EFFECT OF TWIST ON TENSILE STRENGTH OF SINGLE AND RIB KNIT FABRICS

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Abstract
This study investigates the effect of twist on tensile strength of single and rib knit fabrics. The experimental study involved the production of single and rib knit fabrics using yarns with varying twist levels. The fabrics were manufactured under controlled conditions to ensure consistency. The developed fabrics were evaluated for their tensile strength following standardized test procedure. The results indicated that the twist had a significant influence on the tensile strength of both single and rib knit fabrics. Out of which rib knit was more compact compared with single knit due to its structural stability. The findings suggest that higher twist levels enhance the ability of yarns to interlock and improves the resistance against breakage. The research contributes to the knowledge of fabric engineering and provides recommendations for manufacturing knitted materials with enhanced strength characteristics.

Keywords: Twist; Tensile Strength; Rib knit; Single knit; Knitting

1. INTRODUCTION

Twist plays an important role in determining the strength of fibers. It usually aims at holding the constituent fibers with each other. As the number of twists increases in a specific yarn, the force holding these constituent fibers together is also increased, thus making a strong and durable fiber. When a point reaches, where a maximum strength has been achieved in a yarn, further twisting is not required because then it breaks a yarn [1].

Yarn properties greatly affect the properties of an end product. Yarn twist and count govern the performance of knitted and woven fabrics. Twist in yarn is defined as the spiral turns given to the yarn either in clockwise or anti clockwise direction in order to hold the constituent yarns with each other [2]. There is a strong relationship between twist liveliness and spirality. The greater the liveliness, the more spirality exists in the yarn. The degree of movement of yarn from one place to another place also contributes to the spirality factor in twist [3]. Spirality has a direct relationship with the twist in a yarn. As the twist increases, the spirality also increases and vice versa. Basically the degree of freedom in the movement of yarn causes the spirality to rise.

Knitted fabrics can be made by twisting either staple or continuous filament yarns. The type of yarn is important to consider as it produces different properties to the end product. Mechanical and physical characteristics provide a framework to establish comfort behavior of textile materials. Amongst these characteristics, strength is one of the most important parameters in determining an overall performance of knitted fabrics [4]. These fabrics are considered better than woven fabrics in terms of providing excellent extensibility, heat maintenance, air and vapour permeability. Newly manufactured samples by using core-spun yarns provide greater extensibility and durability.

Knitting is done by interlocking of either natural or synthetic yarns. The nature of polymer affects various properties of the end product. Mechanical characteristics such as bending rigidity, flexibility, elongation, stretch-ability, ease, dimensional stability, appearance, and comfort can produce multiple knitted products. Tensile, abrasive and tear strength of materials is essential to consider while evaluating overall behavior of fabrics [5,6].

Deformation in knitting occurs in both directions such as course and wale. Various factors can affect this deformation of knitted structures for example nature of fiber, knitting procedure, knit type and finishing treatment applied over the surface of developed fabrics [7,8].

Many research have explored issues such as the effect of stitch length, fiber and yarn content, type of twist, application of treatments on mechanical and chemical properties etc. twisting mechanism has called a greater attention of the researcher towards its varied effects on the yarns and fabrics. Limited research was conducted to study the effect of twist per inch on knitted fabrics made with various yarn counts and twist per inch.

2. RESEARCH METHODOLOGY

Cotton fibers were taken to produce the knitted fabrics. Firstly, the fibers were drawn and elongated to form a thin continuous strand. It was then fed into the spinning machine, where it undergoes certain rollers and many drafting zones. These rollers rotated at different speeds and levels, making the fibers to twist and turn around each other in a specific direction. The rollers were adjusted according to the amount of twisted inserted in a yarn. Single knit and rib knit fabrics were manufactured at the speed of 30 rpm with loop length set at 2.75 mm. For single knit fabrics, the yarn was casted onto the knitting machine, where the needle was moved in a single direction with a series of plain stitches. For rib knit fabrics, alternate knit and purl stitches were used that helped to create raised vertical ribs in a structure. An adequate tension was given to ensure regular and consistent stitching formation in both types of knitted fabrics. The process was continued row by row till its formation.

The prepared fabrics were scoured and bleached to remove any impurities and give them a finished look. Three yarn counts (Ne) 20, 26 and 32 were used for both types of knits. (Table 1)

Table 1. Construction specification of prepared fabric

Fabric type	Sample code	Yarn count (Ne)	Mass (Gsm)	Tpi
Single knit	S-1	2o	110	15.21
	S-2	26	125	14.31
	S-3	32	146	13.91
Rib knit	R-1	2o	117	19.21
	R-2	26	125	17.31
	R-3	32	130	15.91

All the specimens were tested in a testing environment with 21°C temperature and 65% relative humidity. The specimens were conditioned for 24 hours prior to testing following ASTM D-1776 [9]. Strip method ISO-13934-1 test method was used to determine the tensile strength of knitted fabrics [10]. The test specimen was stretched to its breaking point in accordance with the given specifications. Rectangular strips with a dimension of 250x50 mm were taken from each fabric. The specimens were vertically clamped in a tensile tester and strong gripping of ends was ensured. The grip faces were parallel to each other. The specimen was aligned accurately and was ensured to be free from any wrinkles, creases, or folds. The tester was started, and force was gradually applied at a specific rate. The specimen was stretched till the point of rupture. An electronic device noted the maximum force required to break the specimen for all tested fabrics.

3. RESULTS AND DISCUSSION

The spiral configuration of fibres in a specific yarn, is produced during the spinning process, known as twist. The stability of the resulting knitted fabric can be considerably influenced by the degree of twist in a yarn. A manufacturer should know exactly how much twist is needed to insert in a yarn and for which purpose. There are multiple factors that dictate the amount of twist for example thickness of the yarn, yarn count, construction technique, nature of polymer and most importantly type of end product etc [11].

Twist in yarn and compactness of finished fabric are essential factors that contribute to the spirality of knitted fabrics made with single knit [11]. An increase in twist causes an increase in twist liveliness thus producing higher ratio of spirality in single and rib knit

materials [2]. Stronger fabrics are associated with high twist levels. The main reason is the twist's capacity to lock the adjacent fibers together making them durable. It causes the cohesion of yarns which minimizes the risk of yarn slippage and breakage. It adds improvement in overall stability and strength of finished product.

It is clearly observed from Table 2 that the rib knit has greater strength compared to single knit fabrics. The prominent vertical lines in the form of ribs create alternating columns of knit and purl stitches, the most common types. The rib knit fabrics are characterized by an intricate pattern and interlocking construction caused by these ribs. Rib knit materials are less prone to fraying or tear because these ribs serve as a shield against abrasion and wear conditions. They are appropriate for many applications that require strong and long-lasting materials because of their resilience, pliability, and flexibility. Rib knit fabrics offer improved insulating characteristics as the vertical ribs create air pockets.

Table 2: Tensile strength of prepared fabric

Fabric type	Sample code	Tensile strength (N) Mean	SD
Single knit	S-1	400.12	0.78
	S-2	330.26	0.54
	S-3	253.98	0.36
Rib knit	R-1	450.23	0.82
	R-2	350.23	0.56
	R-3	300.12	0.34

Results of another study concluded that tensile strength and elongation of single jersey, rib knit, and purl knit varied due to the variation in their fiber content with which the specific yarns were manufactured [12]. Mechanical and physical properties of fibers, blend content and ration also key reasons of variations in the strength of knitted materials [13]. Tensile strength and elongation at break are inversely proportional to each other. It was found that single jersey and rib knit with 1 x 1 structure made of cotton and cotton / Lycra blend yarns produced different results for their tensile strength [8]. The results are similar with the current study. Compared to single knit textiles, which have a simpler plain stitch structure, rib knit fabrics have a more intricate and interlocking construction due to this structure. It also helps to induce strength and structural stability throughout the fabric structure. A cohesive substrate is formed by these interlocking stitches. This interlocking reduces stretching and deformation of yarns. Because of the fabric's raised ribs, which give it greater flexibility and recovery, it may be stretched or deformed without losing its original shape. The performance behaviour of knit fabrics can change depending on such factors like fiber nature, yarn properties, density of stitches used, and finishing treatment applied over the surface of fabrics. Manufacturers can further enhance the function of knitted materials to fulfill certain performance needs by altering these variables.

It was studied in research [14]. that when there was an increase in twist per meter, the resultant yarns became more denser in their structure and induced more strength into the finished fabric. It was seen in both lengthwise and widthwise direction of fabrics. It was also due to the reason that an increase in twist level helped to increase the tensile linear density of the yarns [15]. If we knit a fabric with high twisted yarn, a torsional strain is released in relaxation state thus producing high spirality angle in finished fabric [2]. Whereas single knit fabrics are produced by a simple structure of plain stitches, formed by interloping of yarns in a single direction. As a result, compared to rib knit materials, the fabric architecture is substantially more open and less entangled. They may have a lower stability compared to rib knit fabrics as these single knits do not contain reinforced rib structure. The finished fabric thus may have fewer connection points and less cohesion among the yarns. It leads to less structural support, stretching and deformation. The finished fabric is more receptive to distortion in this case.

It was explored that the tensile strength of yarns manufactured with 1 x 1 rib knit structure was less as compared to those made with plain knit yarns. But the elongation % was higher than plain knit structure. One possible reason is due to the geometric deformation of yarn structure due to varied knitting actions [16]. This deformation also reduces the tensile modulus due to reknitting of yarns after deknitting, as the yarns are in crimped form and result in reduced strength [17, 18]. Due to their interlocking and reinforced structure, rib knit fabrics often great strength than single knit materials in this research. The strength of knitted materials is also influenced by yarn count in addition to twist and knit structure. The thickness or fineness of the yarn is referred to as yarn count, which is typically stated as the quantity of units (such as grammes or tex) per length (such as metres or kilometres). Generally speaking, fabrics created from finer yarns with higher yarn counts tend to be lighter and less bulky, albeit they might not be as strong as those made from coarser yarns with lower counts [19]. The strength of knitted materials cannot, however, be determined solely by yarn count because other elements such as fibre characteristics, twist degree, and knit structure also play a significant effect [20, 21].

4. CONCLUSION

The study concludes that the twist in a material significantly influences the tensile strength of a single and rib knit construction. Regardless of twist amount, rib knit fabrics have stronger tensile strength than single knit fabrics because of their interlocking structure. To fully comprehend and optimise fabric strength, additional elements such as yarn count, fibre type, and knitting techniques might be explored in future research. Overall, this research advances the field of textile engineering and makes it easier to create high-performance knit materials.

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