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Cite as: AIP Conference Proceedings 2430, 050004 (2022); <https://doi.org/10.1063/5.0078715>  
Published Online: 24 January 2022

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# Research of Processing of Arselon Fireproof Fibers in the Preparatory Spinning Equipment

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**Abstract.** One of the directions for the production of Belarus innovative textile materials - production of heat & fireproof yarn and fabric. However, a number of problems arise during processing man-made heat-resistant fibers in spinning mills. These problems are associated with the high electrification of the fiber, which makes it difficult to process it, causes an increase in end-breakage and an increase in unevenness of semi-finished products. The purpose of these researches was the development of technological parameters of the card and draw frames in the spinning department, ensuring the production of high quality yarn. The experimental investigations were carried out in the cotton spinning mill Gronitex (Belarus). To produce heat & fireproof yarn we used Arselon fibers, produced in OJSC SvetlogorskKhimvolokno (Belarus).

## INTRODUCTION

Traditionally, textile enterprises in Belarus were focused on the production of ordinary yarn and textile products of natural and man-made fibers and their blends. The share of innovative products was relatively low. However, the economic situation and the wide expansion of cheap textiles from the Central Asia and China countries led to the difficult situation of the Belarus textile enterprises and practically put them on the brink of survival. Earlier, most European countries faced with similar problems, chose the only possible path - they switched to the production of high-tech functional textiles.

Now most of the Belarus textile enterprises, in accordance with the innovative program, are also switching to the production of innovative products, namely textile materials with special protective properties. Although the market for special textiles is relatively small, as practice has shown, competent production planning, deep marketing research of the textiles market allows not only to maintain production and human potential, but also to increase production capacity.

One of the leading Belarus enterprises for the production of special-purpose yarn is OJSC Gronitex (Grodno), where technologies for the production of heat-resistant and electrically conductive yarn was developed [1]. The raw materials for the production of heat-resistant yarn at cotton spinning mill Gronitex are meta- and para-aramid fibers, viscose FR, modified acrylic fibers and Arselon fiber [2]. In Belarus, the only manufacturer of flame- and heat-resistant fibers is OJSC SvetlogorskKhimvolokno, which produces Arselon polyoxidiazole fibers [3, 4]. The main advantage of this fiber is its lower cost in comparison with meta- and para-aramid fibers of foreign production and sufficient level of thermal and fire resistance. The main purpose of Arselon fiber fabrics is the production of protection clothing for firefighters-rescuers and other means of protection against high temperatures and flame [5, 6].

However, the world manufacturers do not produce spinning equipment for processing special-purpose man-made fibers. Therefore, such fibers are processed on conventional spinning equipment designed to process natural and man-made fibers. This fact causes a number of technological problems, since protection fibers, including Arselon, have a high electrification, their staples are quite dense, which makes it difficult to shift during drawing. Therefore,

the purpose of these researches is the choice of a sizing agent for processing Arselon fiber, also obtaining parameters of carding and draw frames for processing high quality semi-finished products.

## MATERIALS AND METHODS

Areslon fiber was processed into yarn with a linear density of 20 tex by a carded spinning system at OJSC Gronitex. The properties of Arselon fiber are presented in Table 1 [7, 8].

**TABLE 1.** Arselon fibers properties

<b>Characteristics</b>	<b>Value</b>
Staple length, mm	37,8
Linear density of fibers, tex	0,163
Tenacity of fibers, mH/tex	310
Elongation, %	33
Deviation of the actual linear density from the nominal, %	-4
Deviation of the actual length from the nominal, %	-3
Humidity, %	9,8
Oxygen index, %	28
Long-term operating temperature, °C	250
Permissible temperature of short-term thermal effects, °C	400
Thermal degradation temperature, °C	480

Analyzing the data in Table 1, it can be noted that the length and linear density of Arselon fiber are suitable for processing on cotton spinning equipment, and the high breaking force of the fiber allows predicting the high tenacity of the yarn produced. Arselon is supplied to spinning mills in bales with pressed oiling staple fibers formed by cutting of the tow [9].

It has been established that the high electrification of Arselon fiber is directly related to the lubricant applied to the fiber during its forming at OJSC SvetlogorskKhimvolokno. To minimize these problems during spinning processing, it is necessary to change the composition of the lubricant and its concentration towards a higher content of the anti-static reagent. Thus, the purpose of sizing is to reduce the electrification of the Arselon fibers, improve their passing through the spinning equipment, and reduce breakage of semi-finished products and yarn.

Two types of sizing liquid were used - Avistat and Duron during the studies of Arselon fiber processing, Avistat is a phosphoric acid ester and is a versatile antistatic agent. Chemical composition of Duron lubricant - alkylbetaine. Duron imparts pronounced antistatic properties to the fiber, leads to balanced dynamic friction between the fibers, has a neutral odor, is easy to wash off, and has a high resistance to evaporation. Arselon fiber is highly electrified, therefore, the manufacturer recommends a composition for it – 0,1 % Duron 1102/P + 0,2 % Duron 14 with a total application amount of about 0,3 % of the processed fiber mass.

Rieter and Zinser spinning technological equipment is installed in the cotton spinning mill Gronitex [10]. Opening of the Arselon fiber was carried out on a short opening chain, consisting of a B34 fiber feeder and a UNIstore A79 feeding machine (fiber accumulator), and carding on a Rieter C 70 carding machine designed for processing man-made fibers. Draw frame SB D-40 and finisher RSB D-45 by Rieter were used [11]. The optimal settings of card and draw frame were determined during experimental studies. Rieter G 35 ring spinning machines were used to produce the Arselon yarn.

## RESULTS AND DISCUSSION

Two batches of Arselon fiber were processed on a C 70 carding machine with the same setting, but different - Avistat and Duron sizing agents for choosing the best of them. Linear density of the carding sliver 5880 tex. Characteristics of sliver unevenness are presented in Table 2.

**TABLE 2.** Characteristics of unevenness of Arselon fibers sliver

Characteristic	Sizing agent:	
	Avistat	Duron
Coefficient of variation Cvm, %	3,8	4,07
Coefficient of variation Cv 1m, %	2,53	1.72
Coefficient of variation Cv 3m, %	2,04	1

Analyzing the test results of the card sliver, it can be noted that the replacement of the lubricant led to a decrease of coefficient of variation Cv 1m of card sliver by 1,5 times, and Cv 3m - 2 times. A slight increase Cvm is not critical, as such unevenness is effectively reduced in the draw and finisher frames.

In order to obtain optimal speed of main cylinder and flats of the C70 card, an experiment was carried out. The purpose of these studies is to establish the speed settings of the card which provide minimal fiber damage and a decrease fibers length [12].

Experimental studies were carried out at three values of the main cylinder speed: 500, 550 and 600 min<sup>-1</sup>. Preliminary studies have shown with a further increase of this speed, the quality of the web significantly deteriorates. The speed of the carding flats was set as follows: 0,19; 0,23 and 0,27 m/min.

The samples of the card sliver were checked for staple length using a laboratory complex LVI from Uster Technologies. The research results are presented in Tables 3, 4 and in Fig. 1, 2.

**TABLE 3.** Influence of the flats speed of the C70 card on the web characteristics at the main cylinder speed of 500 min<sup>-1</sup>

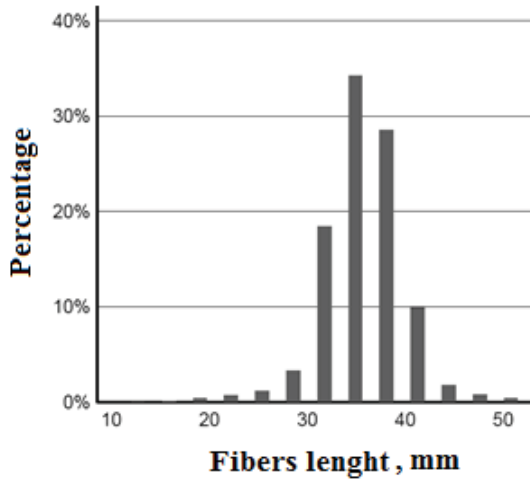
Characteristics	Flats speed: m/min:		
	0,19	0,23	0,27
Middle fiber length ML, mm	26,28	25,89	26,37
UHML, mm	29,72	29,59	30,03
Uniformity index UI, %	88,4	87,5	90,2
Index of short fibers SF, %	4,5	4,7	4,9
Neps amount (inside 1 g of the web)	1,0	0,0	0,0

**TABLE 4.** Influence of the main cylinder speed of the C70 card on the web characteristics at the flats speed of 0,23 m/min

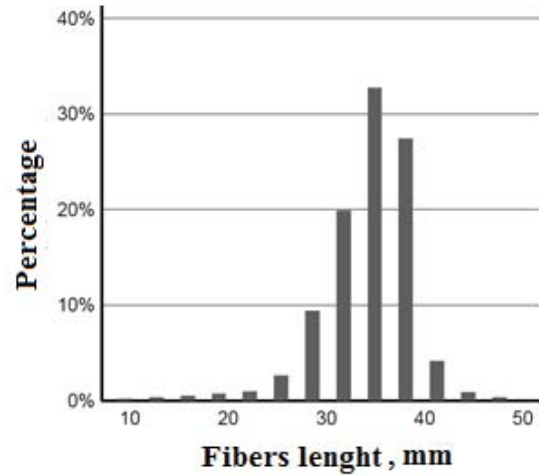
Characteristic	Main cylinder speed, min <sup>-1</sup> :		
	500	550	600
Middle fiber length ML, mm	26,28	26,19	25,8
UHML, mm	29,72	29,63	29,37
Uniformity index UI, %	88,4	88,9	87,8
Index of short fibers SF, %	4,5	3,8	5,5
Neps amount (inside 1 g of the web)	1,0	3,0	2,0

The small values of the Neps content in the web indicate the good technical condition of the card and the card clothing, as well as the correct choice of the carding gaps main cylinder – flats and main cylinder – carding bars.

An increase in the number of short fibers by approximately 1 % and UHML decrease by 2,5 - 3 mm in comparison with the fibers from the bales indicate their insignificant breakage during carding. It has been established that during the processing of Arselon fibers, a further increase in the productivity of the machine will contribute to a greater shortening of fibers and a decrease in the tenacity of the yarn. Analyzing the data presented, it was found that the speed of the flats does not significantly affect the characteristics of the fiber length. It was decided to set the flat speed to no higher than 0,23 m/min, because this value provides good characteristics of the web.



**FIGURE 1.** Histogram of the distribution of fibers length in the feeding web



**FIGURE 2.** Histogram of the distribution of fibers length in the carding sliver

With an increase of main cylinder speed, a monotonic decrease in the fiber lengths characteristics occurs. During speed of main cylinder of  $600 \text{ min}^{-1}$ , the content of short fibers in the web increases. Therefore, it is rational main cylinder speed in the range  $500\div 550 \text{ min}^{-1}$ .

Further, a study was carried out to determine the influence of the finisher frame RSB-D45 delivery speed on sliver unevenness. The speed values were varied in the range  $575\div 670 \text{ m/min}$ . The samples of slivers were checked on the Uster Tester 4 equipment (Table 5).

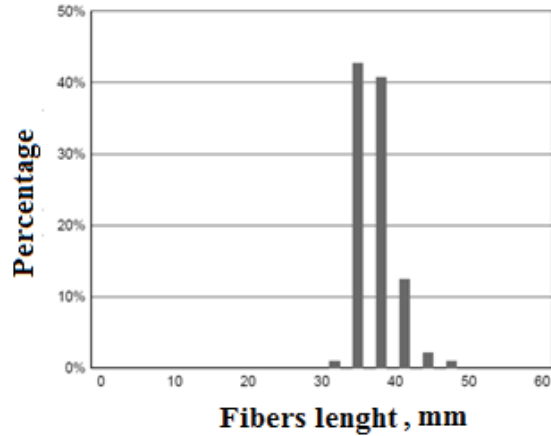
**TABLE 5.** Characteristics of Arselon fibers slivers from RSB-D4 finisher frame

Characteristic	Delivery speed, m/min		
	575	625	670
Coefficient of variation $C_{vm}$ , %	2,91	2,61	2,60
Coefficient of variation $C_v 1m$ , %	0,72	0,54	0,57
Coefficient of variation $C_v 3m$ , %	0,55	0,33	0,41

According to the presented values, it can be seen that the sliver obtained at a delivery speed of  $625 \text{ m/min}$  possesses the lowest unevenness characteristics.

The parameters of the Arselon fibers length from the RSB-D45 draw frame have been determined. It was found that the distribution of fibers in the sliver is characterized by high uniformity and a low content of short and long fibers. Due to the uneven crimp of the fibers in the card sliver, the distribution diagram (Fig. 2) shows a high content of short fibers (up to 4,9 %).

However, when Arselon sliver was passed 2 draw frames SB D-40 and RSB D-45, fibers were slightly straightened and moved to other length classes (from 30 to 40 mm) (Fig. 3). Thus, the data obtained indicate that Arselon fiber sliver can be used to produce high-quality yarns.



**FIGURE 3.** Histogram of the distribution of fibers length in the sliver from RSB-D45 frame

Two pilot batches of 20 tex Arselon yarn were produced on the G 35 R spinning machines with the same setting parameters. One of the batches of the yarn was produced with Avistat sizing, and the second - with Duron. Comparative characteristics of the Arselon yarn are shown in Table 6.

**TABLE 6.** Arselon yarn characteristics

Value	Sizing agent	
	Avistat	Duron
Nominal linear density, tex	20	
Actual linear density, tex	19,7	19,3
Twist factor	27,9	
Yarn tenacity, cN/tex	19,4	20,7
Coefficient of variation of tenacity, %	9,6	9,1
Coefficient of mass variation, Cvm, %	14.04	13.71
Index of irregularity	1.52	1,58
Thin -40%	165,6	170
Thin -50%	7,2	7
Thick +35%	414,6	326
Thick +50%	56.2	48
Neps +200%	130,4	101
Neps +280%	38,6	27

When analyzing the table 5 data, it was found, the use of Duron sizing made it possible to significantly improve the characteristics of Arselon yarn. The tenacity was increased by 6,3 %, the unevenness of the breaking force was reduced by 5,2 %, and mass variation was reduced by 2,35 %. The number of thick, thin and Neps has significantly decreased. For example, the number of Neps + 280 % dropped by 23 %. For special protective fibers, this is a very significant improvement of characteristics. Improvement in yarn properties is associated with better passability of semi-finished products and yarn through all spinning equipment. A decrease in the electrification of the Arselon fiber caused a more regular shift of the fibers during drawing, a decrease of breakage and fluff accumulation.

## CONCLUSION

1. Studies of the C70 card parameters during the processing of Arselon fiber made it possible to obtain optimal setting of speed of main cylinder and flats. Lowest sliver irregularity provides main cylinder speed  $500 \div 550 \text{ min}^{-1}$  and a flats speed of 0,23 m/min.
2. As a result of the research carried out, the delivery speed of the RSB D45 finisher frame have been determined. It was found that the smallest slivers unevenness is achieved at a speed of 625 m/min.

3. Based on the analysis of Arselon fiber processing with two types lubricants - Avistat and Duron, a decision was made to choose the Duron lubricant. It has been established, the use of Duron sizing ensures a decrease of carding sliver coefficient of variation  $C_{vm}$  1m by 1.5 times, and  $C_{vm}$  3 m - by 2 times. When comparing the Arselon yarn characteristics obtained by processing with different sizing agents, it was found that in all quality parameters the yarn with the Duron sizing agent has higher characteristics. The breaking force of the yarn is 6,3 % higher, and the linear density unevenness is 2,35 % lower. The number of thick, thin and neps has significantly decreased. In terms of linear density unevenness, the Arselon yarn entered 15% in accordance with the Uster Statistics bulletins. Thus, the Arselon yarn has a good quality and can be used in weaving and knitting mills for the manufacture of high quality textile materials, including protection clothing [12, 13].

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