Physical and chemical properties of yarn sized with a composition based on starch, PVA and HYPAN

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Abstract. This article deals with the development of a new composition of a polymer composition for dressing cotton yarn. The optimal concentration of the dressing polymer composition, which is 50 g/kg, against the starch-based dressing is 70 g/kg, i.e., the consumption of starch is reduced by 25-30%. It is experimentally established that the concentration of the dressing, which has a significant impact on the cost of the dressing, varies within 45-50 g/kg of the composition, while the true glue remained at the same level.
Keywords: Polymer, composition, dressing, cotton fabric, yarn, preparation, breakage, adsorption, glue, polyvinyl alcohol, starch, humidity.

1 Introduction

The development of chemistry and chemical technology in the textile industry is accompanied by the replacement of food starch, which is used as a sizing agent. The share of starch and its derivatives used in various stages of the textile industry reaches up to 70-75%, and only 25-30% are synthetic water-soluble polymers [1-4].

To date, synthetic materials have been obtained, for example, preparations from synthetic homo- and copolymers, which allow sizing without the use of food products. But these drugs are expensive, difficult to access and do not have multifunctionality with respect to fibers of various chemical structures, are difficult to wash out of the surface of the fabric, the consumption of preparations for desizing increases sharply, and the time for desizing the fabric increases accordingly, in addition, it should be noted that when sizing only with synthetic polymers in the process of drying the yarn after sizing, the yarn sticks to each other, which is the main negative phenomenon of the process, which makes it difficult to carry out efficient processing of yarn on high-performance weaving equipment [5–7].

Therefore, in order to reduce the consumption of food starch, the search for and development of technologies and methods for treating yarn with preparations from water-soluble polymers based on starch, polyvinyl alcohol (PVA) and hydrolyzed polyacrylonitrile (HYPAN) is very relevant, especially since there are practically no scientific studies on this problem and it is little-studied. The issue of creating sizing preparations for cotton yarn using starch, their combination with some water-soluble synthetic polymers, the introduction of

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special textile excipients (TEA) into their composition are reflected only in minor works [8-14].

In this regard, the purpose of this work is the development and physical and chemical justification of the technology for sizing cotton yarn using PVA and HYPAN as sizing agents in order to reduce the consumption of valuable food starch.

2 Experimental

We used rice starch (Uzbekistan), polyvinyl alcohol, hydrolyzed polyacrylonitrile (Russia), the physicochemical properties of which are described in [15, 16].

The breaking load was determined by the single strand method. The elongation at break was determined simultaneously with the breaking load. The strength of a single yarn was tested on a tensile testing machine RM-30 for a single thread. The relative strength or relative breaking load of single threads, which is characterized by the breaking load passing per unit of linear density, was calculated by the formula:

$$P_0 = \frac{P_p}{T}$$

Where, P_P is the breaking load in tension (cH)

T-linear density of yarn (tex.).

It should be noted that during sizing of yarn, complex physicochemical processes occur between the sizing and yarn fibers, which are predetermined by the chemical nature and supramolecular structure of the sizing preparation and the state of the surface of the thread. The influence of these factors, in part, can be described by studying the adsorption of size by yarn fibers, the results of which are shown in Fig.1.

From fig. I (curve I) it can be seen that this is the adsorption isotherm on a hydrophobic surface, which is characteristic of monomolecular Langmuir adsorption. The isotherm for the hydrophobic surface (curve 2) resembles the S-shaped polymolecular adsorption curve of Polanyi and BET. The binding of the adsorbent does not stop after the formation of a monomolecular layer, but continues further [17–18].

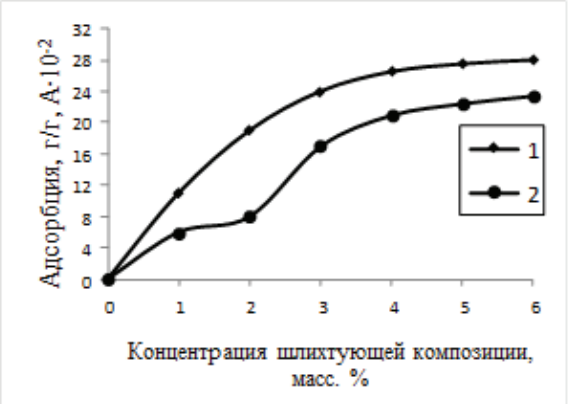

Fig.1. Adsorption isotherms of the composition from aqueous solutions at 25°C; 1- cotton fabric; 2-blended fabric based on cotton and nitrone fibers.

Nevertheless, adsorption on a hydrophobic surface turned out to be greater than on a hydrophilic one. Apparently, the main role in the process of adsorption of the composition

by the fiber is played not by functional groups, but by the main carbon chain, which causes higher adsorption on the cotton fabric than on the blended fabric.

As can be seen from Fig. 1, the rate of the adsorption process of the composition on cotton yarn depends on the physicochemical properties of the sizing agent, fiber, and process parameters. It has been experimentally established that PVA and HYPAN, like starch, have fairly good film-forming properties, so their combination with starch as a sizing agent is fully justified. Adhesive compositions based on starch, PVA and HYPAN do not lose their adhesive ability for a long time, i.e., are kinetically stable systems. They can be used in water of any hardness in a wide range of pH 7-8.

The calculation of the metrological characteristics of the presented methods was carried out in accordance with [19].

3 Results and discussion

It should be noted that with the physicochemical parameters of the dressing preparation process, interaction between polymer groups and the reactive groups of PVA and HYPAN is possible. The products formed as a result of this interaction contain, in particular, amide -CONH-, urea, -NHCONH-, carbamate -OCONH$_2$, ester -OCO- and other groups. Their presence in the macromolecules of the polymer composition makes it possible to improve the elastic, structural and mechanical properties, to reduce the electronegativity of the adhesive film formed on the yarn during sizing [20–23].

An important factor for the sizing of cotton yarn is the drying of the yarn after sizing. Therefore, in order to establish the temperature and time parameters for drying the sized yarn, as well as to determine the speed of movement of the warp during sizing, the kinetics of drying the yarn treated with the compositions was studied (Table 1).

Table 1. Kinetic parameters of the drying process of yarn sized with a composition based on starch, PVA and HYPAN at a ratio of 1:0.05:0.01, respectively.

	Developed sizing composition			**Dressing factory based on starch**
	Drying temperature. °C			
	85	90	95	90
Humidity base. %	58	54	59	43
True glue. %	7	6	6	7
Time of the second drying period. min.	12	10	9	14
Drying speed. m/s	0.5	0.8	0.8	0.5
Total drying time	22	10	10	24

Based on the study of the kinetic parameters of the sizing process, the concentrations of the components that make up the sizing composition, which are presented in Table 2, were determined by the developed compositions. As can be seen from the table, the amount of sizing polymer composition is 50 g/kg, against sizing based on starch - 70 g/kg, i.e. starch consumption is reduced by 25-30%.

It was revealed that the drying rate is predetermined by the chemical nature of the preparation, the fibrous composition of the yarn, the time and temperature regimes of drying. The ability to lose moisture of yarn treated with various sizing agents mainly depends on the type of composition. The relatively low ability to retain water molecules is explained by the presence of hydrophobic cycles in PVA and HYPAN macromolecules.

Table 2. Optimal technological parameters for the preparation of sizing based on the developed composition.

Dressing components	The content of adhesive components. g/l				Starch dressing
	Type of yarn				
	Cotton yarn number				
	34	40/1	40/2	54	
Polyvinyl alcohol. g/kg	3.0	2.0	3.5	3.5	-
Hydrolyzed polyacrylonitrile. g/kg	2.0	2.0	2.5	2.5	-
Starch. g/kg	45	50	50	50	70
Gelatinization temperature. °C	85-90	85-90	85-90	85-90	90-100
Gelatinization time. min	20-25	20-25	15-20	15-20	30-35

From the data obtained, it should be noted that the specific breaking load is one of the main physical and mechanical indicators of cotton yarn. For yarn sized with the proposed composition, the breaking load is 13-15% higher than in the traditional case, with the same coefficient of variation.

Below are comparative results of cotton yarn sizing with a composition based on the developed composition with data on yarn sizing with starch in the conditions of the "Naqsh Oydin" LLC enterprise (Table 3).

Table 3. Physical and mechanical properties of yarn treated with dressing obtained with optimal preparation parameters.

Indicators	Unit rev.	Designed dressing		Factory dressing. starch
		Cotton yarn number		
		34	40/1	34
Viscosity. solution flow time	sek	6	7	7
true glue	%	23-25	19-21	10-12
Relative increase in strength	%	18-20	17-19	13-15
Yarn elongation at break	%	7-8	6-7	9-11
Yarn Moisture	%	10-12	10-11	10-15
Coefficient of variation: breaking load	%	90-100	90-100	90-100
Adhesion to yarn	kg/sm	0.8-1.2	1.0-1.4	0.7-1.2
Wear factor	%	06.-1.2	0.5-0.9	0.8-1.4
breakage	arr/m	0.31	0.37	0.61

As can be seen from Table 3, the dressing concentration, which has a significant impact on the cost of the dressing, ranges from 45-50 g/kg of the composition, against 70 g/kg of starch dressing, although the true glue remained at the same level. According to the results of the experiment, it was found that in the case of sizing of cotton yarn with the developed sizing compositions, a significant reduction in starch is achieved, i.e. by 25-30%, which is economically and environmentally about the feasibility of using the developed composition.

4 Conclusions

Thus, it is shown that the viscosity of aqueous solutions, depending on the concentration, temperature and pH of the solution medium of the sizing composition, is described by a first-order equation. It is approximately 2-3 times lower than sizing preparations from starch dressing. The use of preparations from the developed composition of the sizing composition

makes it possible to increase the speed and degree of impregnation of the yarn during the sizing process, which increases the mechanical fixation of the adhesive film on the fiber and has a positive effect on weaving.

It was found that cotton yarn treated with polymeric compositions can be processed on looms of various types, while reducing the breakage by 35-40% and increasing the productivity of the machine by 5-10% compared to yarn sized with starch dressing.

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