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Research Regarding the Influence of Raw Material and Knitted Fabric Geometry on the Tensile Strength and Breaking Elongation

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Abstract

The main purpose of this research paper is to increase the performance of knitting process during socks manufacturing by choosing the right knitted fabric geometry and raw material. On the other side, tests results show the wear resistance regarding mechanical properties like tensile strength and breaking elongation of knitted fabrics for socks. To obtain samples knitted fabric were used several types of some classic yarns, which already use to obtain socks organic also another type of yarns less used: cotton, organic cotton, bamboo viscose, soy + cotton, Tencel.
From these yarns the following knitted fabric geometry were obtained: plated single jersey, plated ribb 4:2 and plated purl (rice grain). The tests were performed according with standard EN ISO 13934-2:2002 - Textiles -- Tensile properties of fabrics -- Part 2: Determination of maximum force using the Grab method. Graphs, results, conclusions and discussions was done.

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Keywords: tensile strength; breaking elongation; socks; ecological raw material; plated single jersey; plated rib 4:2; plated purl.

1. Introduction

To obtain a good quality, product focus is not only on aesthetics but also its behavior in certain physical and mechanical demands. Product quality is strictly related to possibility of using it without being modified its original features [1].

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These characteristics are influenced by several factors: the nature of raw materials, fabric structure and its density, technological parameters operation of knitting and finishing.

The samples were subjected has standardized dimensions (length 200 mm and width 50 mm) and can be oriented in the direction of the technological axes, like the wales of knitted fabric, respectively rows. In this paper, the tests were done only in the direction of the wales (figure 1) [3, 4, 5, 6, 7, 8, 18, 19].

2. Background

Many test regarding tensile strength was done on knitted fabric, but not on this type of fabric from ecofriendly raw material, geometry and density.

In their paper Bini and all [10] reports some further studies on the tensile properties of plain weft knitted DuPont Kevlar fiber fabric reinforced epoxy matrix composites. One aim of this work is to investigate systematically the anisotropy of knitted fabric composites. Tensile tests were conducted at different off-axial angles (0°, 30°, 45°, 60° and 90°) with respect to the wale direction [10].

Brad and Dinu [12] study the technical and home textiles consist in mechanical properties evaluation. After strength and tensile elongation testing for 3 types of 2 colors Rib based knitted fabrics, one can see that the double layer knit presents the best mechanical behavior, followed by Birdseye backing Jacquard and then back stripes Jacquard. For tensile stress in bias direction, the twill backing Jacquard has a good breakage resistance value due to the higher number of rib sinker loops in structure that are positioned on the same direction with the tensile force.

As a conclusion of their paper, the twill backing Jacquard structure could be considered as an alternative for the quilted double-layer structure for the base material for mattress covers or other applications where a good resistance and elasticity are required [12, 18, 19].

Treigienė and Laureckienė [13] investigate plated jersey knits of different composition and stabilized under hydrothermal conditions of 85°C for 10, 20 or 30 min in steam ambience. The influence of stabilization duration on knit structure was estimated as well as change of mechanical properties of the yarns. The obtained data show that 10 min of stabilization influenced markedly the structure of plated jersey knits comparing with the same effect of 20 min and 30 min. The results of specific breaking force of polyester, cotton and wool yarns show decrease in their strength due to knitting and hydrothermal stabilization processes [11, 13].

So, cotton is the most widely utilized fiber used in yarns that are knit into socks. That is because cotton is the least expensive of the natural fibers and many people think that cotton is suitable for socks since it is a great fiber for outer apparel. It feels good next to the skin and is cool and breathable. Unfortunately, in the closed environment of shoes, cotton can be detrimental to feet. Feet have app 2,200 pores per square inch or 200,000 pores per pair of feet. For the average person sitting or lightly walking their feet give off 50ml of perspiration per 12 hour day per each foot. For the average person not in humid conditions or engaged in high activities their feet give off approximately ½ pint per day or nearly 2 quarts of perspiration per week for both feet. Some people's feet perspire more than others. When your feet perspire cotton socks absorb the perspiration which in turns softens the skin of the feet. Soft skin can easily lead to the development of blisters.

This is the reason the researchers doesn't recommend cotton socks for sports and high activity endeavors. They are fine for everyday wear [14, 17].

3. Testing method and apparatus

The tests were performed according to standard EN ISO 13934-2: 2002 - Textiles. The tensile properties of textile materials. Part 2: Determination of maximum force - Grab method [15]. Before testing samples were conditioned for 24 hours in the standard atmosphere [3, 4, 5, 6, 7, 8].

The device used was electronic dynamometer TITAN 2 [8]:

- The distance between jaws: 100 mm
- Pretension force: 1.00N
- Test speed: 50mm / min; bottom jaw is fixed.

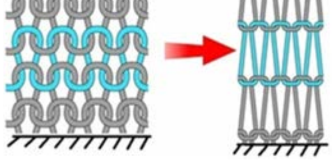


Fig. 1. Testing direction on samples [16].

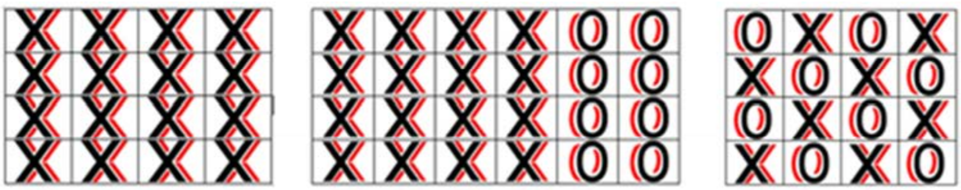
4. Samples

The codification for the samples used in the paper was: **1MDX** (Cotton, 34/1Nm), **2MDX** (Cotton, 40/1Nm), **3MDX** (Cotton, 50/1Nm), **1DC** (Organic Cotton, 34/1Nm), **3DC** (Cotton, 40/1Nm), **4DC** (Cotton, 50/1Nm), **6DC** (Cotton + soy (50% + 50%), 34/1Nm), **7DC** (PES + Viscose, (52% + 48%), 34/1Nm), **8DC** (PES + Viscose (52% + 48%), 34/1Nm), **9DC** (Tencel, 34/1Nm), **10DC** (bamboo + viscose, (50% + 50%), 34/1), **11DC** (Viscose + Silk, (90% + 10%), 34/1), **12DC** (Polyester 100%, 34/1), **13DC** (Polyester 100%, 34/1), **2DC** (Polyamide 6, 44/12x2dtex), **5DC** (Polyamide 6, 78/20x2dtex) and for the codification for the knitted fabric obtained from this yarns see table 1.

In the figure 2 are shown the knitted fabric geometry; were used three type of structure: plated single jersey, plated ribb 4:2 and plated purl.

Table 1. Example of coding variants of samples obtained from yarn 1DC [16].

CODE	Polyamide 6 dyed / not dyed	Fineness of P.A.6	Density
PLATED SINGLE JERSEY (GV)			
GV1.1DC	P.A. 6, not dyed	44/12x2	I
GV2.1DC	P.A. 6, not dyed	44/12x2	II
GV3.1DC	P.A. 6, dyed	44/12x2	I
GV4.1DC	P.A. 6, dyed	44/12x2	II
GV5.1DC	P.A. 6, not dyed	78/20x2	I
GV6.1DC	P.A. 6, not dyed	78/20x2	II
GV7.1DC	P.A. 6, dyed	78/20x2	I
GV8.1DC	P.A. 6, dyed	78/20x2	II
PLATED RIBB 4:2 (PV) and PLATED PURL (LV) - the same.			



a) Plated single jersey b) plated ribb 4:2 c) plated purl

Fig. 2. Knitted fabric geometry [16].

5. Results

In the table 2 are shown the results for all variants of knitted fabric obtained from yarn 1DC. For each sample, the device`s software generate the graph force – elongation load and extension panels display live values during testing, whilst a third panel guides the operator through the test. A real time graph, with user definable axes, shows the force/extension curve of the specimen under test. International textile standards have driven every aspect of Titan's engineering and software design. When a test standard is selected all the parameters are set automatically right down to the statistical analysis and reporting formats [16].

In the figures 3-14 we have the graphs for all knitted fabric geometry, density I and II, obtained from main yarn 1DC – organic cotton, fineness 34/1 Nm, plated with polyamide 6, 44/12x2 dtex.

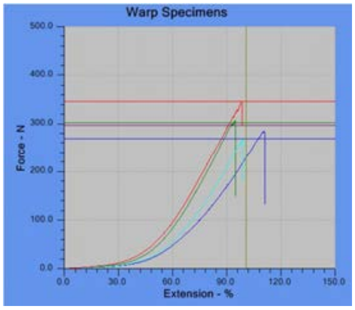


Fig. 3. GV, Organic Cotton 34/1 Nm + Polyamide 6, 44/12x2 dtex, density I.

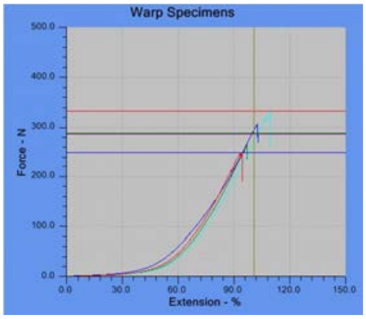


Fig. 4. GV, Organic Cotton 34/1 Nm + Polyamide 6, 44/12x2 dtex, density II.

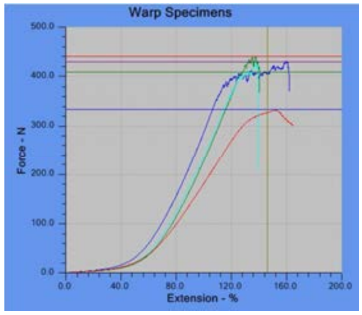


Fig. 5. GV, Organic Cotton 34/1 Nm + Polyamide 6, 78/20x2 dtex, density I.

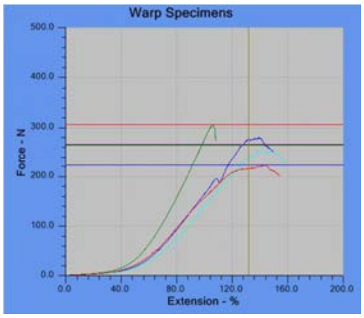


Fig. 6. GV, Organic Cotton 34/1 Nm + Polyamide 6, 78/20x2 dtex, density II.

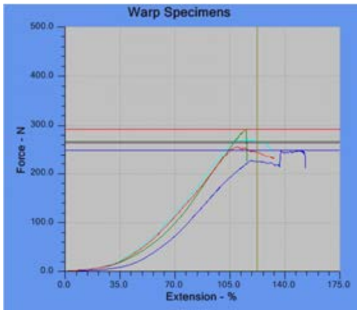


Fig. 7. PV, Organic Cotton 34/1 Nm + Polyamide 6, 44/12x2 dtex, density I.

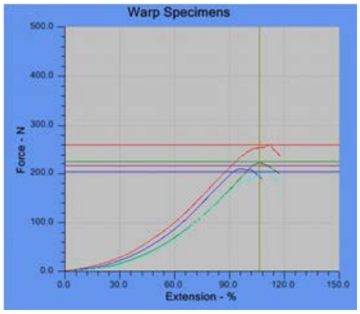


Fig. 8. PV, Organic Cotton 34/1 Nm + Polyamide 6, 44/12x2 dtex, density II.

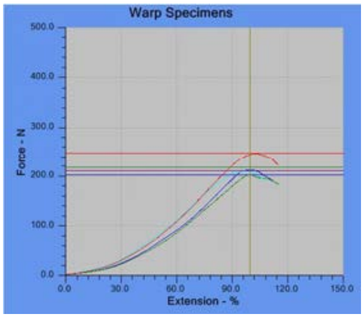


Fig. 9. PV, Organic Cotton 34/1 Nm + Polyamide 6, 70/20x2 dtex, density I.

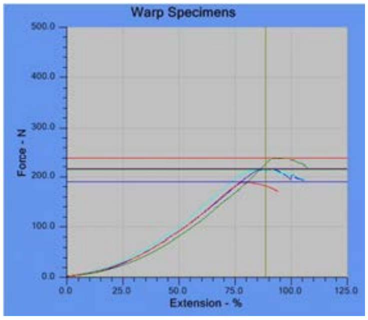


Fig. 10. PV, Organic Cotton 34/1 Nm + Polyamide 6, 70/20x2 dtex, density II.

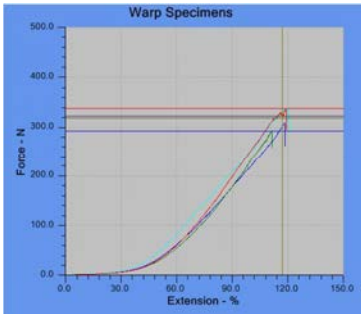


Fig. 11. LV, Organic cotton 34/1 Nm + Polyamide 6, 44/12x2 dtex, density I.

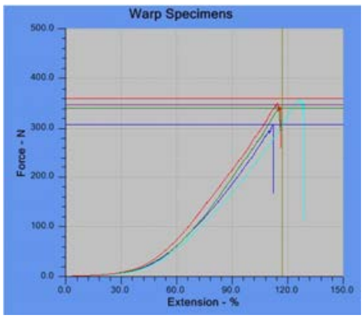


Fig. 12. LV, Cotton organic, 34/1 Nm + Polyamide 6, 44/12x2 dtex, density II.

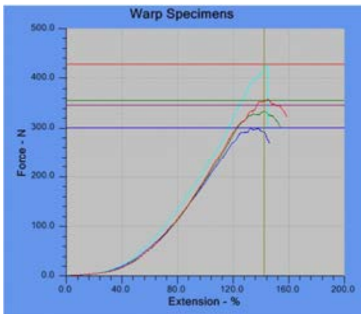


Fig. 13. LV, Organic cotton, 34/1 Nm + Polyamide 6, 78/20x2 dtex, density I.

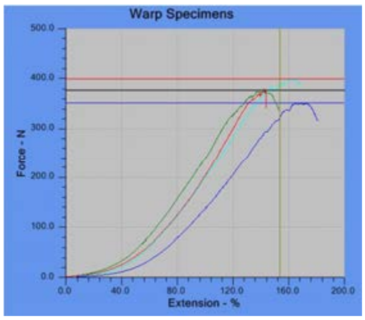


Fig. 14. LV, Cotton organic, 34/1 Nm + Polyamide 6, 78/20x2 dtex, density II.

Table 2. Results for breaking force and elongation in the case of yarn variant 1DC [16].

Coded sample	Knitted fabric geometry	Raw material (main yarn)	Raw material (plated yarn)	Fineness of plated yarn [dtex]	Dens ity	Average of breaking force [N]	Average of breaking elongation [%]	CV of breaking force [%]	CV of breaking elongation [%]
GV3.1 DC	Plated Single Jersey	Organic Cotton (bioRE), 34/1 Nm	Polyamide 6, dyed	44/12x2	I	302.12	100.69	11.21	6.89
GV4.1 DC				44/12x2	II	288.81	100.79	13.11	6.48
GV7.1 DC				78/20x2	I	408.48	146.28	12.22	7.35
GV8.1 DC				78/20x2	II	223.01	144.76	13.45	13.52
PV3.1 DC	Plated Ribb 4:2	Organic Cotton (bioRE), 34/1 Nm	Polyamide 6, dyed	44/12x2	I	267.50	122.45	7.19	15.69
PV4.1 DC				44/12x2	II	224.39	106.12	11.48	7.00
PV7.1 DC				78/20x2	I	218.40	99.48	9.15	2.13
PV8.1 DC				78/20x2	II	215.23	88.70	9.47	7.17
LV3.1 DC	Plated Purl	Organic Cotton (bioRE), 34/1 Nm	Polyamide 6, dyed	44/12x2	I	318.95	117.18	6.94	3.41
LV4.1 DC				44/12x2	II	341.16	117.19	6.76	5.63
LV7.1 DC				78/20x2	I	355.48	142.13	15.21	2.27
LV8.1 DC				78/20x2	II	376.71	153.73	5.25	8.98

6. Conclusions and discussions

Conclusions regarding the influence of raw material on tensile strength and elongation at break in the case of GV3 knitted fabric variant.

Table 3. Values of tensile strength and elongation at break for the variant GV3.

Samples	Raw material	Yarn fineness	Average of breaking force [N]	Average of breaking elongation [%]
GV3. 1MDX	Cotton	34Nm+44/12x2dtex	291.95	106.49
GV3. 2MDX	Cotton	40Nm+44/12x2 dtex	278.31	97.42
GV3. 3MDX	Cotton	50Nm+44/12x2 dtex	276.25	88.99
GV3.1DC	Organic Cotton	34Nm+44/12x2 dtex	302.12	100.69
GV3.3DC	Cotton	40Nm+44/12x2 dtex	256.04	103.11
GV3.6DC	Cotton + soy	34Nm+44/12x2 dtex	226.57	114.59
GV3.7DC	PES + Viscose	34Nm+44/12x2 dtex	237.46	108.29
GV3.8DC	PES + Viscose	34Nm+44/12x2 dtex	228.07	105.36
GV3.9DC	Tencel	34Nm+44/12x2 dtex	203.55	122.97
GV3.10DC	Bamboo + Viscose	34Nm+44/12x2 dtex	235.91	111.59
GV3.11DC	Viscose + Silk	34Nm+44/12x2 dtex	203.91	109.84
GV3.12DC	Recycled PES	34Nm+44/12x2 dtex	464.27	108.88
GV3.13DC	PES	40Nm+44/12x2 dtex	420.27	101.35

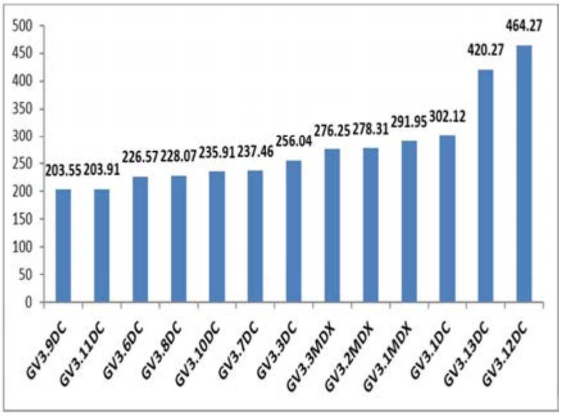


Fig. 15. Histogram of traction force values (variant GV3)

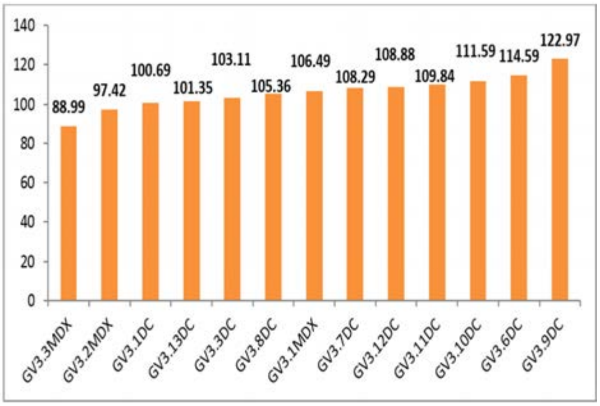


Fig. 16. Histogram of values for elongation (variant GV3)

Analyzing the results (table 2 and figures 15, 16) for played single jersey obtained from the 13 types of yarn (fond yarn) + polyamide 44 / 12x2 dtex (plating yarn), density I, we can say that:

- The highest tensile strength appears on the sample GV3.12DC, and the smallest on the variant GV3.9DC.
- For samples GV3.1MDX, GV3.2MDX, GV3.3MDX obtained from the same raw material (Cotton 100% + polyamide 44 / 12x2 dtex) if we change yarn fineness from 50/1 Nm to 40/1 Nm, tensile strength increases by 0.75% and if we change yarn fineness from 40/1 Nm to 34/1 Nm, tensile strength increases by 4.9%.
- In the case of samples GV3.1MDX, GV3.1DC, GV3.3DC obtained from the same raw material (Cotton 100%, 34/1 Nm + polyamide 44 / 12x2 dtex) the highest tensile value was found on sample GV3.1DC.
- For the samples GV3.7DC and GV3.10DC obtained from mixed fibers, 52% of polyester increases the tensile strength with 0.66%.
- In the case of samples GV3.1MDX and GV3.6DC, the percentage of 50% soy decreases the value of tensile strength by 28.86%. The sample GV3.1DC (Organic Cotton) has a value of tensile strength 3.48% higher than sample value of GV3.1MDX (Classic Cotton).
- The highest value of elongation at break appear on the sample GV3.9DC, and the smallest on the variant GV3.3MDX.
- For samples GV3.1MDX, GV3.2MDX, GV3.3MDX obtained from the same raw material (Cotton 100% + polyamide 44 / 12x2 dtex) if we change yarn fineness from 50/1 Nm to 40/1 Nm, elongation at break increases by 9.47% and if we change yarn fineness from 40/1 Nm to 34/1 Nm, the elongation at break increases by 9.31%.
- For the samples GV3.7DC and GV3.10DC obtained from mixed fibers, 52% of polyester decreases the value of elongation with 13.55%.
- In the case of samples GV3.1MDX and GV3.6DC, the percentage of 50% soy increase the value of elongation by 7.6%.
- The sample GV3.1MDX (Classic Cotton) has a value of elongation at break 5.76% higher than sample value of GV3.1DC (Organic Cotton).

➢ Conclusions regarding the influence of knitted fabric geometry on the tensile strength and elongation at break

For analysis we considered three structures: plated single jersey (GV), plated ribb 4:2 (PV) and plated purl (LV), all plated with polyamide 6, 44/12x2 dtex, in the case of the yarn 9DC (Tencel) - table 4.

For the same type of raw material, the highest values of tensile strength was found on the samples LV3.9DC and LV4.9DC (table 4 and figure 17).

Table 4. The values of tensile strength and elongation at break in the case of samples plated single jersey (GV), plated ribb 4:2 (PV) and plated purl (LV), all plated with polyamide 6, 44/12x2 dtex, in the case of the yarn 9DC (Tencel).

Samples	Geometry	Density	Average of breaking force [N]	Average of breaking elongation [%]
GV3.9DC	Plated single jersey	I	203.55	122.97
GV4.9DC		II	208.21	104.31
PV3.9DC	Plated ribb 4:2	I	160.55	58.73
PV4.9DC		II	234.00	90.65
LV3.9DC	Plated purl	I	428.22	92.62
LV4.9DC		II	396.67	107.09

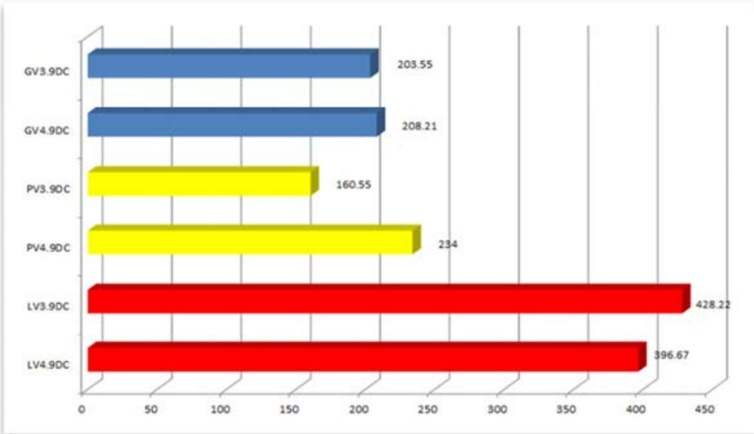


Fig. 17. Histogram of values for tensile strength, correlated with knitted fabric geometry, in the case of samples obtained from yarn 9DC.

Analyzing the samples GV4.9DC, PV4.9DC and LV4.9DC was observed that the value of tensile strength is 69.51% higher when compare LV4.9DC variant with PV4.9DC, also by 90.51% higher when compare LV4.9DC variant with GV4.9DC variant of knitted fabric.

Along with the technical conclusions, we appreciate that the results are useful as an integrated part of the professionals' quality training schemes and development working in textile industry [20, 21, 22, 23].

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