The Impact of Elastic Type and Its Fixation Method on Fabrics' Mechanical Properties

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Abstract: Elastic band is a flexible, stretchable, narrow fabric, it is made from a series of rubber; this rubber is either natural or synthetic rubber. It has significant value for use in textile industry because of its excellent elongation and recovery properties. The single most important property of elastic is their ability to undergo large elastic deformations, that is, to stretch and return to their original shape in a reversible way. Elastic band comes in a variety of thicknesses and widths; different elastics have more or less stretch. Elastic can be threaded through casings or stitched directly to the fabric. This was an experimental study to understand the impact of elastic type and its fixation method on fabrics mechanical properties. Four types of elastic band were used (2cm width raw elastic [A], 2cm width woven elastic [B], 1cm width raw elastic [C], 1cm width woven elastic [D]) ,the degree of elastic stretching relative to the used fabric varied between (1.5 times) and (2 times) and attaching elastic to the fabric by three methods: (the first method: Zigzag stitching elastic band [X], the second method: overlook stitching elastic Band and topstitching [Y] and the third method: flat-fell stitching by placing the elastic inside a folded edge of fabric, then stitching the fold down and topstitched finish [Z].Fabric properties were examined for their relationship to abrasion properties, elongation behavior and appearance for the integrated fabric with elastic to determine whether incorporation of elastic had its impact on performance properties of the selected fabric or not. The study concluded that type A (2cm width raw elastic) fulfilled the highest elongation results and the best appearance, in comparison to other types of studied elastic B, C and D. However, type B (2cm width woven elastic) acquired the superior abrasion resistance (this is possibly due to the woven structure of the elastic band by its fibers intersection that changes the surface smoothness which increases its abrasion resistance), also the wider the surface area of the elastic band the higher the abrasion resistance, thus the results of type D is lesser than type B.
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1. Introduction

Elastic band is a flexible, stretchable, narrow fabric, it is made from a series of rubber; this rubber is either natural or synthetic rubber. It has significant value for use in textile industry because of its excellent elongation and recovery properties (B. Gajjar, 2007).

The single most important property of elastic is their ability to undergo large elastic deformations, that is, to stretch and return to their original shape in a reversible way (A. N. GENT, 2005). It comes in a variety of thicknesses and widths; different elastics have more or less stretch. Elastic can be threaded through casings or stitched directly to the fabric to control fullness in a particular area. Good quality elastic stretches more than twice its length and then returns to its original shape and length. Quality and behavior are determined by the elastic's construction and fiber content. Most elastics are between 1/8" and 2 1/2" wide, although elastic thread is narrower and decorative elastic waistbands can be extra wide (http://www.sewing.org).

The use of elastic yarn in fabric manufacturing gave new life to the use of elastic fabric in fashionable garment. This fabric is characterized by new visual and tactile aesthetics, beside its new fabric properties, such as high stretch and recovery, made it possible to use in swimwear, bras, panties, sportswear and many other end-uses. Nowadays, it is also of great importance in textile industry, medical textile and other medical applications.

The type of elastic band is categorized by how it is constructed and its fiber content as: Braided elastic, knitted elastic, woven elastic and transparent polyurethane (H. Carr, B. Latham, 1989). [Braided elastic]: is used inside casings because it narrows when it's stretched, and it loses its stretch and shape retention when it's pierced or stitched through. Braided elastic has distinctive lengthwise, parallel ribs and is used primarily on sleeve hems, swimwear and leg bands & [Knitted elastic]: is soft, strong and appropriate for most apparel items. Because it's lightweight, it's best-suited for lightweight fabrics. It doesn't narrow when stretched and is not affected by needle piercing, making it as suitable for direct fabric application as it is for casings & [Woven elastic]: is very strong and usually thicker than the other elastics. It's used on heavy weight fabrics, including home

decorating fabric, car covers, bags, accessories, etc. It has both crosswise and lengthwise ribs, giving it a windowpane appearance. It does not narrow when stretched, nor does needle piercing weaken it. Therefore, it can be used in casings or stitched directly to the fabric and [Transparent polyurethane]: also called clear elastic, which is a synthetic product that stretches three to four times its original length with complete recovery to its original size and shape. It's used for direct fabric application and seems to be gaining popularity.

Elastic is classified according to its use into [Waistband Elastics] in which elastic is applied in a casing and require preshrink before measuring except If elastic is stitched on then it does not require preshrinking, [No-Roll or Non-Roll] in which elastic does not roll or twist. It is a woven elastic with lateral ribs. Used in casings, [Knit Non-Roll] is a mono filament elastic that does not roll and shows minimal shrinkage. Used in waistline casings, [Skirt Waistband Elastic] is an elastic that is designed for a gathered waistline finish. The lower edge has a 1/4 inch stitching guide, [Underwear and Pajama Elastic] have a soft stretch and texture to make it comfortable to wear against the skin. It is stitched directly to the wrong side of fabric, [Stretch band] is an elastic with vertical mono filament threads with an open see-through look that pops back to its original shape. It does not roll and is light weighted, [Drawstring] is an elastic with a drawstring inserted in the center. It is a good choice for sweatpants, gym shorts, or other casual sportswear, [Sport Elastic] is an elastic constructed with four unbraided lengthwise rows. Stitching is better to be in the unbraided rows, stretching the elastic to fit, [Stitch and Stretch Elastic] with a polyester woven band and rows of spandex elastic threaded through. The elastic is pulled up to create gathers. Used for waistbands and cuffs. It is not recommended for heavy fabrics, [Ruffled Elastic] is an elastic that is 2-3 inches wide and comes in fashion colors with one ruffled edge. When applied it is totally exposed as the waistband, [Lingerie Elastic] is an elastic that has one or two picot edges with a soft backing for comfort against the skin. It is used for half-slips and panties, [Transparent Clear Elastic] is an elastic made from 100% polyurethane. It stretches three to four times its original length. Before applying clear elastic, stretch and release it several times before applying to ensure 100% recovery. If cut or nicked with scissors, the stretch and recovery are not affected. Used for stitched-on or topstitched applications in swimwear, aerobic wear and lightweight fabrics. It can also be used to stabilize seams in knit garments, [Buttonhole Elastic] is an elastic with buttonhole slots made 1 inch apart in unknitted sections. This allows for easy waistline adjustments on children's wear, maternity wear or whenever waistline adjustments are needed, [Cycling or Waistband Elastic] is an elastic with exposed rows of elastic thread that grips the skin or garment. It keeps pant legs from riding up and shirttails from coming untucked, [Stretch lace Elastic] is an elastic designed especially for lingerie. It is soft and flexible and shapes to the body, [Elastic Thread] is a very thin covered core wrapped with cotton or acetate, used for shirring, smocking and other decorative stitching. Wind bobbin with elastic thread using the bobbin winder or by hand, slightly stretching the elastic thread, and [Fold-over Elastic] that is satin-finished elastic of 81% nylon and 19% Lycra folds in half and stays in place while stitching. On knits, used in place of bias tape to finish a neckline or edge of sleeve (Jasimuddin Mandal, 2013).

Relative to various uses of elastic band, different techniques of sewing were developed. commonly, there were seven ways to attach the elastic band to the fabric: 1) Encased Elastic Band. 2) Zigzag stitching Elastic Band and Topstitching. 3) Zigzag stitching elastic band and topstitching with elastic thread. 4) Elastic gathering and Shirring. 5) Gathering and shirring with elastic thread. 6) Elastic channel. 7) Elastic scrunchie (http://www.youtube.com).

2. Material and Methods

This was an experimental study to understand the impact of elastic type and its fixation method on fabrics mechanical properties. Fabric properties were examined for their relationship to abrasion properties, elongation behavior and appearance for the integrated fabric with elastic to determine whether incorporation of elastic had its impact on performance properties of the selected fabric or not.

Research variables: the first variable was elastic type; four types were used (2cm width raw elastic [A], 2cm width woven elastic [B], 1cm width raw elastic [C], 1cm width woven elastic [D]) represented in this study by letters [A], [B], [C] and [D] respectively (as shown in table (1)). The second variable was the degree of elastic stretching relative to the used fabric that varies between (1.5 times) and (2 times) and the third variable was attaching elastic to the fabric by three methods: (the first method: Zigzag stitching elastic band [X], the second method: overlock stitching elastic Band and topstitching [Y] and the third method: flat-fell stitching by placing the elastic inside a folded edge of fabric, then stitching the fold down and topstitched finish [Z] (http://www.threadsmagazine.com) represented in this study by letters [X], [Y], and [Z] respectively (as shown in table (2)).

Table (1): Elastic band used types

	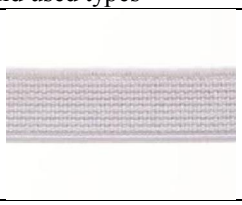
Raw Elastic	Woven Elastic

Table (2): Three common methods of attaching elastic to the fabric

		
Zigzag stitching elastic band [X]	Overlock stitching elastic Band and topstitching [Y]	Flat-fell stitching and topstitched finish [Z]

Research constants: the first constant was the type of used fabric; single jersey (by machine width 20 inch, gauge 24 needle/inch) 100% cotton, yarn count 30/1, weight 125 gm/m^2, the second constant was the sewing thread yarn count and type while the third constant was the type of sewing machine.

Research Approach: Research relies on the analytical experimental approach to achieve the objectives of the research.

Expiremental Tests: As for abrasion test: four specimens from the sample were tested, under a nominal pressure of 12 kPa (795±7g) in accordance with BS EN ISO 12947-2:1999, using a Martindale abrasion tester as described in BS EN ISO 12947-1:1999 (as shown in figure (1)). The reference abradant was mounted over woven backing felt and the physically significant end point assessed when at least two individual threads had broken. The change of shade of the test speciemens was not assessed. The results of the abrasion test were documented.

For the appearance test, the experts made an assessment using a 6-point scale. Six plastic replicas used to visually evaluate the appearance of specimens with values 1 to 6 (control sheets) were given to the experts and they were asked to evaluate the appearance of specimens, subjective evaluation is based on the AATCC/ISO Smoothness Appearance test Method G246K. (S. Hati and B.R. Das, 2011).

Figure (1): Martindale abrasion tester

As for measuring the elongation of the tested fabric which integrated with elastic was determined by the principle of CRE (Constant rate of Extension). Three samples were prepared each one of 10cm×5cm from each type (1.5AX, 1.5BX, 1.5CX, 1.5DX, 2AX, 2BX, 2CX, 2DX) & (1.5AY, 1.5BY, 1.5CY, 1.5DY, 2AY, 2BY, 2CY, 2DY) & (1.5AZ, 1.5BZ, 1.5CZ, 1.5DZ, 2AZ, 2BZ, 2CZ, 2DZ). As "1.5 and 2" accounts for the degree of elastic stretching relative to the used fabric, "A, B, C and D" account for elastic type, "X, Y and Z" accounts for the method of attaching elastic to fabric (Hemlata N. Raval, 2012)

All samples have been conditioned and tested in the standard atmosphere for conditioning and testing textiles (BS EN ISO139: 2005) of (20±2°C temperature and 65±4% relative humidity).

3. Results and Discussion

All the results from the experimental tests were documented, tabulated and analyzed statistically to address the impact of attaching elastic to fabric on its physical and mechanical properties.

For the influence of attaching elastic to fabric on the abrasion test, the results were shown in table (3) & figure (2).

From table (3) it can be noticed that the highest value of abrasion (=45) was related to the 2cm width woven elastic [B] with 1.5 degree of elastic stretching relative to the used fabric using zigzag stitching elastic band [1.5X].

Whilst, the 2cm width raw elastic [A] with two times of elastic stretching relative to the used fabric using either overlock stitching elastic Band and topstitching [2Y] or using flat-fell stitching and topstitched finish [2Z] shared the lowest value of abrasion (=5).

Table (3): Values of abrasion test for different types of elastic

	A	B	C	D
1.5X	10	45	9	24
1.5Y	6	12	7	15
1.5Z	10	19	10	10
2X	10	15	15	15
2Y	5	19	15	15
2Z	5	20	15	15

Figure (2) highlights that results of the abrasion test were almost similar for both 1cm width raw and woven elastic [C & D] with two times of stretching for all methods of elastic sewing [2X, 2Y & 2Z].

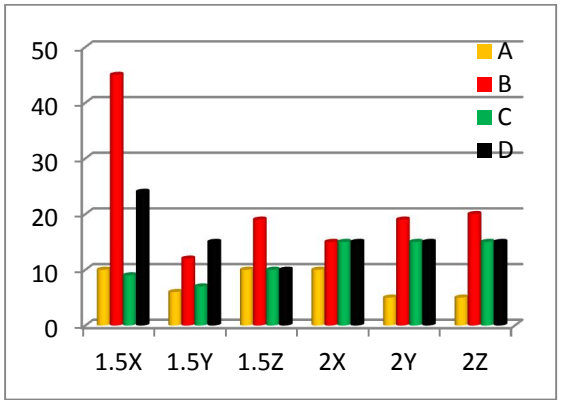

Figure (2): Abrasion test results

By statistically analyzing the results of abrasion test between study groups using standard ANOVA test between subjects, it was found that the P-value was statistically significant ($p<0.012011$).

Moreover, the mean value for type A elastic was 7.67, for type B elastic was 21.67, for type C elastic was 11.83 and for type D elastic was 15.67. So, the highest mean value of abrasion was for type B, while the lowest mean value of abrasion was for type A.

The detailed mean values of abrasion, standard deviations and the effect of variance were shown in table (4).

Table (4): Statistical analysis of abrasion test

ANOVA: Design 1 Between Subject Factor				
ABRASION $F(3,20) = 4.72$ $p<0.012011$ SS=637.12 MSe=45.04				
	A	**B**	**C**	**D**
Mean	7.67	21.67	11.83	15.67
StDev	2.58	11.83	3.6	4.55
Var	6.67	139.87	12.97	20.67

As for the appearance test regarding the effect of attaching elastic to fabric, the results were shown in table (5) & figure (3).

From table (5) it is obvious that the highest value of appearance (=5) was related to the 2cm width raw elastic [A] with two times of elastic stretching relative to the used fabric using either sewn by zigzag stitching elastic band [2X] or overlock stitching elastic band and topstitching [2Y].

Whilst, some results of the three other types of elastic [B], [C] & [D] recorded the lowest value of appearance (=1).

Table (5): Values of appearance test for different types of elastic

	1	B	C	D
1.5X	3	3	4	4
1.5Y	3	1	3	3
1.5Z	2	1	3	2
2X	5	2	2	1
2Y	5	2	2	4
2Z	3	1	1	4

At the first glance, from figure (3) it appears that, type A elastic fulfilled the best results of the appearance test, type B elastic appearance results were the worst, however types C & D demonstrated almost similar appearance results.

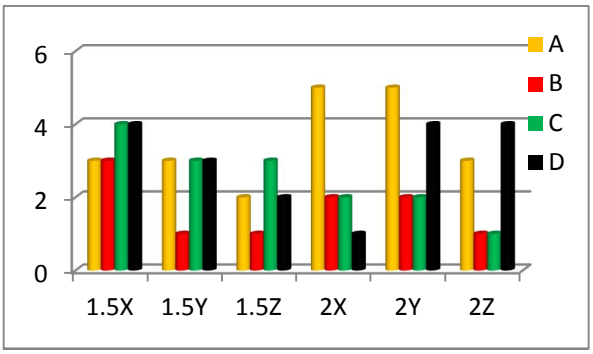

Figure (3): Appearance test results

By statistically analyzing the results of appearance test between study groups using standard ANOVA test between subjects, it was found that the P-value was nearly statistically significant ($p<0.054153$).

Moreover, the mean value for type A elastic was 3.5, for type B elastic was 1.67, for type C elastic was 2.5 and for type D elastic was 3. Though, the highest mean value of appearance was for type A, while the lowest mean value of appearance was for type B.

The detailed mean values of appearance, standard deviations and the effect of variance were tabulated in table (6).

Table (6): Statistical analysis of appearance test

ANOVA: Design 1 Between Subject Factor				
APPEARANCE F(3,20) = 3.01 p<0.054153 SS=11.00 MSe=1.22				
	A	**B**	**C**	**D**
Mean	3.5	1.67	2.5	3
StDev	1.22	0.82	1.05	1.26
Var	1.5	0.67	1.1	1.6

Lastly, for the influence of attaching elastic to fabric on the elongation test, the results were shown in table (7) & figure (4).

From table (7) it is dramatically apparent that the highest value of elongation (=321) was related to the 2cm width raw elastic [A] with 1.5 times of elastic stretching relative to the used fabric using flat-fell stitching and topstitched finish [1.5Z].

Whilst, the 2cm width woven elastic [B] with one and half times of elastic stretching relative to the used fabric using zigzag stitching elastic band [1.5X] recorded the lowest value of elongation (=180).

Table (7): Values of elongation test for different types of elastic

	A	**B**	**C**	**D**
1.5X	245	180	210	195
1.5Y	223	225	187	230
1.5Z	321	200	212	215
2X	275	248	230	213
2Y	297	215	218	219
2Z	215	268	198	245

Figure (4) illustrates that results of the elongation test were almost similar for both 1cm width raw and woven elastic [C & D] for all methods of elastic sewing, corresponding to the results of appearance test type A elastic kept the highest records of elongation test.

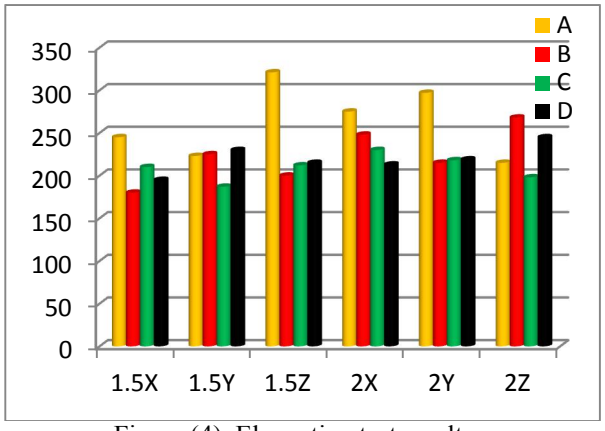

Figure (4): Elongation test results

By statistically analyzing the results of elongation test between study groups using standard ANOVA test between subjects, it was found that the P-value was statistically significant (p<0.022009).

Moreover, the mean value for type A elastic was 262.67, for type B elastic was 222.67, for type C elastic was 209.17 and for type D elastic was 219.5. So, the highest mean value of elongation was for type A, while the lowest mean value of abrasion was for type C.

The detailed mean values of elongation, standard deviations and the effect of variance were shown in table (8).

Table (8): Statistical analysis of elongation test

ANOVA: Design 1 Between Subject Factor				
ELONGATION F(3,20) = 4.00 p<0.022009 SS=9937.00 MSe=827.35				
	A	**B**	**C**	**D**
Mean	262.67	222.67	209.17	219.5
StDev	42.17	31.92	15.08	16.87
Var	1778.27	1019.07	227.37	284.7

4. Conclusion

On the basis of the performed tests conducted on the studied fabrics and the obtained results regarding evaluation of the effect of different types of elastics, the three used methods of elastic attachment and its degree of stretching, it was concluded that type A (2cm width raw elastic) fulfilled the highest elongation results and the best appearance, in comparison to other types of studied elastic B, C and D. However, type B (2cm width woven elastic) acquired the superior abrasion resistance (this is possibly due to the woven structure of the elastic band by its fibers intersection that changes the surface smoothness which increases its abrasion resistance), also the wider the surface area of the elastic band the higher the abrasion resistance, thus the results of type D is lesser than type B.

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