

An overview of sewing threads mechanical properties on seam quality

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This paper provides an overview on the impact of sewing thread on seam quality and its significance on seam serviceability and seam appearance. The findings show that sewing threads properties impart significant influence on the area of seam quality for high consumer satisfaction. The practical implications include consumer satisfaction is based on the significance of sewing thread for seam quality is an important for quality control required by the apparel manufacturers and their customers. This paper provides information on proper sewing thread selection in the manufacturing of apparel.

Keywords: Mechanical properties, sewing thread, seam quality, seam serviceability, seam appearance.

1. Introduction

The apparel industry includes a diversity of fashion products, types, volumes of production and manufacturing environment, therefore, technology applied to apparel sewing increasingly demands versatility and quick response. The management of apparel manufacturers are relatively uncertain in respect of quality and with the advent of advanced technology, the relationship between the raw material properties, sewing performance and seam quality becomes very important.

Fabric and sewing thread is the basic raw material of apparel industry. Characteristic of the raw material influences the seam quality of the garment. The apparel designers are primarily interested in the raw material properties for high seam quality and consumer is mainly interested in appearance, comfort, and wearability of the garment. Proper selection of raw material not only gives comfort to the wearer but also helps in smooth working of manufacturing process and lead to defect free garment [1].

The apparel companies are concerned about properties of fabrics used in apparel manufacturing, because the fabric is the prime raw material in apparel industry. The properties of fabric used in apparel manufacturing can be classified in two groups: primary properties and secondary properties. A primary property is considered as a static physical dimension, whereas a secondary property is the reaction of the fabric when a force is imposed upon it. With the introduction of very high speed sewing machines, automatic line production systems and increasing consumer demands for good quality apparel, excellent fabric for apparel industry may be defined by following properties [2]:

1. Good color, design, and excellent handle.
2. High tailorability.
3. Good wearability and durability.

From the discussion above we can conclude that fabric quality is one of the primary requirements for production of high seam quality in apparel. However, fabric quality alone does not fulfill all the criteria for the production of high quality garment. The conversion of a two dimensional fabric into a three dimensional garment involves many other interactions, such as selection of suitable sewing thread, optimization of sewing parameters, ease of conversion of fabric into garment and actual performance of the sewn fabric during wear of garment.[3] Sewing thread is also a prime contributory factor for satisfactory seam quality. Correct selection of sewing thread requires consideration of its properties in the completed garment under conditions of wear and cleaning.[4] Thus the sewability and seam quality of sewing thread is largely influenced by three factors.[3]

- (i) The material to be sewn.
- (ii) The sewing technique.
- (iii) The end use or the application of the sewn material.

Good seams are essential factor in garment quality. Defective seams may spoil the appearance of a garment and be the cause of

ultimate failure and rejection. The quality of the seam depends on its strength, elasticity, durability, stability and appearance [5, 6]. These characteristics can be divided in two groups : seam serviceability and seam appearance. The quality of sewing threads, as defined by their mechanical and physical properties, is connected with seam quality. Seam quality depends mainly on the following sewing thread properties: tensile, bending properties, dimensional stability, and friction on used fibres [7].

2. Sewing threads mechanical properties and relation with seam quality

A large variety of sewing threads is used in clothing industry. The majority of the sewing threads used by the clothing industry are made from cotton and polyester fibre[8]. Threads made from natural fibres such as linen and silk and certain manmade fibres, for example nylon, acrylic and viscose are also used in clothing industry [9]. These sewing threads are made from spun, continuous filament or core spun yarns. Each type of sewing thread have distinct properties, which are prime contributory factor for seam quality. In a high speed sewing machine thread is subjected to complex kinematic and dynamic conditions. In such conditions the thread is subjected to friction, tensile, bending, compressive, shear and surface stresses [10]. Among these stresses acting on the thread, friction and bending are the important ones for seam quality [11]. Such severe sewing conditions may reduce the initial strength of sewing thread by as much as 60%, in turn, reduces the serviceability of the seam[12].

The reduction in sewing threads strength which is a function of the dynamic strain exerted on the thread is mainly caused by sewing thread properties. Thus the studies of the sewing thread properties are vital for improving seam appearance and seam serviceability.

2.1 Tensile properties

If an external force is applied to a material, it is balanced by internal forces developed in the molecular structure of the material. In high speed sewing machines the external force applied on the needle thread is as high as 200gf. [13]

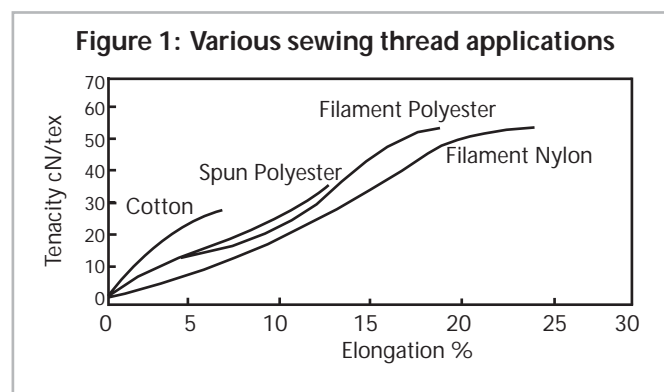


Table 1: Comparison of fibre tenacity, breaking extension, work of rupture and initial modulus

Fibre Material	Tenacity (N/tex)	Breaking extension (%)	Work of rupture (mN/tex)	Initial modulus (N/tex)
Cotton	0.45	6.8	14.9	7.3
Polyester	0.47	15	53	10.6
Nylon	0.47	26	76	2.6

In order to withstand this force during sewing, a thread must possess adequate strength and elongation. Since the different materials have different molecular structures, their behavior in response to this force will be different. (Fig. 1). Some examples of different fibre tenacity levels are also given in table 1. [14, 15]

The straight strength and elongation of sewing thread must be adequate for good sewing performance as well as good seam strength [1]. In case of commercial threads, it is observed that a lower limit of breaking load of 800cN is suitable for most of the common application of sewing thread.

The elongation of a thread determines the effectiveness of the tensile force acting on the thread. Highly extensible thread is generally required only for extensible knitwear garments [10]. It is also necessary to measure loop strength and loop elongation of sewing thread because these properties are very important to the seam quality.

The loop strength of a thread contributes directly to the stitch strength and hence to the seam strength. Loop elongation is an indication of the degree to which a seam, under stress, can be stretched without a thread breaking [3, 4].

From the quality point of view, the initial modulus is one of the important properties in case of sewing thread. A high initial modulus is always essential to prevent slip stitching and seam puckering. However initial modulus in tenacity elongation curve is the not only measure of sewing seam quality [16].

A moderate to high level of toughness (area under the tenacity elongation curve) helps in improving amount of damage during sewing hence seam quality [17, 18]. Thus for proper seam quality adequate yarn strength, tenacity – elongation characteristics and recovery behavior are important for proper performance of a sewing thread.

2.2. Frictional properties

The frictional forces are developed in the sewing thread are mostly due to the friction between the fabrics and machine parts. The most severe occurred in two places,

- the thread and the needle.
- the thread and the fabric is being sewn. [9]

In friction generally following components can act:

- ❖ **Static friction:** This is the force necessary to initiate motion from the rest.
- ❖ **Kinetic friction:** This is independent of the magnitude of the velocity [7]. The kinetic friction is usually less than the static friction. (Table 2) [18]

Table 2: Comparison of fibers kinetic and static friction

Material	Static	Kinetic
Rayon on rayon	0.35	0.26
Nylon on nylon	0.47	0.40
Wool on rayon	0.11	0.09
Rayon on rayon	0.22	0.14

Although fibers do not have a true, constant coefficient of friction, it is useful to quote values of $\mu = F/N$ to express the magnitude of the friction under particular conditions. The coefficient of friction varies with experimental condition, specially on the exact state of the surface. Some examples are given in table 3 and 4 [19, 20].

Table 3: Comparison of coefficient of friction between fibres

Yarn Material (friction between fibres)	Friction
Nylon	0.47
Silk	0.52
Cotton	0.22
Polyester	0.58

Table 4: Comparison of coefficient of friction between fibres and different guides

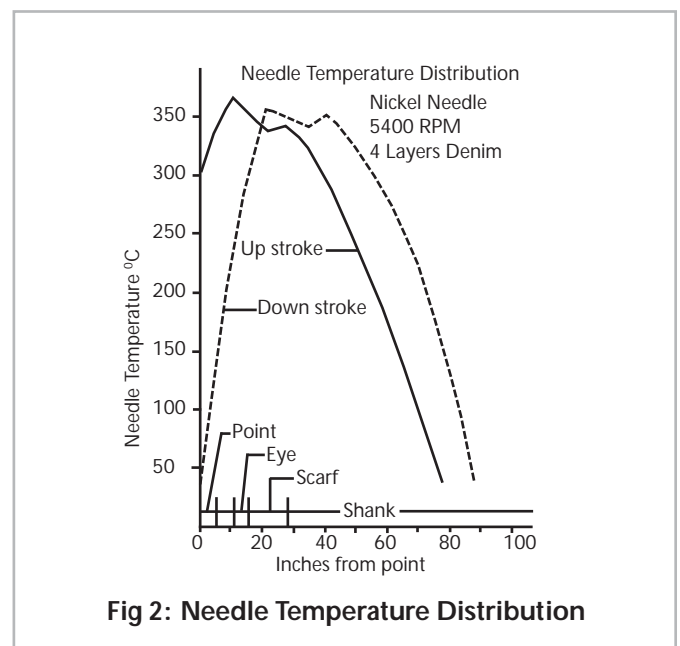
Yarn material	Hard steel	Porcelain	Ceramic
Viscose	0.39	0.43	0.30
Cotton	0.29	0.32	0.24
Nylon	0.32	0.43	0.19

In high speed sewing machine the needle threads rubs against the needle or thread eyelet placed at several points in the machine. However, the coefficient of friction between a needle-thread and a stainless steel or other guide should be less than 0.2 [8]. Thus all the synthetic fibre needle threads requires a lubricant finish to reduce this friction to an acceptably low level [21].

From the quality point of view a moderate to high level of static friction values is necessary between the fibres to allow the stitches to lock [22] and prevent 'run back' of the seam. Spun threads are particularly good in this respect, when compared with the continuous filament threads. The worst offenders are thread made from mono filament [10]. It is important to note that friction must not be too high, which causes the thread breakage, and not too low, which causes loss of thread control. Although coarse and medium fine yarns showed a more hairy appearance, resulting in poor seam appearance [23] after friction. In contrast to fine yarn fibre damage [24] is not discernible and provides good seam appearance.

2.3. Dimensional stability

Ability of a sewing thread to retain its original condition when subjected to varying degrees of temperature, moisture, or other stress is called dimensional stability. Heat is generated during the

**Fig 2: Needle Temperature Distribution**

sewing process as a result of friction between fabric and needle^[25]. The extent of heat generation depends on the machine speed, the size, shape, and surface finish of the needle, the density, thickness, and finish of the fabric, and the type, size, and finish of the sewing thread^[26, 27, 28]. The most severe heat generation that takes place in two regions, (i) the portion of the yarn that is pushed through the fabric, (ii) the part of the emerging loop that is wedged between the needle and the fabric^[29]. A typical graph of needle temperature is shown in fig 2^[10]

Research shows that needle temperature can rise upto 350°C and thread should be

Table 5: Comparison of melting point of different fibre

Material	Melting point
Nylon 6	215°C
Nylon 66	260°C
Polyester	260°C
Polyethylene	120°C

protected to ensure that it passes through the sewing machine and into the seam as smoothly as possible^[30]. Typical values of fibre melting point are shown in table 5^[9]

However, a sewing thread made from silk and cotton can be operated effectively at needle temperature of upto 400°C. Core spun synthetic fibre cotton threads are found to have a thermal stability only 25°C to 30°C higher^[10]. Although synthetic fibre, staple fibre sewing thread and core spun thread exhibit a higher melting resistance at high sewing speeds than continuous filament threads owing to the existence of higher temperature gradient in the yarn cross section.

Table 6: Comparison of swelling of fibres

Sewing thread material	Transverse swelling (%) [Dia.]	Axial Swelling (%)
Cotton	20	0.1
Viscose	25	3.7
Silk	16.5	1.6
Nylon	1.9	2.7

After the manufacturing all the garments should be subjected to washing. When a sewing thread absorbs water, they change in dimension and swelling occurred in transversely and axially. The amounts of swelling depend on the raw material of sewing thread. All the moisture absorbing fibres show a large transverse swelling, but in some cased axial swelling is very small, so that the swelling anisotropy is very high. A typical value of fibre swelling in water are shown in the table 6.^[31]

Research showed that swelling is generally less in synthetic fibre. Thus, a sewing thread made from nylon or polyester exhibit higher dimensional stability during wetting. Sewing thread made from natural fibres have high transverse swelling as a result of less dimensional stability.^[4]

From the quality point of view both dry and wet dimensional stability are important for seam quality. Heat often causes of burn marks on natural fibres such as cotton or wool, and it causes synthetic fibre to soften or melt, leaving a weakened seam or a melted residue on the fabric surface. Sewing thread may also break due to this and may damage the surface of the fabric^[10]. In wet condition cotton sewing thread increases in diameter^[32] and shrink in length is the cause of seam puckering^[33] in sensitive fabric and ultimately affect the seam appearance of fabric^[34, 35].

2.4. Bending properties

The flexural rigidity of a yarn is defined as the couple required to bend the yarn to unit curvature. The flexibility of a fibre depends on its shape, its modulus, its density and fibre is the basic raw material in yarn manufacturing^[19]. The most severe bending takes place when (i) the needle thread is bent at the needle hole and (ii) at the thread eyelets^[13].

Research shows that bending property has severe effect on seam quality. Thus all the thread must be flexible to ensure it passes through the sewing machine and imparted into the seam as

Table 7: Comparison of Flexural rigidity & bending modulus of different fibre

Sewing Thread Material	Flexural rigidity (mN mm ² /tex ²)	Bending modulus (kN/mm ²)
Nylon	0.15-0.22	2.5-3.6
Polyester	0.30	7.7
Viscose	0.35	10

smoothly as possible. Typical values of fibre flexural rigidity and bending modulus are shown in table 7.^[19]

However, due to flexibility, the sewing thread made from spun yarns has good sewing performance, good dimensional stability, and good stitch locking properties. The continuous filament core of core spun yarn also have excellent loop forming characteristics for the high flexibility.

From the quality point of view pucker is wrinkle appearance along a seam in an otherwise smooth fabric. In many cases a seam possessing good mechanical properties will be unacceptable because of its appearance. There are many factors for seam appearance, such as fabric, sewing thread and machineries. High bending rigidity is one of the reasons for seam puckering which lead to poor seam appearance^[13]. In 1994, Mori shows that soft thread whose bending rigidity is low is the causes of low seam puckering.

3. Results and discussions

The problems which arise in case of sewing material are most conveniently divided into (i) problems of stitch formation which give rise to poor seam appearance and performance. (ii) problems of fabric distortion known as 'pucker' which also give rise to poor seam appearance. However, fabric quality alone does not fulfill all the criteria for production of high quality garment. The quality characteristics can be measured by seam parameters such as seam strength, seam slippage, seam pucker, seam appearance, and seam damage^[5]. Each of these parameters is influenced by various raw materials including sewing thread.

Sewing thread mechanical properties, such as tensile, friction, dimensional stability and bending have a relation between them and seam quality characteristics. Among these mechanical properties, the main requirement for sewing threads includes high strength, high modulus, uniform frictional properties, and resistance to abrasion. The strength and modulus of different type of sewing thread are different. Cotton sewing thread exhibits a higher initial modulus but lower strength, whereas polyester thread has lower initial modulus but higher strength. Different Sewing thread of high strength results in high seam strength and good seam serviceability.

High modulus values are closely related to the high stiffness value and the prevention of seam puckering. A control of both the static and kinetic frictional properties of sewing thread is also another requirement for good seam quality. The friction of sewing thread is different under different condition. Cotton sewing thread exhibits a lower friction than synthetic sewing thread.

A moderate to high level of static friction is essential for proper locking of the stitch especially in lockstitch. Seam quality is also depends on the dry and wet dimensional stability of the sewing thread. The dimensional stability of different types of sewing thread are different under different conditions.

Cotton sewing thread exhibits a higher dry dimensional stability where as synthetic sewing thread has higher wet dimensional

stability. High wet and dry dimensional stability are essential for the better seam quality. Sewing thread with high bending rigidity is also unacceptable for sewing industry.

4. Conclusion

Knowledge of the relation between sewing thread mechanical properties and seam quality is essential for apparel manufacturer for prediction of sewing thread mechanical properties, as related to the required properties of high seam quality. By defining the relation between seam qualities and sewing thread mechanical properties, apparel manufacturer can make decision about the optimal sewing thread selection in apparel manufacturing.

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