections $x > 0$ will not be mutually equal. If we define the value of the total longitudinal force in the arbitrary cross section $x > 0$ as N_x , then

$$N_x = \sum_{i=1}^n N_{xi} \tag{3}$$

an equality would be appropriate.

It follows from the last equality that the tension of the ground warp yarns in an arbitrary cross-section $x>0$ of the sample will not be equal to each other.

Therefore, by studying the properties of cotton fiber [11,12], the process of interruption cotton fabric is more complicated than, for example, metal stergen. When the amount of tensile force in metals is increased to the yield point, the stergen will be disconnected suddenly in a very short period of time.

In fabric, for example, during the increase of static stretching force (Figure 3), it can be observed that some yarns break and some continue to resist stretching, and it is possible to observe the process of breaking the tested fabric sample is as follows. For example, when the amount of external tensile force reaches the value $P=P_1$, the internal forces in the cross sections of the ground warp yarns $i=k$ and $i=k+1$ in the $x=a$ cross-section of the sample have taken the values N_k^y and $N_{(k+1)}^y$, respectively, and as a result, let's say that these yarns are broken. As a result of the yarns being broken, the internal forces in their cross-sections will suddenly equal 0, that is

$$N(a)_i = 0, \quad N(a)_{i+1} = 0 \tag{4}$$

an equality would be appropriate.

As a result, the internal forces N_k^y and N_{k+1}^y in the cross-sections of the broken yarns $i = k$ and $i = k + 1$ are distributed to $n - 2$ unbroken yarns of the sample in section $x = a$. That is, the total internal longitudinal force, determined using equation (3), is now distributed over $n - 2$ yarns, not n weft yarns.

If the effect of the tensile force is equally distributed to all yarns of the body and the equality $N_k^y = N_{k+1}^y$ is valid, then the amount of internal tension forces of each of the $n - 2$ warp yarns of the body that are not broken in the section $x = a$

$$\theta = \frac{2}{n-2} N_k^y = \frac{2}{n-2} N_{k+1}^y \tag{5}$$

receives an increase equal to. The total tensile strength in the cross-section of the fabric

$$N_{x=a} = \sum_{i=1}^{n-2} N_{xi} + (n - 2)\theta \quad (6)$$

will be equal to.

As the value of the external force P increases, the number of warp yarns in such a interruption increases, and the number of uninterrupted yarns decreases. When the value of the external force reaches a certain value, all the warp yarns of the unbroken, which are decreasing in number, break together.

4 Conclusion

According to the results of research conducted on assessing the strength of improved fabric, a theoretical method for determining fabric strength has been proposed. This method expresses the indicator that leads to sample breakage through the tensile force P and absolute elongation Δl , which represent the fabric's strength. As the distribution of tensile force along the ground warp yarns decreases, when the amount of internal forces acting on the cross-section of the yarns is equal to 0, the warp yarns are completely broken. If the tension of all ground warp yarns in the stretched sample is considered the same, then the degree of propagation of the influence of external forces decreases. The strength of the fabric and pile yarns increased due to the fact that the ground warp yarns bypass the two weft yarns separately.

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