

OPPORTUNITIES FOR UTILIZING REGENERATED FIBERS IN THE PRODUCTION OF NON-WOVEN MATERIALS AND SPINNING

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Abstract

The article explores the opportunities for utilizing regenerated fibers in the production of non-woven materials and spinning. One of the means for efficient and economical use of the raw material base in the spinning and weaving industry is the rational recycling of production waste. At this stage of the research, the proposed new fiber opening equipment was used to process waste yarns without prior cutting on a cutting machine. Analysis of the properties of the obtained fibers confirmed the possibility of obtaining fibers suitable for textile product manufacturing. To investigate the spinnability of the regenerated fibers, the spinnability limit and the minimal possible linear density of the yarn were determined, which can be in the range of 25-29 tex.

Keywords: Regenerated fiber, production waste, fiber opening equipment, fiber blend, pneumomechanical method, recycling, proportion of regenerated fiber.

Introduction

Worldwide, along with developing the raw material base of the textile industry, increasing the variety of produced fibers, and manufacturing new types of fibers and yarns, special attention is paid to the processing and utilization of secondary raw material resources. A series of significant transformations are being introduced into the global textile industry, with particular focus on utilizing all resources, including secondary raw materials, by returning them to industry for the production of finished goods in regions possessing raw material reserves, thereby increasing the efficiency of their use [1].

In this direction, research aimed at creating technology for obtaining regenerated fibers suitable for textile production based on the recycling of fibrous secondary resources, worn-out textile items, and industrial waste, as well as expanding the technical and technological capabilities of equipment, is considered a priority.

One of the means for efficient and economical use of the raw material base in the spinning and weaving industry is the rational recycling of production waste.

Production waste is inevitably generated during the processes of yarn, fabric, and knitted fabric manufacturing, containing not only short fibers but also long, spinnable fibers. In addition to production waste, the utilization of textile products, including non-woven materials and yarns, has been established [2-4].



However, the possibility of easily converting all types of waste into recycled fiber is limited. Such waste includes yarn remnants, and yarn ends cut during weaving and knitting production. In the accepted classification of the spinning and weaving industry, such waste is called waste yarns [5;6].

In practice, there are many methods for utilizing cotton yarn waste. One of them involves converting pre-cut yarns into a fibrous mass through opening.

Problem Statement and Formulation

At this stage of the research, waste yarns were processed without prior cutting on a cutting machine, using the newly proposed fiber opening equipment. Analysis of the properties of the fibers presented in Table 1 showed that it is possible to obtain fibers suitable for textile product manufacturing.

To test this conclusion in practice, the possibilities of utilizing fibers opened on a single-drum machine for the production of non-woven materials were investigated. Non-woven materials were produced using mechanical technology based on the stitch-bonding method [3].

Under current mill conditions, non-woven materials are produced from a blend consisting of cleaning and carding machine waste, and linters. Here, linters constitute 40% of the blend. The research aimed to reduce spinning mill waste and the added linters.

Research Methods

To assess the impact of the gradual increase in the amount of regenerated fibers from waste yarns on fabric properties, five blend variants were processed. The properties of the produced non-woven materials were determined according to established procedures. The properties of fabrics produced in all variants are presented in Table 2.

Table 1 Properties of regenerated fibers obtained from recycling waste yarns

No.	Indicators	Values
1.	Mic (Micronaire)	4.66
2.	Maturity index	0.86
3.	UHML, [mm] (Upper Half Mean Length)	25.8
4.	UI, [%] (Uniformity Index)	74.2
5.	SFI, [%] (Short Fiber Index)	19.86
6.	Str, [g/tex] (Relative Breaking Strength)	25.2
7.	Elg, [%] (Elongation)	5.8
8.	TrAr [%] (Trash Area)	0.14
9.	Total Neps cnt. [Cnt/g]	376

Analysis of the research results showed a significant increase in the yield from the fiber blend and a decrease in defects in the card sliver. The increase in yield from the blend is explained by the presence of trash and defects in the spinning mill waste, their separation during the cleaning process, and the absence of trash in the regenerated fibers.

The reduction of defects in the card sliver is related to the defects present in the waste; although they partially decrease during carding, their further breakdown leads to an increase in the

number of small neps. The absence of trash and low defect content in the regenerated fibers resulted in higher yield from the blend and fewer defects in the card sliver.

Among the properties of non-woven materials, their breaking strength is considered important. This property mainly depends on the mechanical properties of the stitching yarn. This conclusion was also confirmed in this research. In all variants, the breaking strength of the fabric in different directions remained almost consistent, with no sharp deviations (Figure 1).

Table 2 Properties of non-woven materials produced from fiber blends

Regenerated Fiber in Blend, %	Yield from Blend, %	Fabric Breaking Strength, N			Number of defects in one gram of fibrous layer,
		Lengthwise, Rl	Widthwise, Rw	Tear, Rt	
12	87,6	172,1	89,2	29,8	686
24	91,4	191,3	88,3	30,9	528
36	92,7	193,0	87,2	33,7	354
48	93,6	194,7	87,4	34,8	327
60	94,2	195,6	92,5	35,3	305

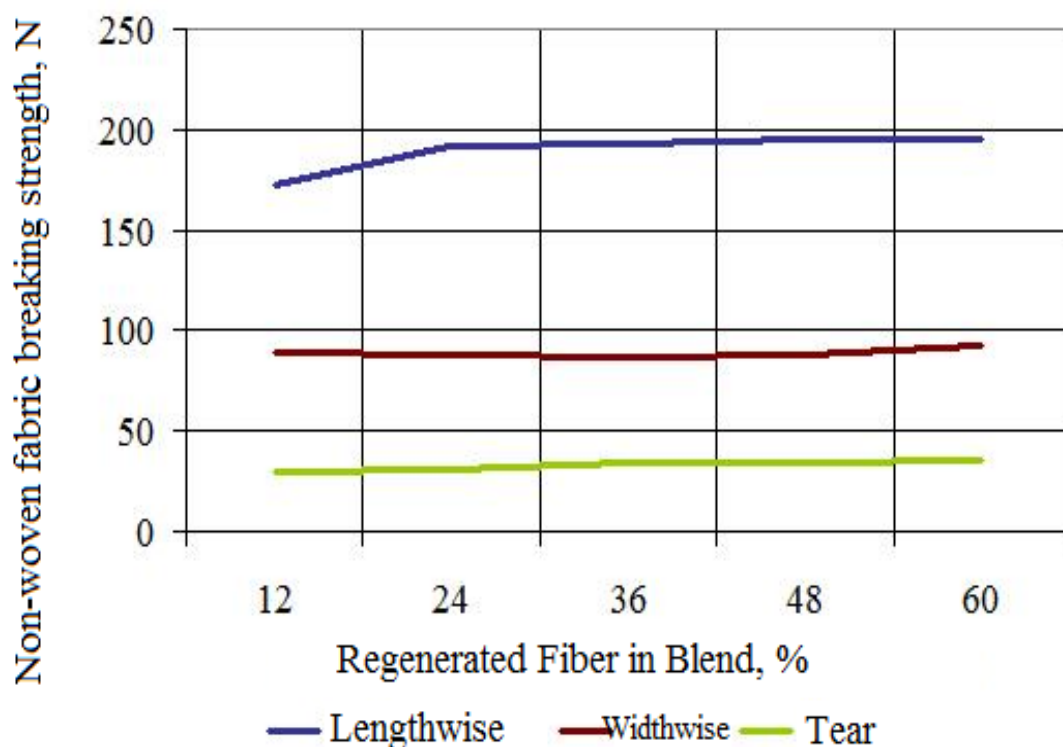


Figure 1. Dependence of non-woven fabric breaking strength on the amount of regenerated fiber in the blend.

Analysis of Obtained Results

Thus, it was determined that there is a possibility of utilizing regenerated fibers, obtained after processing uncut waste yarns on a single-drum fiber opening machine, in the manufacture of

textile products, including non-woven materials. Based on a broader investigation of this problem, the product assortment can be further expanded.

Based on the preliminary research above, a series of experiments were conducted to investigate the process of utilizing regenerated fibers added to a cotton fiber blend in spinning. Based on these, it was found that there is a possibility of adding regenerated fibers to the working blend in pneumomechanical spinning. This conclusion is primarily related to yarn formation in this method [6].

To investigate the spinnability of regenerated fibers, the spinnability limit was determined using the A.N. Solovyov formula. It was found that the minimal possible linear density of the yarn that can be spun may be in the range of 25-29 tex.

Based on the yield of yarn from the blend, considering the absence of trash in regenerated fibers, the abundance of short fibers, and research on the carding process, with an average value of $B = 92\%$ accepted, the following spinnability limit L_s was determined to be achievable.

$$L_s = \frac{10 \cdot B}{T_s} = \frac{10 \cdot 92}{29} = 31,72 \text{ km / kg.} \quad (1)$$

However, considering defects and short fibers, under mill conditions, a small proportion of regenerated fiber was added to the blend. The regenerated fiber mass, after being stored in the sorting department for two days according to regulations, was introduced via the waste feeding machine of the opening-cleaning unit.

Considering the machine's productivity, variants for mixing lap pieces with regenerated fibers in the same proportion and feeding the regenerated fibers themselves through this machine were calculated. As a result, when lap pieces and regenerated fibers were fed together (machine productivity 23.7 kg/hour), the proportion of regenerated fiber in the blend was determined to be 2.1% and 4.2%, respectively.

When the productivity of the feeding machine was increased to 51.2 kg/hour within technical capabilities, the proportion of this raw material in the working blend was found to be 4.2% and 8.8%. Considering the presence of such proportions of fibers in the lap obtained from the carding machine, the quality of the card sliver was determined. It can be concluded that the insignificant increase in fibrous defects in the card sliver (within 5-11%) is related to the effective impact of the carding process.

After double processing, the laps prepared in the four experimental variants were sent for pneumomechanical spinning. The variation coefficient of the lap was also determined. As a result, an increase in the variation coefficient of the prepared lap from the mill's technical control norm of 3.85% to 0.19-0.57% was observed.

Spinning of 50 tex yarn by the pneumomechanical method from the laps prepared in the experiment was carried out according to the current spinning parameters. The properties of the produced yarns were determined using USTER laboratory equipment [7]. Table 3 presents the properties of the yarns determined based on the experimental essence.



Table 3 Yarn Properties

Properties	Regenerated Fiber in Blend, %			
	0	2,1	4,2	8,8
Linear Density, tex	50,0	50,7	50,5	51,2
Relative Breaking Strength, cN/tex	11,84	11,92	12,13	11,26
Coefficient of Variation of Linear Density, CV%	13,41	13,63	13,94	15,23
Coefficient of Variation of Breaking Strength, CV%	9,24	10,14	10,76	13,85
Number of Neps (Neps/1000 m) Neps +280% /km	78	184	197	274
Number of Twists per Meter of Yarn	640	625	642	639
Number of Thick Places, Thick +50%/km	104	118	123	127
Number of Thin Places, Thin -50%/km	3	4	4	3

Thus, it was determined that adding regenerated fibers to the fiber blend can change the yarn properties. At the same time, it was shown that there is an opportunity to reduce raw material consumption by adding regenerated fibers to the working blend in spinning. Although an increase in the proportion of regenerated fiber resulted in a decrease in some yarn properties, these remained within established norms, and such losses can be reduced by optimizing technological conditions and machine parameters.

The possibility of utilizing up to 60% of regenerated fibers, obtained after processing uncut waste yarns on the proposed opening equipment, in the production of non-woven materials was determined.

Research on the process of utilizing regenerated fibers added to a cotton fiber blend in pneumomechanical spinning revealed the possibility of adding up to 8% regenerated fiber to the blend.

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