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THE BEHAVIOUR OF RIB 1:1 AND 2:2 KNITTED COTTON FABRICS DURING DIFFERENT SOLICITATIONS AND TREATMENTS

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Abstract: *The paper presents a study of the behaviour of rib 1:1 and 2:2 knitted fabrics made of 100 % cotton yarns during different solicitations and treatments. The studied knits were grey and finished fabrics obtained on large circular knitting machines in the form of tubular metreage. Grey knitted fabrics were deposited for relaxation, 72 hours in folded condition, in an air-conditioned room in accordance with standard atmosphere parameters. After relaxation, the knits were finished in regular factory parameters and optically brightened. Several aspects were analyzed, namely: vertical density and the mass per square meter; the tesile strength in the direction of the rows of stitches, hydrophilicity and whiteness degree.*
For grey rib 1:1 and 2:2 knitted fabrics, the vertical density after relaxation increases by 60 % compared to the vertical density on the knitting machine. By finishing, the values of vertical density have almost double values compared to the vertical density on the knitting machine. The established vertical density on the knitting machine is decisive for the mass per square meter, the dimensional stability and the shape after several cycles of wear and washing.
The rib 2:2 structures combine elements specific for plain and rib knitted fabrics, which is why they are less balanced in terms of internal tensions. Because of that, this structure behaves differently than rib 1:1 structure during the tensile strength solicitations. The applied Uvitex BLH optical brightener gives to the cotton knitted fabrics an eminent appearance which is called whiter than the whites.

Key words: *rib 1:1 and 2:2 cotton knitted fabrics, grey and finished knitted fabrics, vertical density, tensile strength, hydrophilicity, whiteness degree.*

1. INTRODUCTION

The knitted fabrics are textile structures made of stitches, which are elastic linked. The structures are elastic due to the way they are made on knitting machines and due to the possibility of yarns migrating between the elements of the structure.

After knitting, cotton yarns, try to return to their original state, as unthread loop. This is achieved during relaxation process for 72 hours after knitting. During the relaxation period, the existent internal tensions in knitted fabrics are balanced, tensions that were introduced during the knitting and drawing process, and the loops shape was changed randomly by migrating some quantities of yarn between the elements of the structure. There is no predetermined rule for this modification, the final result being the balancing of the internal tensions in the structure. During the relaxation period, also the vertical density – D_v is modified, this being an essential parameter for the final dimensional stability of the knitwear. The structural elements of a knit that are closely related to both the finishing technology and the dimensional stability obtained are: the yarns fineness, the vertical density and the structure of the knitted fabric [1, 2].

Pre-treatments and finishing operations include steps that have the purpose of removing the natural attendants of the material and technological impurities. A swelling and fixation of the fibre is obtained, as well as modification of the crystalline-amorphous ratio with the arrangement of amorphous areas in the fibre. By removing the non-cellulosic attendants, a better capacity of wetting is conferred to the material [3].

The steps of finishing technological flow for knitted fabrics are:

- Removal of oil stains, made with strong emulsifiers, polyethoxylated fatty alcohols, which have a high emulsifying power and can be used to remove greasy stains;
- Washing step, which in the case of cotton knitwear finishing, has both the purpose of removing the technological impurities, especially the paraffin used for knitting, as well as the maximum swelling of the fibre in order to relax the latent tensions existent in the knitted structure. For dimensional stability, the first washing step is very important, which is why necessary to choose the appropriate washing agents, washing temperature, the duration of the process and mechanical action. The surfactants used in the washing procedure are adsorbed on the surface of the dirt particles, then due to the dispersive and colloid protective character the impurities are passed into the solution and kept there in the dispersed state;
- The alkaline treatment carried out for the removal of hemicelluloses, pectic substances, waxes, fats and for the modification of lignin from the shells of the cotton seeds in a state that allows their rapid removal in the subsequent whitening processes;
- Bleaching for destroying the chromophore of the natural organic pigments of cotton. At the same time, whitening also removes the shells of the cotton seeds that have suffered an advanced swelling during the alkaline treatment process;
- Squeezing, for minimizing the internal tensions introduced into the structure, air blowing system is used, which replaces the classical centrifugation. For proper drying, 3 air passages are used.
- Drying which is done on tunnel type dryers, with tape;
- The last stage of the finishing process is the calendering, operation in which the knit is passed through a frame corresponding to the width of the knitted fabric and among some heated cylinders and afterwards deposited in a folded state for relaxation in air-conditioned rooms with standard atmosphere. To prevent the additional tensions in the fabric, the frames are filled in advance to avoid dragging of the knitted fabric. The parameters of the calendering process are adjusted according to the nature of the yarns and the structure of the knit.

2. EXPERIMANTAL PART

The analyzed knitted fabrics were made on circular knitting machines TERROT and TEXTIMA with large diameter and two needle beds. The technical characteristics of the knitting machines are presented in Table 1.

Table 1: *The technical characteristics of the knitting machines*

No.	Knit structure	The type of knitting machine	Technical specifications			
			Fineness [E]	Diameter [inch]	Number of systems S	Number of needles
1	Rib 1:1	TERROT	18	16	24	2x920
2	Rib 2:2	TEXTIMA	18	20	32	2x1152

The rib 1:1 knitted fabrics were made from 100 % combed cotton yarn with Ne 50/1 yarn count and 12.5 stitches/cm vertical density on the knitting machine. For rib 2:2 structure the same 100 % combed cotton yarn was used but with Ne 40/1 yarn count and 12 stitches/cm vertical density.

The obtained grey knitted fabrics were deposited for relaxation, 72 hours in folded condition, in an air-conditioned room in accordance with standard atmosphere parameters: T = 20 ^{0}C, pressure - P = 760 mm col Hg and relative humidity of air - φ = 60 %. After relaxation, the knits were finished in regular factory parameters and optically brightened. The finishing process was performed according to a preset technological flow so that one of the important parameters like dimensional stability, would be within ± 2%.

The specific reagents used for all steps of finishing technological flow for knitted fabrics were purchase from: CHT Bezema Company (Denimcol Wash RGN – detergent), Huntsman International LLC (Uvitex BLH - optical brightener), Sigma-Aldrich (polyethoxylated fatty alcohol, sodium hydroxide, sodium bisulfite, hydrogen peroxide, sodium carbonate, sodium silicate), and Rotta Company (Sulfolen 148: S-148 alkyl polyglicol ether - wetting agent). The finishing technological flow was consisted of the following operations: washing, alkaline treatment, bleaching and optical brightening, squeezing, drying and calendaring. After drying and conditioning of the samples, a series of analyses were done: vertical density, the mass per square meter, hydrophilicity, tensile strength and elongation at break, whiteness index and yellowness index.

The vertical density of the grey and finished knitted fabrics was done by using a textile magnifying glass. The mass per square meter was determined with an analytical balance Mettler Toledo AB250 according to SR EN 12127-2013 – "*The determination of the mass per unit area on small samples of knitted fabrics*". For structure changes evaluation after finishing, the stereomicroscop Zeiss Stemi 2000 with AxioCam was used. The hydrophilicity evaluation was done according to *AATTCC Test Method 79-2007*. The 5KT testing machine from Tinius Olsen - United States was used to evaluate strength and elongation at break of the raw and finished cotton knitted samples and the values were recorded on the computer by Horizon software. The determinations were done according to ASTM D 5035 – 06 "*Standard Test Method for Breaking Force and Elongation of Textile Fabrics (Strip Method)*". The whiteness and yellowness index were measured by a reflectance spectrophotometer (Datacolor 500 from Datacolor Company, USA) and D65 illuminant was considered in all the cases. The samples were folded six times for an opaque view and measured in five different points. The average value was considered. The Whiteness Index (WI) and E313 Yellowness Index were automatically calculated by Datacolor Tools 2.0 software.

3. RESULTS AND DISCUSSIONS

The studied grey and finished knitted fabrics were evaluated by analysing the physical, mechanical and optical properties. Further on will be presented the comparative results obtain for the rib 1:1 and 2:2 grey and finished knitted fabrics. Table 2 presents the vertical density on the knitting machine, after relaxation and after finishing as well as the mass/m^2 for grey and finished knitted fabrics for both types of structures.

Table 2: *Vertical density and mass/m^2 for rib 1:1 and 2:2 grey and finished knitted fabrics*

Structure	D_v on knitting machine [stitches/cm]	$D_{v\ grey}$ [stitches/cm]	$D_{v\ finished}$ [stitches/cm]	m/m^2 grey [g]	m/m^2 finished [g]
Rib 1:1 100 % cotton, Ne 50/1	12.5	21.0	24.0	160.5	192.6
Rib 2:2 100 % cotton, Ne 40/1	12.0	22.0	23.5	232.4	240.7

For a better evaluation of the changes appeared in the structure of knitted fabrics after finishing, the samples were analyzed with a stereomicroscope. Figures 1 and 2 presents the images of rib 1:1 structure for grey and finished knitted fabrics.

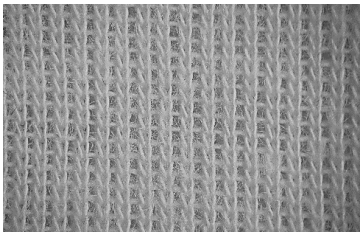

Fig. 1: *Image of rib 1:1 grey knitted fabric*

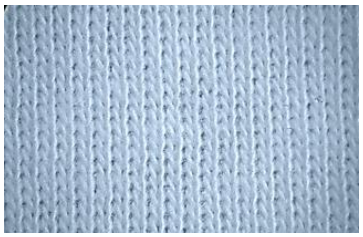

Fig. 2: *Image of rib 1:1 finished knitted fabric*

The rib 1:1 structure has the same appearance on both sides and is one of the most balanced structures due to the arrangement of the sinker loop for rib structure in a different plane from the two planes of the knit. From the images we can see an increase of the knit compactness due to the changes that take place in the fibers and in the knitted structure during the finishing process. The process of finishing is carried out on knitwear in wet condition, at high temperature with controlled and uniform tensions throughout the whole process. Figure 2 highlights the vertical direction of the stitches strings, therefore the minimization of the spiral effect, which shows a technological flow of finishing correctly applied to the knitted fabric. In the bleaching process a swelling of the fibers take place which explains the increase of the vertical density of the knit. By increasing vertical density and knitted compactness, the number of yarn-yarn contact points and the number of contact surfaces between yarns increases, so that, dimensional changes after home laundering are in the accepted limits of ± 2 %.

In figures 3 and 4 are presented the images of rib 2:2 structure for grey and finished knitted fabrics.

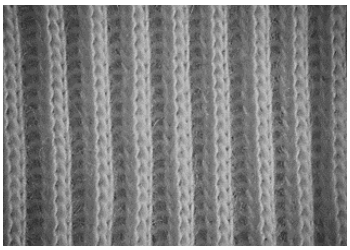

Fig. 3: *Image of rib 2:2 grey knitted fabric*

Fig. 4: *Image of rib 2:2 finished knitted fabric*

The rib 2:2 structure looks the same on both sides but is one of the least balanced structures in terms of internal tensions. This fact is explained by the presence in the structure of both plain and

rib sinker loops. Plain sinker loops are longer than the rib ones, so the yarn-yarn contact surfaces are smaller than in the case of rib 1:1 structures. From figure 4, the same minimization of the spiral effect can be observed, which shows that the technological flow of finishing was correctly applied to the knitted fabric.

The wettability evaluation of cotton knitted samples was made according to AATTCC - Test Method 79-2007. A drop of water was delivered from a burette onto the surface of the fabric. The time required for the water drop to disappear into the fabric was measured and recorded as wetting time. Average values of five determinations on different areas of the fabrics were taken [4]. The average values for all analyzed samples are presented in Table 3.

Table 3: *The hydrophilicity of rib 1:1 and 2:2 grey and finished knitted fabrics*

Sample	Water absorbency [sec.]
Rib 1:1 grey	Does not absorb
Rib 1:1 finished	1 sec.
Rib 2:2 grey	Does not absorb
Rib 2:2 finished	1 sec.

Hydrophilicity values obtained for both finished knitted structures shows a good and effective finishing treatment.

The average values of the tensile strength [N] and of the elongation at break [%] are presented in Figures 5 and 6.

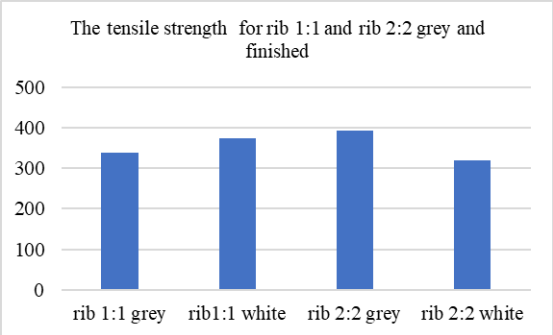

Fig. 5: *Tensile strength of rib 1:1 and 2:2 grey and finished knitted fabric*

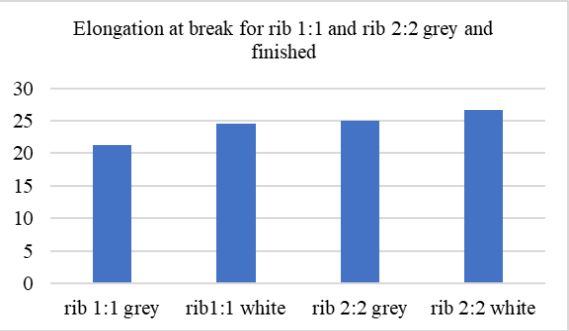

Fig. 5: *Elongation at break of rib 1:1 and 2:2 grey and finished knitted fabric*

By analysing the obtained values, it can be observed that for rib 1:1 structures the breaking force for finished samples is higher than the breaking force for the grey ones. This is explained by the fact that the structure being balanced, the number of points and surfaces of yarn-yarn contact is higher in the finished state than in the grey state. For rib 2: 2 structure the breaking force for the grey knit is higher than for finished one. This fact is explained by that the rib 2:2 structures are the most unbalanced in terms of internal tensions. An advanced waxing of yarn may be another cause of the yarns slippage between the elements of the structure and the increase of the breaking force for the raw state structure. In both cases, for both the rib 1:1 and 2:2, the elongation at break is higher for finished knitted fabric than for raw knitwear. One explanation may be that by washing procedure the paraffin was removed which would allow to the yarns to redistributes between the elements of the structure [5].

An estimated of 15 to 20 % of all textile products are white, the determination and control of whiteness is thus of primary importance to the textile industry [6]. The average values of six measurements for Whiteness and Yellowness Index (CIE/E313) are shown in Table 4.

Table 4: *Whiteness and Yellowness Index (CIE/E313) of rib 1:1 and 2:2 grey and finished knitted fabrics*

Sample	Whiteness CIE/E313	Yellowness E313
Rib 1:1 grey	21.19	26.21
Rib 1:1 finished	178.82	-39.60
Rib 2:2 grey	20.49	29.98
Rib 2:2 finished	177.12	-39.61

The bleaching treatment destroyed the chromophore of the natural organic pigments of cotton and the optical brightener Uvitex BLH increased the apparent reflectance of the article in the blue-violet region of the spectrum. From the above result, it can be seen that the concentration of OBA applied led to a whiteness index over hundred and a negative value for yellowness. Uvitex BLH gives to the cotton knitted fabric an eminent appearance which is called whiter than the whites.

4. CONCLUSIONS

1. For grey, rib 1:1 and 2:2 knitted fabrics made of 100 % cotton yarns, the vertical density after relaxation increases by 60 % compared to the vertical density on the knitting machine. By finishing, the values of vertical density of the rib 1:1 and 2:2 knitted fabrics have almost double values compared to the vertical density on the knitting machine.

2. The vertical density established on the knitting machine is decisive regarding the mass per square meter of the knits, the dimensional stability and the shape after several cycles of wear and washing.

3. The rib 2:2 structures have combined elements specific for plain and rib knitted fabrics, which is why they are less balanced in terms of internal tensions. Because of that, this structure behaves differently than rib 1:1 structure during the tensile strength solicitations.

4. The Uvitex BLH optical brightener gives to the cotton knitted fabric an eminent appearance which is called whiter than the whites.

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