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EFFECT OF SIZING, WEAVING, AND ABRASION ON THE PHYSICAL PROPERTIES OF COTTON YARN¹

By Walter T. Schreiber, Martin N. V. Geib, and Omar C. Moore

ABSTRACT

A method was developed for determining the effects of the amount and quality of sizing on the physical properties of cotton warp yarns and on their performance during weaving and abrasion tests. The strength, elongation under a 35-gram load and at rupture, and the permanent set under a load of 35 gram were measured on yarns before and after sizing them with white-potato starch; after weaving and removal from the cloth; and before and after abrasion in a laboratory apparatus simulating the effects of a loom. The experimental results show that the sized yarns have greater strength, less elongation, lower permanent set, and are more uniform in their physical properties, and possess better weaving qualities than unsized yarns. A simple mill method for the testing and control of sized yarns, based on these results, is suggested.

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I. INTRODUCTION

Sizing cotton warp yarns with starch is an important process used as standard practice in the textile industry. There appears to be little published information on the effect of the sizing on the physical properties of the yarn and on the performance of the yarn in the weaving operation. A quantitative knowledge of these effects is necessary if one wishes to study the possibility of using other sizing materials, as, for example, starch manufactured from sweet potatoes, which is of interest in connection with the industrial utilization of farm products.^{2,3,4} Accordingly, the National Bureau of Standards, in cooperation with the Alabama Polytechnic Institute, has investigated the effect of sizing cotton yarn with the white-potato starch commonly used for this purpose.

¹ This study was carried out in the laboratories of and in cooperation with the Alabama Polytechnic Institute, Auburn, Ala.

² Balch and Paine. *Production of starch from sweet potatoes*. *Ind. Eng. Chem.* **23**, 1205 (1931).

³ Weber, Shaw, and O'Leary. *Quality of Sweet-Potato Starch for Beater Sizing of Paper*. Misc. Pub. BS 150 (June 1935).

⁴ Schreiber, Geib, and Moore. *Consistency of potato starch size*. BS J. Research **11**, 765 (1933), RP623.

II. EXPERIMENTAL WORK

1. PRELIMINARY EXPERIMENTS

Four spools of 20s cotton warp yarns were prepared containing different percentages of white-potato starch. Sixty ends from each spool were laid side by side and tied into the center of a warp beam. Before entering the loom, the yarns passed through the lingoes of a small jacquard harness frame to make sure that each yarn was under the same tension when weaving began. The number of yarns in 60 ends which broke in weaving 5 yards is shown in table 1.

TABLE 1.—*Number of yarns in 60 ends which broke in weaving 5 yards of fabric*

Amount of starch in yarns	Number of broken yarns	
	First run	Second run
<i>Percent</i>		
7.85	0	1
6.75	0	0
4.93	1	0
0	5	6

By means of a pair of clamps and a Jolly balance, an attempt was made to measure the tautness of each yarn before and after weaving. The results were not conclusive.

There were great differences in the elongation and other properties of different samples from the same skein of unsized yarn, and there was some indication that the differences were increased by weaving. On the other hand, the weaving appeared to have little effect on the sized yarn, whose properties were more uniform.

2. EFFECT OF WEAVING ON THE PHYSICAL PROPERTIES OF COTTON WARP STRANDS

An experimental yarn sheet of 20s cotton warp yarns was sized so that it contained 9.75 percent of white-potato starch. This yarn was threaded through a dobby loom as a part of the warp. The loom had been set up to make a fabric having 45 ends and 23 picks per inch. The lingoe arrangement previously described was used to bring all the warp yarns under the same initial tension before the weaving was begun. After weaving, the fabric was split along the warp and the warp yarns unravelled for test.

All of the physical tests were made on 50 specimens of yarn conditioned at 65-percent relative humidity and 70° F.

The breaking strength and elongation at rupture were measured with a single-strand tester, the jaws being 18 inches apart at the beginning of the test. The speed of the pulling jaw was 12 inches per minute.

The elongation and permanent set caused by a load of 35 g were measured with the apparatus shown in figure 1. A loop is made at one end of the specimen, 6, to which is attached a pointer, 2, weighing 8 g. The specimen passes over the pulley, 4, and is fastened to the base by the clamp, 5, in such a position that the free length is 36 inches under the tension of 8 g produced by the weight of the

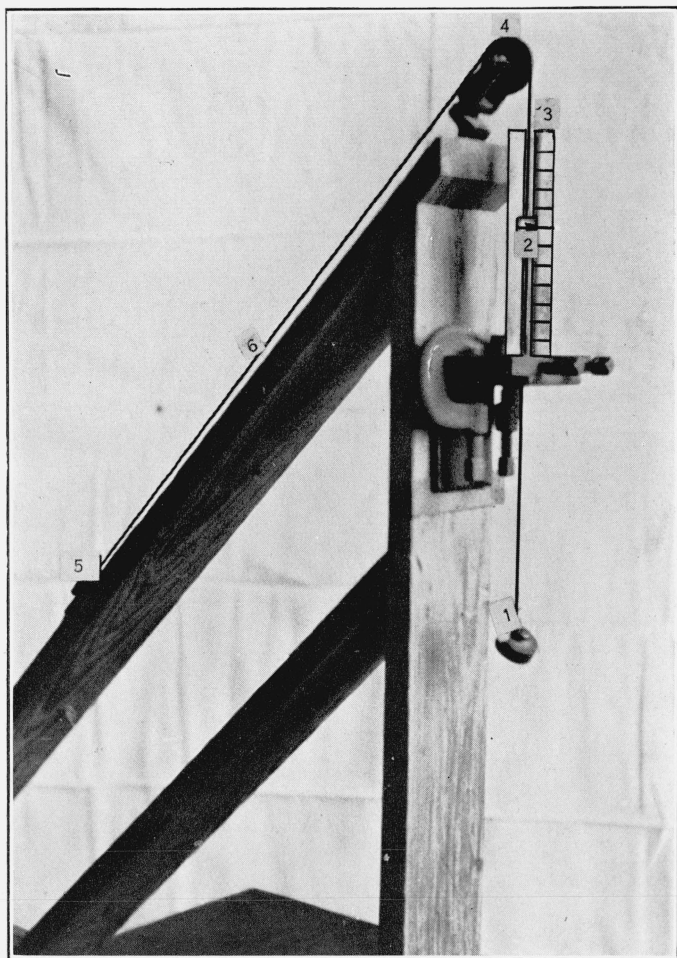


FIGURE 1.—*Apparatus for measuring elongation and set of yarns.*

1, Weight; 2, pointer; 3, scale; 4, pulley; 5, clamp for holding specimen; and 6, specimen of yarn.

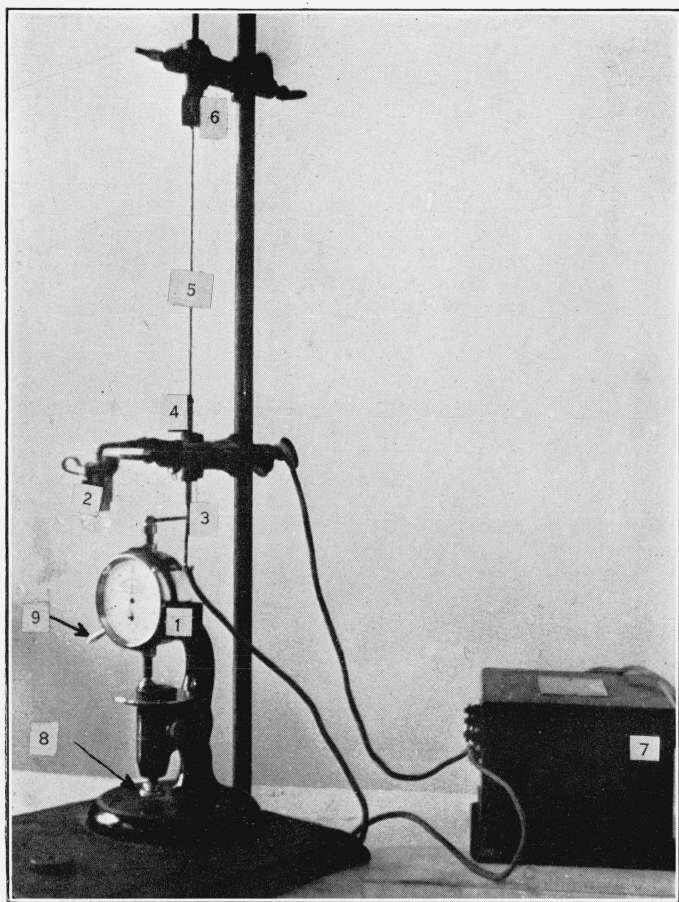


FIGURE 2.—*Apparatus for measuring length of yarns.*

- 1 Dial micrometer; 2, incandescent electric light to indicate contact between 3 and 4; 3, contact on upper end of plunger of dial micrometer; 4, contact affixed to specimen; 5, yarn specimen; 6, upper hook, in actual use 36 inches above contact 4; 7, transformer; 8, screw for zero adjustment of dial micrometer; and 9, micrometer dial lever.

pointer. The pointer moves over the scale, 3. Readings are made (a) under the load of the pointer only (8 g); (b) 30 seconds after the addition of a weight, 1, of 27 g; and (c) 30 seconds after the removal of the 27-g weight. The difference between readings (a) and (b) is called the "elongation at 35-g load" and the difference between readings (a) and (c) the "set at 35-g load."

The change in length caused by weaving was measured by the apparatus shown in figure 2. A dial micrometer, 1, with a working range of 0.5 inch is held in a clamp stand with the lower end of its plunger resting on the zero adjustment screw, 8, and the upper end carrying a metal contact, 3. The specimen carries a brass strip, 4, which serves as a second contact. When the contact, 3, just touches the contact, 4, an electric circuit is completed through the transformer, 7, as indicated by the incandescent electric light, 2. The apparatus is prepared for measurement as follows: A piece of wire exactly 36 inches long is suspended from the hook, 6, and the brass contact strip, 4, weighing 8 g, is attached to its lower end. A suitable thickness gage is placed under the plunger to make the micrometer dial read 0.250 inch, and sufficient shims are inserted under the micrometer base to make contacts 3 and 4 barely touch and complete the electric current through the electric light 2. The 0.250-inch thickness gage is then removed. The wire is then taken out and the warp yarn with the end loops is inserted in place of the wire. By moving the dial lever, 9, to bring 3 and 4 into contact, the difference between the over-all length of the yarn and 36 inches can be read directly from the dial, provided this difference does not exceed 0.250 inch. In preparing the specimen for this test care must be taken to prevent untwisting the yarn during handling and measuring.

Each of 50 specimens was provided with end loops, measured, and tied into a warp sheet in such a way that about 11 inches of the specimen was included in the fabric, without permitting the loop on either end to get into the loom. After the weaving the fabric was unravelled, and the specimen removed and retested. The data from these experiments are shown in table 2, only averages of the 50 specimens and average deviations being given.

Table 2 results show that the sized yarn had greater strength, lower elongation at rupture and at a 35-g load, and lower set at 35-g load, than the unsized yarn. Weaving caused a decrease in strength, but it had little effect on set or elongation for both sized and unsized yarn. It produced a considerable increase in length of the unsized yarn, whereas the length of the sized yarn was not affected.

TABLE 2.—*Effect of weaving on properties of yarns*

Sizing	Weaving	At rupture				At 35-g load				Length increase due to weaving	
		Breaking strength		Elongation		Elongation		Set			
		Average	AD ¹	Average	AD	Average	AD	Average	AD	Average	AD
Sized ² -----	Before-----	oz. 17.0	1.3	% 4.3	0.4	% 0.42	0.02	% 0.14	0.01	%	-----
Do-----	After-----	15.8	1.7	3.9	.4	.33	.02	.08	.02	0.05	0.02
Unsized-----	Before-----	13.3	1.5	6.0	.7	.90	.06	.25	.04	-----	-----
Do-----	After-----	9.5	1.4	6.1	.6	.98	.07	.36	.05	.78	.21

¹ AD is average deviation.² Sized yarns contained 9.75 percent of white-potato starch.

3. EFFECT OF ABRASION ON THE YARNS

(a) ABRADING MACHINE

Since the actual weaving of experimental yarns is a laborious process, and tying them into the warp and ravelling them out of the fabric may cause unintentional changes in the yarns, an effort was made to develop a laboratory device which would simulate the action of the loom. Although it is not known whether the principal effect of the loom is to stretch the yarn by repeated tensile forces or actually to remove part of the yarn by abrasion, the simulating device shown in figure 3 is designated for convenience an "abrading machine."

(b) SPECIMENS OF YARNS

The specimens for this machine were identical with those used for the length-measurement apparatus, i. e., yarns with loops at each end and 36 inches in over-all length. A 20-g weight, 1, is hung on the loop at one end of each specimen. The specimens run through heddle eyes, 3, over a smooth-glass guide bar, 4, to a bar, 5, which is caused to travel in a cylindrical path by the driving mechanism, 6. The result of the motion of the bar, 5, is to pull the yarn back and forth through the heddle eye with a stroke or travel of $11\frac{1}{2}$ inches.

(c) RESULTS OF TESTS

Of 100 similar specimens, 50 were tested for breaking strength and elongation at rupture (thus destroying these specimens) and 50 were measured for length and elongation and set at 35-g as previously described. These latter specimens were then placed in the abrading machine for a definite number of strokes, and the physical properties redetermined. The results shown in table 3 indicate that the abrading machine produces the same qualitative effect as the loom, i. e., a decrease in strength but little change in elongation or set for both sized and unsized yarn, and considerable increase in length for unsized yarn, but little increase in length for sized yarn.

TABLE 3.—*Effect of abrading machine on properties¹ of yarns*

Sizing	Abrasion	At rupture				At 35-g load				Length increase	
		Breaking strength		Elongation		Elongation		Set			
		Average	AD ²	Average	AD	Average	AD	Average	AD		
Sized.....	None.....	oz 17.0	1.3	% 4.3	0.4	% 0.42	0.02	% 0.14	0.01	%	-----
Sized ³	6 strokes.....	15.2	1.5	3.8	.4	.37	.02	.09	.02	0.02	0.01
Sized.....	16 strokes.....	15.7	1.5	4.0	.4	.45	.03	.14	.02	.09	.03
Unsized.....	None.....	13.3	1.5	6.0	.7	.90	.06	.25	.04	-----	-----
Unsized.....	6 strokes.....	10.2	1.0	6.0	.4	.94	.05	.34	.03	.40	.08
Unsized.....	16 strokes.....	11.6	1.1	6.6	.3	1.04	.07	.43	.05	.63	.14

¹ Data based on 50 determinations.² AD is average deviation.³ Sized yarns contained 9.75 percent of white-potato starch.

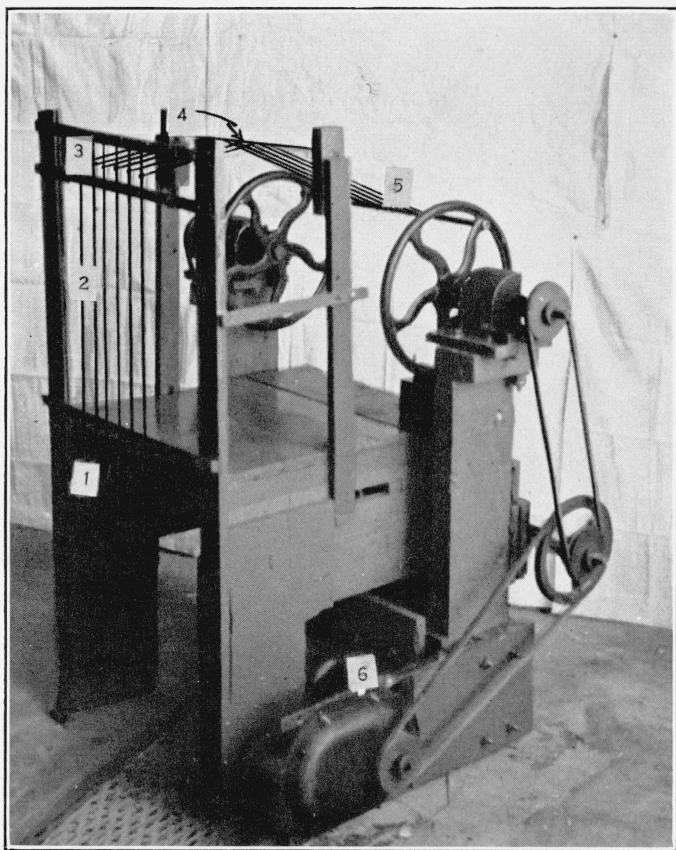


FIGURE 3.—*Machine for abrading yarns.*

1. Weights on lower ends of specimens, 20 grams each; 2, yarn specimens; 3, heddle eyes; 4, guide bar to maintain constant angle at heddle eye; 5, driving bar; and 6, driving mechanism.

[NOTE.—This machine may be provided with a handle for hand operation.]

III. EFFECT OF SIZING ON THE PERFORMANCE OF YARNS

The data in table 3 show that sizing tends to increase the strength of the yarn and also to increase its ability to resist permanent elongation when stretched. The action of the loom tends to stretch all yarns an equal amount. If some yarns in a warp sheet are poorly sized, they would fail to recover from this stretching as fully as other yarns, would become slack, and might even become entangled. Moreover, a difference in length of yarns in the same warp would cause an uneven distribution of the load, which might cause an excessive number of breaks. For these reasons it is important that the sized yarns be uniform.

IV. SUGGESTED MILL CONTROL

This suggests the possibility of establishing certain simple tests which can be applied in the mill to determine whether or not a warp is properly sized. At present this can be ascertained only after the warp has been threaded into the loom, and some fabric woven—a very expensive procedure. A test which could be applied to the yarn as it leaves the slasher would enable the mill man to duplicate satisfactory yarn without question, and would also permit him to experiment with possible changes in his sizing procedure.

In the present work, it was necessary to develop such tests. The equipment is simple but sufficiently accurate for the purpose. It is described here with the thought that some mills may find it worthwhile to install similar devices.

Cut from the warp sheet a number of yarns. Since uniformity is one of the criteria, a sufficient number of samples (50 are recommended) should be taken to be representative of the whole. Measure either the set under a 35-g load, using the apparatus shown in figure 1, or the length with the apparatus shown in figure 2. Transfer the specimens to the abrading machine shown in figure 3 and run for a predetermined number of strokes. Transfer back to the original apparatus and repeat the original measurements.

Certain standards must be established for each individual case, by testing yarns of known satisfactory quality, and fixing the number of strokes of the abrading machine to produce a sufficient change in the properties of the yarn so that it can be readily measured.

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