Original Article

# Physical And Mechanical Indicators Of Yarn Sized With Water-Soluble Polymer Compositions

**R. A. Ismatova, M. R. Amonov**
Bukhara State University
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## Abstract

The change in the viscosity of starch and polymer sizing compositions depending on the cooking temperature was studied. A change in the temperature of gelatinization and the achievement of the maximum viscosity of the starch and the developed composition were revealed. It has been established that the breaking load and elongation of the sized yarn mainly depend on the type of dressing.

**Keywords:** Dressing, yarn, polymer, composition, breakage, breaking load, breaking elongation, starch, polyvinyl alcohol, hydrolyzed polyacrylonitrile.

## INTRODUCTION

Sizing is a complex process that involves the interaction between the yarn and the components of the sizing solution. As a result, with the constancy of temperature-time significant parameters, not only the quality of the dressing is determined, but also the surface-adhesive properties of the yarn after sizing are determined.

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Since the sizing of yarn is the main important and necessary step in the refinement of cotton fibers and yarn based on them. Existing chemical reagents that are used as a sizing ingredient must meet a set of requirements, however, as can be seen from practice, none of the numerous sizing preparations based on natural and synthetic water-soluble polymers fully meets these requirements [1-5].

In this regard, it is possible to study and develop the composition and technologies for obtaining highly effective multicomponent sizing compositions when combined with polymers of natural and synthetic components. As a natural polymer, starch and its derivatives can be recommended, and as a synthetic polymer PVA and GIPAN, the combination of these components allows you to change or adjust the physico-chemical properties of the dressing, as a result of which, firstly, negative phenomena are eliminated during the preparation of dressing and yarn sizing , secondly, it ensures a high-quality sizing process.

Currently, starch is mainly used as a sizing agent in production, the share of which is about 75%. However, starch is a valuable food product, and in addition, the elastic properties of starch hydrogels, due to the presence of an amylose fraction in the composition, contribute to rapid elastic deformation and the presence of amylopectin fraction in the composition of starch, which helps to provide highly elastic properties, i.e. slow elastic deformation. In this regard, to give them plasticity, it is necessary to introduce plasticizers, or water-soluble synthetic polymers.

Based on the above, this article discusses the issue of creating a highly effective sizing composition based on starch, PVA and GIPAN. The role of PVA and GIPAN in the composition of the sizing composition is as follows: a reduction in food starch by 20-25%, a dynamic tensile strength, an increase in the fluidity of the sizing composition, a strong elastic film formed during drying on the surface of the yarn in drying drums. In the case of starch hydrogels, the strength of the sizing films is not enough, due to which its shedding increases, and this, in turn, leads to an increase in the breakage of the sized yarn on the loom.

It should be noted that, in the process of sizing, the yarn is glued with polymer compositions, due to which a significant change in the mechanical properties of the yarn is observed; namely: as a result of gluing (up to 5-7%), the mass of sized yarn increases significantly; a polymer composition that has an increased adhesive ability, gluing of individual intervening fibers occurs, and this, in turn, contributes to an increase in the strength of the yarn and, at the same time, a decrease in elongation is observed in relation to soft yarn.

It is important to note that during starch clustering, alkali not only plays the role of a catalyst for the polysaccharide cleavage reaction, but also stimulates the swelling of starch grains. When starch swells, the viscosity of the gel increases, and when depolymerization, it decreases. In this regard, the result is determined by which action is shown more powerfully. From the developed composition, it is noticeable that there are no swollen starch granules in the finished polymer sizing compositions, and the starch itself is significantly split.

In order to confirm this theoretical conclusion, it was checked how the viscosity of starch and developed polymer sizing compositions changes during their preparation and what happens to starch grains. The experiment was carried out in such a way that during the cooking of starch gels, samples were periodically taken, and at the same time, the temperature and time of outflow from the capillary were measured, i.e. the viscosity of the starch hydrogel and the polymer composition developed by us, making observations under a microscope.

The nature of the change in the viscosity of the sizing composition is shown in fig. 1. As can be seen from the figure, the introduction of PVA in an amount of 0.4% into a 4% starch composition leads, first of all, to a 5-fold decrease in the maximum time of the composition expiration from the capillary, that is, it repeatedly reduces the swelling of starch granules. In addition, the gelatinization initiation temperature and the maximum gel viscosity temperature are also significantly reduced. So, for example (Fig. 2.), if in a starch gel of a traditional composition the increase in viscosity begins at 71°C and ends at 85°C, then in the developed sizing compositions based on starch and PVA, respectively, at 56°C and 66 °C.

As can be seen from the data obtained, in ordinary starch compositions at 343–353 K, the swelling of starch grains is mainly observed, and their destruction becomes significantly noticeable only at 358 K. for 30 minutes) of cooking, swollen starch granules still remain in the composition of the dressing.

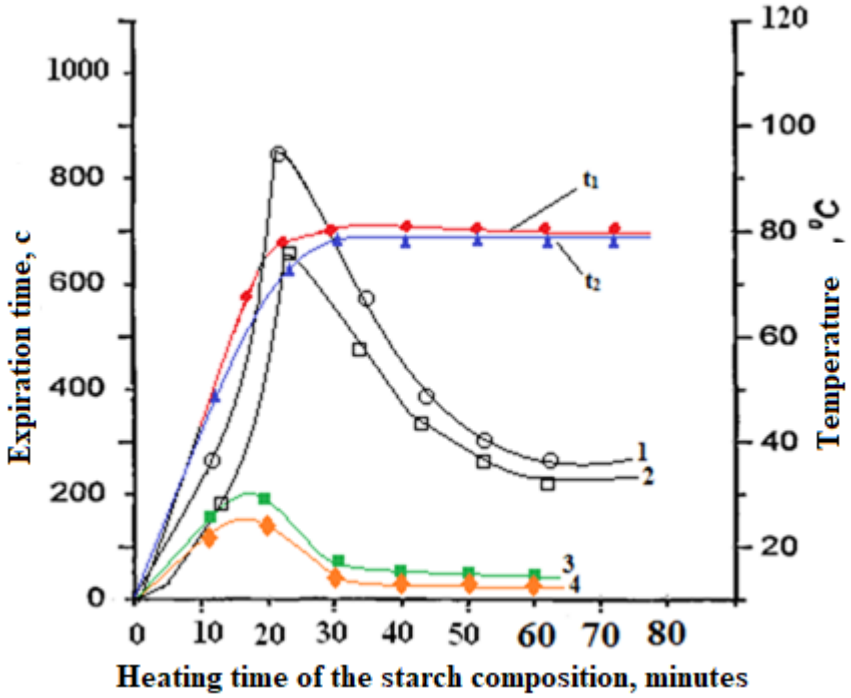


Figure 1. Change in the viscosity of starch (1, 2) and polymer sizing compositions (3, 4) on the cooking temperature.

Component concentration: starch — 1-4%; 2-5%; sodium hydroxide — 0,1%; modifiers, % by weight of starch: 3- PVA – 0,4; 4- PVA -0,2, PAA -0,5 and sericin -0,2.

It is known that from a practical point of view, a significant circumstance is that in order to obtain a hydrogel of a given viscosity according to existing methods, it is mainly necessary to cook it for a long time, i.e. approximately 50-60 minutes after reaching the boiling point. This achieves high quality and relative stability of the properties of the sizing gel, which ensures the invariability of the sizing process. As one would expect when preparing only starch gel (curve 1 in Fig. 1.), the viscosity always decreases monotonically, therefore it is difficult to obtain a good reliability of the result. When PVA is introduced into a starch hydrogel, a hydrogel with a constant viscosity can be prepared relatively quickly, which does not change either during further cooking or during storage. Moreover, the cooking time of the developed sizing composition is no more than 30 minutes at the boiling temperature.

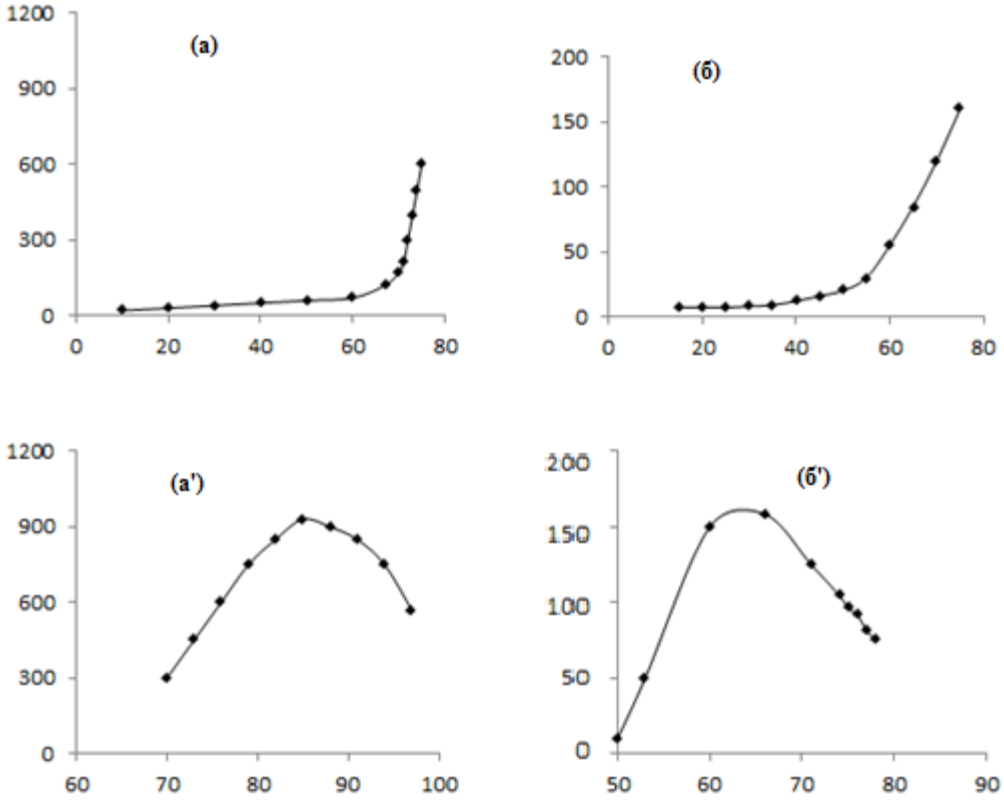


Figure 2. The dependence of the change in gelatinization temperature (a, b) and the achievement of maximum viscosity (a, b) starch (a, a ') and the developed composition (b; b ').

The total cooking time, taking into account the time required to stabilize the viscosity, in the case of standard sizing compositions is 60-70 minutes, while in the case of the developed one it is 20-25 minutes. And this, in turn, leads to the achievement of savings in steam and electricity consumed for the needs of the process of preparing the developed compositions for sizing cotton bases.

According to theoretical concepts [6-7] and the results of experimental data, when sizing cotton yarn, the yarn strength increases up to 20-25%, and the breaking elongation of the yarn decreases to 25-30%. During the weaving process, the yarn undergoes various mechanical stresses. In this regard, in order for the sized yarn to resist mechanical stress due to the elasticity of the polymer coatings of the films, the sized yarn must be smooth, resist abrasion, have the necessary moisture, which increases the elasticity of the polymer films and must reach a certain percentage of adhesion. In addition, in the process of yarn sizing, the nature of the constituent components of the incoming sizing compositions as an adhesive agent also affects.

In table. 1 shows the physical and mechanical properties of cotton yarn sizing developed polymer compositions based on starch, polyvinyl alcohol and hydrolyzed polyacrylonitrile at a ratio of 5.0:1.5. From the obtained data it follows that in the case of starch dressing, the burst the load averaged 306.5 cN, which is 16.2% lower than the breaking load of the yarn sized with the developed sizing compositions. The breakage of cotton yarn on a loom is significantly lower than that of a warp sized with starch dressing (cf. 0.37), i.e. breakage is almost 1.5 times less, which contributes to an increase in production productivity.

Table 1 Breaking load indicators and elongation of sized yarn depending on the type of dressing

| P / n | Breaking load of sized yarn, size based on starch,P (cH) | Breakage (arr / meter) | Breaking elongation of sized yarn | | Breaking load of sized yarn sizing based on polymer composition, P (cH) | Breakage (rev / meter) | Breaking elongation of sized yarn | |
|---|---|---|---|---|---|---|---|---|
| | | | % | mm | | | % | mm |
| 1 | 306 | 0,35 | 5,4 | 94 | 368 | 0,23 | 4,2 | 84 |
| 2 | 313 | 0,32 | 4,3 | 98 | 376 | 0,21 | 4,4 | 88 |
| 3 | 309 | 0,34 | 5,0 | 92 | 357 | 0,26 | 4,5 | 90 |
| 4 | 312 | 0,32 | 4,8 | 108 | 378 | 0,19 | 4,3 | 86 |
| 5 | 296 | 0,47 | 5,6 | 104 | 361 | 0,24 | 4,8 | 96 |
| 6 | 308 | 0,34 | 5,1 | 96 | 356 | 0,26 | 4,7 | 94 |
| 7 | 314 | 0,32 | 4,1 | 112 | 372 | 0,20 | 5,2 | 104 |
| 8 | 294 | 0,48 | 5,8 | 116 | 358 | 0,25 | 5,0 | 100 |
| | average 306,5 | 0,37 | 5,13 | 102,5 | average 365,8 | 0,24 | 4,64 | 92,8 |

The results of experimental data obtained in laboratory and production conditions make it possible to use the developed sizing compositions on an industrial scale, the advantages of which are to reduce the consumption of food starch by 25-30%, reduce the breakage of yarn on a loom by 1.5 times less than starch, due to which labor productivity rises.

Table 2 Production indicators of dressing preparation

| Indicator | Industrial dressing | | Sizing based on the developed polymer composition |
|---|---|---|---|
| | based on native starch | based on KMC | |
| Amount of sizing agent in solution, % | 7,0 | 6,0 | 5,0 |
| Splitter quantity, g/kg | 0,2 | 0,1 | 0,1 |
| Dressing temperature in the vat, $^0$C | 90 | 85 | 85 |
| Mixer rotation speed, rpm | 45 | 40 | 40 |
| Slurry boiling time | 40 | 30 | 30 |
| Dressing flow time, sec | 24 | 25 | 26 |
| Cleavage degree, % | 80 | 85 | 95 |
| Dressing temperature in the trough, $^0$C | 85 | 85 | 80 |
| Yield strength, g/cm$^2$ | 38,3 | 37,5 | 37,2 |
| Degree of thixotropic dressing reduction, % | 87,0 | 92,0 | 98,0 |
| Pressing pressure of squeezing shafts, atm. | 0,5 | 0,5 | 0,5 |
| Glue, % | 6,5 | 6,3 | 5,4 |

In table 2 shows technological indicators, preparation of sizing and sizing of cotton yarn with the developed compositions. To compare the indicators, we took dressings currently used at the enterprise LLC Sevinch tex service and Naksh oydin in Bukhara.

From the obtained data it follows that the dressing based on the proposed composition is superior in all respects than dressing from native starch or dressing based on carboxytilyl starch (CMC). So, for example, the consumption of dressing material instead of 70 kg/1000 l decreased to 50 kg/1000 l, the degree of splitting increases to 95%, the adhesive is 5.4%, which corresponds to the norms.

Thus, the results of the analysis of the technological parameters of the yarn sizing process with the developed polymer compositions (Table 2) indicate that the sizing yarn is quite strong compared to the factory ones.

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