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Investigating the Effect of Finishing Processes on Spirality in Single Jersey Weft Knit Fabric

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Abstract

In textile industry, the spirality influences knit fabric's functional and aesthetic performance and clothes made from them show as a displacement of the side seam and arising a significant quality issue of fabric. This industry-based research aims to investigate the effect of various finishing processes while it is treated in the industry and find out the possible solution to control the spirality problem in the industry. The materials used for this study are 100% cotton ring yarn in counts 30 Ne, 32 Ne, 34 Ne, 36 Ne and 40 Ne. Then dyeing, tumble drying, stenter and compacting process have carried out to investigate the effects. It is revealed that finer count yarn shows higher spirality compared to coarser count while other parameters remain constant. Thus, we recommend taking the necessary steps when processing knit fabric with a finer spinning thread. In addition, we have observed that the compacting process provides a significant contribution to controlling the spirality. In this research, the experimental results indicate that the increase in stitch length causes a decrease in spirality while the yarn count is fixed. On the contrary, when stitch length is fixed, the increment of yarn count results in increments of spirality. Some exceptions were also experienced. The finding will help to the producer or buyer to get an idea about suitable stitch length toward the control of knit fabrics spirality in the industry. Thus, this research will help to step up a real problem of textile industry that is control of knit fabrics spirality at a tolerance level.

Keywords— knit fabric, spirality, single jersey, finishing process.

1. Introduction

A plain- knit fabric [1] (single jersey), the simplest of the weft knit structures, is made up of a single length of yarn formed into a repeating pattern or matrix of fabric from yarn by the formation of the intermeshing loop [2]. Some knit goods are specially processed for "permanent" structural and dimensional stability [3]. The establishing processes are inadequate because after washing, loop distortion occurs, resulting in changes in the shape, structure and texture of the knitwear. This is particularly evident in single jersey knit fabrics [4, 5]. Knit fabric dimensional stability is an essential feature in the knitting business [6]. The wale on a knit fabric must be perpendicular to the course, however, weft knit textiles tend to suffer specific dimensional changes that induce distortion, causing the knit loops to bend over, causing the wales to be diagonal instead of perpendicular to the courses [7]. As the wales don't always run parallel to the course, they can skew to the right or left, creating a spiral angle, which can be a severe issue, especially for the apparel industry. There is no longer a right angle between the wales and the courses [8]. A significant part of the textile industry comprises ready-made knit garments, t-shirts, underwear and lingerie [9]. There are several problems with single jersey fabric spirality, but the most important one is that it causes significant problems in clothing manufacturing [10]. Several quality problems are associated with fabric spirality in the t-shirt industry, for example, mismatched patterns, sewing difficulties, side seam displacement and garment distortion. Spirality or distortion in the wale lines not only affects fabric aesthetics but also decreases fabric utilization yield during the cutting process, increasing material costs [11]. With a high number of feeders in a machine that produces widthwise striping, spirality becomes more prominent [12]. Several practical issues are associated with spirality in garment production, including seam displacement, pattern mismatches and sewing difficulties, etc. To overcome this problem, many studies have been carried out. For example, plain knit fabrics' spirality and thickness modeling were reported in a recent study. An analysis of the effect of heat settings on knit fabric production is reported by the Chowdhury et al [13]. Single jersey knit fabrics manufactured from different fibers and fiber blends under the same conditions are compared in terms of fabric spirality and the effect of the fabric spirality on the efficiency of apparel production is evaluated [14]. In another study, the significant influence of three-weft knit structures on numerous parameters such as dimensional stability, fabric breadth, areal density, spirality, pilling resistance and so on has been reported [15]. As based on our knowledge, the effect of dyeing and different finishing effects including stenter compacting etc. with the single jersey weft knit fabric have not been studied yet.

Therefore, the prime goal of this research is to identify the spirality in single jersey knit fabric at different finishing processes and compares them to identify suitable stitches. Additionally, suggest a stitch length that is appropriate for a particular yarn count in order to maximize the textile industry's output. These findings will help the management of textile industries to make decisions about the knit dyeing process.

2. Materials and methods

Materials used for this study are 100% cotton ring yarn with counts 30 Ne, 32 Ne, 34 Ne, 36 Ne, 40 Ne respectively. A four-track single jersey circular knitting machine was used for this purpose. 30 Ne, 32 Ne, 34 Ne, 36 Ne and 40 Ne yarn was interlooped to produce plain single jersey knit fabric. The machine had a positive feeding device and structural diagram of single jersey knit fabric are given in Figure-1.

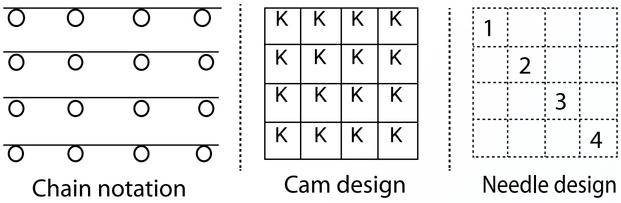

Figure 1. Structural diagram of single jersey knit fabric

All the samples are pre-treated in a winch dyeing machine. The details parameters of the pre-treatment process are given below:

2.1 Dyeing process

Dyeing was carried out in Athena 3 dyeing machine having a capacity of 1000 kg. The knit sample fabrics were dyed in light shade with reactive dye. Recipe of the dyeing is mentioned in Table 1. A single bath dyeing is used where caustic soda responsible for scouring, hydrogen per oxide for bleaching. In addition, dyes, stabilizer, fixing agents and other auxiliaries have used to carry out whole dyeing process.

Table1. Recipe of the dyeing process

Dye and reagents	Amount
Jintergeks 90	1 gm/l
Jinsofter CBA	1 gm/l
Jintex 2UD	0.5 gm/l
Caustic soda	2 gm/l
Hydrogen peroxide	2 gm/l
Stabilizer (Kappazon h53-250)	0.4 gm/l
Neutro acid	0.8 gm/l
Fixing Agent (OEM)	0.5 gm/l
Glucuronoxylomannan polysaccharide (GXM)	0.5 gm/l

2.2 Finishing process

The final steps included dryer, slitter and dewater on the Bianco machine. It was compacted at Ferraro compacting machine. Process flow for producing finished knit fabric is given in Drying. To measure the spirality of dyeing fabric, we used the Tumble dryer which is used to take away moisture from a load of fabric. Drying is done after de-watering of fabric.

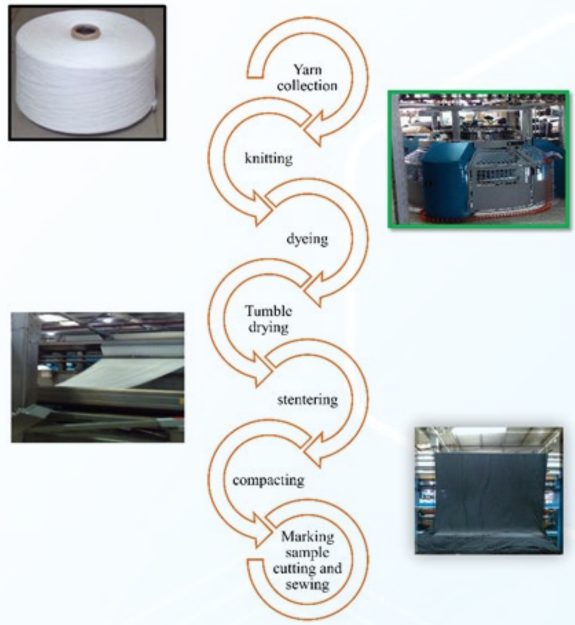

Figure 2: Process flow for producing finished knit fabric Tumble

2.3 Stenter machine

Santaframe Stenter machine, origin- Italy is used to perform this finishing process. As mentioned, parameters in the Table 2, stenter machine is used to bring length and width together in order to predetermine dimensions as well fell impact on the improvement of spirality. With an over-feed system using variable frequency drives with AC geared motors, the fabric can be controlled to over-feed anywhere from -10% to +50% by adjusting the motor speed.

Table 2: Parameters used in the stenter machine

Parameters	Values
Temperature	150^0C
Over feed	50%
Speed	20 m/min.
Set Diameter	190 cm
Roller Pressure	3 bars
Squeezing roller pressure	4 Lay

2.4 Compactor machine

The compacting machine named Ferraro, origin Italy is a knit fabric shrinkage control machine, which can compact the fabric in the lengthwise direction, to provide overfeed to the fabric while processing in presence of steam and able to control the shrinkage. The parameters are mentioned in the Table 3.

Table 3. Parameters used in the compactor

Parameters	Values
Compaction%	3%
Diameter setting	190
Over feed	50%
Speed	20 m/min
Upper felt tension adjust	4.75 bar
Lower felt tension adjust	4 bars
Temperature	120-150^{0}C

2.5 Spirality determination

Firstly, samples were collected after dyeing, stenter and compacting for measuring spirality. The collected folded fabric is marked using a template in each direction, a minimum of 50 cm^2 and 50cm apart from all edges of the test specimen & sewing by overclock machine. It is considered that the sample should be preconditioned in a standard textile testing atmosphere.The principle of this test is the specimens are cut, prepared, marked and laundered according to specified procedures. Spirality is measured in percentage of a marked distance. The following apparatuses are used automatic washing machine, as described in ISO 6330, the type agreed upon between parties, automatic drying machine, as described in ISO 6330 and agreed upon between parties, calibrated ruler, at least 500 mm in length with 1 mm graduated marks, conditioning rack, sewing machine, marking template, of dimensions (350 X 350) mm, methodology for single jersey without Lycra.

3. Results and discussion

The purpose of this study was to assess how yarn count and stitch length affected the spirality of single jersey cotton knit fabric. The effects of yarn count and stitch length were examined and contrasted individually. The same process was used for all experiments to create the fabric, dye it and finish it. Following drying, stenter and compacting, the side seam displacement values for each sample were calculated and reported as a percentage. All measurements were made at conventional textile testing temperatures of 20.80°C and 20°C and relative humidity levels of 62.5% ± 2%. When calculating the proportion of spirality, samples were not under tension. In the gray fabric the tested spirality obtained 16-20% for the count 30 Ne to 40 Ne. The effect of different finishing process on the spirality have addressed in the rest part of this paper.

3.1 Effect of finishing techniques on the spirality% for stitch length 2.65 mm

In Figure 3, the horizontal axis indicates the different finishing techniques like drying (D), stentering (S), compacting (C) for the stitch length 2.65 mm. Vertical axis of this graph represents the spirality percentages. The effect test has been conducted for various counts including 30 Ne, 32 Ne, 34 Ne, 36 Ne and 40 Ne. The Figure 3 shows that the 30 Ne counts spirality percentage is the lowest throughout the finishing process whereas count 40 Ne shows the lowest amount of spirality percentage after treatment at dryer, stenter and compactor. For the count 34 Ne, it starts just above the 6% then drastically declined and finally reached around 3.5%. The overall, it is observed the downward trends for the whole curve in the Figure 3.

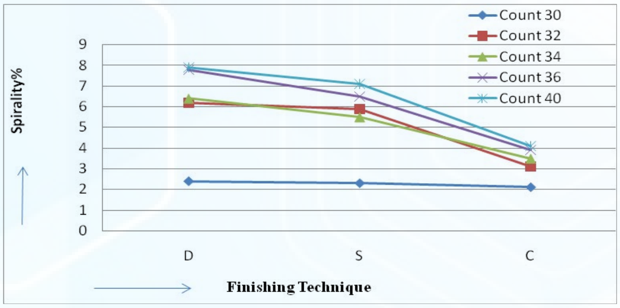

Figure 3: Effect of dryer, stenter compacting on spirality% for stitch length 2.65 mm

3.2 Effect of finishing techniques on the spirality% for stitch length 2.72 mm

As shown the Figure 4, for the stitch lengths of 2.72 mm, the horizontal axis indicates different finishing techniques such as dryer, stenter and compacting. This graph shows spirality percentages along the vertical axis. We conducted the effect test for several counts, including 30 Ne, 32 Ne, 34 Ne, 36 Ne and 40 Ne. Count 30 Ne shows the lowest spirality percentage throughout the finishing process, while count 40 Ne shows the highest spirality percentage after being treated by the dryer, stenter and compactor. It starts just below 8%, then drops dramatically and finally reaches around 4% for the count 34 Ne. Overall, the whole curve shows downward trends.

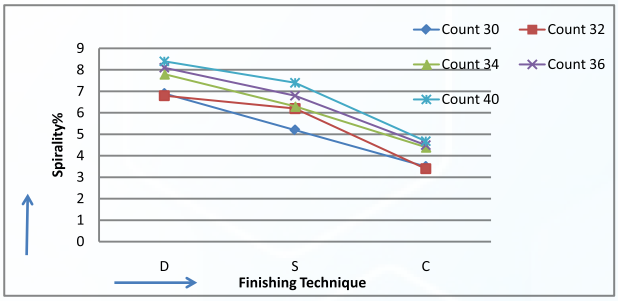

Figure 4: Effect of dryer, stenter and compacting on spirality% for stitch length 2.72 mm

3.3 Effect of finishing technique on spirality% for stitch length 2.75 mm

As shown in Figure 5, the role of the different finishing processes on the spirality have illustrated by considering the various count for stitch length 2.75 mm. It is shown similar trends to the previous graphs, that is 40 Ne count yarn shows the maximum spirality that starts at just below 9% and ends just below 5% over the processes. On the other hand, 30 Ne shows the lowest spiritly which begins at just above 7% and ends at around 5% in the curve. Spirality shows the downward from dryer to compacting.

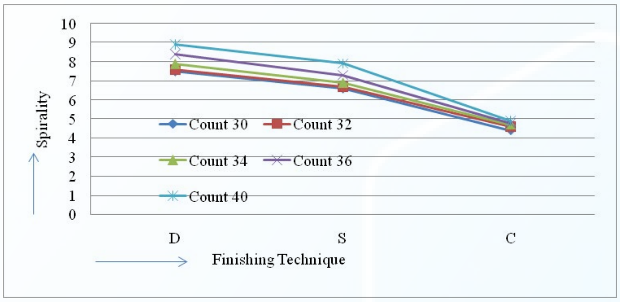

Figure 5: Effect of dryer, stenter, compacting on spirality% for stitch length 2.75 mm

3.4 Spirality after dryer

The spirality of the samples produced from three different stitch lengths (2.65 mm, 2.72 mm & 2.75 mm) for various counts (30s, 32s, 34s, 36s & 40s) was measured after the dryer. The results are listed in the Table 4.

Table 4: Spirality % for various stitch lengths and yarn count after the dryer

Spirality% after dryer					
Stitch length	Count 30	Count 32	Count 34	Count 36	Count 40
2.65	2.4	6.2	6.4	7.8	7.9
2.72	6.9	5.8	7.8	8.1	8.4
2.75	7.5	8.5	7.9	8.4	8.9

3.5 Spirality after stenter

In Table 5, the spirality % of the samples produced from three different stitch length (2.65 mm, 2.72 mm & 2.75 mm) for various count (30s, 32s, 34s, 36s, & 40s) were measured after stenter and the results are presented.

Table 5: Spirality % for various stitch length and yarn count after stenter

Spirality% after dryer					
Stitch length	Count 30	Count 32	Count 34	Count 36	Count 40
2.65	4.7	5.9	5.5	6.5	7.1
2.72	5.2	6.2	6.3	6.8	7.4
2.75	6.6	6.7	4.92	7.3	13.9

3.6 Spirality after compacting

The spirality % of the samples produced from three different stitch length (2.65 mm, 2.72 mm & 2.75 mm) for various count (30s, 32s, 34s, 36s & 40s) were measured after compacting. The results are listed in the Table 6.

Table 6: Spirality % for various stitch length and yarn count after compacting

Spirality% after dryer					
Stitch length	Count 30	Count 32	Count 34	Count 36	Count 40
2.65	2.2	3.1	3.5	3.9	4.1
2.72	3.5	3.4	4.4	4.5	4.68
2.75	4.4	4.7	4.8	4.75	4.9

Table 4 to 6 show that spirality increases with increasing the stitch length for each count and at the same time spirality increases with increasing the yarn count. But in Table 5 which is shown at yarn count 32s, unexpected spirality results because may be high-speed running of the dyeing and dryer machine and also dryer temperature was not properly maintained. In Table 6 which is shown at the count 34s, exceptional results to others. To maintain GSM, we have to feed the fabric in stenter with the underfeeding system.

4. Conclusion

The spiral formation in single knit fabrics is particularly problematic due to their asymmetrical loop formation. This can occur during the greying, washing and finishing processes. It depends on yarn count, machine parameters and fabric structure. Thus, sustainable process is needed to control the real problem of the industry. The spirality % of the samples produced from three different stitch length (2.65 mm, 2.72 mm & 2.75 mm) for various count (30s, 32s, 34s, 36s & 40s) were measured after drying, compacting and stentering process. The spirality of finer count yarn is higher than that of coarser count yarn, while other parameters remain the same. Thus, we recommend taking the necessary steps when processing knit fabric with a finer count yarn. Due to the positive impact of compacting process, it is highly recommended to use the stenter and compacting machine in the process of weft knit fabrics in dyeing mills. Also, spirality has increased with the increasing the stitch length. So, management has to be more conscious while processing knit fabric with high stitch length. Future studies can be carried out by considering the pretreatment process on the effect of spirality on knit fabrics.

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