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Characterization the Performance of Elastic Band Using Different Polyester Microfiber Cross-Sections and Stitch Densities

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Abstract

The Elastic band plays a tremendous role in fashionable garments due to its excellent elongation and recovery. Recently the elastic band had a significant value in the compressive garments, which support multiple applications such as medical textile. Several referencesmentionedthat elastic band properties are affected thruvarious parameters consequently on its performance. Currently, polyester microfiber characterizes novel properties that make it used widely in the textile industry. Therefore, the article aimed to produce an elastic band withdifferent polyester microfiber cross-sections and stitch densities. Various functional properties and elasticity properties were tested. Three analytical tools were executed; Correlation coefficient, ANOVA test, and Radar area.
The findings indicate that yarn cross-section effect significantly on samples performance where Trilobal cross-section achieves the highest rank than circular.Furthermore, the findings point that increasing stitch density degrades the functional property of the elastic band, whilst improving elasticity properties. In addition, the findings refer thatthe tightness factor plays a striker role in elastic band behavior, especially on stiffness as a functional property and modulus as an elasticity property.

Keywords: Elastic band, polyester microfiber, Trilobal, stitch density.

1. Introduction

Elastic bands are widely utilized in numerous applications. Usually, they are manufactured from spun core yarn with an elastin. Using of the elastic fabrics in garment manufacturing gave new fashionable trends [1]. This type of fabric had distinguish with a visual and tangible aesthetics, as well as new properties such as high tenacity, compact, high stretch and recovery, which made it a functional supplements in different aspects of end-uses like; swimwear, bras, panties, sportswear,…*etc*. Furthermore, the role of an elastic fabric cannot be ignored in compressive garment, which is rapidly becoming a significant and increasing segment of the medical textile. In the many studies was highlighted of the importance of compressive garments in health care field[2].

Several of elastic fabrics are classified according to their construction and fiber content such as; woven elastic, knitted elastic, and translucent polyurethane that often known as a clear elastic, as stretch to three or four times of its original length [3].Various references have clarified a considerable impact of process parameters i.e. elastin ratio, elastin stretch-ability, twist multiplier factor,…*etc*. on the tenacity and low-stress properties of elastic knitted fabrics. As well as, modeled the load extension behavior. The majority of those references were used the single loop as a structural unit and were based on a plain weft-knitted structures[4].

Moreover, many studies have presented a conditional balance for giving a specific characterization. Therefore, the most fascinating aspects for creating a knitted fabric to a varietyof applications is depending on the mechanical properties

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that can determine during the stretching cycle as; unloading, loading and resting [5].

Currently, microfiber yarns award a major role in the garments production, whereas microfibers featured with various properties such as; lightweight, softness, tenacity, stability and high water permeability compared to other traditional yarns[6, 7]. Microfiber commonly constructed of acrylic, viscose, modal, polyamide and polyester within count range of 1.2 – 0.5 dtex with different cross-section shapes[8].

Several studies pointed that microfiber yarns have become popular to produce apparel as a viable alternative to cotton due to their wick ability that keeps the body cool and dry, which makes it a preferable combination with elasticity yarns to use in undergarments [6, 8].As well, the studies confirmed the efficiency of microfiber yarns to generate multiple technical applications, especially in medical products.[9].

In the same vein, many references represented that the microfiber yarns cross-section impact on the mechanical, physical and morphological properties of produced fabrics. In addition, they concluded that fibers movement within microfilament resulting to novel properties like elasticity, dimensional stability and comfortability [10].

Polyester microfiber is one of continuousfilament that can be formed with various cross-sections shapes. Trilobal polyester microfiber yarn (Y) was manufacturing during 1960. A triple cross- section is featuring with luster and shiny that makes it a good alternative to expensive yarn like silk. As well as the fabrics developed from this type of yarn are characterized by high porosity and low thickness [11]. Figure 1illustrates the polyester trilobal and circular cross-section shapes.

It is worth mentioning that elastic band is one of the main issues that faced the Egyptian garment industry because of its degradation throughout the product's lifetime, resulting in reducing quality, customers satisfactions' and subsequently losing market share. Therefore, the article aimed to manufacture elastic band utilizing different polyester microfiber cross-section and stitch densities. As well as, study its influence on several functional, elasticity properties.

2. **Experimental work**

2.1. Manufactured Samples:

Six elastic band knitted samples were performed with two different Polyester microfiber cross-sections; Circular and Trilobal, yarn count used 150/288 denier. Three different stitch densities wereapplied. Open pillar stitch chain (1-0/0-1), it was used spandex yarn count 40 tex for band structure. A crochet knitting machine was conducted to produce all of the samples. Tables (1&2) present the specification of crochet knitting machine and manufactured elastic band knitted samples, respectively.

Table (1): Specification of Crochet knitting machine

Model	**Muller**
Country Of Manufacture	Switzerland
Machine Gauge	18
Main Shaft Speed	200 r/min
Production Efficiency	24 Kg/ Day
Gide Bar	2 Bar (warp yarns) & 1 Bar (inlay yarn)
Needle Bar	1 Bar
Operational Width	81 cm
Design Device	Link-Chain Device

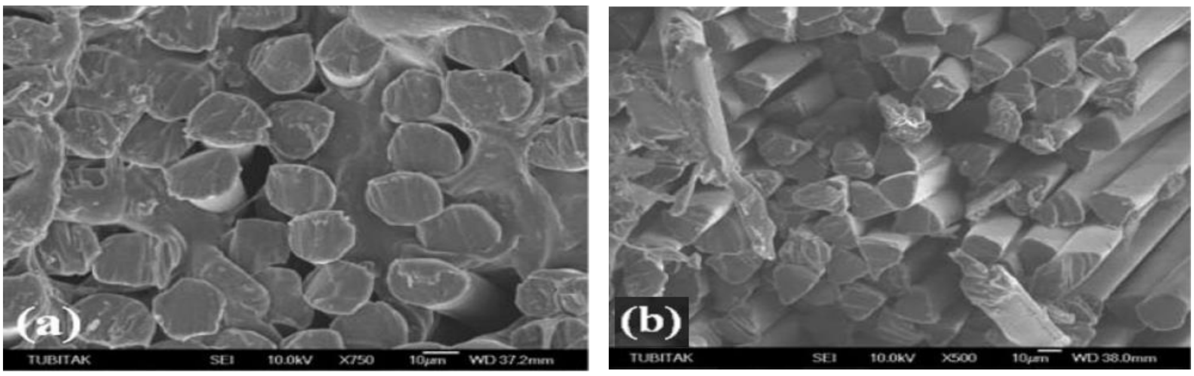

Figure 1. Different cross-section shapes of polyester; (a) Circular, and (b) Trilobal[8].

Table (2):Specification of manufactured samples

Sample Code	Polyester Cross-Section	Stitch Density Stitch/cm^2	Loop Length (mm)	Thickness (mm)	Weight (g/m^2)	Tightness Factor	Fabric Structure
1	Circular	13	5.41	1.47	883.5	2.26	
2	Trilobal		5.31	1.44	872.0	2.30	
3	Circular	48	5.23	1.54	952.6	2.34	
4	Trilobal		5.12	1.46	938.2	2.39	
5	Circular	84	4.95	1.56	973.7	2.47	
6	Trilobal		4.85	1.47	954.8	2.52	1-0/0-1

2.2. Conditioning and testing samples

All samples exposed to the standard condition for textile testing 24 h as defined in standard method ISO 139, i.e. a temperature of 20 ± 2° C & a relative humidity of 65 ± 2% [12], before carried out the evaluation test to determine the impact of parameters on the stretch properties for the elastic band samples that were as follows;

- Mass per unit (Weight) test according to standard test method ASTM D3776[13], an electronic balance with four digits.
- Thickness test according to standard test method ASTM D1777[14]. The test was conducted withportable thickness gauges.
- Dimension stabilityaccording to standard test method BS 4736: 1995[15].
- Crease Recoveryaccording to standard test method ASTMD-1295[16]
- Absorbency according to standard test method AATCC 79[17].
- Stiffness according to the standard test method JIS-L1018, using Universal Wear Tester, Toyoseiki-Japan [18].
- Elasticity according to standard test method BS EN 14704-3: 2006. The test method scope to determine the elasticity of narrow fabric at different parameters, whereas elastic elongation, modulus, tension decay as well as residual extension are measured on the tensile testing machine (CRE). The samples subjectedto a specified force (15 N) relating to a mass per unit. Furthermore, the modulus specified at three different elongations (30%, 50%, and 70%)[19].

2.3. Data Analysis

Determination of the effectiveness of different polyester microfiber cross-sections on functional and elasticity properties of the elastic bands. An ANOVA test with P value (0.05) was accrued. In the same context, to assign the impact of the tightness factor for tested properties, a correlation coefficient was calculated. In addition, the radar chart area was measured to demonstrate the performance of the manufactured samples for tested properties and ordering the samples according to their performance.

3. Results and discussion

The results show the functional properties and the different elasticity properties of the manufactured samples, in which the effect of the cross-sectional difference of the polyester yarn, which are presented as follows:

3.1. Function and Elasticity results

Tables (3&4) refer to the functional properties and elasticity properties of manufactured samples, respectively. The findings present a variation in values between samples that detect the impact of cross-sections and stitch density on samples behavior, which is statisticallyoffered in the following data analysis…
Table 3 shows that the high density of stitches had a positive effect on the crease recovery property, because the bands became more compact, which helped to resist wrinkles. Also, the higher of stitches' density gets lower the absorption efficiency. However, the produced samples from trilobal cross- section polyester were faster in absorbing than the circular-section polyester, because the trilobal cross-section of the yarn enhances the osmotic property of absorption [20].

Table (3): Functional properties of manufactured elastic bands

Sample Code	Polyester Cross-Section	Stitch Density (Stitch/cm^2)	Crease Recovery (˚)	Absorbency (Sec.)	Stiffness (mLg)	Shrinkage	
						Length %	Width %
1	Circular	13	120	73.653	4614.4	1.66	2
2	Trilobal		120	62.5	4841.6	1.11	0.5
3	Circular	48	125	86.61	6265.6	0.5	0.1
4	Trilobal		130	75.47	5838.4	0.1	0.5
5	Circular	84	175	180	14952	5.55	1.66
6	Trilobal		160	141.77	13528	3.33	0.1

Also, we found that the increase of stitch density raises the stiffness of the samples, the stitch densities (48, 84)/cm^2 of the trilobal cross- section polyester samples give higher stiffness behavior than the circular cross-section polyester samples. Finally, we find that the shrinkage (%) in the produced samples wasvery low generally, but the produced samples from trilobal cross-section polyester were more stable in dimensions compared to the produced samples from circular cross-section polyester.
Table 4 shows the effect of the difference of polyester cross-section. Where the modulus with different extensions (30%, 50%, and 70%) increased with the circular cross-section of polyester, while the rate of extension gave high results with trilobal cross-section polyester. As well, the tension decay reduces with trilobal cross-section polyester and vice versa with the residual extension. In the same vein, the various stitch density gave a positive effect with different tension for modulus, while giving a high percentage of tension decay especially with 84 stitches /cm2 for the two cross-sections used. Finally, the 84 stitches/ cm2 had a negative effect on extension rate and residual extension.

3.2. Correlation Coefficient:

Tightness is one of the main factors, which is affected yarns' cross-sections and stitch density, in order to determine the influence of the tightness factor on varied tested properties, the correlation coefficient was calculated.
Table 5 shows the correlation coefficient amongst tested functional properties and tightness factor of produced samples. The findings indicate the positive correlation except for width shrinkage direction(%) the justification maybe return to the narrow width of elastic band that maintains yarns to be more fixed in the width direction. Furthermore, the values identify that stiffness is the most affected property whilst thickness is the lowest.
In the same vein, to designate the impact of the tightness factor on the elasticity properties of manufactured samples, the correlation coefficient was considered as shown in Table 6. The findings state the positive correlations for all elasticity properties, excluding the extension (%) and residual extension (%), which could explain as the result of the reduction in yarn movement, where the more compact the fewer free. Moreover, the findings denote that modulus is the most affected property while tension decay is the lowest.

Table (4): Elasticity properties of manufactured elastic bands

Sample Code	Polyester Cross-Section	Stitch Density (Stitch/cm^2)	Extension (%)	Modulus(Kgf)			Tension Decay (%)	Residual Extension (%)
				30%	50%	70%		
1	Circular	13	1212	1.642	2.245	2.920	7.80	3
2	Trilobal		1348	1.178	1.866	2.365	4.39	3.5
3	Circular	48	1195	1.687	2.346	4.989	12.08	2.6
4	Trilobal		1249	1.457	1.980	2.547	8.39	3.4
5	Circular	84	675.8	5.172	7.253	10.64	15.65	2
6	Trilobal		719.3	5.050	7.064	9.64	10.63	2

Table (5):Correlation coefficient of the functional properties

Properties	Correlation Coefficient
Weight (g/m^2)	0.807548616
Thickness (mm)	0.314943565
Crease Recovery (˚)	0.892109436
Absorbency (Sec.)	0.831345634
Stiffness (mLg)	0.907488555
shrinkage length %	0.639586941
shrinkage Width %	-0.282356484

In addition, the findings mention that correlation decreased relatively with raising extensions on modulus, the interpretation comes back to the relative dropping in the intermeshing of yarns at sample structure during elongation.

Table (6):Correlation coefficient of the elasticity properties

Properties	Correlation Coefficient
Extension (%)	-0.871543531
Modulus 30%(Kgf)	0.88019189
Modulus 50%(Kgf)	0.877412477
Modulus 70%(Kgf)	0.856060755
Tension Decay (%)	0.622195648
Residual Extension (%)	-0.753131631

3.3. Analysis *of Variance(ANOVA) test*

In order to recognize the significant effect of polyester microfiber cross-sections on produced elastic bands. ANOVA test at P-value ≤ 0.05 was performed for functional and elasticity properties as presented in the Tables (7 &8), respectively.

The results show the enormous effectiveness of yarn cross-sections at a varying stitch density on the functional properties of elastic bands, excepting thickness and shrinkage of width direction, which could be traced back to utilizing the same yarn count (150/288) denier for circular and trilobal polyester microfiber,as well as to the narrow width of samples (5cm) providing more yarns stability. In the same context, ANOVA test results assign that the elasticity properties of the elastic bands were affected significantly by yarn cross-sections excepting tension decay and residual extension (%), which might be joined to using the same structure (Open pillar stitch chain) with the same material and count of yarns maintaining to closeness tension load and elongation as possible..

Table (7): Effect of cross sections on functional properties

Tested Properties	ANOVA (P-value)
Weight (g/m^2)	0.008119645**
Thickness (mm)	0.540815467
Crease Recovery (˚)	0.009779713**
Absorbency (Sec.)	0.021790991**
Stiffness (mLg)	0.001081882**
Shrinkage of length %	0.045565723**
Shrinkage of Width %	0.395082175

Table (8): Effect of cross sections on elasticity properties

Tested Properties	ANOVA (P-value)
Extension (%)	0.004565018**
Modulus 30%(Kgf)	0.000718719**
Modulus 50% (Kgf)	0.000310548**
Modulus 70% (Kgf)	0.012088879**
Tension Decay (%)	0.193616368
Residual Extension (%)	0.091282648

3.4. Radar Chart Area:

Aiming to rank the search samples' and observe their behavior toward different functions and elasticity that were tested, the radar chart area was being executed as well as calculated in the following:

3.4.1. Functional properties

Figures (2&3) illustrate the radar chart area for elastic band samples withvarious functional properties. The consequences indicate that the samples with stitch density (48/cm^2) obtain the utmostarea whether for circular and trilobal polyester microfiber cross-sections. On the other hand, the consequences point that the increasing stitch density of elastic band samples decreases some of its functional properties, which indicates the applied more stitch density reflects negatively on improving elastic band behavior.

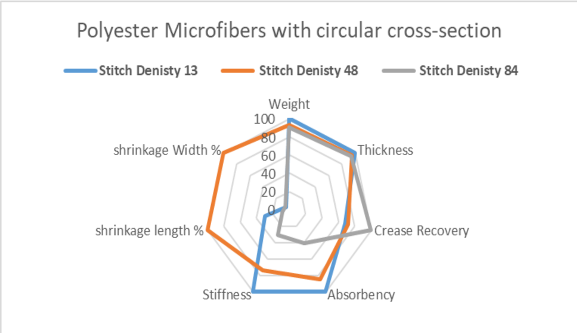

Fig. (2): Radar chart area of the functional properties of elastic bands with circular cross-section

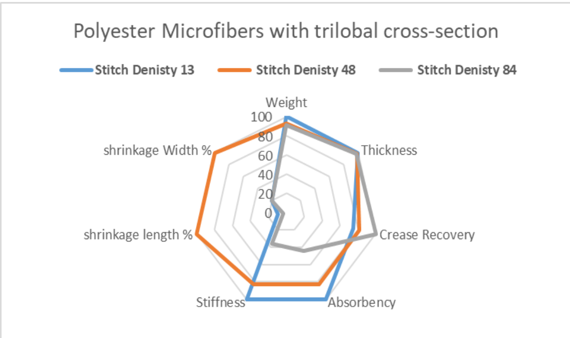

Fig. (3): Radar chart area of the functional properties of elastic bands with trilobal cross-section

3.4.2. Elasticity properties:

The radar chart area for elastic band samples with varying elasticity properties is depicted in Figures (4&5). The consequences indicate that the samples with the highest stitch density (84/cm^2) perform best at various polyester microfiber cross-sections. Furthermore, the consequences denote a positive relationship between stitch density and sample elasticity characteristics, where the higher the density gets better the elasticity.

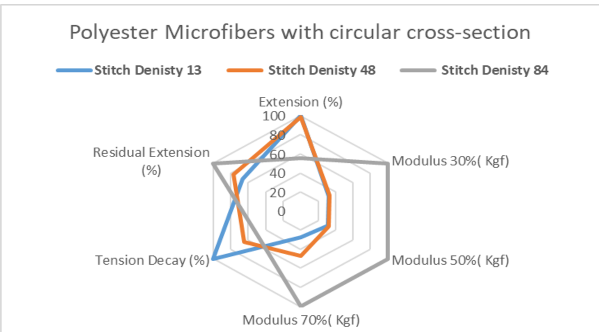

Fig. (4): Radar chart area of the elastic properties of elastic bands with circular cross-section

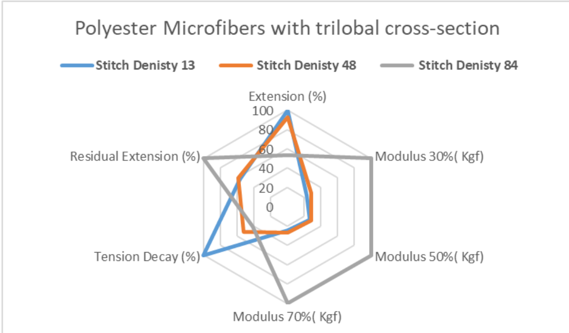

Fig. (5): Radar chart area of the elastic properties of elastic bands with trilobal cross-section

3.4.3. Sample Rating:

Depending on the radar area,the rankingperformanceof manufactured elastic band samples in both functional and elastic properties has been defined as displayed in Table9. The findings refer that the elastic bands with trilobal cross-section achievedasuperiorrating at the different stitch density whether in functional or elasticity properties, implying the impact of yarn cross-section on elastic band performance. In addition, the findings confirmed thatraising of stitch density reducesthe elastic band characterizations, whereas stitch density (48/cm^2) implemented the best values with different cross-sections more than stitch density (84/cm^2).

Table (9): Ranking of samples

Rate	Cross-Section	Stitch Density	Radar Area
1	Trilobal	48	16309.49355
2	Trilobal	84	15153.36809
3	Trilobal	13	14403.715
4	Circular	48	12791.32645
5	Circular	84	12401.19677
6	Circular	13	11231.21111

4. **Conclusion**:

The tightness factor plays a striker role in elastic band behavior, especially on stiffness as a functional property, and modulus as an elasticity property.According to the ANOVA test; polyester microfiber cross-section effect significantly on the major functional properties, and elasticity characteristics. Otherwise, some properties were affected directly bythe yarn count and sample structure.

Furthermore, the radar chart area shows that applying a higher stitch density has a contrasting impact, as reducing functional properties and increasing elasticity characteristics. In the same context, the radar chart area indicates that the yarn cross-section has a strong effect on elastic bandsbehavior, where the trilobal cross-section achieves the highest rating with different stitch densities.

5. Conflict of interest

The authors have declared no competing interests; none of the authors have any conflict of interest or relation with any third part that bias the publication of this report.

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8. References:

1- GajjarB., Warp knitting Fabric Technology, *Emerlad Ink Publishing*, ISBN978-1-885373-46-5(2007).
2- Mashaly R.and HusseinS., Evaluation of the performance of elastic band used for readymade garment manufacturing, *Alexandria Engineering Journal*, **50**(4),291–295(2011).
3- Olena Kyzymchuk and Liudmyla Melnyk, Stretch properties of elastic knitted fabric with pillar stitch,*Journal of Engineered Fibers and Fabrics*, **13**(4), 1-10 (2018).
4- Eryuruk S.H., and Kalaoglu F., Analysis of the Performance Properties of Knitted Fabrics Containing Elastane, *International Journal of Clothing Science and Technology*, **28**(4), 463-479(2016).
5- Abramavictute J.,Daiva M. and Ričardas Č., Structure Properties of Knits from Natural Yarns and their combination with Elastane and Polyamide Threads,*Materials Science(MEDZIAGOTYRA)*, **17**(1), 43-46(2011).
6- Abdel-Megied Z. M., Seddik K.M. and Abd ElAziz M.Y., Improve UV Protection Property of Single Jersey for Summer Protective Clothes,*Journal of Textile & Apparel Technology & Management (JTATM)*, **10**(3),1-9(2018).
7- Abdel-Megied Z.M., Seddik K.M, Abd El-Aziz M.Y. and El-Gabry L.K., The Enhancement of the Functional Properties of Polyester Microfiber Single Jersey Using Some Nano-materials, *Egypt. J. Chem*. **63**(1), 145–154 (2020).
8- Karaca E. and Ozcelik F., Influence of the Cross Sectional Shape on the Structure and Properties of Polyester Fibers, *Journal of Applied Polymer Science*, Vol. **103**, 2615–2621(2007). https://doi.org/10.1002/app.25350
9- Dina M. Hamoda., Using Some of Ordinary Fibers and Micro Fibers to Produce Knee Support for Women to Improve Function Performance, *Egypt. J. Chem*. **62**(6), 1307–1316 (2019).
10- Doaa H. Elgohary., Yahia S.and Seddik K.M., Characterization the properties of blended single jersey fabrics using different microfiber yarn cross-sections and gauges machine, *Egypt. J. Chem*. **64**(6), 3041–3048(2021).
11- Fotovati S., Tafreshi H.V. and PourdeyhimiB., Analytical Expressions for Predicting Performance of Aerosol Filtration Media Made Up of Trilobal Fibers, *Journal of Hazardous Materials*, **186**(2-3), 1503-1512(2011). DOI: 10.1016/j.jhazmat.2010.12.027.
12- ISO 139, “Textiles - Standard atmospheres for conditioning and testing”(2005).
13- ASTM D3776, "Standard Test Methods for Mass per Unit Area (Weight) of Fabric" (2002).
14- ASTM D1777, "Standard Test Methods for Thickness of Textile Materials" (2002).
15- BS 4736, "British standard test method of dimension stability to cold water" (1995).
16- ASTMD1295, "Standard Test Methods for Crease Recovery" (2001).
17- AATCC 79, "Test Method for Absorbency of Textiles"(1992).
18- JIS L1018, "No.311 Gurley Type Stiffness Testerto evaluate the textile"99th Edition (2004).
19- BS 4952, "Method of test for elastic fabric" (1992).

20- Saad M.A., Metwaly F., Gad S.Y., Mansour K.andAli M.A., "Effect of Using Trilobal® Polyester on the Functional Performance of Fencing Suit", *Research Journal of Textile and Apparel*,**25**(1), 1-18 (2021).