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VISUALIZING SPUN YARN DEFORMATION: INSIGHTS FROM OPTICAL INSTRUMENTATION

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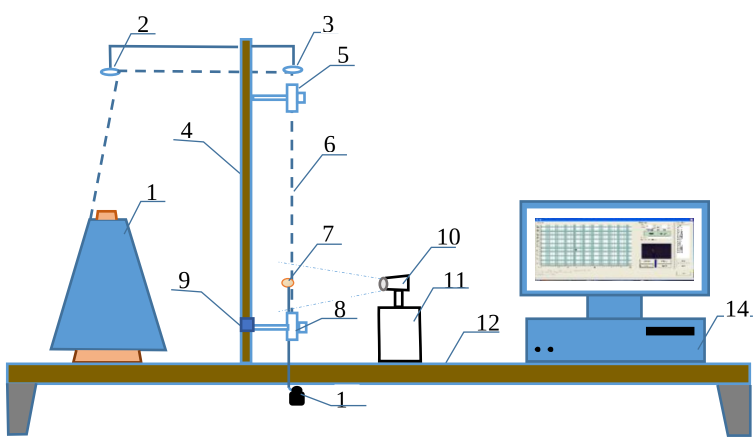
Abstract
This article presents a comprehensive analysis of key quality indicators for spun yarns, focusing on yarns with a linear density of T=20 (Ne=30) tex produced on both simple and compact ring spinning machines. Through the utilization of optical instrumentation, various parameters including relative breaking strength (Rkm), strength, elongation at break (E %), and hairiness (H %) were meticulously examined to evaluate yarn quality. The study delves into the assessment of yarn unevenness (CV %) as a crucial quality metric, aiming to provide insights into the deformation characteristics of spun yarns. By employing advanced optical techniques, such as high-resolution imaging and precise measurements, the deformation behaviour of yarns under different spinning conditions is elucidated. The findings shed light on the influence of spinning machine type on yarn quality parameters, revealing nuanced differences in strength, elongation, and hairiness between simple and compact spinning processes. Additionally, the analysis highlights the correlation between yarn deformation and overall yarn quality, emphasizing the significance of understanding deformation mechanisms in optimizing textile manufacturing processes. Through a rigorous examination of these quality indicators, this research contributes valuable insights into the intricate dynamics of spun yarn deformation and its implications for textile production. The utilization of optical instrumentation offers a novel approach to visualize and quantify yarn deformation, providing a deeper understanding of the factors influencing yarn quality and performance in industrial settings.

Keywords Deformation, fibre, cotton yarn, elongation at break, hairiness, relative breaking strength.

INTRODUCTION

Access to clean and reliable water is a fundamental A high level of competition for yarn and fabrics on the world market, the creation of modern, advanced technologies and equipment that make it possible to quickly change types of fabrics in qualitative and quantitative terms, to produce high-quality and competitive products. Further improvement of the consumer characteristics of textile products that ensure the production of yarn requires the creation of new techniques and technologies for the development of regulatory and technological indicators [1,2]. In this regard, radically change the quality indicators of yarn, conduct targeted scientific research in such areas as the production of calvan yarn with competitive indicators, and at the same time create an effective system for improving the quality and competitiveness of yarn. It is important to develop methods for optimizing indicators and develop high-performance technical, measuring and control means and technologies for spinning enterprises [3,4].

Review of the electrical measuring circuit of the displacement sensor of the strain gauge amplifier TOPAZ-3-01. These devices are far behind modern technology, and we have taken it upon ourselves to more accurately determine yarn strain percentages using computer programs and web cameras [5-7].



1-spool, 2 and 3-thread guides, 4-horizontal support, 5-fixed clamp, 6-thread, 7-installed reflective ball, 8-movable clamp, 9-movable clamp trigger, 10-web camera, 11-web Camera support, 12 main support table, 13 luggage, 14 computer.

Figure 1. Basic diagram of the tool

Initial experiments were conducted by modernizing the relaxometer RP-5 device. After that, the device was further improved. First, the principle scheme of the device was developed (Fig. 1). To study the changes (deformation) of threads under the influence of load in the experiments, a special measuring device was created with the help of light (on a web camera).

This device helps to accurately measure the state of deformation of a thread when a load is applied to it. To determine the deformation of the thread, researches were carried out with a load of 25% of the strength of the thread.

Experimental part

In order to carry out experiments at the MRT textile enterprise located in the Namangan region, the quality indicators of yarns obtained from the German "Zinser-350" ring spinning machine and compact spinning machines installed at this enterprise were checked. During the experiments, samples of tex yarn with a linear density of T=20 (Ne=30) were taken at a spinning frequency of 17,000 min-1, a density of 830 b/m and a linear density of T=20 (Ne=30). During the research, yarn was spun from a mixture of fibres of type IV type 1 of Namangan 77 and Mehnat cotton selections.

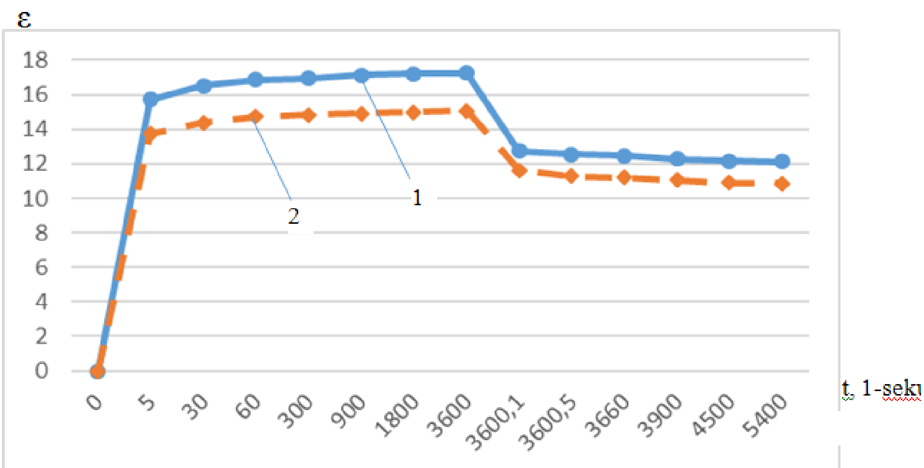
To determine the quality indicators of the obtained samples, the equipment available in the company's laboratory (USTER TESTER 5, Zweigle D 314) was used and the results were summarized in a table.

Table 1. Physico-mechanical parameters of textile yarns with linear density T= 20 (Ne 30)

№	Thread Number (Ne)	Spinning method	The frequency of rapid rotations is $x10^3$, min^{-1}	Practical spinning, K_a, b/m	Relative breaking strength, (Rkm)	Elongation in interruption, E, (%)	Hairiness, H, (%)	Unevenness, CV, (%)
1	30	melange yarn	17000	830	14,28	4,20	6,2	16,76
2		Compact	17000	830	17,84	4,1	4,5	16.0

Deformation characteristics of the obtained kalava yarn samples were determined in the newly proposed tool. The physical and mechanical properties indicators are presented in this table. The deformation index of these received yarns was determined. The samples are deformed differently from the load, and the difference between the graphs increases over time. The first example - a simple thread stretches in a relatively short time. The deformation of the compact thread at the initial moments of loading is slower than that of the ordinary thread. This situation, of course, is explained by the difference in the structure of the yarn and the position and location of the fibres in the yarn. A similar situation occurs when the thread is unloaded.

Regular yarn shrinks more slowly, while compact yarn shrinks faster. It can be seen from the graph that the residual deformation of the threads is different. It was found that the residual deformation in the compact thread is relatively less. The change of thread deformation per unit of time is a law of rheology, and for the first time, it was determined that this phenomenon exists using a web camera tool.



1. Simple melange yarn, 2. Compact melange yarn

Figure 3. Graphs of thread deformations

It can be seen that the deformation graphs of ordinary and compact yarns of the same number are different from each other in the newly proposed equipment (Fig. 2). It was found in the study that the compact thread (Fig. 3, 2) is less deformed than the ordinary thread (Fig. 2, 1). This situation is related to the structural structure of the thread. Such a difference in threads affects the characteristics of the fabrics made from them and leads to different quality indicators of the fabric.

Experiments were conducted to fully study the changes of two or more seconds of plain and compact mélange yarn samples obtained in the experiment. The results of the experiment are presented in Table 2 below.

Table 2. Deformation of simple and compact threads.

830 rpm, 17000 rpm, Ne 30

№	4 sec			3-sec			2 sec		
	simple	compact	X	simple	compact	X	simple	compact	x
0	0	0	0	0	0	0	0	0	0
1	0,067	0,067	0,05	0,067	0,067	0,05	0,067	0,067	0,05
2	12,451	6,651	0,1	12,441	6,672	0,1	12,365	6,599	0,1
3	13,415	7,902	0,15	13,422	8,145	0,15	13,442	8,368	0,15
4	14,136	9,208	0,2	14,157	9,325	0,2	14,181	9,546	0,2
5	14,836	10,207	0,25	14,828	10,222	0,25	14,818	10,294	0,25
6	15,236	10,858	0,3	15,375	10,907	0,3	15,361	11,057	0,3
7	15,751	11,376	0,35	15,747	11,545	0,35	15,753	11,671	0,35

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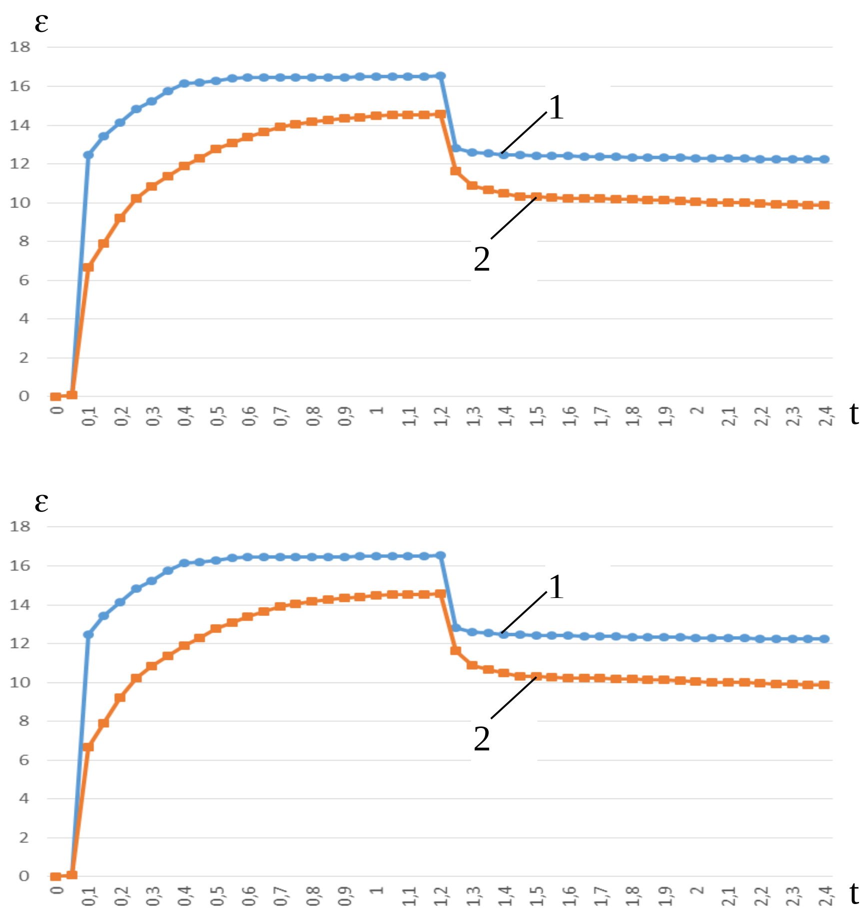
8	16,141	11,902	0,4	16,112	12,058	0,4	16,019	12,235	0,4
9	16,203	12,276	0,45	16,208	12,445	0,45	16,191	12,665	0,45
10	16,302	12,759	0,5	16,299	12,854	0,5	16,294	12,996	0,5
11	16,425	13,098	0,55	16,407	13,182	0,55	16,363	13,367	0,55
12	16,439	13,364	0,6	16,424	13,471	0,6	16,401	13,588	0,6
13	16,455	13,631	0,65	16,451	13,786	0,65	16,446	13,837	0,65
14	16,461	13,919	0,7	16,458	14,025	0,7	16,452	14,011	0,7
15	16,467	14,053	0,75	16,453	14,125	0,75	16,447	14,198	0,75
16	16,471	14,156	0,8	16,469	14,298	0,8	16,468	14,204	0,8
17	16,475	14,284	0,85	16,471	14,383	0,85	11,854	10,603	0,85
18	16,48	14,371	0,9	16,479	14,402	0,9	11,458	9,508	0,9
19	16,487	14,405	0,95	16,482	14,445	0,95	11,068	9,084	0,95
20	16,493	14,483	1	16,488	14,501	1	10,817	8,803	1
21	16,502	14,524	1,05	12,524	11,378	1,05	10,548	8,586	1,05
22	16,511	14,537	1,1	12,161	10,552	1,1	10,398	8,357	1,1
23	16,521	14,548	1,15	11,824	10,032	1,15	10,234	8,125	1,15
24	16,531	14,569	1,2	11,525	9,567	1,2	10,137	8,017	1,2
25	12,815	11,65	1,25	11,321	9,325	1,25	10,002	7,903	1,25
26	12,615	10,899	1,3	11,254	9,225	1,3	9,882	7,812	1,3
27	12,531	10,643	1,35	11,112	9,118	1,35	9,754	7,704	1,35
28	12,468	10,474	1,4	11,058	9,014	1,4	9,635	7,625	1,4
29	12,452	10,321	1,45	10,971	8,934	1,45	9,553	7,562	1,45
30	12,439	10,295	1,5	10,836	8,865	1,5	9,474	7,501	1,5
31	12,427	10,254	1,55	10,785	8,812	1,55	9,412	7,458	1,55
32	12,415	10,237	1,6	10,683	8,785	1,6	9,386	7,416	1,6
33	12,391	10,211	1,65	10,603	8,705	1,65			
34	12,378	10,204	1,7	10,584	8,694	1,7			
35	12,367	10,186	1,75	10,571	8,688	1,75			
36	12,346	10,162	1,8	10,558	8,655	1,8			
37	12,334	10,148	1,85	10,536	8,631	1,85			
38	12,323	10,115	1,9	10,524	8,628	1,9			
39	12,315	10,082	1,95	10,511	8,609	1,95			
40	12,304	10,044	2	10,497	8,587	2			
41	12,295	10	2,05						
42	12,284	9,996	2,1						
43	12,271	9,987	2,15						
44	12,265	9,961	2,2						
45	12,256	9,934	2,25						
46	12,248	9,913	2,3						
47	12,236	9,894	2,35						
48	12,225	9,886	2,4						

This table shows the results obtained on the initial deformations of compact and simple yarns under loading and unloading of the yarn at 4, 3, and 2 seconds. Based on the obtained results, graphs were constructed.

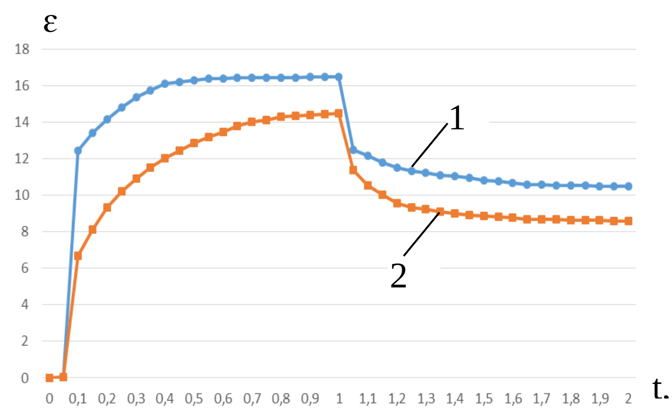


1. ordinary kalava thread, 2. compact kalava thread.

Figure 4. Loading and unloading deformation of plain and compact threads for 4 seconds.

The graph shows the changes in the condition of the compact and simple melange yarns obtained in the experiment in a short time, i.e., 4 seconds, under the influence of load and unloading (Fig. 4). As can be seen from the graph, the compact mélange yarn stretched slowly under the load in a short period of time compared to the plain yarn (1). The reason that ordinary thread stretches very quickly under load is related to its structure. In a compact yarn (2), the fibres are arranged in an orderly, parallel position relative to each other, and all fibres participate in the formation of a twist. When a force is applied to the thread, the fibres move. In this process, compact yarns have high load resistance.

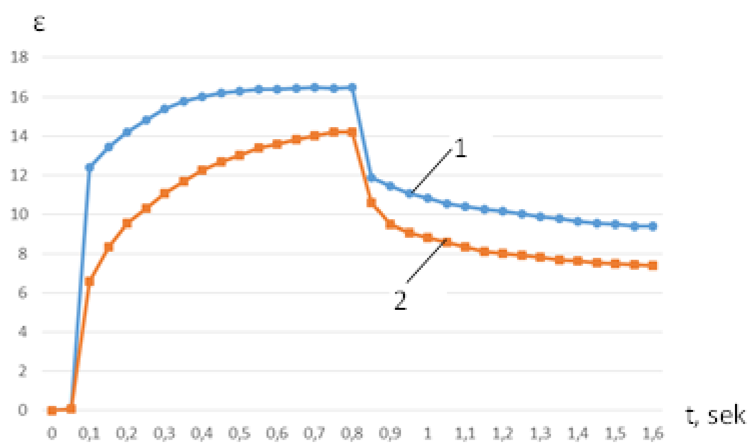
In addition to the research, the elongation of the experimental compact and ordinary yarns under the influence of load and the state of the last relaxation process after removal of the load were analyzed in a small time interval of 3 seconds. In a short period, i.e., 1.5 seconds under load, and 1.5 seconds at rest, a graph of one-cycle deformation was constructed (Fig. 5).



1. Simple melange yarn, 2. Compact melange yarn

Figure 5. Loading and unloading deformation of plain and compact melange yarns for 3 seconds.

Even within 3 seconds, it was found that the resistance of the compact thread to the impact of the load is higher than that of the ordinary thread.

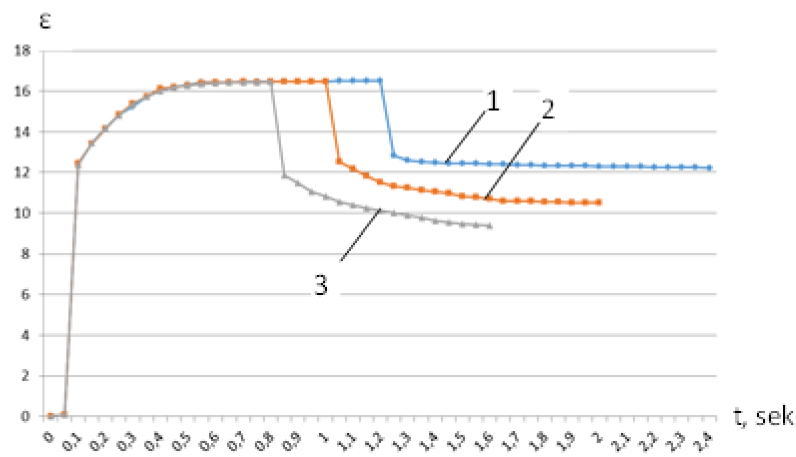


1. Simple melange yarn, 2. Compact melange yarn

Figure 6. Loading and unloading deformation of plain and compact melange yarns for 2 seconds.

After that, one-cycle deformations of compact and simple melange yarns were studied at a time interval of 2 seconds (Fig. 6). When the compact (1) and ordinary melange thread (2) were subjected to load, it was found that the resistance index of the compact thread is 13% higher than that of the ordinary thread. In the process of unloading, it was found that the compact melange thread returned to its original shape by 21%.

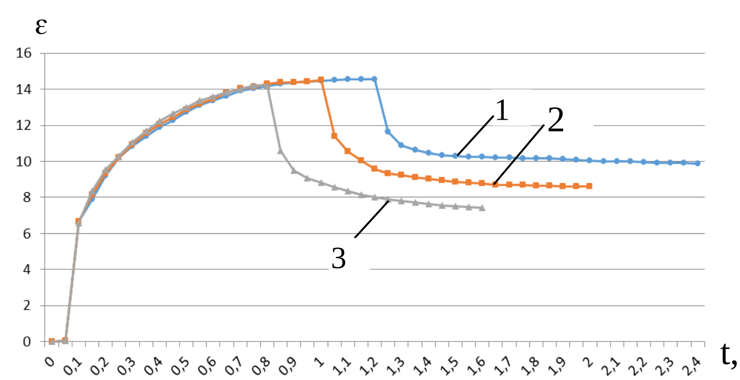
General graphs of compact and simple melange threads obtained in the experiment were saved and analyzed (Figures 6-7). When the one-cycle deformations of ordinary threads in the time interval of 4, 3 and 2 seconds are summarized (Fig. 6), the resistance of the threads to the load decreases as the time increases. The reason why the resistance of the thread (Fig. 6, 3) to the load at the time interval of one second is higher than the resistance of the threads for two (Fig. 6, 2) and three (Fig. 7, 3) seconds, the thread is unloaded for a short period without experiencing full resistance. Therefore, yarns with a small period of time are less stretched than yarns that are subjected to a large period of load.



1 - 4 seconds, 2 - 3 seconds, 3 - 2 seconds.

Figure 7. Loading and unloading deformation of ordinary yarns.

When summarizing the one-period deformations of compact melange yarns (Fig. 8), similar to ordinary yarns, the resistance of the yarn to the load in a small time interval (Fig. 8, 3) is relatively large. As the time increased, it was observed that the resistance of the threads to the load decreased in two (Fig. 8, 2) and three (Fig. 8, 1) seconds.



1 - 4 seconds, 2 - 3 seconds, 3 - 2 seconds.

Figure 8. Loading and unloading deformation of compact yarns.

The deformation of compact melange threads, that is, their resistance to load, is higher than ordinary melange threads can be described as follows. Fibres in the composition of compact yarns are gypsum and parallel to each other (Fig. 9).

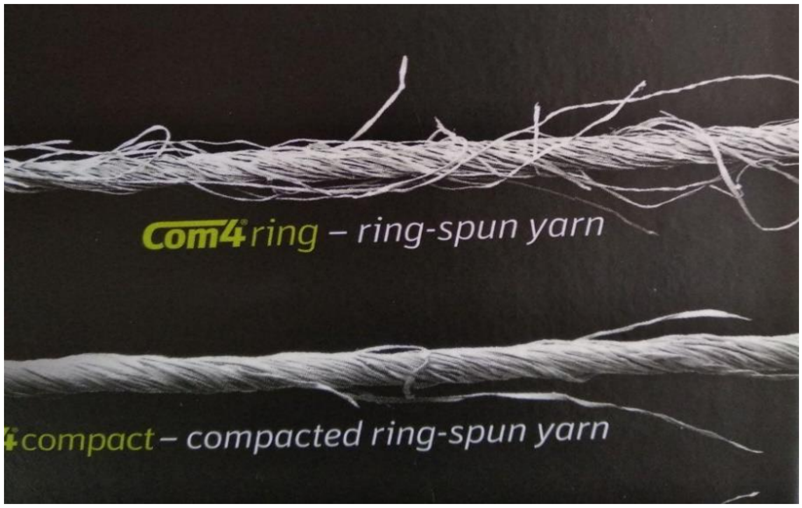


Figure 9. The appearance of simple and compact threads with the help of a thread.

The load-induced changes of both plain and compact yarns are the same as the changes after the load is removed, i.e. at rest. We can see that if the resistance of the threads to the load is high in a small time interval, the return to its original state when the load is unloaded is higher than in a long time. As can be seen in Fig. 9, the ordinary thread is relatively loose, and the fibres are irregularly arranged compared to compact threads. We can see that the hairiness index of the normal thread is high. Therefore, ordinary threads have relatively little resistance to load.

CONCLUSIONS

With the help of a newly created optical device, 16 change points of the samples were expressed in numbers within the initial seconds, that is, in one second. It was found that the linear density of compact and ordinary yarns at the initial moments of yarn deformations is the same, but their resistance to stretching is different. When analyzing the one-cycle deformations of compact and simple melange yarns, it was found that compact melange yarn has a higher resistance to stretching and the residual deformation is smaller than that of ordinary melange yarn. It was determined with the help of an optical web camera that when compact and simple threads are unloaded in a short period of time, their residual deformation is also less. When the deformations of the yarn were determined with the help of a microscope, it was found that the fibres in the compact yarn were densely and regularly arranged.

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