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INVESTIGATION THE DYNAMICS OF CHANGE IN RELATIVE HUMIDITY IN TECHNOLOGICAL TRANSITIONS OF COTTON YARN AND FINISHED PRODUCTS: Parts I

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ANNOTATION

This article studies the influence of the dependence of the moisture content of materials on the mechanical and physical properties of textile materials, as well as the actual values of relative humidity in technological transitions. This dependence is the more significant, the higher the sorption capacity of fibers and threads. Therefore, it is necessary to carry out tests at normal material humidity, which is achieved by preliminary curing of the samples and carrying out the tests themselves in normal atmospheric conditions. The moisture content of textile materials is one of the important physical indicators affecting their mechanical properties, that in order to determine these indicators during scientific experiments, yarn was obtained from 100% cotton fiber in production and finished products are made from them - terry towels.

Key words: Sorption, adsorption, absorption, relative humidity, yarn moisture, technological process, mechanical properties of yarn, moisture moistening, moisture measurement, coefficients of variation in technological transitions.

Introduction. The ability of textile fibres and their products to absorb water vapor (sorption) and release them to the environment (desorption) characterizes their hygroscopic properties.

Sorption is a complex process in which moisture is retained by a sorbent due to intermolecular forces of interaction. It includes adsorption, absorption and capillary condensation.

Adsorption (surface sorption) is due to the presence of energy of the non-compensated forces of the intermolecular interaction, which hold moisture molecules on the surface of fibers, threads. The value of water vapours at adsorption depends on many factors: primarily the structure and properties of the fiber and yarn constituents, sorbent surface, pressure, temperature, relative humidity of the environment. Adsorption of moisture occurs rapidly and equilibrium is achieved in a fraction or a few seconds. Furthermore, the larger the sorbent surface, the higher the pressure and relative humidity of the environment and the lower the temperature, the higher the adsorption of moisture [2].

Then the moisture molecules penetrate (diffuse) into the fiber, called absorption. It flows slowly and reaches equilibrium in a long time (up to a few hours). The presence of unbalanced intermolecular forces inside the fibers or threads holds deep-penetrating moisture molecules; when desorption occurs, the reverse movement is also slow. Capillary condensation consists in the liquefaction of water vapours in the fiber capillary walls. It occurs when the capillary walls are wetted with water. As a result, vapours that have not yet reached saturation pressure relative to the flat surface become saturated or even saturated in relation to the liquid phase in the capillary. This process occurs at high relative humidity and can last for tens of minutes and even several hours.

In desorption, the equilibrium is established at higher moisture than at sorption. This phenomenon is called sorption equilibrium. It is associated with a change in the structure of the sorbent of the filament: an increase in the intermolecular distance, a change in the fibrils and microfibrille location and orientation. Reconstructing the structure before sorption is possible when the fibers (threads) are heated. The humidity of the yarn fibers corresponding to the sorption equilibrium is called equilibrium humidity. The equilibrium humidity of fibers and yarn depends not only on their structure and properties, but also on the temperature, pressure and relative humidity of the environment. When these conditions change, the equilibrium humidity of the fibers and the yarn changes.

When the relative humidity and temperature of the air change, the equilibrium humidity of the material changes. This can be judged by the equilibrium moisture curves of Wp fiber against relative air moisture φ at a constant temperature (25°C) called sorption is others. As the relative humidity of the air increases, the equilibrium humidity of the material increases.

The most important characteristics of the hygroscopy quality of textile towels are: humidity, hygroscopy, humidity, water absorption, water absorption, capillary capacity [3].

Humidity W, % is the percentage of the mass of water removed at a certain temperature to the mass of dry material

They distinguish between actual, equilibrium, conditioned (normalized), normal and maximum. The moisture of textiles is an important physical indicator affecting their mechanical properties, such as strength, rigidity, multi-cycle resistance, and friction, heat and electrical performance. As a result, they play a significant role in the optimization of their processing processes.

Material humidity refers to the degree to which they contain water vapour (capillary) and are mechanically held in their molecular structures. If its actual significance affects the operational parameters of the various technological transitions, and its normalized value (set by the standard) plays an important economic role in the settlement with suppliers and buyers.

On the basis of the above, we have decided to study the actual values of relative humidity in the process transitions, in the production of a yarn of 100% cotton in the manufacture and in the production of finished products - soaked towels

Methods.

Research was carried out in factories under production conditions, at the production of yarn Nm 20/1 (in the factory I.P. «MRT-textile»), Nm16/1 (in the factory of OOO Antex) and in windbreakers for household towels (in the factory of OOO «ART SOFT TEXTILE CLUSTER»).

The humidity of the raw materials, semi-finished products, yarn and finished products was measured on the GES HGM04 (Turkish production). The instrument makes it possible to measure the relative humidity in per cent of the measured objects with high precision [4].

Discussions. During yarn preparation in yarn and weaving, semi-finished products are influenced by the climatic conditions of the workshops, especially the humidity of the air. The moisture content of a material is the content of sorbed water vapour and mechanically held water in the liquid phase. The humidity depends on the ability of the material to absorb water vapour molecules from the environment, due to the chemical composition, the presence of hydrophilic atomic groups, as well as the supermolecular structure of the substance, the size of its internal surface and its accessibility to water vapour.

The strength of the fibers, threads and the product itself, as well as the degree of the wetted surface, determines the ability of the material to retain the mechanically captured water. The material humidity changes with the environmental parameters (temperature and air humidity) and depends on the background of the material, i.e. the material has been drier or wetter before it has been incorporated into the conditions.

The humidity of the material becomes equilibrium when, it acquires when the sorption processes are stabilized under these environmental conditions. Equilibrium humidity during drying (desorption process) is slightly higher than equilibrium humidity during humidification (sorption process).

Therefore, normal humidity is when the equilibrium humidity of a material is obtained by holding it under normal atmospheric conditions, i.e. at a temperature t = +20 C and relative humidity of the air W = 65% [5].

An analysis of the studies to be examined shows that the relative humidity of the cotton stored in boilers in the warehouses of both enterprises has similar values, i.e. 8.27% and 8.4%.

In subsequent technological transitions, the relative humidity value in semi-finished products gradually decreases to 5.08 per cent and 4.99 per cent in the yarn produced from motor machines. In order to bring the yarn humidity up to the normal values (7-8%), the yarn wrapped in a granny in the firing chambers shall be soaked to 11.63% and 11.86% of the ready yarn relative humidity, respectively.

After the moisturizing operation at the plant I.P.MT-Textile the process of forming finished products is carried out, within 8-10 hours in special rooms with normal climatic conditions, This results in a moisture content of 8.15 per cent before the finished product is packaged into the bag and then into the box. The results of the studies conducted in the cotton mills are shown in table -1.

Table -1 shows the average of 10 measurements and their coefficients of variation for the process transitions of 100% cotton yarn production in two cotton mills.

Table 1.

№	Technological transitions	I.P. «MRT-textile»		LLC «ANTEX-textile»	
		average %	Coeff. of variations%	average %	Coeff. of variations %
1	cotton in bales	8,27	1,978	8,44	2,44
2	bale in rate	8,19	7,85	8,34	0,58
3	scratch tape	7,68	2,096	8,04	0,858
4	drawing machine	7,61	1,8	7,57	2,78
5	Finisher machine	7,61	1,8	7,57	2,78
6	roving	6,34	1,52	5,97	5,8
7	Spinning yarn	5,16	1,872	5,09	3,2
8	yarn after winding machine	5,08	1,244	4,99	2,39
9	yarn after the steam chamber	11,63	6,1	11,86	3,18
10	packing yarn	8,15	1,84	11,86	3,18

In order to study the dynamics of the moisture content of the raw materials during weaving, the relative moisture content of the semi-finished and finished products was measured in the production of windy fabrics made of dyed yarn in the working conditions of the LLC weaving and finishing plant "ART SOFT TEXTILE CLUSTER". The average values of the 10 measurements and their coefficient of variation for technological transitions are given in table-2.

The analysis of the data obtained showed that the yarns received by the factories had a relative humidity of 11.72 per cent, which is slightly higher than the established standards. And the finished product has a relative humidity of 4.59%.

Table 2.

№	Technological transitions in the production of wafer fabrics from dyed yarn	Technological transitions in the production of wafer fabrics from dyed yarn	Coefficient of variations,
1	Yarn in the warehouse	11,72	1,32
2	Yarn after soft winding	8,5	3,62
3	Yarn after dye	163,82	11,76
4	Yarn after centrifuge	48,35	10,44
5	Yarn after radio frequency drying	7,14	0,06
6	Yarn after rewind	6,55	4,59
7	Dyed yarn in warehouse	6,32	0,052
8	Yarn in the frame	6,6	3,13
9	Buckle in a straight roller	6,83	4,85
10	Wool buckle loom	5,36	5,35
11	Finished products (Terry fabric)	4,59	5,7

Two groups of humidity determination methods, direct and indirect, shall be used in determining humidity.

Direct methods are those that measure the amount of moisture removed from the sample by drying, distillation, extraction and other methods.

Indirect are electrical methods of determination based on the dependence of omic resistance or dielectric constant material on its water content.

Considering the form of the moisture connection to the material, all natural and many chemical fibers of the textile materials under normal conditions (temperature T=20 +-2 C and relative air humidity W=65+-2%) are characterized by high humidity, which increases markedly with the relative humidity of the ambient air.

Fabrics, knitted and non-woven fabric, as well as other materials in the manufacture and use of sewing products, are constantly exposed to moisture vapour from the air and often from water treatment. When interacting with water, textiles, depending on the fibrous composition and structure, can absorb and retain more or less moisture. In such materials characterized by porous structure, the absorption of water is determined not only by the type, nature of the fibre and the equilibrium dissolution of the water in the polymer, but also, to a large extent, by the action of the unbalanced internal stresses in the material, Filling pores and capillaries with moisture in fibers, capillary absorption of moisture, capillary porous structure of the material.

According to the classification proposed by P.A. Rebinder and based on the energy of breaking the bonds and removing the moisture from the material, all the various forms of connection of moisture with the material are divided into three main groups: chemical, physic-chemical, and physic-mechanical.

Thus, the forms of the connections of water molecules to the material substantially affect the quantity and distribution of moisture in the structural elements of the materials, determine the basic physic-chemical properties of this moisture, and determine the characteristics of the phase transition of water-vapour at elevated temperatures. (water-ice at low temperatures).

In order to know in detail the effect of humidity on the mechanical properties of semi finished products (fibers and threads), we conducted tests of cotton yarn Ne 30/1 under the production conditions of OOO "FT-TEXTILE". We know that according to the standard cotton thread Ne 30, under normal atmospheric conditions the humidity is W=8%. On this basis, the cotton thread samples were conditioned under different atmospheric conditions, as for W1=4 per cent humidity and W10=13 per cent humidity. The incremental humidity change was 1%. After each storage of the cotton thread samples under certain conditions, reduced or elevated humidity temperature, tests according to GOST 3813-72. Textile materials [6]. Fabrics and pieces. Methods for determining tensile breaks where the Uster tenzajet-4 device was used to determine the mechanical properties of the cotton thread.

The test results are presented in Table 3. The CV table presents the calculation of coefficients of variation for each indicator.

Table 3.
Test result

№	Indicator name	Humidity temperature									
		4%	5%	6%	7%	8%	9%	10%	11%	12%	13%
	Breaking force Pp(cH)	245,3	243,5	243,7	235,0	229,5	242,8	249,7	260,8	236,6	245,4
	CV%	8,28	7,65	8,49	7,11	8,34	8,15	8,04	6,82	8,69	7,45
	Tensile elongation L0(per cent)	3,64	2,86	3,13	2,89	3,58	3,73	4,14	4,22	3,85	4,08
	CV%	9,29	10,39	9,67	10,06	8,68	10,86	8,86	8,28	9,98	8,83
	Relative breaking load δp(sH/tex)	12,71	12,62	12,63	12,17	11,89	12,58	12,94	13,51	12,26	12,71
	CV%	8,28	7,65	8,49	7,11	8,34	8,15	8,04	6,82	8,69	7,45
	Work of the gap Rp(sH*mm)	257,7	203,3	224,3	196,9	240,2	265,6	300,8	318,2	264,0	289,2
	CV%	15,31	17,13	16,48	16,60	14,79	17,47	15,35	14,26	16,51	15,21

The results were also presented as a graph.

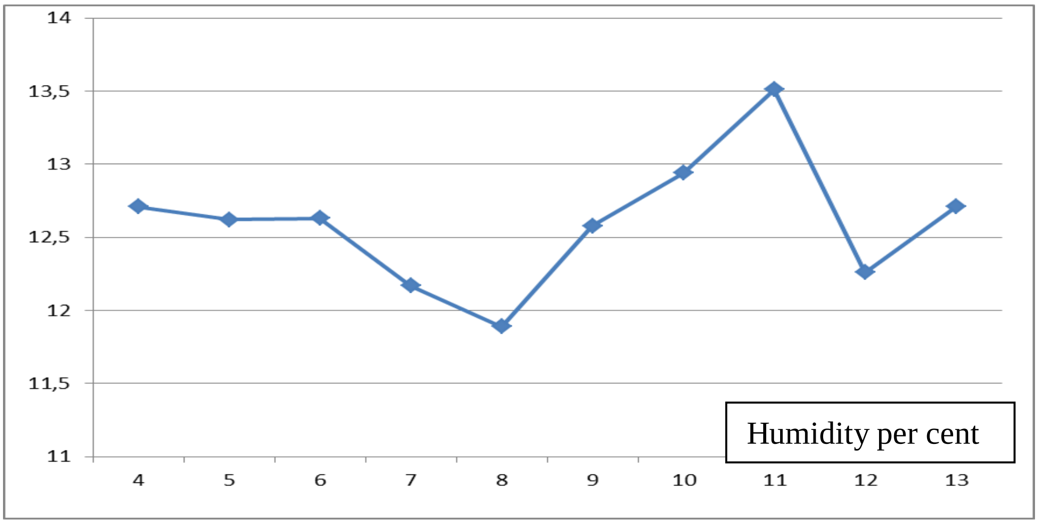

Figure-1. Variation of the relative tensile load of the yarn (Rkm) according to the variation in humidity.

The graph in Figure 1 shows that the cotton yarn number Ne 30/1 is more robust when the air humidity is W=11 per cent (δp=13.51 (cH/tex), which is higher than the humidity W=8 per cent(δp=11.89 cN/tex). But as a consequence of increased air humidity, the strength of the thread decreases δp=12.26 cN/tex and δp=12.71 cN/tex, but all remain higher than when the humidity is W=8% (δp=11.89 cN/tex).

It is also evident from the graph that the strength of the cotton thread changes more from the strength of the taken with air humidity W=8 per cent(δp=11.89 cN/tex). As in the case of low or high humidity, the strength of the cotton yarn is high.

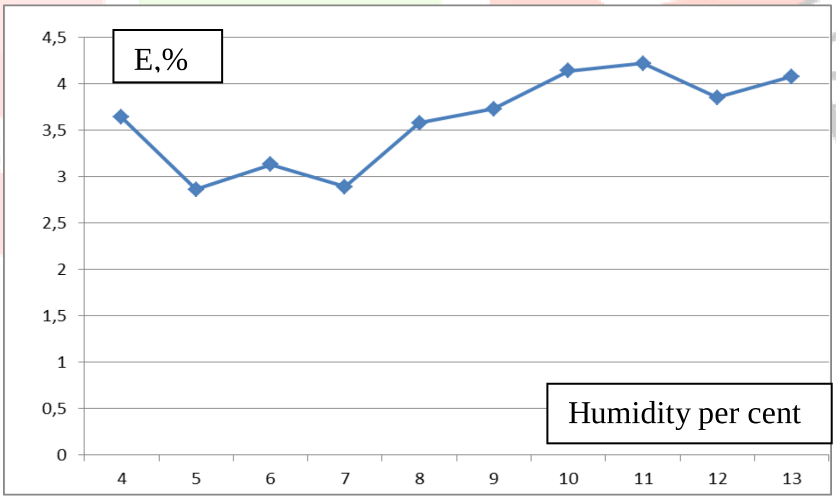

Figure-2. Variation of tensile Elongation (E) of the yarn according to from the humidity change.

Figure 2 shows that the cotton yarn with the number Ne 30/1 has a more relative elongation at the humidity W=11% (L0=4.22%) than the elongation at the humidity W=8% (L0=3.58%). And as a consequence of increased air humidity, the relative elongation of the filament decreases L0=3.85% and L0=4.08%, but still remains higher than when the humidity is W=8 per cent (L0=3.58%).

Here, it is also evident that all elongation rates except the humidity of W=5% (L0=2.86%) remain higher than the elongation of W=8% (L0=3.58%).

CONCLUSIONS:

1. Given the important influence of the relative humidity of raw materials on the course of the technological process, it is necessary to establish their normative values for technological transitions in the production of both yarn and finished products.

2. Relative humidity must be taken into account in economic relationships with suppliers of raw materials and buyers of finished products.

3. When calculating the cost of the yarn and the finished product thereof, the loss of physical weight of the fibres and the yarn due to the difference in relative humidity of the raw materials and finished products must be taken into account.

It should therefore be borne in mind that the material's moisture strongly affects its mechanical and physical properties - strength, rigidity, resistance to multiple mechanical effects, friction, heat, electrical and other properties. Therefore, all tests of textile materials, especially hydrophilic ones, have to be carried out under normal material humidity, which is achieved by the preconditioning of the samples and the tests themselves under normal atmospheric conditions.

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