VARIATION OF WOOL CHARACTERISTICS BY INDIVIDUAL VAPORIZATION AND REWINDING

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REZUMAT, Unele produse tricotate necesită fire voluminoase şi total stabile la formarea cârceilor de torsionare. Obţinerea acestor calităţi se realizează printr-o operaţie tehnologică de vaporizare individuală a firului pe o maşină specială de vaporizat şi rebobinat. În lucrare se prezintă variaţia caracteristicilor firelor tip lână prin vaporizare individuală. Se caracterizează efectul vaporizării individuale prin coeficienţi numerici de stabilitate ai firului la formarea cârceilor de torsionare şi prin coeficienţi de creştere a volumului. Se prezintă şi alte modificări le caracteristicilor firelor, ca de exemplu: fineţe, rezistenţă şi alungire la rupere etc.

Cuvinte cheie: **fire, proprietăţi fire vaporizate, stabilitate la torsiune a firelor, proces de vaporizare în flux continuu a firelor**

SUMMARY. Some knitted products require bulky and totally stable yarns to form torsion crutches. Achieving these qualities is accomplished by a single individual vaporization process of the yarn on a special vaporized and rewound machine. The paper presents the variation of individual wool characteristics. The effect of individual vaporization is characterized by numerical stability coefficients of the yarn in the formation of torsion crutches and by volume increase coefficients. There are other changes to the characteristics of the yarn, such as: fineness, strength and elongation at break, etc.

Keywords: yarns, vaporization process, characteristics of yarns, stability of torsion yarns

1. THE TECHNOLOGICAL PRINCIPLE OF INDIVIDUAL YARN VAPORIZATION

Classical vaporization of wool yarns takes place in autoclaves, with the main purpose of stabilizing the formation of crutches. Vaporization of the yarn is done on coils or pipes, in a stationary process.

Vapor penetration into coils or pipes is made unevenly, generating vaporization unevenness along the yarn. There are areas where the yarn tends to form the crutches. In order to obtain a uniform vaporization along the length and increase the yarn volume, the individual vaporization of the yarn is used.

The individual vaporization of the yarn was made on the conveyor belt inside the vapor tunnel, from the flow of a BE.MA.TEX rewinding technology operation (fig.1.1.a), with the support of the specialists from SC "Transilana" SA.

At the entrance to the vaporization tunnel, a special device deposits the yarn on the vaporization band in the form of parallel segments (Fig. 1.1.b). At the exit of the vaporization tunnel (fig.1.1.c), the yarn cools and then winds on the rewinding coil (fig.1.1d).

The main effect of this technology is the increase of thread volume and stability in the formation of crutches. It is especially used for knitted yarns.

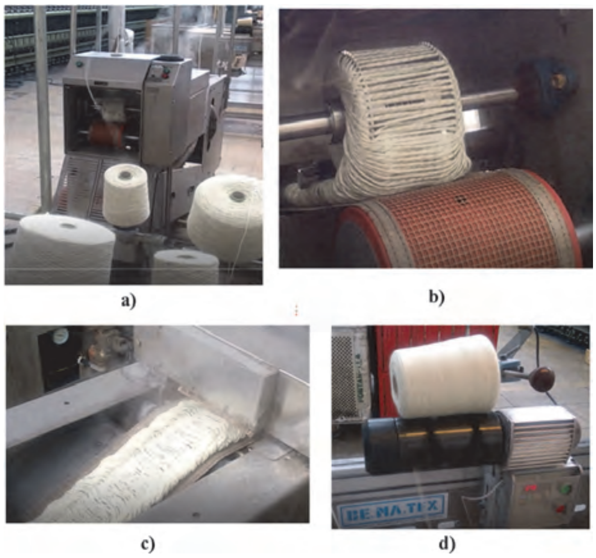

Fig.1.1. The technological principle of individual vaporization and yarn rewinding:
a) Tunnel rewinding flux for vaporizing the yarn;
b) Seating the yarn segments on the sieve strip vaporization of the transport and vaporization yarn; c) Exit the thread in the tunnel; d) Rewind the vaporized yarn vaporization for rewinding

2. CONDITIONS FOR EXPERIMENTING AND TESTING THE CHARACTERISTICS OF YARNS

The main parameters of the individual yarn vaporization are:

- The vaporization temperature;
- The length of the yarn on the vaporization path;
- Yarn feed rate;
- Yarn speed (winding);
- The speed of the band in the vaporization tunnel.

The values of these parameters have been set according to the characteristics of the yarns, the technological purpose and the possibilities of the machine. Table 1 shows the technological parameters used for the vaporization of three types of knitted yarn.

Table 1 **Technological conditions of individual vaporization of yarns**

Yarn fineness and fiber nature	**Vaporization technology parameters**				
	Vapor temperature, T, ^{0}C	**Wire feed rate, va, m / min**	**Wire cutting speed (winding) Vd,, m / min**	**Tunnel band speed, Vb, m / min**	**Yarn length on tape, Lv, m**
Nm 18,5/2 ; 100% contractable melon	106	500	300	30	250
Nm 7/3; 95% wool + 5% nylon	106	500	270	60	250
Nm 8,5/3; 100% wool	106	550	300	60	250

The main characteristics of the individual vaporized yarns that are changed as a result of this process are: fineness and torsion of the yarn, resistance and elongation to tear, clues to loose loops, fiber volumes increasing, etc. Laboratory determinations on yarn fineness and torsion, resistance and elongation were performed in the laboratory of the Transilana plant and the TPMI Iasi faculty. Determination of stability in crutch formation was carried out according to the principle in Fig. 2.1 [1, 2], based on the measurement of some lengths and the torsion of the crutches formed in the free loop of the yarn. The ratios for stability of cricket stability used in this case are:

- The yarn stability coefficient in the formation of the torsion crutches, i.e. the percentage stability;
- The coefficient of instability of the yarn in the formation of the torsion crutches, respectively the percentage instability;
- Twist self-twisting, etc.

The yarn stability coefficient for the formation of torsion cores, C_{sT}, is calculated by:

$$C_{sT} = \frac{L}{L_o} \quad (1)$$

The coefficient of instability of the yarn in the formation of torsion crutches, C_{iT}, is calculated with the relation:

$$C_{iT} = \frac{\Delta L}{L_o} = \frac{L_o - L}{L_o} = 1 - C_{sT} \quad (2)$$

where: ΔL is the length of the yarn turned into a hook (fig.2.c). L - length of the yarn that has not been turned into a hook in the approaching phase and the joining of the pretensioning clamp 2 and 3 (fig. 2); L_0 - the initial length of the yarn sample between the two clamps 2 and 3.

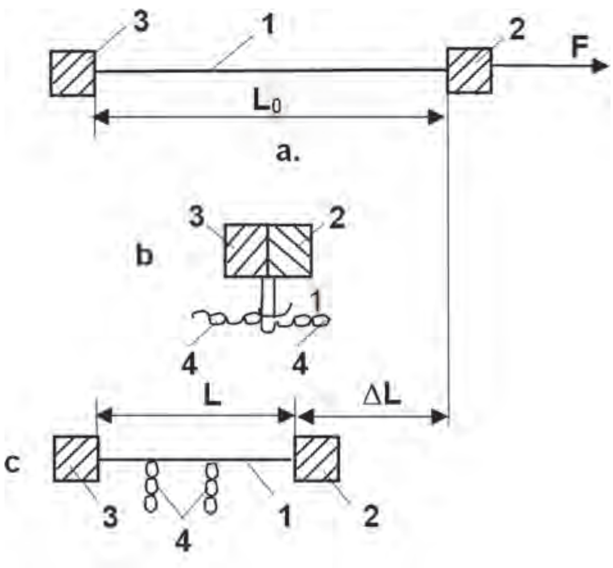

Fig. 2.1. Scheme for the formation of the crutches and the measurement of the lengths
1 - sample yarn; 2 - the yarn pretensioning clamp, in phase a, and the approach to adjoining, in phase b; 3 - fixed clamping clamp; 4 - Uncoiled yarn cloth. F - yarn pretensioning force;

The sum of the two coefficients, C_{iT} and C_{sT}, is always equal to 1, i.e.:

$$C_{sT} + C_{iT} = 1 \quad (3)$$

The stability and instability of the yarns in the formation of torsion cords is also determined by the following formulas:

$$S_T = \frac{L_o - \Delta L}{L_o} 100 = (1 - C_{iT})100 = 100\, C_{sT} \qquad (4)$$

$$I_T = \frac{L_o - L}{L_o} 100 = (1 - C_{sT})100 = 100 C_{iT} \qquad (5)$$

where: S_T - represents the percentage stability of the yarn in the formation of the crutches; I_T - Percent instability of the yarn in the formation of crutches.

The twisting torsion of the crutches is calculated using the formula:

$$T_{bc} = \frac{N_r}{\frac{\Delta L}{2}} = \frac{2N_r}{\Delta L} = \frac{2N_r}{L_o - L} \qquad (6)$$

where: T_{bc} - twist self-twisting torsion, in torsion/m; N_r - The total number of self-twisting (twist-off) rotations in the crutch.

Characterization of the volumetric growth of the individual vaporization yarns can be done by two indicators:

- The volumetric variation of the yarns under predetermined pressure on the layers;
- Coefficient of volumetric variation of yarns under predetermined pressure on layers or variations of these pressures;

For simplicity, a special device with the * U * shaped test area was used to lay the yarns (figure 2.2.a). In this way, the deformation of the layers under the action of a pressing force can be done only in one direction (vertical), and by pressing only the thickness of the layers will be changed.

The volumetric variation (V_v) and the volumetric variation coefficient (K_v), under the action of some pressure on the layers of yarn, were determined with the formulas:

$$V_v = \frac{V_0 - V_1}{V_0} \cdot 100; V_v = (1 - \frac{V_1}{V_0}) \cdot 100; \quad V_v = (1 - \frac{\Delta_1}{\Delta_0}) \cdot 100; K_v = \frac{\Delta_1}{\Delta_0} \qquad (7)$$

where: V_v - Volumetric variation of the layers of yarns subjected to preset pressure, in%; K_v - volumetric coefficient of the yarn (decrease in volume under the action of a pre-determined force); V_0 -the sample volume of unprinted thread, and V_1 - the volume of the sample of pressed yarn. Δ_1 -thickness of pressed yarn layers, Δ_2 - thickness of unpressed yarn layers.

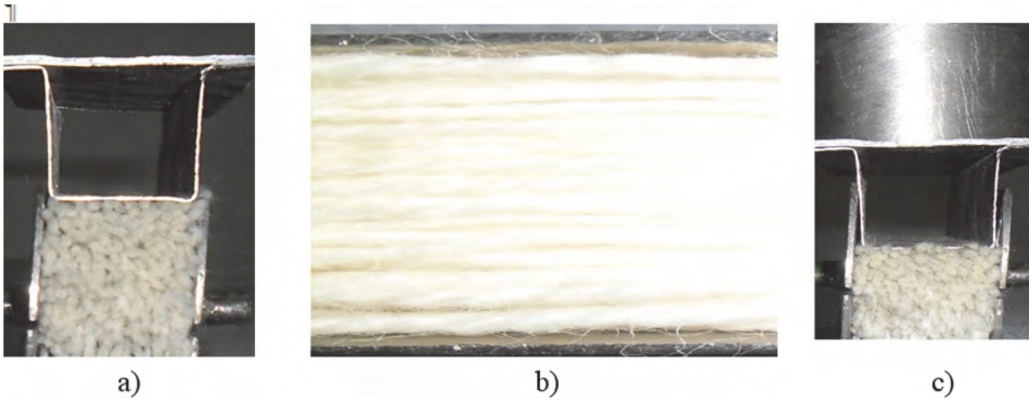

Fig. 2.2. Yarn presse:
a) Unstressed yarns; b) Thread position in the press area; c) Pressed yarns.

3. VARIATION OF THREAD CHARACTERISTICS FOLLOWING THE PROCESS OF INDIVIDUAL VAPORIZATION

The main purpose of vaporization of the individual thread is to increase its volume, based on thermal shrinkage fibers or filaments twisted wire components.

Besides increasing, are subject to change and other physical and mechanical characteristics, such as: smoothness, torque, load and elongation at break, etc. These changes are highlighted in Table 2.

Thread count falls, at all three types of yarns due to thermal contraction of fiber thread components vaporized in free lane tunnel grid vaporization. On the 100% contactable melon thread, the fineness drops by 22,9%. On yarns of 100% wool or a low percentage of nylon yarn, the yarn fineness decrease is insignificant (-1,5% for yarn of 100% wool and –2,1% for yarn spun with 5% nylon).

The yarn torsion increases only to the 100% contactable mélange yarns, where the value increases by 19,3%. Also at this yarn in contactable melamine there was a decrease of 21,1% of the breaking load and an increase of the elongation at break by 144,3%. On the other yarns, these changes are much smaller (0.4% of the breaking load and + 6,5% in the yarn breaking elongation of 8,5 Nm/3, 100% wool).

Table2 **Variation of physical-mechanical characteristics following individual yarn vaporization**

Name of the characteristic	Experimental values of the measured characteristic			
	Before vaporization	After vaporization	Absolute variation	Percent variation
Yarn Nm 18,5/2; 100% contractable melon				
Fineness: Nm , în m/g	24/2	18,5/2	-5,5/2	-22,9%
Torsion: T, în m^{-1}	181	216	+ 35	+19,3%
Breaking load, Sr, în cN	1004	792	-212	-21,1%
Elongation at break, în %	12,4	30,3	+17,9	+144,3
Yarn Nm 7/3; 95% wool + 5% nylon				
Fineness: Nm , în m/g	7/3	6,9/3	- 0.1/3	
Torsion: T, în m^{-1}		115		
Breaking load, Sr, în cN		3579		
Elongation at break, în %		39,2		
Yarn Nm 8,5/3; 100% wool				
Fineness: Nm , în m/g	8,5/3	8,38/3	- 0,13/3	-1,5%
Torsion: T, în m^{-1}	116	116	0	0
Breaking load, Sr, în cN	2370	2361	-9	-0,4%
Elongation at break, în %	18,4	19,6	-1,2	+6,5%

Vaporized yarns have had relatively low torsion because they are designed for knitting. However, they have a certain torsional instability and tend to deform the product. By vaporization the yarns become more stable in the formation of the crutches, and the product will keep better its flat shape (fig.3.1)

The torsion and crutch stability changes significantly in all yarns, and Table 3 shows the variation of stability indexes in crutch formation resulting from individual thread vaporization by rewinding. As a result of this process, the torsional stability coefficient increased by 85.9% for Nm 18,5/2 - 100% contactable melon and 78.5% for Nm 7/3 – (95% wool + 5% nylon)

Fig.3.1. Forms of the tool: forward vaporization (self-twisting); after vaporization (parallel turns without self-twisting)

At the same time, the coefficient of instability in crutch formation decreased by 100%, the yarn becoming totally stable (fig.4).

The total stability of the individual vaporized yarns is also reflected by the numerical torque index in the hook. On non-vaporized torsion, the torso had values of 90,4; 50 and 60,46 torsion/m (Table 3). After vaporization, all three types of yarn twisted into zero, proving the overall stability of the yarns.

The volumetric variation of the yarns was evaluated percent (V_v in %) either by increasing the pressure from (0…100) cN/cm^2 or by increasing the thickness at the same pressure. The values obtained can be found in Table 4.

Following individual vaporization and the same pressure on the layers of wool, the volumetric variation has significantly lower values for wool yarn than contracted mélange (12.1% versus 64.7%). At the same time, at the increase of the layer pressure from 0 to 100 cN/cm^2, the volumetric variation of the 100% mélange wool (V_v = 46%) approaches the 100% wool yarn (V_v = 49%) if the mélange yarns are individually vaporized. Practical results regarding the increase in the volume of individual wires support the necessity of using this technological operation, first of all, for synthetic fiber yarns. The volumetric indices of 100% wool yarns or blends have corresponding values even by autoclave vaporization only.

Table 3 **Variation of stability indexes in the formation of torsion skids**

Name of the characteristic	**Experimental values of the measured characteristic**			
	Before vaporization	**After vaporization**	**Absolute variation**	**Percent variation**
Yarn Nm 18,5/2, 100% contractable melon				
Coefficient of stability, C_{st}	0,54	1	+ 0,46	+85,1 %
Coefficient of instability, C_{iT}	0,46	0	-0,46	-100%
Torsion in the crutches; T_c, m^{-1}	90,4	0	-90,4	-100%
Yarn Nm 7/3, 95% wool + 5% nylon				
Coefficient of stability, C_{st}	0,56	1	+0,44	+78,5%
Coefficient of instability, C_{iT}	0,44	0	-0,44	-100%
Torsion in the crutches; T_c, m^{-1}	54,5	0	-54,5	-100%
Yarn Nm 8,5 / 3, 100 % wool				
Coefficient of stability, C_{st}	0,57	1	+0,43	+75,4%
Coefficient of instability, C_{iT}	0,43	0	-0,43	-100%
Torsion in the crutches; T_c, m^{-1}	60,46	0	-60,46	-100%

Table 4 **Volumetric variation of yarns through individual vaporization**

Characteristics	**Values measured or calculated on yarns:**		**Volumetric variation V_v, %**
	Unvaporized	**Vaporized**	
Yarn Nm 18.5 / 2, 100% contractable melon			
Total number of yarns in layers	600		
Layers thickness without pressing, Δ_i, m	Δ_n = 13,5	Δ_v = 26	92,5
Layers thickness pressed with 100 cN / cm^2,Δ_1, mm	Δ_{1n} = 8,5	Δ_{1v} = 14	64,7
Volumetric variation , V_v, %	37	46	
Yarn Nm 7/3, 95% wool + 5% nylon			
Total number of yarns in layers	200		
Layers thickness without pressing, Δ_i, mm	Δ_n = 20	Δ_v = 25	25
Layers thickness pressed with 100 cN / cm^2, Δ_1,mm	Δ_{1n} = 10,7	Δ_{1v} = 12	12,1
Volumetric variation , V_v, %	46,5	52	
Yarn Nm 8.5 / 3, 100% wool			
Total number of yarns in layers	200		
Layers thickness without pressing, Δ_i , mm	Δ_n = 19,3	Δ_v = 25,66	32,9
Layers thickness pressed with 100 cN / cm^2, Δ_1, mm	Δ_{1n} = 10	Δ_{1v} = 12,66	26,6
Volumetric variation , V_v, %	48,1	49	

4. CONCLUSIONS

1) By individual vaporization of wool yarns, some of their physico-mechanical characteristics have changed:
   a) Nm 18,5/2 -100% contractable melon occurs:
   - decrease of thread fineness by 22,9%;
   - turn increase by 19,3 5%;
   - the breaking strength by 21,1%;
   - increase of the elongation at break by 144,3%.

   b) Nm 7,3/3 –(95% wool + 5% nylon) yarn and Nm 8,5/3 -100% wool does not show significant changes in physical and mechanical characteristics.
2) Knitted wool yarns have certain instability in crutch formation, even at small twists. The specific indicators for characterizing the effect of individual vaporization on the yarn's stability in the formation of torsion crutches have highlighted the following:
   a) Significant increase of the yarn stability coefficient in the formation of torsion crutches (+ 75,4% for Nm 8,5/3 - 100% wool and + 85,1% for thread Nm 18,5/2 - 100% melon contract);
   b) 100% decrease of the instability coefficient on all yarns, which become totally stable;
   c) Total displacement of torso in the hat (100%); No torsion creases are formed.
3) Individual yarn vaporization, although low in productivity, is nevertheless recommended for certain threads of contractable synthetic fibers to ensure the increase in the volume of these yarns.

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