TECHNICAL BULLETIN

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TRI 2002

KNIT FABRICS AND THE REDUCTION OF TORQUE

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INTRODUCTION

Cotton single jersey knits exhibit a tendency for the course and wale loops to skew when allowed to relax. The ideal model for a single jersey fabric would have the courses and wales aligned at a perpendicular angle with the wales oriented parallel to the edge of the knitted tube or open width fabric (See Figure 1).

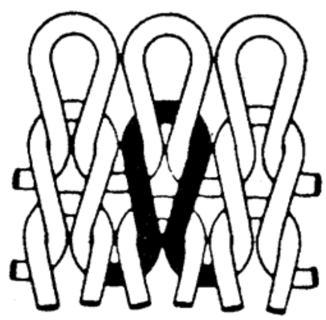
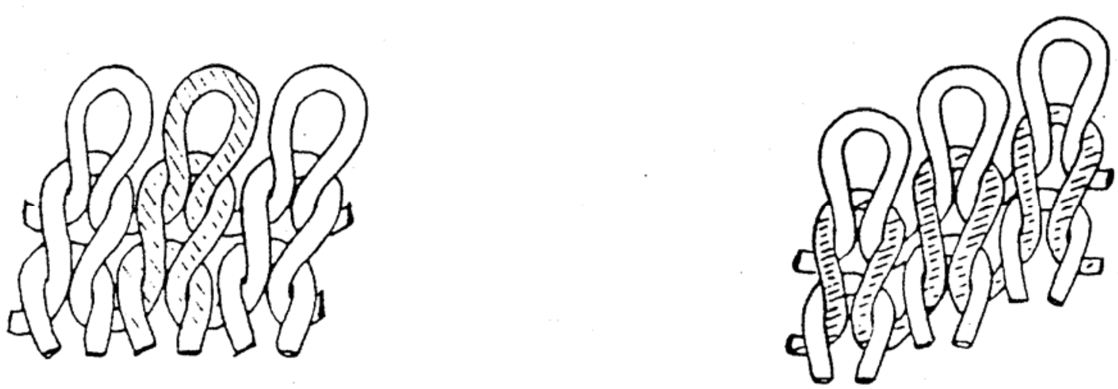


Figure 1 - Ideal alignment of course and wale loops. Wale loops are vertical and course loops are horizontal.

DEFINITION

Skew can be defined as a fabric condition resulting when the knitted wales and courses are angularly displaced from that ideal perpendicular angle. Other terms such as torque, spirality, bias and shear distortion are often used to refer to the same phenomena. Regardless of the term used, this displacement of the courses and wales can be expressed as a percentage or as an angle measurement in degrees. Examples of skew can be seen in Figure 2.



Wale Skew

Course Skew

Figure 2 - Example of wale skew and course skew.

If the wales are skewed from the vertical, the resulting configuration will be called "wale skew". Conversely, if the courses are skewed from the horizontal, the resulting configuration will be called "course skew" (See Figure 3).

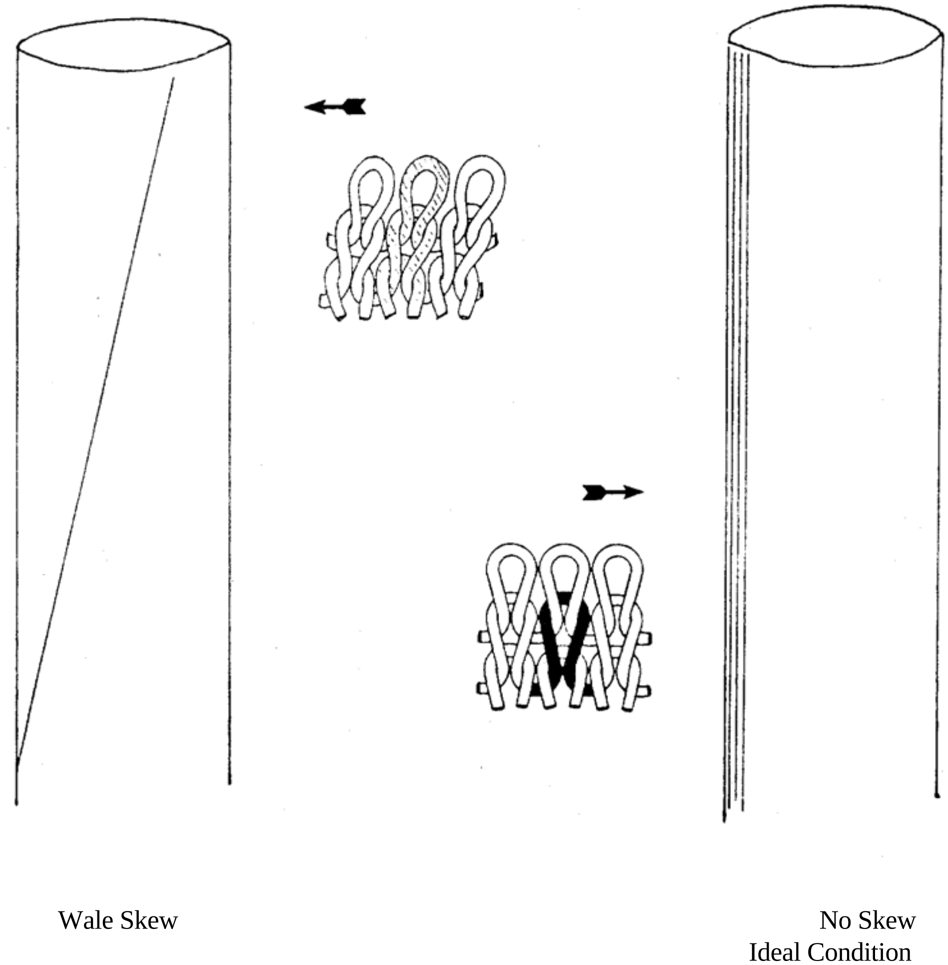


Figure 3 - Knit fabric skew or torque caused by wale loop distortion.

When knitted fabrics are allowed to relax off the knitting machine, they will skew. Some relaxation of yarn and knitting stresses occurs when the fabric is first unrolled after knitting. If the goods are subsequently wet processed, relaxation certainly occurs. Finally, drying without tension will maximize skew.

CAUSES

When discussing tubular knit goods, the skew deviation is usually composed of distortion caused by the yarn, the number of feeders on the machine, and the manner in which the yarn is knitted. Skew caused by the yarn is realized as a spiraling of the wales at a steep angle around the knitted tube. This type of skew is shown in Figure 3 and causes the tube to torque. If a single wale is followed up the length of this tube, it can easily be seen that the wale will spiral around the tube. The courses will generally not be deflected from the horizontal. Distortion of the wale loops is usually seen in goods that are processed in tubular form in a preparation or dyeing process. In fact, wale skew is readily seen when the fabrics are unloaded from the preparation or dyeing vessel prior to de-twisting and extraction. If the fabric is then finished in a tubular manner and the wales are not straightened, then the distortion of the wales will be realized.

For open-width finishing, one or several adjacent needles may be left out of the knitting machine cylinder to create a gap in the wales of the fabric (See Figure 4).

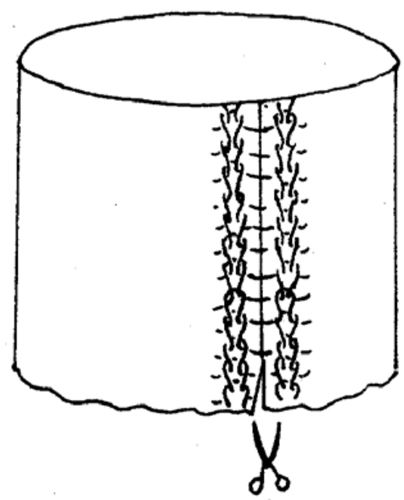
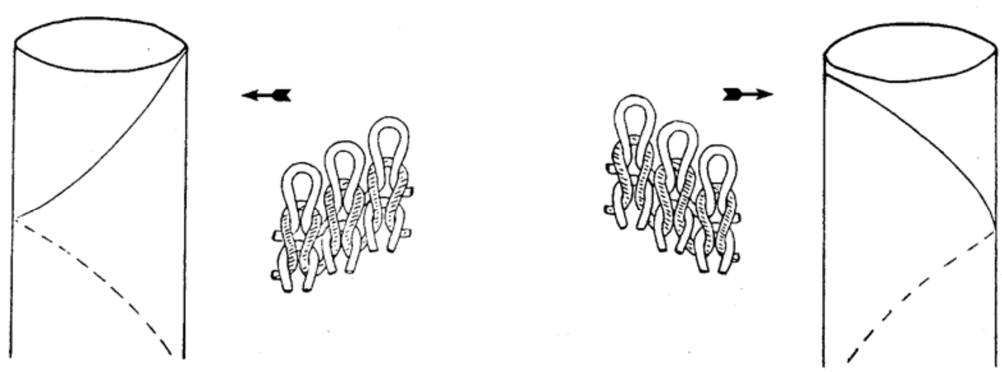


Figure 4 - Slitting of a knit tube on a needle-out slit line.

The fabric is then slit after wet processing on this vertical line or gap that runs parallel to the wales in the fabric. Now the fabric can be finished open width, and the wales will be automatically straightened (be aligned parallel to the edge of the open fabric). The distortion will now be seen as a skewing of the courses from the horizontal (See Figure 5).



Right Hand Skew

Left Hand Skew

Figure 5 - Skew of course loops where the row of wales are straightened parallel to the edge of the fabric.

The level of course skew will include both yarn and machine influence. Also, it is important to realize that if the fabrics are slit in the greige on the same wale line and wet processed through drying, then the wales will be straight and the courses may be skewed.
On a knitting machine making single jersey, one revolution of the machine will make a course of fabric for each feed of yarn. The more the number of feeders, the more courses are made. Figure 6 demonstrates the spiral formation of a knit fabric. As the cylinder rotates and each needle knits, it stacks these courses on top of each other. The distance between the spiral lines represents the production of courses for one revolution of the cylinder. Therefore, the formation of a circular knit fabric is a source of skew and its severity is related to the number of yarn feeders on the machine. Machines with a large number of feeders will make a fabric that has substantial "course skew" as the fabric comes off the knitting elements.

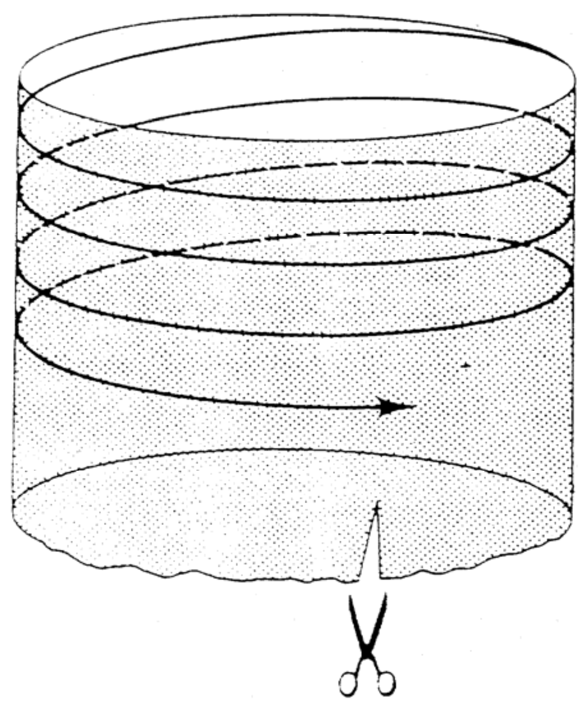


Figure 6 - Spiral formation of a knitted fabric.

Yarn parameters that affect skew include twist level (twist multiple or turns per inch of twist), twist direction (S or Z), twist liveliness, and the spinning system. It is important to realize that skew from the yarn and the skew from the number of feeders on the machine can combine together to create more skew, or they may partially offset each other and result in less skew. This addition or subtraction of skew depends primarily on the yarn twist direction and the direction of rotation of the cylinder on the knitting machine.

EFFECT OF TWIST MULTIPLE, TWIST DIRECTION AND SPINNING SYSTEM ON SKEW

In order to eliminate factors other than the above, a single quality of cotton fiber with uniform staple length and micronaire was spun into 18/1 Ne yarns on a ring spinning frame, an open-end frame and an air jet spinning frame. Twist multiples (TM) of 3.0, 3.5 and 4.0 were spun on the ring spun and open-end frames. Both "S" and "Z" twist directions were spun for the ring spun and air jet conditions. However, only one twist multiple was evaluated for air jet spinning. Based on the nature of the air jet spinning system, the best possible setup for yarn strength was used which determined the twist multiple. Also, the open-end evaluation only included a "Z" twist direction.

These yarns were knit on an 18 cut single jersey machine with a 10 inch diameter cylinder, a single yarn feeder and positive yarn feeding. The use of the single feeder machine eliminated the effect of yarn feeder skew (course skew).

After knitting, the fabrics were measured for skew using a proposed test method being developed by AATCC (See Appendix A). In this test the samples are marked with a square before washing and tumble drying. If the fabric skews after five wash and dry cycles, the square can be measured for percent skew. The method uses a mathematical formula for shear distortion (skew) and is shown below:

$$\% \text{ Skew} = \frac{2\,(AC - BD)}{AC + BD} \times 100$$

Where AC and BD are the diagonals of the square.

Greige goods were tested to measure the actual skew and the results are in Table I. The fabrics were tested in the greige to study the effect of the yarn and the construction on skew without the influence of preparation, dyeing and finishing.

The data for all ring spun and open-end conditions show that the higher the twist multiple, the greater the tendency to skew. Twist multiple is related to the number of turns per inch of twist for any given yarn count. Also, the higher the TM, the greater the twist liveliness of the yarn. When the yarns are relaxed, the liveliness is reduced.

All "Z" twist cotton yarns exhibit skew in a direction referred to as "right-hand" skew. Right-hand skew refers to a wale loop distortion that leans to the right. All "S" twist yarns yield a "left-hand" skew with the loop leaning to the left (See Figure 2).

In this comparison, the open-end yarns resulted in less skew than the ring-spun or air jet-spun yarns.

TABLE I EFFECT OF TWIST MULTIPLE, TWIST DIRECTION AND YARN SPINNING SYSTEM ON SKEW*		
Condition Greige Goods	% Skew (5 HLTD's)	Skew Direction
Ring Spun "Z' twist		
3.0	10.5	Right
3.5	12.6	Right
4.0	18.5	Right
Ring Spun "S" twist		
3.0	15.8	Left
3.5	17.6	Left
4.0	20.3	Left
Open-End "Z" twist		
3.0	3.5	Right
3.5	5.2	Right
4.0	8.7	Right
Murata Air Jet		
"Z"	12.3	Right
"S"	17.6	Left
* 18 Cut Single Jersey with 18/1 Ne Carded 100% Cotton Yarn - Greige		

EFFECT OF TWIST DIRECTION AND MACHINE ROTATIONAL DIRECTION ON SKEW

Fabrics were made on two 28 cut single jersey machines with 26 inch diameter cylinders and 60 yarn feeders. Combed cotton ring spun yarns (30/1 Ne) were knit at a course length of 245 inches per revolution (a tight stitch). The difference between the machines was the direction of cylinder rotation. One machine (Monarch XLJS) rotated clockwise, and the other machine (Terrot S3P172) rotated counterclockwise. The same fiber was used to spin the ring spun yarns with both "S" and "Z" twist directions at a TM of 3.5.

Knitting evaluations included three yarn feeder setups. Comparisons included fabrics made with all feeds of "S" twist, all feeds of "Z" twist and alternating feeds of "S" and "Z" twist.

Greige goods were again tested for skew using the proposed AATCC method for shear distortion (skew). The results of testing are shown in Table II.

TABLE II EFFECT OF YARN TWIST DIRECTION AND MACHINE CYLINDER ROTATION DIRECTION ON SKEW*		
Condition Greige Goods	% Skew (5 HLTD's)	Skew Direction
Clockwise Rotation		
"Z"	15.3	Right
"S & Z"	1.4	Right
"S"	11.0	Left
Counterclockwise Rotation		
"Z"	5.7	Right
"S & Z"	2.6	Right
"S"	7.5	Left
* 28 Cut Single Jersey with 30/1 Ne Combed Ring Spun 100% Cotton Yarn		

The data in Table II reveals that by alternating feeds of "S" and "Z" twist, the tendency to skew can be greatly reduced. This is because the courses with "Z" twist yarn will lean to the right, and the courses with the "S" twist yarn will lean to the left (See Figure 7). By alternating these yarns, the skew of each twist direction will counter the other.

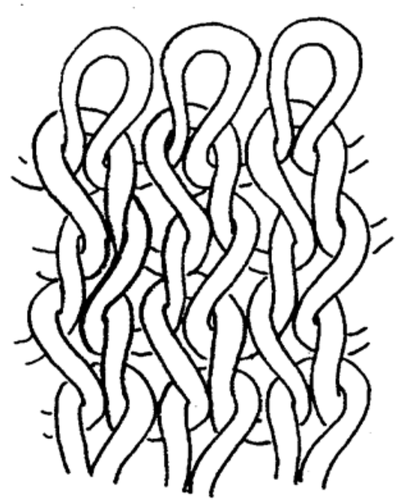


Figure 7 - Loop diagram with alternating courses of "S" and "Z" yarn.

Comparison of knitting machine rotation in Table II points out that "Z" twist gives less skew on a machine of counterclockwise rotation. Fabrics coming off the needles of a counterclockwise rotating machine have courses with left hand skew (See Figure 8). Yarns with "Z" twist yield fabrics with right hand wale skew. This better performance is a result of course skew from the feeders subtracting from the wale skew from the yarn twist.

Also, the data in Table I shows that the "Z" twist for the ring spun and air jet yarns resulted in less skew on the sample machine which rotates counterclockwise.

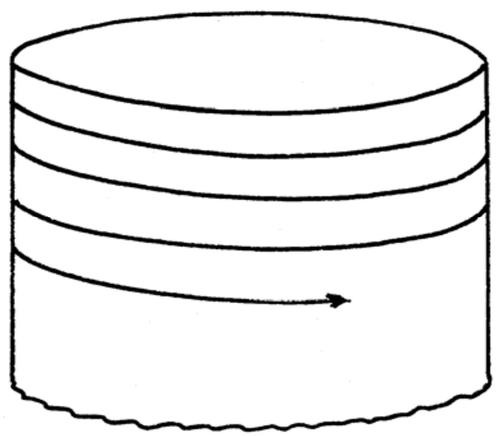


Figure 8 - Fabric course skew (spiral) for counterclockwise cylinder rotation. Fabric has a left hand skew.

Clockwise rotating machines yield less skew with yarns of "S" twist. Fabrics coming off a clockwise rotating machine have courses with right hand skew (See Figure 9). Yarns with "S" twist yield fabrics with left hand wale skew. Therefore, the yarn and machine skew tendencies for "S" twist and clockwise rotation of the machine partially offset each other.

In Table II, the lower values for the counterclockwise machine compared to the clockwise machine may be related to differences between the knitting elements of the machines and is not investigated in this report.

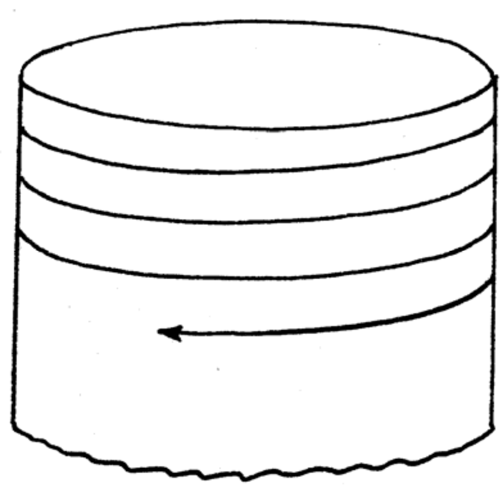


Figure 9 - Fabric course skew (spiral) for clockwise cylinder rotation. Fabric has right hand skew.

EFFECT OF TIGHTNESS OF STITCH ON SKEW

Four course lengths were knit on the 28 cut single jersey machine (Monarch XLJS) resulting in a range of knitting from tight (245 inches per revolution) to loose (280 inches per revolution). In this comparison both greige goods and dyed goods were compared for skew.

TABLE III
EFFECT OF STITCH TIGHTNESS ON SKEW *

Condition Course Length	% Skew (5 HLTD's)+	
	Greige	Dyed Corrected for Skew
245"	8.6	8.1
260"	12.3	9.5
270"	15.1	15.2
280"	16.8	17.2

* 28 Cut Single Jersey with 30/1 CP Ring Spun 100% Cotton Yarn

+ All samples had right hand skew.

Results in Table III show the tighter the stitch, the less the skew. Also, although the dyed goods were corrected for skew during drying (i.e. the courses and wales were aligned to the ideal perpendicular angle), they skewed as much as the greige goods.

EFFECT ON SKEW USING PLIED AND PARALLEL YARNS

It has been shown that alternating feeds of "S" and "Z" twist yarns will reduce skew to lower levels. If the twist multiple of the yarns is exactly balanced, the opposing forces working as a team will yield a torque free fabric. The use of balanced, plied yarns has been practiced for years to give torque free fabrics. Table IV gives data for "S" and "Z" yarns spun side-by-side on the Murata Twin Spinning™ (MTS) system and wound parallel onto the same package. Also shown is the data for MTS yarns with both strands having "Z" twist, wound onto the same package and then plied on an uptwister at different turns per inch of twist.

TABLE IV
EFFECT OF PARALLEL AND PLIED YARNS ON SKEW
USING THE MURATA AIR JET SPINNING SYSTEM *

Condition 18 Cut, 100% Cotton	% Skew 5 HLTD's	Direction
"S & Z" - 0 TPI	1.2	Right
"Z & Z" - 0 TPI	21.0	Right
"Z & Z" - 2.5 TPI	17.0	Right
"Z & Z" - 6.5 TPI	11.3	Right
"Z & Z" - 12.5 TPI	0.0	None
"Z & Z" - 14.5 TPI	3.5	Left

* Each individual strand was a 40/1 Air Jet Yarn.

The data in Table IV shows that a Twin Spun™ yarn with "S & Z" singles knitting parallel yields no skew. This has the same effect as alternating the feeds on a knitting machine with "S & Z" twist yarns. The appearance of the fabric will be much more uniform with all wales straight as compared to a zig-zag appearance with the yarns alternating. However, with the yarns fed from the same package in a parallel manner, yarn tensions become critical so as not to create a plaiting effect with yarns of different twist direction. If the yarns plait randomly, then the light reflectance will be different for the "S" and "Z" twist yarns depending on which one is on the surface.

Plying of the "Z & Z" twist MTS yarns offers control of skew if the uptwisting balances the torque of the "Z" yarns with "S" twist in plying. The data shows that a twist level of 12.5 turns per inch on these 2 ends of 40/1 Ne yarns will yield no skew.

EFFECT OF FINISHING TECHNIQUES ON SKEW

The manner in which fabrics are finished has an influence on skew. The 28 cut single jersey (Monarch XLJS) with a 30/1 Ne combed 100% cotton ring spun yarn was jet prepared, dyed, dried and finished. The finishing techniques included either compaction or resin finishing and each included correcting the skew and not correcting the skew during finishing. Table V has data for all conditions.

Resin finishing gives the best control of skew. Finishing the fabrics with the skew already realized gives better results than trying to straighten the goods after either compaction or resin finishing.

TABLE V
EFFECT OF FINISHING TECHNIQUES ON SKEW *

CONDITION	% SKEW, 5 HLTD's	
	WITH CORRECTION	WITHOUT CORRECTION
Greige	---	8.6
Dyed & Compacted	8.1	3.5
Dyed & Resin Finished	6.0	2.0

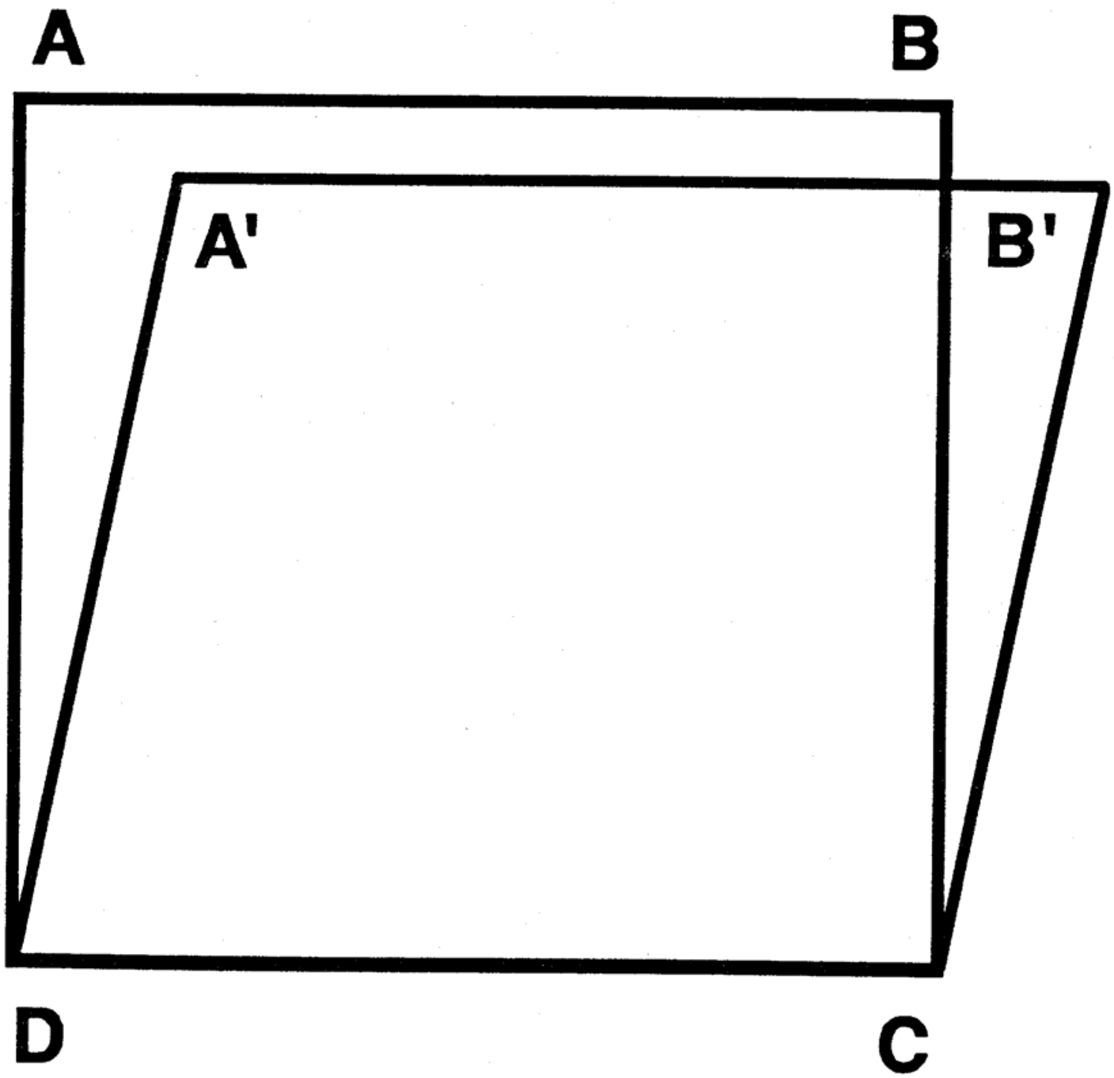
* 28 Cut Single Jersey, 30/1 Ne Combed Ring Spun 100% Cotton, 3.5 TM "Z"

SUMMARY

Skew on 100% cotton single jersey is related to the level of yarn twist, the spinning system used, the strand configuration, the tightness of the knitted stitch, the number of feeders on the knitting machine, the rotational direction of the knitting cylinder and the finishing techniques used. Any process that could be developed to reduce the twist liveliness of yarns could help reduce the total level of skew. Also, development of finishing techniques that could relax the yarns without inducing torque would be of interest. Today, the best answer for skew reduction is either the use of plied yarns or alternating feeds of opposite twist. If singles yarns must be used, then resin finishing offers reasonable control of skew.

APPENDIX A:

AATCC TEST METHOD 179



ABCD = GREIGE GOODS SQUARE, ∠DAB = 90°
A_B_CD = LOCATION OF SQUARE AFTER RELAXATION
∠DA_B_>90

RESEARCH AND TECHNICAL SERVICES

Cotton Incorporated is a research and promotion company representing cotton worldwide. Through research and technical services, our company has the capability to develop, evaluate, and then commercialize the latest technology to benefit cotton.

- Agricultural research leads to improved agronomic practices, pest control, and fiber variants with properties required by the most modern textile processes and consumer preferences. Ginning development provides efficient and effective machines for preservation of fiber characteristics. Cottonseed value is enhanced with biotechnology research to improve nutritional qualities and expand the animal food market.

- Research in fiber quality leads to improved fiber testing methodology and seasonal fiber analyses to bring better value both to growers and then mill customers.

- Computerized fiber management techniques result from in-depth fiber processing research.

- Product Development and Implementation operates programs leading to the commercialization of new finishes and improved energy and water conserving dyeing and finishing systems. New cotton fabrics are engineered -- wovens, circular knits, warp knits, and nonwovens -- that meet today's standards for performance.

- Technology Implementation provides comprehensive and customized professional assistance to the cotton industry and its customers -- textile mills and manufacturers.

- A fiber-to-yarn pilot spinning center allows full exploration of alternative methods of producing yarn for various products from cotton with specific fiber profiles.

- The Company operates its own dyeing and finishing laboratory, knitting laboratory, and a laboratory for physical testing of yarn, fabric, and fiber properties including High Volume Instrument testing capable of measuring micronaire, staple length, strength, uniformity, color, and trash content.

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