THE INFLUENCE OF THE WEAVE AND THE METHOD OF STITCHING ON SELECTED MECHANICAL PROPERTIES OF WOVEN DOUBLE FABRICS

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Abstract:

This paper reports the influence of the weave and the method of stitching on the mechanical properties of double woven fabrics. Double fabrics have a more complex construction, which is altered not only by type of weave, yarn fineness, and thread density in comparison with single fabrics, but also by the method of stitching. The main goal of our research was to find out if the type of weave and method of stitching have a statistically important effect on selected mechanical properties of woven double fabrics, such as breaking strength, breaking elongation, tearing strength, wrinkle recovery and fabric stiffness, in order to extend the knowledge of double fabric construction. The testing samples were made from 100% cotton fabrics.

Keywords:

Double fabrics, woven fabrics, weave, type of stitching, mechanical properties

1. INTRODUCTION

Fabrics are designed to fit different projected demands in order to be suitable for their end use. For a fabric constructor it is essential that the relationships between the constructional parameters of fabrics and their individual properties, i.e. those that should fit the desired quality, are well defined. The mechanical properties are of considerable importance to fabric end use, so a lot of research has dealt with them and there have been a number of efforts to try to define different models [Chen, Jong, Reallf, Shananah, Sinoimeri, Fangning]. Double fabrics have a more complex construction, which is altered not only by type of weave, yarn fineness and thread density in comparison with single fabrics, but also by the method of stitching [Elnashar]. Double fabric is composed of upper and lower layers, which are woven one above the other and stitched together. Stitching these two layers of fabric together forms one of the principal features of double fabric construction. The main goal of our research was to find out if the type of weave and method of stitching have a statistically important effect on selected mechanical properties of woven double fabrics in order to extend the knowledge of double woven fabric construction. The results of this research could help the constructor by developing a new fabric construction with more appropriate properties.

2. METHODS OF STITCHING

Multi-layer woven fabric consists of at least two layers, which are woven one above the other and stitched together. Double woven fabric contains two systems of warp, face and back, and two systems of weft. The fabric can be called either two-ply fabric or double fabric. Interlacing the face warp threads with the face weft threads forms upper fabric (layer), and the interlacing the back warp threads with the back weft threads forms the lower fabric (layer) of the double fabric. By stitching of the back and face fabric, double fabric can be constructed according to the following methods of stitching [Blinov]:

- Stitching from back to face or warp stitching, where the back warp is stitched to the face fabric;
- Stitching from face to back or weft stitching, where the face warp is stitched to the back fabric;
- Combination stitching or double stitching, where the stitching from back to face and from face to back is applied simultaneously.
- Stitching with an extra warp: the face and back fabric are stitched together by an extra warp that binds the face and back wefts.
- Stitching with an extra weft: the face and back fabric are stitched together by an extra weft that binds the face and back warps.
- Warp interchange with interlacing; where the face warp interchanges with the back warp when desired to obtain special colour effects.
- Weft interchange with interlacing; where the back warp interchanges with the face warp when desired to obtain special colour effects.
- Chessboard stitching; where face and back warp interchange their positions in order to obtain special colour effects.

Table 1. Double woven fabric constructional parameters

Type of weave		Thread fineness of face fabric, tex		Thread fineness of back fabric, tex		Fabric density warp – weft face/back, threads per cm
face	back	Warp	Weft	Warp	weft	
plain	plain	20,4	39,4	39,4	39,4	48–18 / 18-18
twill	plain	20,4	39,4	39,4	39,4	48–18 / 18-18
sateen	plain	20,4	39,4	39,4	39,4	48–18 / 18-18
hopsack	plain	20,4	39,4	39,4	39,4	48–18 / 18-18

Table 2. The results of measured mechanical properties of double woven fabrics

Method of stitching	No. Samples / Type of face weave*	Breaking strength, N		Elongation at break, %		Fabric stiffness			
						warp		weft	
		warp	weft	warp	weft	face	back	face	back
A	1. plain	363	590	32.6	18.3	1.30	1.70	2.12	1.37
	2. twill	568	677	23.6	20.5	0.95	1.55	1.75	1.25
	3. sateen	381	583	21.6	17.6	0.89	1.40	1.75	1.87
	4. hopsack	334	500	30.0	25.0	0.99	1.67	1.30	1.58
B	5. plain	353	578	30.0	15.6	1.16	1.55	1.95	1.39
	6. twill	519	708	24.0	20.5	0.95	1.34	1.70	1.33
	7. sateen	381	583	21.6	18.6	0.76	1.41	1.85	1.45
	8. hopsack	316	603	32.6	19.0	0.85	1.33	1.45	1.45
C	9. plain	506	556	33.0	15.6	1.31	1.85	1.68	1.46
	10. twill	467	583	35.0	18.0	0.87	1.81	1.95	1.93
	11. sateen	374	556	25.0	16.0	1.16	1.93	1.94	1.93
	12. hopsack	307	645	35.0	21.0	1.18	1.85	1.48	1.50
D	13. plain	382	579	30.0	15.6	1.15	1.40	2.05	1.38
	14. twill	578	608	19.0	19.6	0.95	1.34	1.70	1.33
	15. sateen	392	565	20.0	17.0	0.76	1.41	1.85	1.45
	16. hopsack	285	632	37.0	20.0	0.85	1.33	1.45	1.45
E	17. plain	316	632	35.0	20.0	1.205	1.71	2.30	1.25
	18. twill	443	779	24.0	19.6	0.89	1.62	1.53	1.28
	19. sateen	352	688	22.0	18.0	1.04	1.01	1.11	1.32
	20. hopsack	332	616	30.0	22.0	0.96	1.77	1.34	1.34
F	21. plain	485	559	26.0	14.6	1.415	1.95	1.76	1.38
	22. twill	583	521	36.0	19.0	0.81	1.87	1.91	1.85
	23. sateen	408	538	25.6	15.0	1.225	1.95	1.80	1.90
	24. hopsack	343	592	37.0	16.2	1.305	1.68	1.15	1.45

*The type of lower weave for all samples is plain

Method of stitching	No. Samples / Type of face weave*	Tearing strength, N		Wrinkle recovery			
				warp		weft	
		warp	weft	face	back	face	back
A	1. plain	134	107	80	108	98	75
	2. twill	142	169	120	115	113	90
	3. sateen	145	168	53	120	98	118
	4. hopsack	150	169	91	128	91	110
B	5. plain	140	109	67	117	122	111
	6. twill	166	188	74	103	84	105
	7. sateen	157	185	55	110	105	90
	8. hopsack	177	199	45	133	90	96
C	9. plain	111	122	60	113	104	82
	10. twill	142	146	43	129	62	76
	11. sateen	138	169	46	110	43	82
	12. hopsack	133	202	51	115	93	100
D	13. plain	134	96	65	135	97	117
	14. twill	157	201	57	101	92	96
	15. sateen	144	172	60	110	72	80
	16. hopsack	183	189	59	130	104	120
E	17. plain	139	113	65	110	94	65
	18. twill	138	166	60	104	145	83
	19. sateen	123	174	50	101	102	81
	20. hopsack	142	167	42	27	66	72
F	21. plain	124	158	68	117	85	70
	22. twill	125	182	40	102	60	125
	23. sateen	138	184	46	101	75	63
	24. hopsack	133	202	50	115	75	82

*The type of lower weave for all samples is plain

3. MATERIALS AND METHODS

To find out the statistically important constructional parameters influencing double woven fabric (type of weave and the methods of stitching) on some selected mechanical properties, twenty-four double woven fabrics representing different structures were selected for this research. The woven samples are used for apparel, curtain, and upholstery applications and made from 100% cotton yarns (Giza 70 staple fibres) on a ring spinning machine. In order to analyze the effect of weave and method of stitching, all the samples had the same warp and weft density of face and back fabrics and the same weave (plain) of back fabric, but different weaves of face fabric (see Table 1). All of them were designed and woven at Helwan University, Faculty of Applied Arts, Textile Department.

The woven samples were grouped into five classes, according to the method of stitching: group A: warp stitching (back warp is stitched to face fabric), B: weft stitching (face warp is stitched to back fabric), C: weft and warp stitching (stitching from back to face and from face to back with warp), D: stitching with warp interchange (face and back fabrics are stitched together with a warp interchange by stitching), E: stitching with weft interchange (face and back fabrics are stitched together with a weft interchange), F chess-board stitching (face and back fabrics are stitched together with a warp and weft interchange). Within each group 4 samples representing different weaves of face fabric were chosen as follows (weave according to the ISO 9354): plain (10-01 01-01-01), twill (20-03 03-01-01), sateen (30-01 05-01-02 05 04 04 01) and hopsack (10-03 03-03 03-01).

The following mechanical properties were measured in accordance with applicable standards: breaking strength and elongation (ASTM D1682), tearing strength (ASTM D2262), wrinkle recovery (ASTM D1295) and fabric stiffness (ASTM D1388).

4. RESULTS AND DISCUSSION

The measurements of mechanical properties of double woven fabrics are summarized in Table 2. The results were further statistically assessed using the analysis of variance to define the significance of the constructional parameters (type of weave and the method of stitching) on the selected mechanical properties. The results of analysis of variance are listed in Table 3.

Table 3. The results of analysis of variance at 95% confidence level (+ important effect, - no effect)

Fabric property	Type of weave	Method of stitching
Breaking strength		
warp direction	+	-
weft direction	-	-
Elongation at break		
warp direction	+	-
weft direction	+	-
Tearing strength		
warp direction	-	+
weft direction	+	-
Wrinkle recovery		
warp direction: face	-	-
back	-	-
weft direction: face	-	-
back	-	-
Fabric stiffness		
warp direction: face	+	-
back	-	+
weft direction: face	+	-
back	-	-

The results clearly indicate that wrinkle recovery is not altered by weave or the method of stitching. The method of stitchinghas a statistically important effect only on fabric stiffness in back warp direction and tearing strength in warp direction.

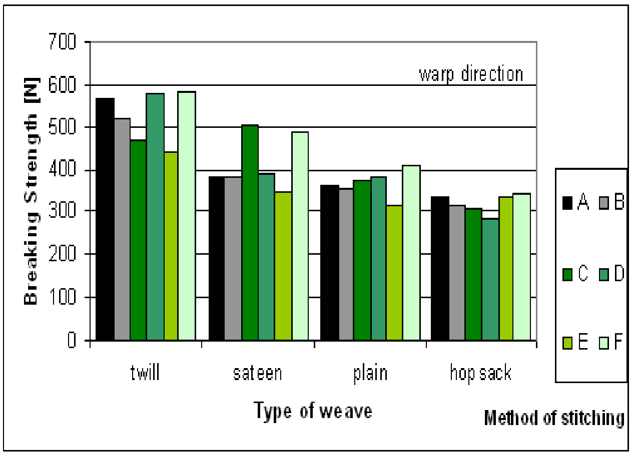

Figure 1. Breaking strength results

The importance of type of weave is much more evident regarding the breaking strength, breaking elongation, tearing strength and fabric stiffness. The effect of weave on breaking strength is important only in warp direction. This is probably the consequence of the yarn fineness used. In warp direction, the face and back yarns had different finenesses, while on the other hand the fineness of face and back weft was the same. So, when the yarn fineness of face and back fabric differs, the influence of weave becomes important. This well known phenomenon arises from the fact that because of the crimp, the fabric strength is less than the strength of twisted yarns. If all other things are equal, plain weave fabrics which have the highest crimp will have the lowest strength. Our results show the following decreasing range of breaking strength with regard to the type of weave: twill-sateen-plain-hopsack (Figure 1). Despite the fact that twill, sateen and hopsack weave all have the same number of thread passages in weave repeat of 6 x 6 threads, and so equal crimp, the breaking strength differs.

4. CONCLUSIONS

The purpose of this study was to establish the dependencies between the constructional parameters of double woven fabrics, namely type of weave and the method of stitching, and following mechanical properties: breaking strength and elongation, tearing strength, wrinkle recovery and fabric stiffness. The results of variance analysis clearly indicate that the method of stitching doesn't have a statistically important effect at a 95% confidence level on the above-mentioned mechanical properties, except for the tearing strength in warp direction and fabric stiffness. The influence of type of weave is much more evident regarding the mechanical properties. All the above-mentioned mechanical properties are influenced by weave, except for wrinkle recovery. It is worth mentioning that all samples consisted of 100% cotton fabrics used for apparel and upholstery applications. The results of this research could help the constructor in developing a new fabric construction with more appropriate properties.

5. REFERENCES

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