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Studying the Bending Stiffness of Polyester/Linen Fabric Seams with Different Structures

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Abstract: Bending stiffness is a fabric property that affects the aesthetic and comfort properties of clothing. This paper presents a study of the effect of some sewing parameters of polyester/linen woven fabric of three levels of picks per unit length with three different weave structures on the bending stiffness of sewn seams.
Bending lengths and stiffness were measured using Shirley stiffness tester for the seams made of two type of PES sewing thread (spun, core spun) and three levels of stitch density. The effects of both fabric and seam parameters on the bending properties of the sewn seams have been evaluated.
Keywords : polyester/linen, sewn seams, regression analysis, average float, fabric tightness.

Introduction:

The sewn seams are highly affected by the fabric stiffness. Fabric stiffness is mostly wanted to be reduced for a good drape in apparel fabrics. Therefore there is necessity to optimize the sewing parameters such as sewing thread type and size, stitch density and seam allowance in order to control the stiffness of the fabric on the garment. It is also believed to affect garment drape significantly with the implications of the pre mentioned sewing parameters[1,2,3,4].

A wide variety of sewing threads is used in clothing industry. The majority of sewing threads used by the clothing industry are made from cotton and polyester fibers. These sewing threads are made from spun, continuous filament or core spun yarns. Each type of sewing thread has distinct properties, which are a contributory factor for seam quality[8].

Resistance to bending or flexural rigidity is called stiffness in textile test methods, which is calculated by measuring the bending length. The longer the bending length, the stiffer is the fabric. Fabrics with very high bending rigidity values may lead to sewing and handling problems as they are too stiff to be manipulated and controlled. The stiffness of fabrics is commonly measured along the warp and weft direction in woven structure[5].

Although the effect of the sewing thread on seam performance is generally much less noticeable than that of the fabric. Many situations occur when the use of better sewing thread represent a practical solution to a seam performance problem.

Weave factor, is a mathematical factor for the woven fabrics, which refers to a number that accounts for the number of interlacements of warp and weft threads in any woven repeat. It is also called “average float”, and could be mathematically expressed as: $M=E/I$, where *“E”* is number of threads per repeat, and *“I”* is number of intersections per repeat of the thread crossing[9].

In this study, determination of the relationship between the bending properties and seam parameter of the sewn seams made from PES/Linen blended fabrics were studied based on the measurements of bending length.

Materials and Methods

1. Specimens:

In this study, the PES/Linen blended fabrics of varying picks per unit length (38, 46 and 54 per inch) were produced with three different weave structures (Plain, Twill 2/1 and Sateen 4) (see Table 1). All samples were stitched using two type of sewing yarn; Ne 40/2 ring spun and Ne 40/2 core spun, (Table 2) with three different levels of no. of stitches per unit length (7, 10 and 13 per inch).

Table (1) Fabric Specifications

Fabric Specifications	Warp	Weft
Raw Material	Linen 100%	Polyester/Linen (50%/50%)
Yarn count, Ne	40/2	24/1
Density yarns/ inch	43	42

Table (2) Sewing Yarn Specifications

Specifications	Sewing Yarn 1	Sewing Yarn 2
Structure	Ring spun	Core spun
Raw material	100% polyester	polyester / polyester
Sewing yarn count Ne	40/2	40/2
Breaking strength cN/tex	18.85	18.43
Breaking elongation %	20.72	22.54

The average float was calculated to the three weave structures under study based on the pre mentioned equation: $M=E/I$, where *"E"* is number of threads per repeat, and *"I"* is number of intersections per repeat. The resultant average floats were 1, 1.5, and 2 for the plain, twill 2/1 and sateen 4 resp.

The factorial designs are powerful tools in the experimental design techniques for investigating effects and interactions between parameters on sewn seam stiffness made of the fabrics under study. Table (3) provides the experimental parameters for full factorial design.

Table (3) Experimental Parameters for Box and Behnken factorial design.

Variable	-1	0	+1
picks per inch (X_1)	38	46	54
stitches number per inch (X_2)	7	10	13
Average float for weave structure (X_3)	1 for (plain)	1.5 for (twill 2/1)	2 for (sateen 4)

Also, the multiple linear regressions modelling have been used, and the general relation between the response Y (in this case Y = stiffness properties of sewn seams) and different parameters (x_i, is coded values of the three factors) will be:

$$Y = b_o + \sum_{i=1}^{k} b_i x_i$$

Where:

b_o: Constants.

b_i: The coefficient of the main factors, and k: is the number of factors chosen (in this case 3 factors).

2. Testing procedure:

The woven samples were conditioned in the standard testing temperature (20C° ± 2C°) and humidity (65% ± 2 RH) for 24 hour according to (ASTM) standards before conducting the tests.

2.1. Sewn seams stiffness:

The stiffness properties of stitched samples were measured by the Shirley stiffness tester according to[6,7] test methods.

Results and Discussion

Table (4) summarizes the experimental conditions and results of stiffness properties of seams by using two types of yarn (40/2 Ne ring spun and 40/2 Ne core spun).

A three variable Box- Benhnken design was used to study the influence of picks per unit length, average float for weave structures and no. of stitches per unit length on stiffness properties. The test of significance was carried out at 95% confidence level. The multiple regression equations for the stiffness properties with multiple correlations are shown in table (5). The goodness fit of these models was assessed by F- test.

Table (4) Experimental results for seams stiffness properties

Fabric No.	Picks per unit length, (x_1)	Stitches per unit length (x_2)	Average float for weave structure (x_3)	Stiffness of the sewn seams; mg.cm (warp direction)		Stiffness of the sewn seams; mg.cm (weft direction)	
				40/2 Ne ring spun	40/2 Ne core spun	40/2 Ne ring spun	40/2 Ne core spun
1	-1	-1	-1	5258	5550	7977	4866
2	0	-1	-1	7630	7753	8630	7016
3	1	-1	-1	9567	8569	10861	9533
4	-1	-1	0	5446	4719	4446	4309
5	0	-1	0	5714	6281	5418	5281
6	1	-1	0	7115	7543	6400	6699
7	-1	-1	1	5494	5064	4192	3529
8	0	-1	1	7078	7185	6114	6549
9	1	-1	1	7286	7353	6986	6482
10	-1	0	-1	7902	5432	5976	5852
11	0	0	-1	7533	10103	7834	10567
12	1	0	-1	8485	11161	9840	10961
13	-1	0	0	5498	4719	3970	6423
14	0	0	0	5973	6841	6703	5660
15	1	0	0	6794	8262	6440	6722
16	-1	0	1	5159	5630	4716	3539
17	0	0	1	7480	7756	6081	7480
18	1	0	1	8371	7751	7830	8265
19	-1	1	-1	7387	5550	7444	5803
20	0	1	-1	8757	9922	10195	12066
21	1	1	-1	10567	12416	11422	18372
22	-1	1	0	5211	4814	4923	6113
23	0	1	0	7196	6954	7240	5954
24	1	1	0	7722	8018	7575	11575
25	-1	1	1	6001	6329	5237	4050
26	0	1	1	7699	8192	6392	7333
27	1	1	1	9174	7994	7998	8165

Table (5) Multiple regression equations

Response (stiffness)	Equation	Multiple R
(Y_1) for ring spun-Warp D.	$Y= 92.8+150.9\ X_1+169.0\ X_2-1038.1\ X_3$	0.82
(Y_2) for core spun-Warp D.	$Y= -2341.5+217.1\ X_1+188.4\ X_2-1466.9\ X_3$	0.84
(Y_3) for ring spun-Weft D.	$Y= 1273.0+ 183.8\ X_1+137.1\ X_2-2736.9X_3$	0.86
(Y_4) for core spun-Weft D.	$Y= -5852.4+293.7\ X_1+466.0\ X_2-3293.6\ X_3$	0.83

1. Stiffness of the sewn seams using 40/2 Ne ring spun and 40/2 Ne core spun sewing threads in warp directions:

The influence of picks per unit length, stitches per unit length and average float for weave structures on stiffness properties in warp directions using 40/2 Ne ring spun sewing threads are shown in table 4. The multiple regression equations; Y_1 (table 5) and contour lines figures 1 clearly show that with an increase in picks, stitches number per unit length and average float for weave structure the stiffness in warp direction increase, and then slightly decrease with increasing them. The significance test was giving p-values of 0.00, 0.007, and 0.00 for the 3 parameters. This may be due to an increase of fabric tightness achieved at higher level of picks and stitches number per unit length but then decrease at higher level of float ratio for weave structure at low levels of picks and stitches number per unit length which slightly decrease with interactions by previous factors.

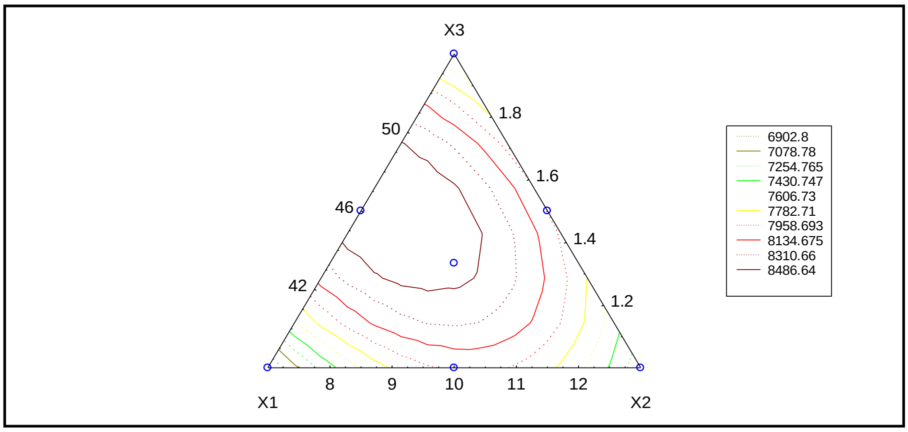

Figure (1) Effect of picks per unit length, stitches per unit length, and average float on Seam Stiffness in warp direction using Ne 40/2 ring spun sewing threads.

The influence of picks per unit length, stitches number per unit length and average float for weave structure on stiffness properties in warp directions using 40/2 Ne core spun sewing threads are shown in table 4. The multiple regression equations; Y_2 (table 5) and contour lines figure 2 show that with an increase in picks and stitches per unit length the stiffness in warp direction decreases, while increases to some extent with the increase of average floats for weave structure. The significance test was giving p-values of 0.00, 0.034, and 0.00 for the 3 parameters. This may be due to the effect of the higher extensibilities of the core spun sewing yarns which leads to decrease fabric tightness.

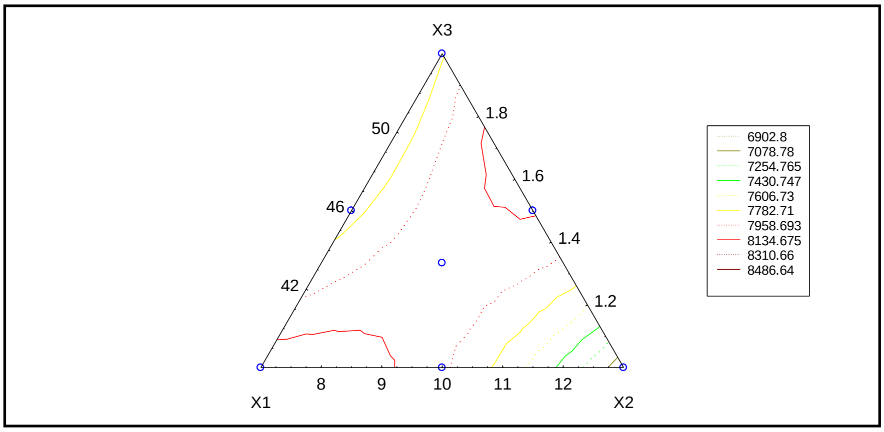

Figure (2) Effect of picks per unit length, stitches per unit length, and average float on Seam Stiffness in warp direction using Ne 40/2 core spun sewing threads.

2. Stiffness of the sewn seams using 40/2 Ne ring spun and 40/2 Ne core spun sewing threads in weft directions:

The influence of picks per unit length, stitches number per unit length and average float for weave structure on stiffness properties in weft directions using 40/2 Ne ring spun sewing threads are shown in table 4. The multiple regression equations; Y_3 (table 5) and contour lines figure 3 show that with the increase of picks and stitches per unit length the stiffness in weft direction increases to some extent and then decreases, while decreases with the increase of average floats for weave structure. The significance test was giving p-values of 0.00, 0.005, and 0.00 for the 3 parameters. This may be due to the increase of fabric tightness with the least average floats.

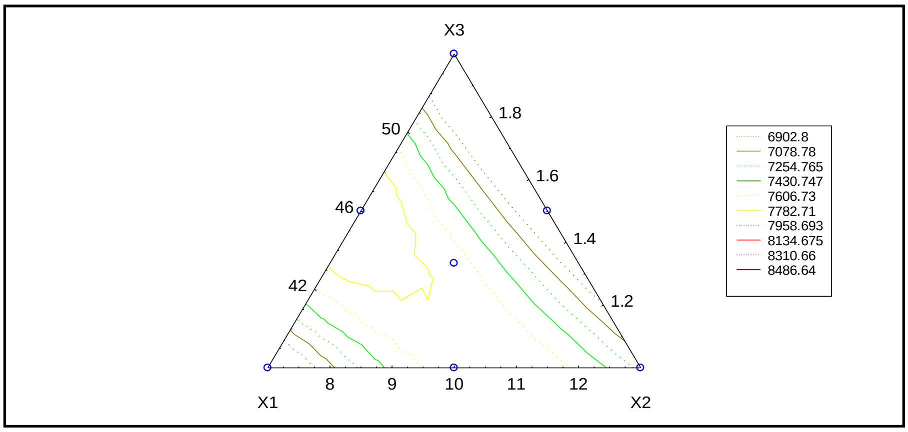

Figure (3) Effect of picks per unit length, stitches per unit length, and average float on Seam Stiffness in weft direction using Ne 40/2 ring spun sewing threads.

The influence of picks per unit length, stitches number per unit length and average float for weave structure on stiffness properties in weft directions using 40/2 Ne core spun sewing threads are shown in table 4. The multiple regression equations; Y_4 (table 5) and contour lines figures 4 show that with the increase of picks and stitches per unit length the stiffness in weft direction increases to some extent and then decreases, while increases with the increase of average floats for weave structure. The significance test was giving p-values of 0.00, 0.018, and 0.003 for the 3 parameters.

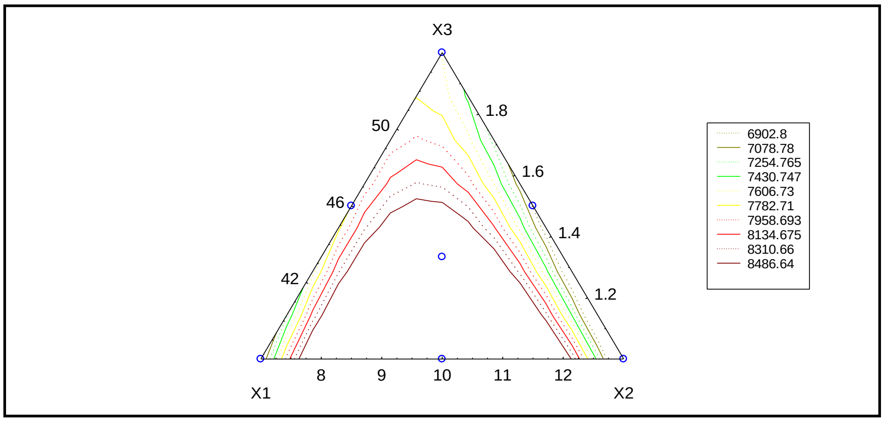

Figure (4) Effect of picks per unit length, stitches per unit length, and average float on Seam Stiffness in weft direction using Ne 40/2 core spun sewing threads.

Conclusions:

In this study the effects of both fabric and seam parameters on the bending properties of PES/linen seams have been evaluated. The results could be summarized as follows:

Both the fabric density and sewing stitch density are having a significant effect on the seam stiffness with both ring spun and core spun sewing threads.

The higher the average float of the fabric the less the seam stiffness will be because of the fabric tightness.

The sewing threads of core spun have better stress strain behavior which allows the sewn seams to preserve the limpness and drape of the used woven fabric.

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