Study of Properties of Arselon Spun Yarn

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Abstract. The paper is devoted to development of the range of ring-spun yarns of Arselon fibers. Arselon is a polyoxadiazole heat-resistant fiber produced at JSC "SvetlogorskKhimvolokno" (Belarus). The investigated yarn count range was from 16 to 29 tex (Ne37 – Ne20). It was determined the influence of linear density of the Arselon yarn on its mechanical properties and evenness. In addition, it was shown that winding and assembling lead to significant reducing the number of frequently-occurred faults of 2-ply yarns. The developed range of Arselon yarns is the base for creation of new textile products such as woven and knitted fabrics and heat resistant goods which can be made of them.

1. Introduction

Arselon is a polyoxadiazole heat-resistant fiber produced at JSC "SvetlogorskKhimvolokno" (Belarus). As the production process was designed alternatively to meta-aramid fibers, thus by its properties Arselon is very similar to various meta-aramid fibers. The staple fiber Arselon is a basis for spun yarns and felts which further can be processed into many kinds of materials for thermal application.

The manufacturer indicates the following main features of Arselon:

- Oxygen index (LOI) is 30%;
- No melting;
- Temperature of use is 250 °C;
- Heat shock temperature is 400° C;
- Flexible at high low temperatures;
- Low thermal expansion coefficient;
- Friction coefficient (metal surface) is 0,2;
- Good adhesion to rubber;
- Moisture level is 10-12% (similar to cotton);
- High electrical insulation properties.

Manufacturer indicates the following applications of Arselon:

- Heat resistant spun yarns and fabrics (protective apparel, gloves, home and office textile);
- Woven and nonwoven filtering materials, bag filters (for metallurgy, cement, asphalt);
- Composites (sealing, sliding bearings, packing).

Despite of the mentioned features of these fibres before 2017 Belarusian mills produced only one kind of Arselon spun yarn. It was carded yarn 29,5 tex×2 (Ne 20/2). Moreover, the number of

publications devoted to investigation of Arselon fibers and yarns processing is very limited. There are papers describing twisting of mentioned type Arselon spun yarns [1, 2], also Arselon filament yarns texturizing [3] and properties of textiles and composites produced on the base of these fibers [4, 5].

The aim of presented research was evaluating of Arselon yarns count on their properties. Development of wide range of Arselon yarns will create the base of new textile products such as woven and knitted fabrics and goods from them.

2. Materials and methods

Properties of used Arselon fibers are presented in Table 1. Cased on these data it is possible to make the conclusion about possibility to use machinery of short-staple fibers processing for manufacturing of Arselon yarn.

Table 1. Properties of Aselon fibers

Property	Value
Length, mm	36
Linear density, mtex	162
Breaking tenacity, cN/tex	32,7
Elongation, %	38
Crimps per 1 cm	3,2

Samples of ring-spun carded yarns were produced using the following machinery:

- Blowroom (Rieter);
- Card C60 (Rieter);
- Drawframe SB-D45 (Rieter);
- Drawframe RSB-D45 (Rieter);
- Roving frame 668 (Zinser);
- Ring spinning machine G35 (Rieter).

For 2-ply Arselon yarns manufacturing the following machinery were used:

- Automatic winder Polar L (Savio);
- Assembly winder TW-2D (SSM);
- Twisting machine Geminis S261 (Savio).

To obtain yarns with the highest achievable properties during our research in each stage of the technological process experiments were carried out.

Strength tester RM-3 and evenness tester Uster Tester 5 were applied for yarns quality assessment.

3. Properties of ring-spun Arselon yarn

The yarn count range was from 16 to 29 tex (Ne37 – Ne20). Mechanical properties of ring-spun yarns and results of their testing using Uster Tester 5 are presented in Table 2.

Experimental data presented on the Table 3 show that breaking tenacity and elongation of Arselon ring-spun yarn increase with raise of its linear density.

Table 2. Properties of ring-spun Aselon yarns

Property	Value				
Nominal linear density, tex	16	20	22,2	24	29,5
Actual linear density, tex	15,8	19,4	21,6	24,1	29,5
Breaking force, cN	297,0	364,7	438,5	503,7	601,8
Breaking tenacity, cN/tex	18,8	18,8	20,3	20,9	20,4
Coefficient of variation of breaking force, %	10,8	12,1	10,7	10,9	9,1
Elongation, %	12,8	14,0	13,9	15,6	15,1
Coefficient of variation CVm, %	16,7	14,7	14,3	13,2	12,2
Thin places (-50 %) per 1 km	114,2	33,2	101,4	4	10,8
Thick places (+50 %) per 1 km	174	64,2	53,2	29,8	13
Neps per (+200 %) 1 km	259,2	168,2	144,4	49,2	26,2

For evenness and frequently occurring yarn faults the following regression equations were obtained:

— Coefficient of variation CVm (%):

$$CVm = \frac{66,3}{\sqrt{T}}, \tag{1}$$

— Thick places (+50 %) per 1 km:

$$Thick_{(+50\%)} = 4950 \cdot e^{-0,21 \cdot T}, \tag{2}$$

— Neps (+200 %) per 1 km:

$$Neps_{(+200\%)} = 2469 \cdot e^{-0,14 \cdot T}, \tag{3}$$

where T is actual linear density of Arselon ring-spun yarn (tex).

Obtained equation (1) for evenness CVm calculation looks like Martindale's formula for the limiting irregularity calculation.

A similarity of these formulas indicates the stability of the technological process of Arselon yarns manufacturing. Using equation (1) and Martindale formula we found that for whole range of Arselon yarns count index of irregularity is about 1,65.

On the figure 1 the spectrogram of yarn 22,2 tex. For the rest samples almost similar spectrograms were obtained. On presented spectrogram there is no high peaks corresponding to disturbing periodic yarn faults. Dip on the wavelength at 36 mm (actual fibers length) indicates the stability of the drawing process on machinery of spinning production.

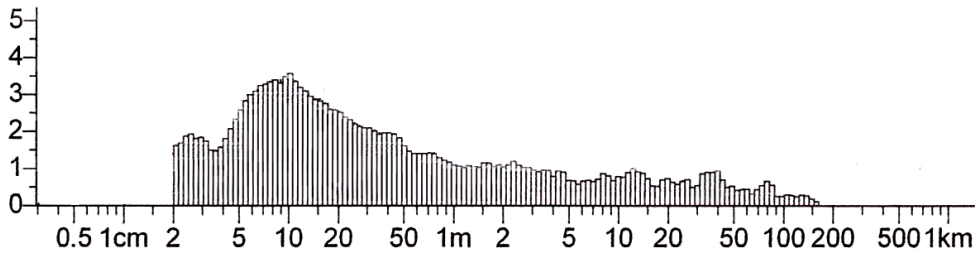

Figure 1. Spectrogram of Arselon ring-spun yarn

Additional task solved within research is determining minimal linear density of yarn, which satisfies the following criteria:

- Breaking tenacity must be not less than 16 cN/tex;
- Coefficient of variation CVm must appropriate Uster® Statistics Percentile not higher than 50 %.

All investigated samples of yarns satisfied the requirements for yarns strength.

For evaluation of yarns evenness we used information from Uster® Statistics 2013 (US 2013) about cotton carded yarn for weaving. It is due to the lack of information about heat-resistant fibers. On the other hand, data about properties of polyester yarn were not used as the base for evaluation because presented data related to yarn manufactured of fibers 133 tex with length 38 – 40 mm. As we used Arselon fibers 162 tex the yarn evenness must be significantly higher. So, we cannot recommend use-developed technology for producing Arselon yarn with linear density less than 20 tex.

On the figure results of CVm evaluation are presented. The diagram shows that only for yarn 16 tex coefficient of variation CVm exceeds the limit: USP 50 %. So, we cannot recommend producing Arselon yarn with linear density less than 20 tex using for developed technology.

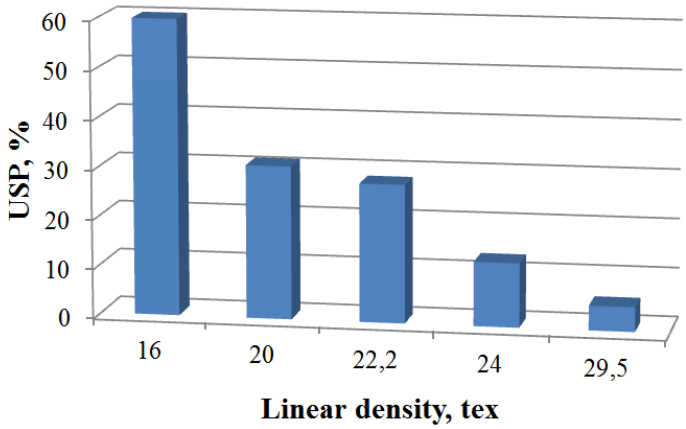

Figure 2. Uster® Statistics Percentiles for CVm of Arselon yarns of different linear density

4. Properties of 2-ply Arselon yarn

Properties of 2-ply yarns obtained after their twist optimisation are presented in Table 3.

Table 3. Properties of 2-ply Aselon yarns

Property	Value		
Nominal linear density, tex	16×2	20×2	22,2×2
Actual linear density, tex	31,7	39,7	43,3
Breaking force, cN	713,5	909,6	930,0
Breaking tenacity, cN/tex	22,51	22,91	21,48
Coefficient of variation of breaking force, %	4,97	8,17	8,03
Elongation, %	16,74	17,10	18,12
Coefficient of variation CVm, %	13,14	12,30	11,32
Thin places (-50 %) per 1 km	0,0	0,0	2,0
Thick places (+50 %) per 1 km	54,0	20,0	11,0
Neps per (+200 %) 1 km	57,0	35,0	8,0

Analysing presented data the following conclusions were drawn:

- The breaking force of 2-ply yarn increases almost directly in proportion to its linear density, while the breaking tenacity in the investigated range changes insignificantly;
- Rise of yarn linear density leads to its elongation increasing, to reducing irregularity and the frequently-occurred faults. Decreasing of coefficient of variation CVm is due to increasing of fibers number on the yarn cross-section;
- Comparison of data presented in the tables 2 and 3 shows that breaking tenacity of 2-ply yarns 16 tex×2 and 20 tex×2 by 20 % higher than breaking tenacity of corresponding single ring-spun yarns;
- Yarns winding and assembling lead to significant reducing the number of the frequently-occurred faults. Thin places are almost eliminated, thick places and neps number reduced by more than 3 times.

5. Conclusions

1. Developed technology allows manufacturing Arselon ring-spun yarns 20 – 29,5 tex of acceptable quality. Coefficient of variation CVm of these yarns appropriate USP not higher than 50 %. It is proven that index irregularity of the yarns for whole range is 1,65 that can be used for Cvm prediction for yarns of other linear densities. For yarn of linear density less than 20 tex it was recommended to correct technology on the further stage of research.

2. Winding and assembling lead to significant reducing the number of frequently-occurred faults of 2-ply yarns. Thin places are almost eliminated, thick places and neps number reduced by more than 3 times. Breaking tenacity of 2-ply yarns 16 tex×2 and 20 tex×2 by 20 % higher than breaking tenacity of corresponding single ring-spun yarns.

3. The developed range of Arselon yarns is the base for creation of new textile products such as woven and knitted fabrics and goods which can be made of them.

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