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The Effects of Different Fabric Types and Seam Designs on the Seams [sic] Efficiency

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Abstract
Fabricated textile products require joining fabric together by some means. A variety of methods include: sewing, gluing, thermally bonding, etc. This joined fabric is required to have similar strength at the point of joining as the original fabric. This method of joining is commonly called seaming. Seams are the basic element of structure of any apparel, home furnishing product and industrial textiles.

The main focus of this investigation is to study the joining parameters of fabric using a standard sewing machine. Two different seam designs will be investigated on three woven fabrics made from cotton, wool and silk. Textile products are produced from various fibers and different fabric construction, hence finding a specific seam that will best suit each individual product. Fabric seams are the most important parameter to maintain product integrity.

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The Effects of Different Fabric Types and

Seam Designs on the Seams Efficiency

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INTRODUCTION

Fabricated textile products require joining fabric together by some means. A variety of methods include: sewing, gluing, thermally bonding, etc. This joined fabric is required to have similar strength at the point of joining as the original fabric. This method of joining is commonly called seaming. Seams are the basic element of structure of any apparel, home furnishing product and industrial textiles.

The main focus of this investigation is to study the joining parameters of fabric using a standard sewing machine. Two different seam designs will be investigated on three woven fabrics made from cotton, wool and silk. Textile products are produced from various fibers and different fabric construction, hence finding a specific seam that will best suit each individual product. Fabric seams are the most important parameter to maintain product integrity.

STATEMENT OF PROBLEM

It is necessary to determine the most appropriate seam for each type of fabric to achieve a desired product quality. Quality reflects the performance of the apparel or textile product. Distinct seams are suitable for particular fabrics because each fabric has its own unique properties. Fabric quality is related to physical property and performance features. The fiber content influences the overall characteristics of a fabric. Understanding the components of the fabric and the quality of the seam will ensure the best performance for that particular product.

PURPOSE OF STUDY

This study will lead to the optimization of seam designs for cotton, wool and silk fabrics that are used in home furnishing and apparel manufacturing. From this purpose of study the following specific objectives will be addressed:

1) Determine the effect of two different seam designs on fabrics produced from cotton, wool and silk yarns.
2) Determine the range of seam efficiency within the same fabric utilizing a specific seam.
3) Determine which seam design produces the highest seam strength for each of the three fabrics.

SIGNIFICANCE OF STUDIES

Maximize a potential seam to ensure that seam will interact with the components of the fabric to ensure the best product durability. Besides the strength of the fabric, seams help guarantee the construction of a product. The functional performance features of the fabric and seam enhance serviceability. The majority of fabrics aesthetic properties relate to luster, drape, texture and hand. Each seam construction will establish a different relationship to the fabric because of the properties of the fabric and of the sewing thread. Comprising the knowledge of a specific seam that produces the greatest seam strength will be highly beneficial for new tests and products.

REVIEW OF LITERATURE

This study will investigate the features of the fabric and how they are comprised. It is essential to have a background of the processing of fiber to the finish product, fabric. Once the construction of the fabric is complete various parts of a fabric must be joined utilizing a sewing needle. The component of the sewing machine that initiates control is the sewing needle, but what is a sewing needle without thread. Thread is precisely placed on the sewing machine to guarantee ideal stitches. Threads are made of various fibers and finally twisted into a thin continuous strand of yarn. The selection of the sewing thread is crucial to the process of seaming. Seaming is the final step in the process to manufacture the product and obtaining strength and quality.

COTTON FIBERS AND FABRIC

“The U.S. is the world’s most reliable producer of high quality cotton (Cotton Incorporated).” Cotton is a natural fiber that grows within a pod from developing seeds. Cotton is also referred to as a seed fiber or cellulosic fiber. Cellulose is defined as a polymer of glucose found in all plant fibers. Once the seed is removed from the plant the initial step is to remove the fiber from the seed. Cotton is known as the most prominent seed fiber. Cotton grows in climates where the weather is above 70°F and is sufficiently irrigated. Cotton grows on bushes that can reach six feet in height. Inside a typical pod are seven to eight seeds. Seeds can have as many as 20,000 fibers growing from the surface. Once the pod is ripe the cotton fiber will expand from the pod. Cotton is picked by machine and another mechanical device known as a gin, which separates the fibers from the seeds. Cotton is than pressed into bales and sold to a spinning mill.

Cotton is white in appearance and produces a staple fiber. A staple fiber is made from the natural surroundings and is short in fiber length. The length of the fiber affects many aspects of the fabric's construction. Characteristics of cotton include: comfortable hand, good absorbency, color retention, machine washable, good strength, drapes well and importantly easy to handle and to sew (Kadolph et al. 33-35).

WOOL FIBERS AND FABRIC

Wool is a natural fiber produced from animal hair. Wool was widely used before the Industrial Revolution. The most valuable wool comes from Merino sheep. Merino wool is three to five inches long and has a soft hand and luster. Different breeds of sheep vary in the type of wool they produce. Sheep are sheared once a year in the spring time. The fleece is removed in one continuous piece and the process begins at the legs and belly. To eliminate shearing costs the sheep can be given either a chemical feed addictive or an injection. The chemical feed addictive makes the wool brittle and many weeks later the fleece can be pulled off from the sheep. The injection can cause the sheep to shed fleece about a week later (Kadolph et al. 50-52).

The physical structure of wool depends on the animal and the length of time between shearing. Like cotton, wool is also a staple fiber and it affects many aspects of the fabric's construction. Main characteristics of wool include: resist wrinkles, resists soiling, is durable, repels moisture, resiliency, retains shape and resists flames (American Wool). Distinctive characteristics may separate wool fibers from others because of the different breeds of sheep.

SILK FIBERS AND FABRIC

Silk is a natural protein fiber produced from the larvae of a moth. The production of cultivated silk begins when moths lay eggs. Once the eggs hatch the caterpillars are fed fresh mulberry leaves. After about thirty-five days the caterpillars are ready to spin a cocoon. The silkworm begins moving its head in a figure eight motion on the straw frame that is placed specifically for this purpose. Silk is produced in two glands within the silkworm and the silk that is in the form of a liquid comes through the spinnerets, which are the openings found on the silkworms head. The silk solidifies once it is forced out the spinnerets into air. After two to three days the silkworm has spun approximately one mile of filament. Many silkworms do not live after these few days, but the silkworms that do live are used to breed more silkworms. Silk is considered a luxury fiber and it takes quite a bit of silkworms to produce enough silk. Silk is also the only natural fiber that is produced in filament form. Cotton and wool are natural fibers, but they are produced in staple form. Once the silk is produced it is sorted by fiber size, quality and defects. Filaments are then gathered and wound onto reels. It takes several filaments to form a yarn. It is essential that when the filaments are combined that they remain similar in size, this is the most valuable silk.

Wild silk does not follow the same process. Wild silk produces silk, but it is not as uniform because it lacks the nutrition that the previous silkworms receive. The most common form of wild silk is Tussah. This silk does not resemble the beauty and hand of the controlled production silk.

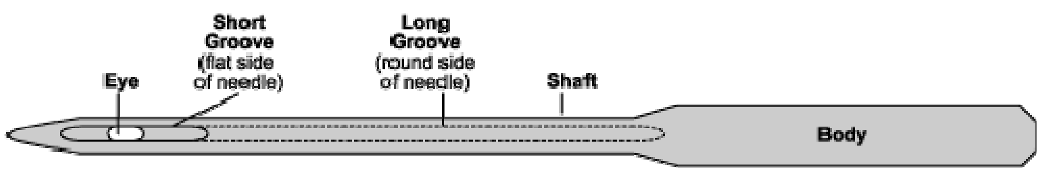
Silk has many characteristics that synthetic fibers can not compete against. The luster of silk is beautiful and soft. Silk is popular for its appearance and comfort. The properties of silk influence its ability to create a variety of fabrics. The properties of silk are regarded for the high cost of silk (Kadolph et al. 61-65).

SEWING MACHINES

Sewing machines join fabric with thread. The lockstitch is the most common type of home sewing machine. The lockstitch sewing machine consists of interloping sewing threads. Lockstitch sewing machines are comprised of a needle thread and a bobbin thread. The needle thread is delivered through a cone and the bobbin thread is spun onto a spool and enters the fabric from below. A shuttle hook revolves around the bobbin and captures the needle thread when it is brought down through the fabric. Seams are formed when the sewing machine needle is threaded and penetrates the fabric.   The interloping of threads is produced to form a stitch. The quality of the stitch is affected by both the needle and the thread (Brown et al. 240-241).

SEWING NEEDLE

Figure 1 Parts of the Machine Needle (Sewing, 2006)



Hannan (1963) states the sewing needles (figure 3) have three functions in the sewing machine, “(1) to penetrate the material and provide a hole for the thread to pass through, (2) to carry the needle thread down through the material to a point where the stitch forming part can enter the loop at the proper time, and (3) to enter the looper thread loop (on machines of the two-thread chain stitch or overedge types) and assist in forming the stitch.” Sewing machine needles must be selected with the fabric and thread type in mind, to develop a quality stitch. The point of a sewing machine needle as well as the size of the needle must be considered before undertaking a project. The point and size of the needle is determined by the characteristics of the fabric. Different needle points and sizes are designed to perform on specific fabric structures. The sewing needle is also a factor in establishing the sewing thread (Shaeffer et al. 44).

SEWING THREAD

Thread is a major factor in the overall production of a garment. Thread is comprised of yarn, which determines the effectiveness of that thread. Textile fibers are the main component of yarns, which create sewing thread. The more common sewing threads are cotton, polyester, nylon and rayon. The thread chosen for a particular garment does not only affect the life expectancy of that garment, but the overall design. Sewing thread is chosen according to the sewing needle and fabric structure. The sewing thread must conform with the garment, making it pleasing to the eye, but the product must also be of quality. The sewing thread is a huge indicator of style as well as the durability of the product.

The strength of sewing thread is critical to the performance of stitches and seams. The sewing thread should be comparable to the wear and care of the garment. It is important to compare the strength of the fabric with the strength of the sewing thread. The sewing thread should never be stronger than the fabric. Besides being compatible in strength, the sewing thread should be extensible against the stress of the garment (Brown et al 213-214).

SEAMS

Seaming is the most common of fabric joining done today. Seams are constructed when two or more pieces of fabric are sewn together. The row of stitching joining the two or more pieces of fabric is known as the seam line. The stitching comprising the seam line is usual parallel to the raw edge of the fabric. The seam line is also a specific distance from the raw edge. This distance is adequate for the durability of the home furnishing or apparel product.

Two different seam designs were utilized in the investigation of this study. The first seam was the SSa seam. This seam is the most common form of superimposed seams. This plain seam is the most common for joining garment pieces. The SSn seam is a more complex seam and its complexity is indicated by the lower case n. Two seams are illustrated in Figure 2 (Brown et al. 263-264).

Figure 2 Illustrates Seam Types (Amoco, 1996)

SEAM STRENGTH

Strength is known as one of the tensile properties of textile materials. The stitches used to make seams help determine the functional and aesthetic performance of the garment. Strong stitches directly affect the durability of seam strength. The strength of the seam can be found within the seam type and seam width. The location and type of seam must be suitable for the overall construction of the garment. The quality of manufactured products can be determined by the tensile testing machine (Brown et al 238-239).

TENSILE TESTING MACHINE

Collier (1999) states, “to get an accurate determination of tensile properties, it is necessary to use a machine that applies a force or extension in a fairly constant manner, so you can evaluate how force relates to elongation.” The most commonly used tensile testing machine used today is the CRE also known as the Constant Rate of Extension. The CRE tensile testers can be used for fibers, yarns, fabrics and other materials. The specimen is placed between a bottom clamp and a top clamp. Once the specimen is securely mounted the required data is entered into the computer system, initiating the test. After the test has been completed the results will be processed and visible on the computer monitor. The results can be compared to other tests that have been performed on the tensile testing machine (Collier et al 108-109).

PROCEDURE

The three fabrics obtained for this test included: cotton, wool and silk. Four samples were cut from each of the fabrics. Tensile tests on the sample fabrics were performed to determine seam efficiency using the ASTM D 5034-95 (grab) and the ASTM D 2261-96 (tear) methods.   The twelve samples were cut exactly 4 inches wide and 8 inches long. After all twelve samples were cut, according to the measurements, the middle of each sample was determined. The samples were measured individually, 1 ½ inches from the top left edge and 1 ½ inches from the bottom left edge, indicating a small dot at each point. The dots were connected by a straight line from top to bottom. This middle sector made it possible for the sample to be mounted correctly. Next, the clamps of the machine were placed 3 inches apart. The sample was then placed lengthwise in the top and bottom clamps of the tensile testing machine. The edge of each dot was aligned with the left sides of the top and bottom clamps. After the sample was securely mounted, the appropriate data was entered into the computer system. The next step required the computer settings to set channels to 0 (to align), 1 inch width, .125 thickness and 3 inches for length of clamps. The results were then recorded on the computer monitor. The remaining eleven samples followed the same procedure.

The second part of the procedure involved determining the fabric weight of the cotton, wool and silk fabrics. To begin, the eight samples of cotton were cut into 2-11/16" circles. All eight samples were placed on the balance and weighed in grams. The weight of the eight samples in grams gives the weight of the fabric in ozs/yd^2. The same procedure was followed for the wool samples and then the silk samples. Fabrics are designed using different yarns to produce a light, medium or heavy weight fabric. A light weight fabric is a fabric that weighs less than 4.0 ozs/yd^2**.** A medium weight fabric ranges from 4-6 ozs/yd^2. Lastly, a heavy weight fabric weighs 6.0 ozs/yd^2 or more.

The third part of the procedure involved cutting eight samples from each of the fabrics. The twenty-four samples were cut exactly 4 inches wide and 8 inches long. Once the samples were cut, each sample was ironed to remove any creases that had formed on the fabric. Next, two cotton samples were sewn together using a 1985 Singer sewing machine with:

- 12 stitches per inch
- Size 80 sewing needle
- Sewing thread comprised of 100% polyester
- SSa seam

The samples were sewn in pairs with cotton and cotton, wool and wool and silk and silk. In the end, there were four samples of cotton, four samples of wool and four samples of silk, creating a total of twelve samples. Individually, the samples were opened lengthwise and measured, 1 ½ inches from the top left edge and 1 ½ inches from the bottom left edge indicating a small dot at each point. The dots were connected by a straight line from top to bottom. This middle sector made it possible for the sample to be mounted correctly. Next, the clamps of the machine were placed 3 inches apart. The sample was then placed lengthwise in the top and bottom clamps of the tensile testing machine. The edge of each dot was aligned with the left sides of the top and bottom clamps. After the sample was securely mounted, the appropriate data was entered into the computer system. The next step required the computer settings to set channels to 0 (to align), 1 inch width, .125 thickness and 3 inches for length of clamps. The results were then recorded on the computer monitor. The remaining eleven samples followed the same procedure.

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- 12 stitches per inch
- Size 80 sewing needle
- Sewing thread comprised of 100% polyester
- SSn seam

The samples were sewn in pairs with cotton and cotton, wool and wool and silk and silk. In the end, there were four samples of cotton, four samples of wool and four samples of silk, creating a total of twelve samples instead of twenty-four. Individually, the samples were opened lengthwise and measured, 1 ½ inches from the top left edge and 1 ½ inches from the bottom left edge indicating a small dot at each point. The dots were connected by a straight line from top to bottom. This middle sector made it possible for the sample to be mounted correctly. Next, the clamps of the machine were placed 3 inches apart. The sample was then placed lengthwise in the top and bottom clamps of the tensile testing machine. The edge of each dot was aligned with the left sides of the top and bottom clamps. After the sample was securely mounted, the appropriate data was entered into the computer system. The next step required the computer settings to set channels to 0 (to align), 1 inch width, .125 thickness and 3 inches for length of clamps. The results were then recorded on the computer monitor. The remaining eleven samples followed the same procedure.

This procedure verified valuable information that was essential in identifying the strength of a fabric. The main focus was to determine the peak load, mean, standard deviation and seam efficiency. The seam efficiency was only necessary when calculating the six experiments with seams involved. To calculate seam efficiency, the following equation was used:

$$\% \text{ Seam Efficiency} = (\text{Fabric Strength with Seam} \div \text{Fabric Strength without Seam}) \times 100$$

The computer will provide the necessary information after each sample has been tested. The peak load is the pound per force or can also be defined as the amount of force to cause a fabric to break. Different fabrics will have a different breaking strength than others. A fabric's properties and performance is due mainly to fiber structure and morphology. The molecular orientation and crystallinity of fibers will contribute to the fabric strength. The machine acts as a force and produces the breaking load of a fabric, the load at which the fabric breaks.

RESULTS

Test results of the experimental fabrics have been summarized and presented in tables I through IV:

Table I Fabric Tensile Strength Values

Cotton Strength		Wool Strength		Silk Strength	
Samples	**Peak Load (lb/f)**	**Samples**	**Peak Load (lb/f)**	**Samples**	**Peak Load (lb/f)**
Sample A	69.077	Sample A	90.525	Sample A	51.117
Sample B	62.258	Sample B	90.158	Sample B	45.284
Sample C	65.609	Sample C	93.020	Sample C	56.793
Sample D	64.655	Sample D	94.557	Sample D	61.992
Mean	65.400	**Mean**	92.065	**Mean**	53.796
Standard Deviation	2.828	**Standard Deviation**	2.092	**Standard Deviation**	7.206
Fabric Strength in lbs/unit thickness	13.9	**Fabric Strength in lbs/unit thickness**	12.7	**Fabric Strength in lbs/unit thickness**	16.8
Fabric Weight (ozs/yd²)	4.7	**Fabric Weight (ozs/yd²)**	7.2	**Fabric Weight (ozs/yd²)**	3.2
Fabric Classification	Medium Weight	**Fabric Classification**	Heavy Weight	**Fabric Classification**	Light Weight

Table II Fabric Seam Strength of Cotton

Cotton Samples SSa Seam		Cotton Samples SSn Seam	
Samples	**Peak Load (lb/f)**	**Samples**	**Peak Load (lb/f)**
Sample A	45.235	Sample A	55.670
Sample B	58.169	Sample B	57.000
Sample C	50.764	Sample C	56.242
Sample D	53.832	Sample D	45.700
Mean	52.000	**Mean**	53.653
Standard Deviation	5.438	**Standard Deviation**	5.330
Seam Efficiency, %	79.511	**Seam Efficiency, %**	82.038

Table III Fabric Seam Strength of Wool

Wool Samples SSa Seam		Wool Samples SSn Seam	
Samples	**Peak Load (lb/f)**	**Samples**	**Peak Load (lb/f)**
Sample A	37.893	Sample A	50.170
Sample B	48.369	Sample B	58.167
Sample C	35.002	Sample C	43.350
Sample D	46.293	Sample D	46.538
Mean	41.889	**Mean**	49.556
Standard Deviation	6.449	**Standard Deviation**	6.381
Seam Efficiency, %	45.499	**Seam Efficiency, %**	53.827

Table IV Fabric Seam Strength of Silk

Silk Samples SSa Seam		Silk Samples SSn Seam	
Samples	**Peak Load (lb/f)**	**Samples**	**Peak Load (lb/f)**
Sample A	27.689	Sample A	28.373
Sample B	29.701	Sample B	28.008
Sample C	26.775	Sample C	27.194
Sample D	29.895	Sample D	31.180
Mean	28.515	**Mean**	28.689
Standard Deviation	1.53	**Standard Deviation**	1.733
Seam Efficiency, %	53.006	**Seam Efficiency, %**	53.329

DISCUSSION

Fabric Strength

Overall, fabric strength depends on the fiber type, fabric construction and thickness. The wool fabric having the highest weight exhibited the greatest strength (92 lbs) followed by cotton fabric (65 lbs) and silk (53 lbs). It is interesting to note that when the strength data was rationalized by the fabric weight, silk became the strongest fabric followed by cotton and wool, which follows the usual strength ranking of the fibers.

Seam Type Effects

Because of the high standard deviation values of the strength data, there was no clear superiority of one seam type over the other for seam efficiency. However, seam SSn appears to produce a stronger joint in the wool fabric, since it is a more complex stitch and provides a higher frictional resistance between the fabric panels.

Fabric Effects

Highest seam efficiency was obtained for the cotton fabric and the least efficiency was noted for wool fabric, which was the strongest fabric, but the weakest fiber. Although silk was the strongest fiber, it had the lowest coefficient of friction (much lower than cotton yarn) resulting in a lower seam efficiency than cotton.

The investigation indicated that the seam efficiency was influenced by multiple factors, including fabric type, fabric effect and seam design.

CONCLUSION

The purpose of this study was to investigate the effects of different fabric types and seam design on the seam efficiency of the product. The following conclusions are made within the scope of the parameters of the study:

1) Although wool was the weakest fiber among the three used in the study, the wool fabric produced the highest breaking load because it was the heaviest fabric.

2) Two types of seams were examined in this study, SSa and SSn. The seam efficiency of the wool fabric was slightly higher for the SSn seam than the SSa seam. This effect, however, was not clear for the other two fabrics.

3) The highest seam efficiency was found in the cotton fabric for both seam types, which was followed by the silk and wool fabric. This may be attributed to the higher friction between the cotton yarn or fabric and the sewing thread than that of the other two fabrics.

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