Effect of Thread Type and Tension Control on Cotton Fabric Sewability

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Abstract:
Thread plays an important role in the apparel manufacturing process. When the thread is stronger than the material that it is being used to join and if seams are placed under stress the material may tear before the thread breaks. Garments are usually sewn with threads of lesser strength than the fabric so that if stressed the seam will break before the garment.
Tension control is also a very important element that is used to adjust how loose or tight sewing stitches are. Top thread and bobbin thread should be meeting between the two layers of fabric. If the top thread is not going into the fabric, the tension should be loosen; and vice versa, if the bobbin thread is not going into the fabric the tension should be tighten. Thread runs between various tension disks, and the amount of tension which is set by the regulator will determine how much pressure these disks put on the thread. In this study five different tensions are applied on four types of thread by using super imposed seam. These seams examined for thickness, stiffness, seam appearance, seam pucker, tensile strength and extensibility according to standards. Tests took place into conditioned atmosphere of 21ºC and 65% RH. Comparisons have been made among the five different tensions and the four different thread types this was done with reference to seamed lines' durability, efficiency and appearance.
Keywords:
Thread, spun thread, filament thread, tension control, sew ability

1. Introduction
Sewing thread is usually less than 1/1000th of the weight of apparel, but it carries more one half the responsibilities for its performance. (1) Threads are used to form the stitches that hold the fabric parts together. They can be described by fiber type, construction, and size. Threads can be made from a single fiber type such as cotton, linen, silk, rayon, nylon, polyester, or rubber or from a combination of fibers such as cotton/polyester. (2)

1.1. Classification of sewing thread according to fiber type
1.1.1. Natural fiber threads the most common natural fiber used for threads, cotton threads. They have excellent suability with little kinking or skip stitching. They are rarely affected by hot needles a common element of high-speed sewing machines and even sew well on poorly adjusted machines. (1) Cotton threads dye well, and since they mold to the fabric better than other fibers, they are particularly attractive for topstitched elements. Compared to synthetic threads, their strength and resistance to abrasion is inferior, and they shrink and mildew when wet. (3) Cotton threads are produced with three finishes: soft, glace and mercerized. Soft finish threads receive no additional processing except bleaching and dyeing. Used on inexpensive garments, they are relatively inexpensive with good suability but because they have a high shrinkage, seam pucker. This is frequently problem after washing. Glace' threads are treated with wax and special chemicals for a hard, glossy finish. They are stronger, more resistant to abrasion, and stiffer than other cotton threads. They are available in a limited color selection and used for gathering and for sewing heavy materials, leather, vinyl, and canvas. Mercerized threads are treated with a caustic solution to create a smooth, strong, lustrous thread. They are frequently used on cotton garments that will be dyed. (4) Linen and silk threads are rarely used because of their high cost. (3)

1.1.2. Synthetic fiber threads the most common synthetic threads, polyester and nylon, were developed to perform well on synthetic fabrics and withstand the chemicals and heat of durable press treatments. (2) Compared to cotton threads of the same size, they are stronger, more resistant to abrasion, mildew and ultraviolet radiation, and have less shrinkage.

1.1.3. Blended fibers threads One of the most common threads in use today is a combination of cotton and polyester, which combines the sew ability of cotton with polyester's strength and resistance to abrasion. [3]

1.2. Classification of sewing thread according to construction

Although there are a variety of thread constructions, most threads used in garments are twisted, core spun, monofilament, or textured. [2]

1.2.1. Twisted threads All natural fibers, with the exception of silk, begin with fibers - short lengths of staple, which are twisted together to make a single-ply thread. Then two or more plies are twisted together in the reverse direction to make a sewing thread with a balanced twist. Without this balance, the thread could not be controlled. Most threads are finished with a "Z" or left twist because the action of the lockstitch machine would cause threads with an "8" twist to unwind One exception is the double-needle lockstitch, which has two bobbins one revolving to the left and one to the right. This type of machine requires threads with both twists. [5] Spun cotton thread is manufactured with a great degree of care and professionalism. It's the most widely-used natural fiber; highly-versatile cotton is known for its strength and comfort and is used in an amazingly wide variety of textile materials. [6]

In addition to the natural fibers, polyester, silk, and nylon filaments cut or broken into staple lengths. [5] Spun polyester thread is the most common. Sometimes referred to as "PP" or "PP Spun", are made by spinning 100% polyester staple fibers into yarns and then plying these yarns into a sewing thread. They are normally made in two or three ply constructions depending on the yarn size. [6]

1.2.2. Core spun threads begin with a continuous filament of polyester, which is then wrapped with a cotton or polyester sheath to make a single-ply thread. Then the two to four plies are twisted together to make the sewing thread. [7] Cotton/poly threads have the advantage of better sew ability, while poly/ poly threads can be dyed in a one-step process. [8]

1.2.3. Monofilament threads are simply a single filament of nylon or polyester. It is stiff, wiry, and unravels easily. It is uncomfortable next to the skin and harsh on machines. [7] Monofilament threads are translucent and reflect the fabric's color. They are used primarily for blind hemming and surging inexpensive garments and Household textiles. [8]

1.2.4. Textured threads made of multifilament that have been crimp textured or bulked by twisting, crimping and untwisting, textured threads have a soft land, good coverage and elasticity. [7] The most common use of textured threads is in the over edge and cover stitch machines; however, very fine sizes can be used as needle threads on chain stitch and over edge machines. They can also be used as bobbin threads to add moderate stretch to a lock stitched seam. [9]

1.3. Classification of sewing thread according to thread size

The thread size is dependent on many factors- such as the fabric weight and type, stitch and seam type, machine speed, needle size, end use, and seam strength. Most threads are sized using Tex system or the cotton count system. [2]

1.4. Factors in thread selection

- Garment design, type, quality, end use, and life expectancy.
- Desired strength and durability.
- Fabric weight and type.
- Stitch and seam type, number of stitches/inch, machine speed, and needle size.
- Cost. [10]

1.5. Tension control

Control and adjust sewing machine tension empower to sew creatively. Sewing thread in machine must feed through three main points; the tension disks, the take-up, and the needle. The bobbin must also be threaded properly to enable the machine to form a good stitch. Bobbins have their own mechanism for controlling tension on the thread.

Upper and lower tensions must be balanced to produce a perfect stitch. The upper tension varies in location on different machines. It may be on the faceplate, on the front of the needle-bar housing, or on the upper arm of the machine head. It is usually adjusted with a dial. The lower tension, located on the bobbin case, may be adjusted by a screw.

Lower tension should only be adjusted if the problem cannot be fixed by adjusting the upper tension.

As shown in fig.1 a perfect stitch will have threads locked midway between the two layers of cloth, with no loops on the top or bottom of the seam and no puckers in the cloth. If the bobbin thread loops show on the top side of the seam and the top thread is straight, the upper tension is tighter than the lower. If spool thread loops show on the underside of the seam and the lower thread is straight, the upper tension is looser than the lower.

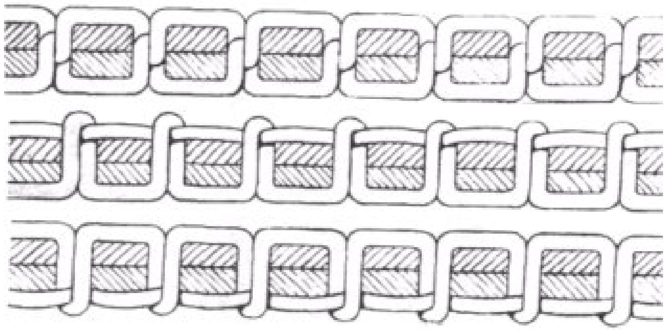

Fig.1. Effect of tension control on sewing stitches. (11)

2. Experimental work

2.1. Fabric specifications

The following table1 illustrates the specifications of the tested fabric

Table 1 Fabric specifications

Fabric type	Fabric structure	Yarn warp/cm	Yarn weft/cm	Mass (gm/m2)	Thickness (mm)
100% cotton	Twill 2/1	38	24	245	0.45

2.1. Sewing thread specifications

This study concerned with spun (cotton & polyester) thread and filament polyester thread. The following table2 illustrates the specifications of the tested sewing thread.

Table 2 Sewing thread specifications

Thread no.	Thread color	Thread type	Thread size
1	Red	Spun polyester thread	Ne 40/2
2	Brown	Spun cotton thread	Ne 40/3
3	Green	Spun polyester thread	Ne 22/3
4	White	Filament polyester thread	Denier150/1

2.3. Sewing specifications

Tested samples are sewed by using Mitsubishi sewing machine model LS2-1150 with speed 220 volt, 2850 cycles per min., and 5000 stitches per min.

Table3 illustrates the sewing specifications.

Table 3 Sewing specifications

Stitch type	Seam type	Stitch density/cm	Stitch length(mm)	Needle number
Lock stitch 301	Superimposed	5	2.5	12

2.4. Thread tension specifications

Five different tension levels are used as shown in table 4. Number of rounds describe how loosen or tight is the thread tension (as the number of rounds decreases thread tension increases and vice versa.)

Table 4 Thread tension specifications

Thread tension 1	Thread tension 2	Thread tension3	Thread tension 4	Thread tension5
2 rounds	5 rounds	7 rounds	9 rounds	11 rounds

2.5. Experimental tests

All tests were done in conditioned atmosphere of 20ºC ± 2 and 65% ± 2 RH. Testing seams included thickness test which was carried out by using Erazier Pregision Instrument, according to (B.S.-2544). [12] Thickness of seams obtained from average of four readings. Stiffness test obtained using Shirley stiffness tester according to ASTM D 1388 [13]. Tensile strength and extensibility obtained using tensile tester according to BS 3320:1988 [14]; average of three readings has been obtained for each property. Seam pucker has been evaluated, according to AATCC 88B-1978 [15] and seam appearance;

average of five readings has been obtained for each property.

3. Results and Discussion

3.1. Effect of thread type at different tension levels on seam properties

3.1.1. Effect of thread type at different tension levels on seam thickness

Table5 illustrates the effect of thread type at different tension levels on seam thickness

Table 5 Effect of thread type at different tension levels on seam thickness

Thread tension level	Seam thickness (mm)			
	Thread 1	Thread 2	Thread 3	Thread 4
1	0.97	1.03	1.14	0.99
2	0.94	1.01	1.11	0.97
3	0.92	0.98	1.07	0.94
4	1.02	1.06	1.21	1.04
5	1.05	1.12	1.27	1.08

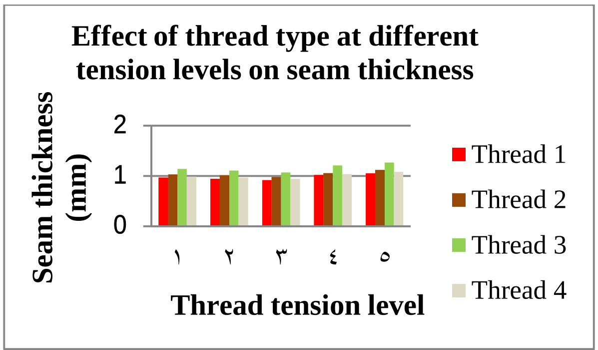

Fig.2. Effect of thread type at different tension levels on seam thickness

- *(As shown in table5, fig.2) it can be noticed that thread1 gives the least seam thickness then thread4 then thread2 while thread3 gives the highest value as seam thickness increases by increasing thread size.*
- *Logically by increasing thread tension seam thickness decreases and vice versa. Duo to the higher tension that tighten the seams. But this didn't happen as follows.*
- *Despite tension level1 is very tight, tension2 is tight, tension3 is middle tension, tension4 is loose and tension5 is very loose, results indicate that, tension3 scored the least seam thickness then tension2 then tension1. This can be attributed to the occurred seam pucker by increasing the tension which increases seam thickness.*
- *Using tension5 and4 make fabric during sewing uncontrolled and gathered bobbin thread behind fabric which leads to more increase in seam thickness.*
- *The thread type regression equation for thread1 is $y= 0.024x + 0.908$, for thread2 is $y= 0.023x + 0.971$, for thread3 is $y= 0.036x + 1.052$ and for thread4 is $y= 0.025x + 0.929$. Where y=seam thickness & x=thread tension level. The thread type correlation coefficient on seam thickness is positive but its significant effect in general is weak, as the correlation is strong when the value of R^2 nearest to 1. For thread1 $R^2 = 0.4881$, for thread2 $R^2 = 0.4648$, for thread3 $R^2 = 0.5063$ and for thread4 $R^2 = 0.4992$.*

3.1.2. Effect of thread type at different tension levels on seam stiffness

Table6 illustrates the effect of thread type at different tension levels on seam stiffness

Table 6 Effect of thread type at different tension levels on seam stiffness

Thread tension level	Seam stiffness (mg.cm)			
	Thread 1	Thread 2	Thread 3	Thread 4
1	215.8	233.7	240.9	216.8
2	211.7	229.6	236.7	212.9
3	204.6	224.9	229.6	207.3
4	216.3	235	241.8	219.3
5	217.8	235.4	242.6	221.5

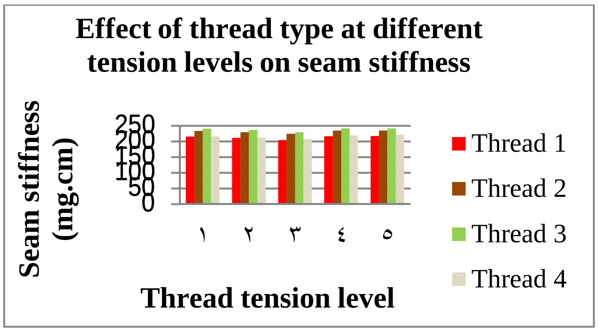

Fig.3. Effect of thread type at different tension levels on seam stiffness

- *(As shown in table6, fig.3) it can be noticed that thread1 gives the least seam stiffness then thread4 then thread2 while thread3 gives the highest value as seam stiffness increases by increasing thread size. (There is direct relation between thread number and seam stiffness).*
- *The fact that seam stiffness decreases by decreasing thread tension and vice versa, happened in case tension level1,2 and3 while tension4 and5 differed as seam stiffness increased by decreasing thread tension. This can be referred to the gathered bobbin thread behind fabric which increased stiffness.*
- *The thread type regression equation for thread1 is y= 0.86x + 210.66, for thread2 is y= 0.88x + 229.08, for thread3 is y= 0.85x + 235.77 and for thread4 is y= 1.58x + 210.82. Where y=seam stiffness & x=thread tension level. The thread type correlation coefficient on seam stiffness is positive but its significant effect in general is too weak, as the correlation is strong when the value of R^2 nearest to 1. For thread1 R^2= 0.065, for thread2 R^2= 0.0977, for thread3 R^2= 0.0624 and for thread4 R^2= 0.198.*

3.1.3. Effect of thread type at different tension levels on seam tensile strength

Table7 illustrates the effect of thread type at different tension levels on seam tensile strength

Table 7 Effect of thread type at different tension levels on seam tensile strength

	Seam tensile strength (kgf/mm^2)			
Thread tension level	Thread 1	Thread 2	Thread 3	Thread 4
1	0.5494	0.4215	0.7308	0.1869
2	0.4432	0.4199	0.6874	0.1349
3	0.4306	0.4094	0.5409	0.1107
4	0.3984	0.3602	0.4915	0.0876
5	0.3279	0.2192	0.4497	0.066

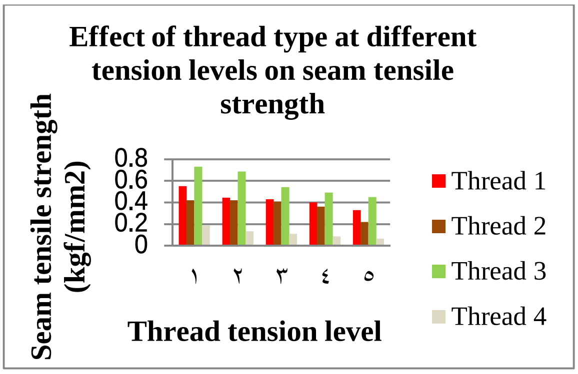

Fig.4. Effect of thread type at different tension levels on seam tensile strength

- *(As shown in table7, fig.4) it can be noticed that thread3 gives the highest seam tensile strength, as thread size increases durability increases.*
- *Despite thread1 and2 have the same size, thread1 gives higher tensile strength which can be attributed to fiber type as polyester is more durable than cotton.*
- *Thread4 scored the smallest seam tensile strength duo to its filament construction, whereas spun construction is more durable than filament construction.*
- *As tension level1 refers to very tight tension, tension2 is tight, tension3 is middle tension, tension4 is loose and tension5 is very loose, results indicate that, there is an inverse proportional relation between seam tensile strength and thread tension level. Hence seam tensile strength increases by increasing*

thread tension and vice versa. Where tighten seams are durable than loosen seams.

- *The thread type regression equation for thread1 is y= -0.0488x + 0.5762, for thread2 is y= -0.0464x + 0.5053, for thread3 is y= -0.0758x + 0.8075 and for thread4 is y= -0.0289x + 0.204. Where y=seam tensile strength & x=thread tension level. The thread type correlation coefficient on seam tensile strength is negative but its significant effect in general is very strong, as the correlation is strong when the value of R^2 nearest to 1. For thread1 R^2= 0.9204, for thread2 R^2= 0.7319, for thread3 R^2= 0.9481 and for thread4 R^2= 0.9594.*

3.1.4. Effect of thread type at different tension levels on seam extensibility

Table8 illustrates the effect of thread type at different tension levels on seam extensibility

Table 8 Effect of thread type at different tension levels on seam extensibility

	Seam extensibility (%)			
Thread tension level	Thread 1	Thread 2	Thread 3	Thread 4
1	9.045	6.944	6.167	4.778
2	9.833	7.278	6.209	5.111
3	9.945	7.889	6.389	5.611
4	10.83	8.05	6.5	5.833
5	13.89	8.89	6.94	5.984

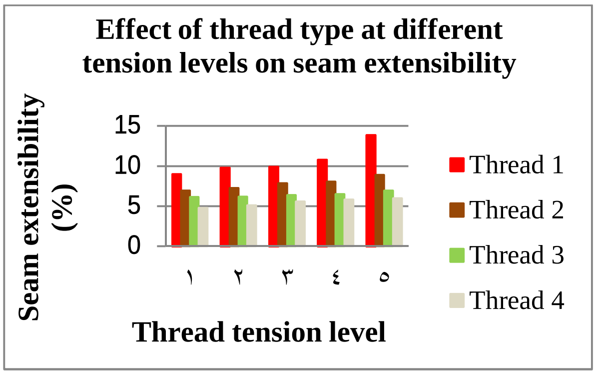

Fig.5. Effect of thread type at different tension levels on seam extensibility

- *(As shown in table8, fig.5) it can be noticed that thread4 gives the smallest seam extensibility that can be attributed to its filament construction, while spun construction is more extensible than filament construction.*
- *Despite thread1 and2 have the same size, thread1 gives higher seam extensibility which can be attributed to fiber type as polyester elongate more than cotton.*
- *Whereas thread1 and3 have the same fiber type and construction, thread1 gives higher seam extensibility that can be referred to thread number, as thinner thread is more extensible.*
- *Results detect that, there is a direct proportional relation between seam extensibility and thread tension level. (Tension level1 refers to very tight tension, tension2 is tight, tension3 is middle tension, tension4 is loose and tension5 is very loose) Hence seam extensibility increases by decreasing thread tension and vice versa. Loosen seams elongates more than tighten seams.*
- *The thread type regression equation for thread1 is y= 1.0687x + 7.5025, for thread2 is y= 0.4664x + 6.411, for thread3 is y= 0.1837x + 5.8899 and for thread4 is y= 0.3134x + 4.5232. Where y=seam extensibility & x=thread tension level. The thread type correlation coefficient on seam extensibility is positive but its significant effect in general is very strong, as the correlation is strong when the value of R^2 nearest to 1. For thread1 R^2= 0.8013, for thread2 R^2= 0.9611, for thread3 R^2= 0.8786 and for thread4 R^2= 0.9598.*

3.1.5. Effect of thread type at different tension levels on seam pucker

Table9 illustrates the effect of thread type at different tension levels on seam pucker

Note: Seam pucker evaluated according to AATCC where 5 means no pucker and
1 means severely pucker

Table 9 Effect of thread type at different tension levels on seam pucker

Thread tension level	Seam pucker (level)			
	Thread 1	Thread 2	Thread 3	Thread 4
1	4.4	3.8	3.2	2.8
2	4.6	4.4	3.8	3.4
3	4.8	4.6	4.4	3.8
4	3.6	3.4	3	2.4
5	3.4	3	2.8	2.2

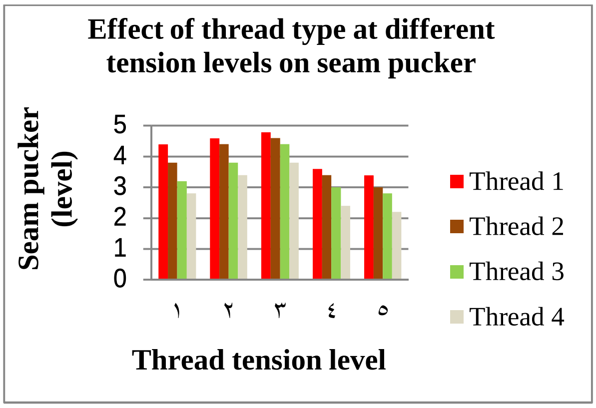

Fig.6. Effect of thread type at different tension levels on seam pucker

- *(As shown in table9, fig.6) it can be noticed that thread4 gives the highest seam pucker that can be attributed to its filament construction, while spun construction puckers less than filament construction.*
- *Despite thread1 and2 have the same size, thread1 gives lower seam pucker which can be attributed to fiber type as polyester puckers less than cotton.*
- *Whereas thread1 and3 have the same fiber type and construction, thread1 gives lower seam pucker that can be referred to thread number, as thinner thread makes fewer pucker.*
- *Seam pucker decreases by decreasing thread tension in case tension level1, 2 and3, while tension4 and5 differed as seam pucker increased by decreasing thread tension. This can be referred to the gathered bobbin thread behind fabric which increased pucker.*
- *The thread type regression equation for thread1 is $y = -0.3x + 5.06$, for thread2 is $y = -0.26x + 4.62$, for thread3 is $y = -0.16x + 3.92$ and for thread4 is $y = -0.22x + 3.58$. Where y=seam pucker & x=thread tension level. The thread type correlation coefficient on seam pucker is negative but its significant effect in general is weak, as the correlation is strong when the value of R^2 nearest to 1. For thread1 $R^2 = 0.5799$, for thread2 $R^2 = 0.3772$, for thread3 $R^2 = 0.1495$ and for thread4 $R^2 = 0.2677$.*

3.1.6. Effect of thread type at different tension levels on seam appearance

Table10 illustrates the effect of thread type at different tension levels on seam appearance

Note: Appearance evaluated (from2 to10) where 10 means best appearance and 2 means worst appearance.

Table 10 Effect of thread type at different tension levels on seam appearance

Thread tension level	Seam appearance (level)			
	Thread 1	Thread 2	Thread 3	Thread 4
1	8.8	7.6	6.4	4.8
2	9.2	8.8	6.8	5.2
3	9.6	9.2	7.2	5.6
4	7.2	6.8	6	4
5	6.4	6	5.6	3.2

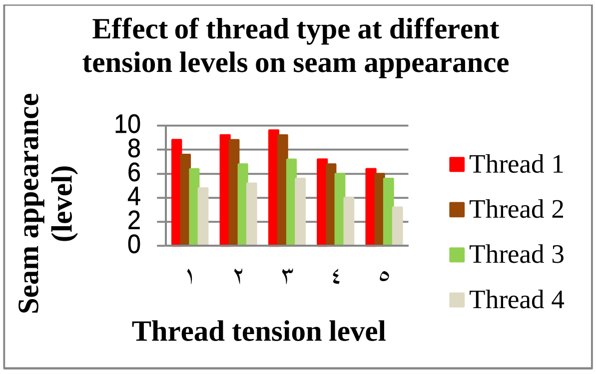

Fig.7. Effect of thread type at different tension levels on seam appearance

- *There is an inverse relation between seam appearance and seam pucker as seam appearance increases when seam pucker decreases.*
- *(As shown in table10, fig.7) it can be noticed that thread4 gives the lowest seam appearance that can be attributed to its high pucker resulted from its filament construction, while spun construction gives lower pucker thus better aesthetic appeal.*
- *Despite thread1 and2 have the same size, thread1 gives higher seam appearance which can be attributed to fiber type as polyester puckers less than cotton therefore appears better.*
- *Whereas thread1 and3 have the same fiber type and construction, thread1 gives better seam appearance that can be referred to thread number, as thinner thread makes fewer pucker thus better appearance.*
- *Seam appearance increases by decreasing thread tension in case tension level1, 2 and3, while tension4 and5 differed as seam appearance decreased by decreasing thread tension. This can be referred to the gathered bobbin thread behind fabric in addition to open stitches occurred which decreased appearance.*
- *The thread type regression equation for thread1 is $y = -0.68x + 10.28$, for thread2 is $y = -0.52x + 9.24$, for thread3 is $y = -0.24x + 7.12$ and for thread4 is $y = -0.44x + 5.88$. Where y=seam appearance & x=thread tension level. The thread type correlation coefficient on seam appearance is negative but its significant effect in general is intermediate, as the correlation is strong when the value of R^2 nearest to 1. For thread1 $R^2 = 0.6123$, for thread2 $R^2 = 0.3772$, for thread3 $R^2 = 0.36$ and for thread4 $R^2 = 0.5216$.*

4. Conclusions

- *Thread and tension control are very important elements in apparel manufacturing process.*
- *Sewing thread which is described by fiber type, construction, and size, has a significant effect on seam properties.*
- *Thread 1 gives best result, due to its small size as well as its polyester fiber type in addition to its spun construction. So the authors recommend using it for its best sew ability.*
- *Thread tension has a significant effect on seam properties.*
- *Tightened thread tension causes seam pucker that raises seam thickness which effect inversely on aesthetic appeal.*
- *By loosen the thread tension fabric during sewing became uncontrolled and bobbin thread was gathered behind fabric that leads to worst seam properties.*
- *The authors recommend using the middle tension (tension control 3) that gives the best seam properties.*

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The effect of sewing thread on sewability Sewing thread tension variations during the sewing process, which they linked to the number of resistance points from, thread guides which cause an increase in thread tension. The physical and mechanical prop-erties by which the quality of thread should be judged include breaking strength, elongation at break, variation of physical and mechanical properties, and twist stability (thread liveliness).Â In some circumstances particularly in the unfavourable speed range with maximum thread tensions, a high static tension and the existence of weak places in the thread itself could cause thread breakages. The fabrics were sewn with different stitch types based on the feasibility of the fabric. ASTMD 1683 â€“ 04 method assert that if fabric mass up to 270 g/m2 then Stitch density should be (4.7Â±1â„2) stitches per centi-. Ã˜ Extension Range : 39.37 in.Â Seam Efficiency for Cotton fabric in both warp and filling di-rections is shown in Table 5 for Stitch class 300 (type 301 and 304).Overall, All stitch has higher seam efficiency in warp di-rection compared to filling direction.T4 thread shows better. Thread/ Stitch 401. IJSER Â© 2015 http://www.ijser.org. Step 1: Pristine cotton fabric and P4VP are connected by polymeric graft chains containing epoxy groups. Step 2: Silver ions are attached to P4VP because of the affinity of pyridyl groups. Step 3: Copper is deposited onto cotton fabric.Â Table 1 The major elemental analysis of pristine cotton fabric, coated cotton fabric by XPS. . 35 Table 2 The major element analysis at the intersection of cotton fabric sample after absorbing silver ions. . 44.Â This design also allows free movement, especially for babies who cannot control themselves, which is greatly appreciated by parents and doctors. 2. Figure 1-1 Wearable instrumented garment for monitoring vital signs.