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The Effect of Twist Liveliness on the Woven Fabric Distortion

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Abstract: This paper deals with the grey fabric deformation during relaxation. It investigates the effect of twist direction and twist liveliness on the 2/2 twill weave woven fabric distortion, during relaxation This experimental work shows that twist liveliness increases the natural tendency of the twill weave woven fabric to skew. In addition when the twist direction of the warp and weft is opposite to each other the bias curling occurs too.

Keywords: Twill weave woven fabrics, Skewness, Twist liveliness, Bias curling

Introduction

Woven fabrics are constructed with lengthwise (warp) and crosswise (weft) yarns interlaced at right angles. During weaving warps and wefts both, are under tension and this condition makes the fabric contract during relaxation. This work investigates fabric deformation when they are released from the tension. Bias curling and skewing are the two phenomena which are considered in this experiment.

Bias curling in woven fabric is the condition where the alternate corners try to turn up and down, the northeast and southwest corners turning one way and the northwest and southeast corners turning the other way (Figure 1). This unexpected phenomenon is said to be caused by the additive torque effects of warp and weft sets of yarns [1,2]. For example, if the warp yarns have a tendency to untwist and if this tendency is not balanced by some other tendency in the opposite direction (or by special treatment) one might expect that the whole sheet would tend to curl in the same direction as the individual yarns.

Skewness in woven fabric (Figure 2a (not the b)) is a condition where the warp and weft yarns, although straight, are not at right angles to each other [3]. The causes of skewness could be divided into two categories;

a) Improper working conditions of the machineries. For example, uneven tensions applied to the warps due to the increase of tension across the width of the warp beam (improper slope or tension applied to each band of warp at sectional warping machine) or variation in running speed across the width of the fabric either during weaving or finishing process) [4].

b) Inherent movement of the twill weave woven fabric

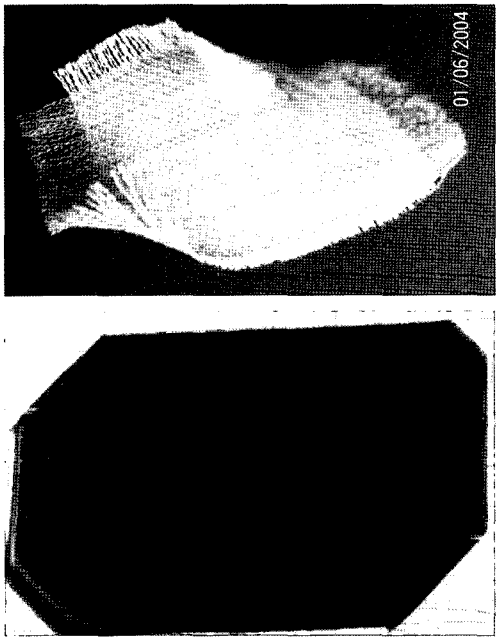
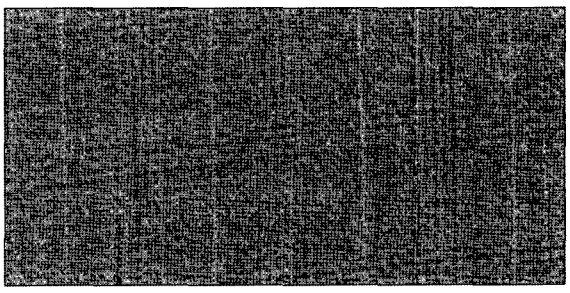
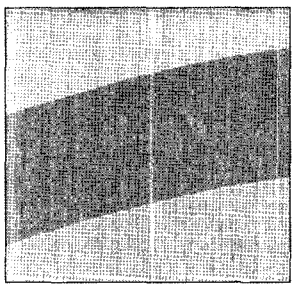


Figure 1. Bias curling in woven fabric.



(a) Skewing due to twill weave inherent movement



(b) Bowing due to uneven warp tension

Figure 2. Deformed woven fabric.

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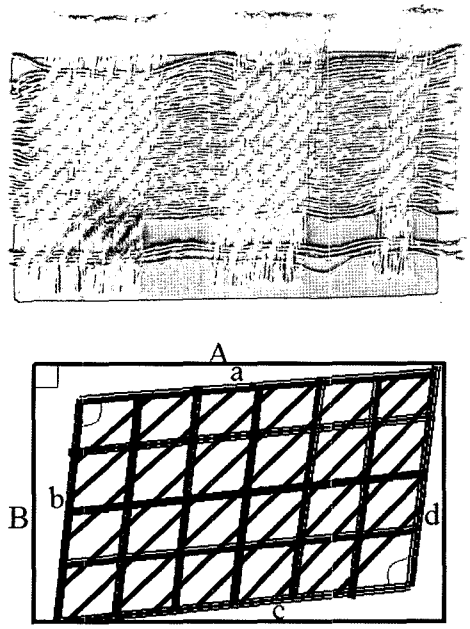


Figure 3. Twill weave woven fabric, as a sample to show the distortion.

which results in skewness at the relaxation state [5]. This type of distortion occurs when twill weave woven fabrics are released from the weaving tensions (during relaxation). Deformation is such that the fabrics will become skewed in the twill direction (Figure 3). The reason is that during relaxation (when yarns are shrinking) each float acts like in-plane lever making warp float and the neighbouring weft float act like the two arms of a scissor causing elongation of the main diagonal and shortening of the off diagonal, making the fabric shear.

The float length and free spaces between the yarns are considered as the important elements affecting the quantity of the skewness. It is shown that the longer the floats and the higher the number of the free spaces in one repeat, the more freedom there will be for floats to move and as a result, the higher the skewness.

In present work we look in to the effect of twist (direction and liveliness) on inherent movement of twill weave woven fabrics. In other words, this experimental work investigates the effects of twist direction and twist alive on the bias curling and skewing of the 2/2 twill weave woven fabric. It shows that during relaxation, stored potential energy due to the existence of twist liveliness increases the tendency of self shearing movement of the fabric.

Experimental

Test Materials

To find the effect of twist liveliness (level & direction) on the skewness and curling of the fabrics, two sets of yarns (S & Z) each contains 6 different twist levels were produced. The only difference between the two sets of yarns was the twist direction.

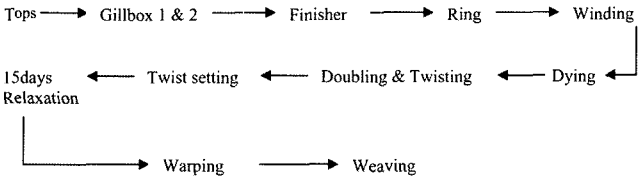
Table 1. Specification of the fibers and produced yarn

Material used	T/m	Nm
1- Australian merino fleece wool top as per international standard (IWTO)	450	48/2
Wool specification: 22 micron (maximum average),	500	48/2
65 mm (minimum average), sliver weight 20 gr/m	550	48/2
2- DuPont Polyester Tops, 20 gr/m	600	48/2
Polyester tops, 3 den, 76 mm, raw white, semi dull,	675	48/2
low pilling.	750	48/2

Finally, twelve 60 meter rolls of cloth with the same structure were woven. The fabrics were all, 2/2-twill weave, 45 % wool 55 % polyester, 27.2 warp/cm, 20 weft/cm and 1.5-meter width (Table 1).

Production Line

The production line (tops to fabric) is as below:



Twist Setting

In order to set the twist, the yarns were steamed under conditions shown in Table 2.

Weaving

From each party (of S twist yarn) 200-meter warp beams were prepared by sectional warping machine, making the total of six warp beams. Two groups of fabrics (1.5-meter width, 2/2 twill, 68 dents per10 cm, 20 weft/cm and 321 gr/m weight) were woven on the Dornier SW5 weaving machine (200 picks/minute). This results in twelve cases of woven fabrics.

The difference between the groups was the weft yarn twist direction and the difference within each group was the twist amount. In order to eliminate the effect of the weaving machine, all the fabrics were woven on the same mentioned weaving machine.

Measurements

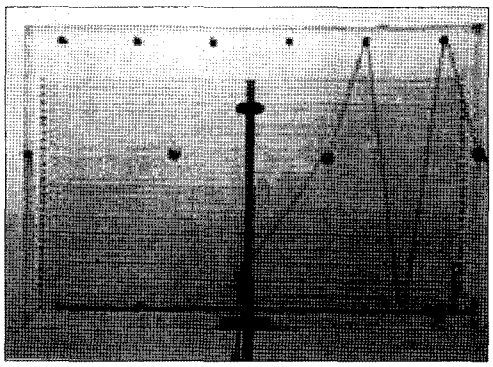
Twist Liveliness

Twist liveliness was measured by using a special apparatus (shown by Figure 4), fifteen days after twist setting. Bottom row of the Table 2 shows the results indicating the difference between the yarns.

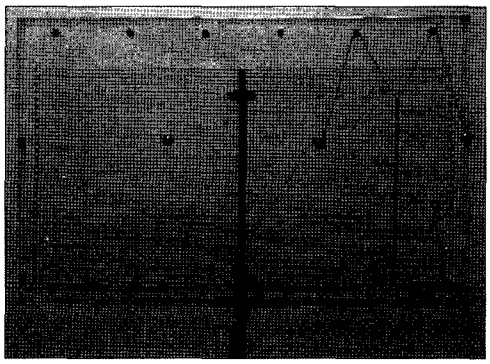
Table 2. The steamer specification and the steaming conditions

Weight per party	60 kg		60 kg		60 kg		60 kg		60 kg		60 kg	
Twist T/m	453		500		551		602		676		752	
Temperature	100		100		100		100		100		100	
Pressure	−1 to +1		−1 to +1		−1 to +1		−1 to +1		−1 to +1		−1 to +1	
Steaming cycles	3	2	3	2	3	2	3	2	3	2	3	2
Steaming time	15	10	15	10	15	10	15	10	15	10	15	10
Total processing time (min)	60	35	60	35	60	35	60	35	60	35	60	35
Spirality (turns)	0	0	0	3	0	6	1	11	3	15	6	25

Steamer: Hemmer, volume: 4400 liters, model: VATS 140-250/2, max temperature: 151c, years: 1978, max pressure: 4at, working conditions.



(a) case 1



(b) case 2

Figure 4. Apparatus and the way used to measure the twist liveliness.

Skewness

Fabric skewness was measured according to ASTMD-3882-88 test method (ASTM, 1989) [6]. Measurements were taken at 50-cm intervals, so that for each cloth role of 60 meters more than 100 cases were taken. In other words, each value is the average of more than 100 samples.

Results and Discussion

In the previous work [5] it was shown that twill weave woven fabrics skew in the direction of the twill at the relaxation state. This phenomenon was due to the inherent movement of the structure which is affected by

a) Shrinkage of the yarns (floats) in twill weaves causes the floats to be affected by two forces acting opposite to each other and makes each float work like an in-plain lever (Figure 5).

b) The weave factor (yarn freedom to move). The lower the weave factor, the higher the freedom of the yarns to move.

In order to eliminate the skewness one way was to increase the interlacing points (which would eliminate the inherent movement of the fabric) and the other way was reversing the direction of the twill (which would neutralize the tendency to skew) like herringbone fabrics.

Table 3 shows the results of this experimental work. It shows that twist direction affects the fabric skewness. When warp and weft twist directions are opposite to each other, the skewness is higher in comparison to the condition in which the twist directions are the same (Figure 6).

It also indicates a direct relationship between the quantity of the twist liveliness and skewness. It shows that as twist liveliness increases the skewness also increases (Figure 7).

This founding could be due to two reasons:

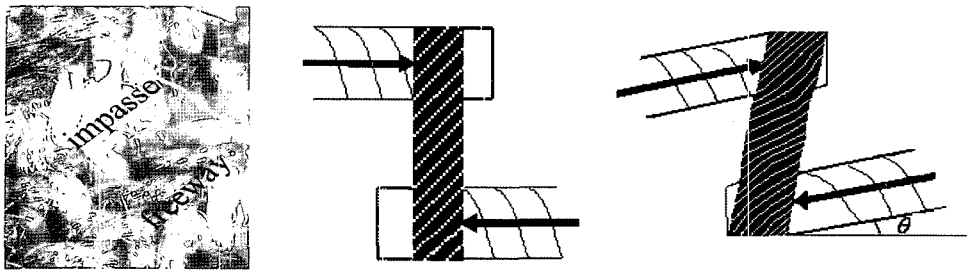
a) The effects which twist direction could have on the shearing properties.

b) Additive torque effects of warp and weft sets of yarns on the distortion of the fabric.

The Effect of Twist Direction

One of the main elements affecting on the shearing rigidity is the twist direction. When the twist direction for warp and weft is the same, the twist on the underside of the top thread is in the same direction as that on the upper side of the lower thread (Figure 8a). Such condition is favourable for the threads to bed into each other and form a compact cloth in which the weave and thread structure is not distinct. This results in having higher shearing rigidity, giving a lower degree of freedom to the yarn movement and as a result lower fabric distortion.

When the twist direction for warp and weft is not the



(a) actual case showing the effect (b) Situation for each float in right hand 2/2 twill (c) Skewed float in right hand 2/2 twill

Figure 5. Float distortion during relaxation.

Table 3. Spirality and skewness

	Twist	Single Yarn = S, Plied = Z				Single yarn = Z, Plied = S			
		3 times steaming		2 times steaming		3 times steaming		2 times steaming	
Party #	T/m	Sp (turns)	Sk (cm)	Sp (turns)	Sk (cm)	Sp (turns)	Sk (cm)	Sp (turns)	Sk (cm)
1	453	0.00	**1.22**	0.00	**1.20**	0.15	**1.88**	0.00	**1.74**
2	500	0.10	**1.81**	3.00	**2.20**	0.20	**2.13**	2.10	**3.11**
3	551	1.00	**2.15**	6.18	**3.50**	1.11	**3.70**	6.22	**5.09**
4	607	1.21	**2.55**	11.27	**4.16**	1.15	**3.15**	11.40	**6.05**
5	676	3.11	**3.52**	15.10	**6.23**	3.30	**4.10**	15.70	**7.47**
6	752	6.13	**5.59**	25.50	**9.18**	6.10	**6.97**	25.33	**11.10**

Sk: skewness, Sp: spirality, sample testing to measure the yarn twist for each party was 20.

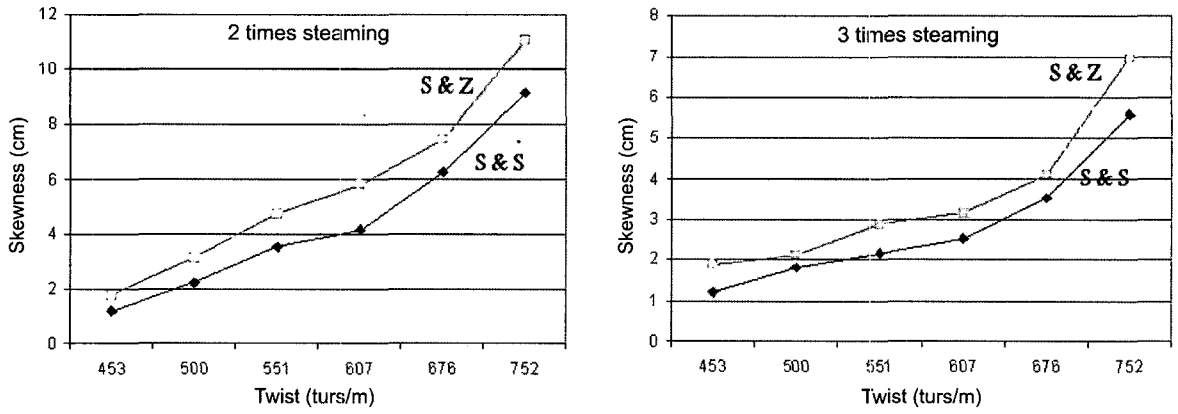
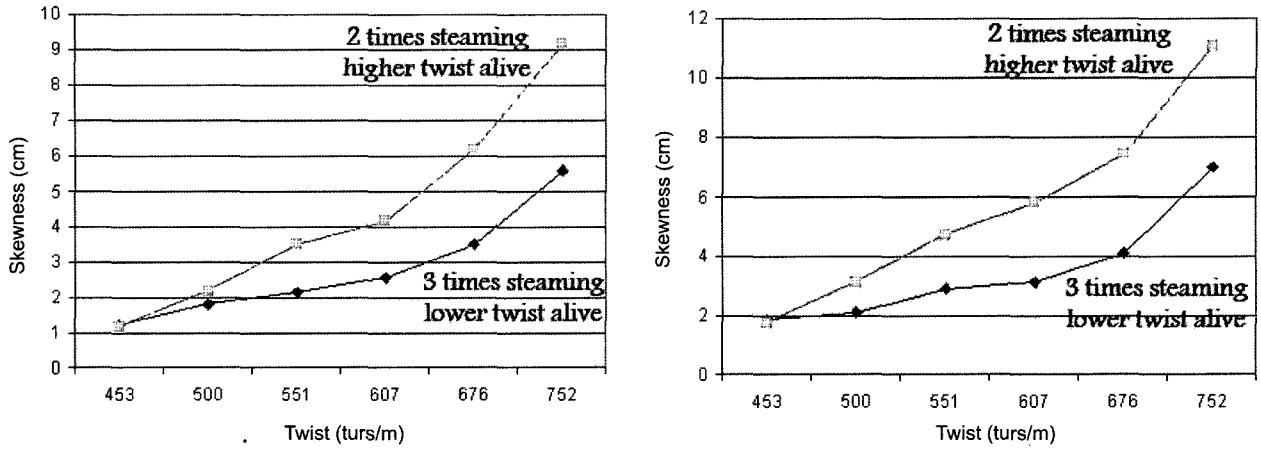


Figure 6. The effect of the twist direction on the amount of fabric skewness.

same, the twist on the underside of the top thread is in the opposite direction of that on the upper side of the lower thread. In this case the condition is such that the threads can not bed into each other. They do not form a compact cloth (the weave and threads structure is distinct) especially when the twist is high or it is not completely set (i.e., yarns have twist liveliness), as a result the shearing rigidity is lower. So, whenever the fabric gets free from the weaving tensions (due to the existence of stored energy) it will try to find the equilibrium status. Therefore, it will deform (contracts and skews). This deformation could be higher in comparison to the case when warp and weft twist is the same (Figure 8b).

Additive Torque

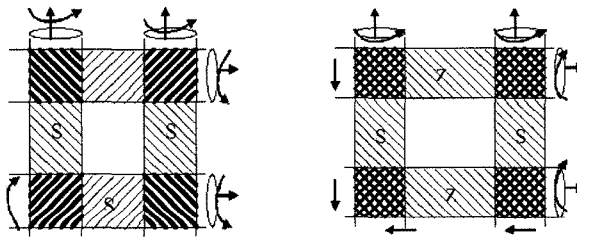
When the twist direction of the warp yarns is *s*, the torque direction acting on the plain of the warp sheet is in the opposite way (-*z*–). This energy causes the warp plain deforms in the *Z* direction. But the quantity of the tendency is partially balanced by the filling yarns. As the filling per centimetre increases, the tendency is eliminated and more balanced. However, the float length plays a vital role. As the float length increases the quantity of the torque is increased.



(a) Twist directions: warp=S and weft S

(b) Twist directions: warp=S and weft Z

Figure 7. Relationship between twist liveliness and skewness of the woven fabric.



(a) Twist direction for both (warp and weft) is the same (S).

(b) Twist direction for warp and weft is not the same (lower shearing rigidity)

Figure 8. Contact point and the twist direction.

Because $\vec{\tau} = \vec{F} \times \vec{L} = k\vec{\theta} \times \vec{L}$ where τ is the effective torque, F is the effective twist liveliness force, k is a constant which depends on the yarn physical properties and θ is the twist angular.

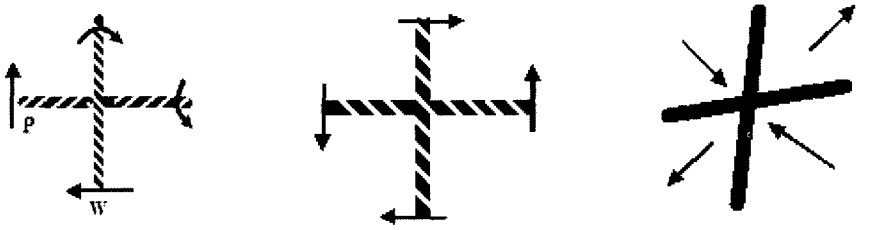
Obviously if the fabric is right hand twill (diagonal line is *Z*) then the natural tendency of the warp float to skew increases and if the fabric is left hand twill (diagonal line is *S*) then the tendency is eliminated (Figure 9a).

This is also the same for the weft yarns. If twist direction of the weft yarn is **S**, the direction of the torque affecting on the weft plane would be **Z** causing the weft plain to deform downward. Undoubtedly, if the fabric is right hand twill (diagonal line is Z) then the natural tendency of the weft float to skew decreases and if the fabric is left hand twill (diagonal line is S) then the tendency to skew increases.

However, twill weave fabrics skew in the twill direction, but the quantity of the skewness is dependent upon the twist direction of the warp and weft yarns and the amount of the warp twist alive (the amount of the additive torque on the warp float) as well as the amount of the weft twist alive.

At such a case, even though fabric skewness happens but curling does not occur. The reason is that when the direction of the both warps and wefts yarns are the same (for example both are Z or S) the additive torque on weft plane and warp plane does not act on the same direction.

If the warp twist direction is **S** and weft twist is **Z**, then the warp yarns would like to turn counter clockwise and weft yarns are inclined to turn the other way (Figure 9 a and c). This condition makes the two corners of the rectangular piece of fabric to move forward, causing the fabric to shear forward and role inward, opposite the face of the fabric while the other two corners of the fabric shear inward and role inward the face of the fabric (Figure 10).

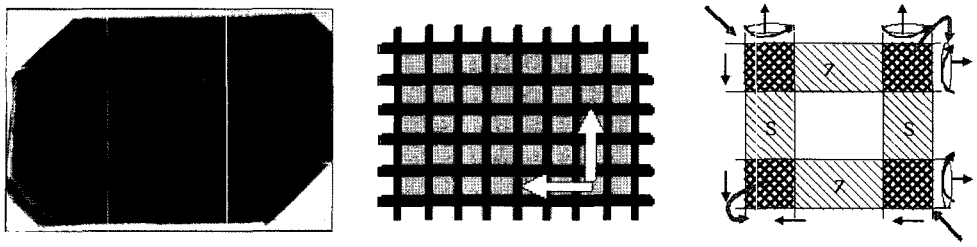


(a) Warp and weft, the same twist direction

(b) Warp and weft different twist direction

(c) Manner of deformation

Figure 9. A unit cell of the woven fabric.



(a) The actual fabric deformation (b) Explanation of the behavior

Figure 10. The effect of the twist liveliness on the woven fabric when the warp twist direction is *s* and weft twist direction is *z*.

Conclusion

This experimental work shows that;

Twist liveliness is effective on the woven fabric skewness and curling. As the twist liveliness increases, the skewness will increase. This is due to the fact that when the twist goes up three phenomena will happen.

- The yarns get rounder, (shearing rigidity lowers).
- The yarn will get stiffer (flexibility reduces).
- The torque related to the twist liveliness gets higher and as a result gets more effective.

The direction of the warp and weft twist is effective on the manner of deformation and the amount of skewness. This is due to the twist direction on the contact point between warp and weft yarns. When the twist directions are opposite to each other the skewness is higher ending to bias curling of the fabric.

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