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Examination of Alternative Fabric Joining Techniques Compared to Traditional Sewing

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EXAMINATION OF ALTERNATIVE FABRIC JOINING TECHNIQUES COMPARED TO TRADITIONAL SEWING

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ABSTRACT

Ultrasonic seaming could soon replace the needle and thread technique with a safer, more efficient technology. In this designed experiment, the Chase FS-90 Ultrasonic Sewing Machine will be compared to the traditional sewing machine. The goal is to examine the sewing quality of textile fabric using ultrasonic methods by finding ideal parameters. The parameters are amplitude, speed, and pressure by using materials, including one thermoplastic fabric, one natural fabric, and low-melting polymer tape. The ultrasonic seam with the best properties will then be compared to the traditional needle and thread seam. The final product will be a designed dress using all ultrasonic seams. The material found to have the best seam properties will be used for the design.

INTRODUCTION

Constructing apparel is most commonly done with needle and thread; however, traditional sewing has evolved using a safer, more efficient technology such as ultrasonic seaming. Ultrasonic seaming could soon replace the needle and thread technique with newer equipment and faster methods. Sewing by needle and thread is the most common way of joining fabric together, however, current literature suggests there are alternative processes for creating fabric seams. These alternative methods include: thermal bonding, laser enhanced bonding, adhesive bonding, or ultrasonic seaming. This study will concentrate on ultrasonic seaming. In past research, it has been found that traditional sewing has some disadvantages, such as: the amount of time it takes to produce a garment sewn with needle and thread, the sewing thread deteriorating over time, and the needle and thread producing perforated seams that can allow harmful gases and fumes to pass through the seam. Ultrasonic seaming is one of the many alternatives under consideration by apparel manufacturers. According to Ghosh and Reddy (2009), ultrasonic seaming uses thermoplastic polymer or fabrics that contain a great amount of thermoplastic fibers. This technique requires no needle, thread, adhesives such as glue, tape, or other binding substances. Therefore, it is more cost efficient than traditional sewing. Generating heat energy within the fibers helps to keep the fibers preserved, and minimizes fiber degradation. The use of foreign threads, yarns, and adhesives makes it harder or even impossible to recycle the product. This technique also eliminates impermeable seams, which make the use of such products safer. One use of this is the gear worn in contaminated and hazardous environments (Ghosh & Reddy, 2009).

Purpose of Study

This study's purpose is to examine the seaming quality of textile fabric using ultrasonic methods by finding ideal parameters. The parameters measured are amplitude, speed, and pressure, using materials of one thermoplastic fabric and one natural fabric. This study will compare seam strength, seam efficiency, seam perforation, cost efficiency, and total garment recyclability.

Problem Statement

This investigation will examine problems with traditional sewing, such as fiber degradation, perforated seams, and producing garments that cannot be recycled. The study will show that these problems can be solved with ultrasonic seaming.

LITERATURE REVIEW

Fabric Joining Methods

Thermal bonding is a process by which materials to be joined are heated individually using several methods, causing the thermoplastic materials to melt. They are then compressed by applying pressure, which causes an intermingling of polymers. A seam is formed as the material cools and solidifies. Disadvantages of this technique are stiffness and fiber degradation caused by excessive heat conducted through the fibers (Reddy, 2007).

Laser enhanced bonding is a process that uses a laser to drive a polymer adhesive into the materials being joined. The nozzle tip of the gun, which discharges the polymer into the seam, is a coaxial window through which a near infrared beam from a laser is focused onto a liquid adhesive polymer as it is applied to the edges of the join (Hecht, 1995). The adhesive polymer conducts light energy to the nozzle area, which drives the heated agent into the adjacent materials forming a seam joint (DeMeis, 1995). While dissimilar materials can be joined by this method, compatibility of the materials and adhesive is important (DeMeis, 1995). The strength of the seam is closely linked to the laser energy input. Insufficient energy does not melt enough material to yield a strong weld. Excessive energy melts the fabrics completely, creating a line of weakness at the edge of the weld and reducing its strength. This is a major disadvantage to apparel manufacturers (Reddy, 2007).

Adhesive bonding uses four techniques to bond textiles using adhesives: mechanical, hydrogen, chemical, and thermodynamic bonding. Adhesives are used for sealing, providing extra strength to seams, creating stiffness, and water proofing seams. Adhesives can be applied in several ways, including nozzles and tapes. While adhesives may seem simple, the cost and the additional weight of the adhesives are two disadvantages (Reddy, 2007).

Sewing

Today, the most common way of joining fabrics is with a sewing machine; this technology was first introduced in the late

1700s (Foresdyke). Before the sewing machine, hand sewing was the only way to join two pieces of fabric. This technique was extremely labor intensive and, according to Reddy (2007), was not economically feasible in a mass production industry. The sewing machine was invented by Walter Hunt, Elias Howe, and Isaac Singer, and made the production of apparel by machine possible, thereby speeding up the manufacturing process (Reddy, 2007).

One thing that has not changed is the element used to join the fabric pieces together: the thread. Reddy (2007) stated that the most widely used stitch in the industry is the lockstitch. This stitch is typically formed by interlacing needle threads from a spool at the top and bobbin threads at the bottom. This is the way most sewing machines are designed (Reddy, 2007). This technique works in five steps, as illustrated in Figure 1 (Shaeffer, 2001).

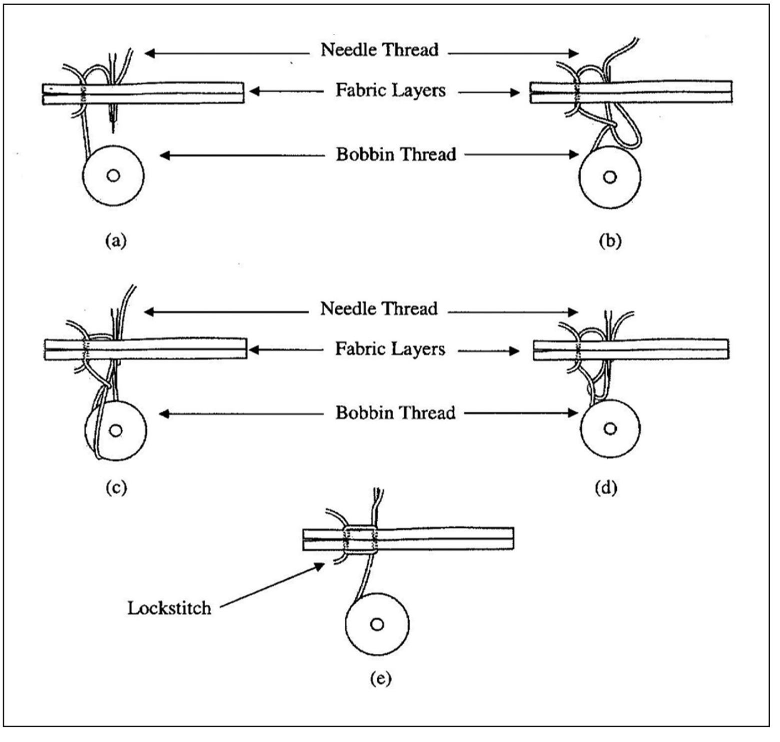

Figure 1. Lockstitch Formation: (a) Penetration, (b) Loop, (c) Confirmation, (d) Cast-off, and (e) Set stitch (Reddy, 2007, pg.5)

Ultrasonic Seaming

There are some disadvantages associated with traditional sewing, such as thread recyclability, deterioration, perforated seams, and cost. Thread is often composed of more than one type of fiber, or often foreign yarns (Reddy, 2007), making it harder to recycle, since not all fabrics can be recycled due to foreign thread or yarn. Sewing at high speeds forces the thread at repeated tensile stress at very high rates (Eryuruk & Kalaoghu, 2010). Perforated seams make garments unsuitable and unsafe for products such as medical apparel and protective garments (Reddy, 2007). Sewing costs are reduced by using the ultrasonic seaming technique, because the use of thread, bobbins, wasted fabric, needles and other consumables is eliminated (Reddy, 2007).

According to Little and Shi (2000), Ultrasonic Seaming is an advanced technique for joining synthetic materials and blends to produce continuous and impermeable seams. Ultrasonic seaming is a fast, clean, and cost effective way to join fabric (Little & Shi, 2000). There are additional advantages to using ultrasonic seaming, such as the "conservation of energy, possibility of precise automated assembly using computer-aided-manufacturing technology, and recyclability of the product, as foreign yarns are not used to make a seam" (Reddy, 2007, pg.9).

Ultrasonic seaming works with 100 percent synthetic fabrics (thermo-fabrics) or blends such as poly/cotton with up to 40 percent natural fiber content. The ultrasonic seaming machine, such as the Chase FS-90 Ultrasonic sewing machine used in this study, employs frictional heat caused by high frequency mechanical vibrations (20-40kHz). This heat melts and bonds the synthetic fibers. For blends with more than 40 percent natural fibers, heat activated materials are inserted between the two pieces of fabric and bonds them (Little & Shi, 2000). Urethane and olefin ribbon are used in this study to bond the blended fabrics. The ultrasonic technique has many applications, yet little research has been done on the seaming and heating mechanisms of woven fabrics (Little & Shi, 2000). While ultrasonic seaming is not new, it could be a new technique for apparel manufacturers. Ultrasonic seaming uses newer equipment that produces faster methods and produces seams with better wearable comfort.

Thermoplastics

Thermoplastics are man-made synthetic fibers. They consist of linear or branched polymer chains and have no cross-links. Thermoplastics are known for their ability to melt under heat and become solid again when cooled. This property gives thermoplastics the ability to soften or fuse when heated. Thermoplastic materials can be re-melted and cooled time after time without undergoing any significant chemical change (Kadolph, 2007).

Of all the fibers in the world, thermoplastics are one of the most versatile. Some advantages of thermoplastics include greater possibilities for recycling, better environmental resistance, infinite shelf life, low-cost, and shorter processing time. Most, but not all thermoplastics have extremely high strengths and are lightweight (Hou, 1998). While the advantages outweigh the disadvantages, there are still disadvantages to consider when working with thermoplastics. Some thermoplastic fibers fade in sunlight, shrink in high temperature water or fade under ultraviolet light. Common thermoplastics used in apparel are polyester, nylon, acrylic, and polypropylene. Other common thermoplastics not used in apparel include polyethylene, polystyrene, polyester, polyvinyl chloride, acrylics, nylons, spandex-type polyurethanes, and cellulosic. There are many different uses of thermoplastics because polyester is known to exhibit moderate to high strength (Kadolph, 2007).

Polyester (PET)

Polyester is defined as "manufactured fibers in which the fiber-forming substance is any long-chain synthetic polymer composed of at least 85% by weight of an ester of a substituted aromatic carboxylic acid, including but not restricted to substituted terephthalate units" by the Federal Trade Commission. The most common form of polyester is polyethylene terephthalate, commonly known as (PET) (Kadolph, 2007). PET is most commonly used for soft drink and water bottles (afma.org). Polyester is an artificial man-made fiber and is generally manufactured from petroleum. "It is becoming increasingly common to recycle after use by re-melting the PET and extruding it as fiber" (afma.org). There are different methods of manufacturing polyester, depending on whether it will be solid or liquid. Polyester refers to the linking of several esters within the fibers and can also be classified as *saturated* and *unsaturated* polyesters. Polyester was first discovered in the early 1940's in England. Terylene was the first polyester fiber produced in the United States in 1951 (Kadolph, 2007).

There are many ways to characterize polyester. Polyester fibers blend well and maintain a natural fiber look and texture (Kadolph, 2007). Polyester fibers are extremely strong, durable, and resistant to most chemicals. It stretches and shrinks and is wrinkle, mildew and abrasion resistant (Kadolph, 2007). It has the ability to withstand harsh climates, is hydrophobic in nature and quick drying. It can be used for insulation by manufacturing hollow fibers. Polyester is also known to retain its shape. It retains heat and is good for making outdoor clothing, is easily washed, dried and is crisp and resilient when wet or dry (Kadolph, 2007; amfa.org).

As Reddy (2007) has noted, polyester is used in a wide range of applications, such as in apparel, furnishings and industrial fabrics. It is used in several different fabric constructions, including woven, knit, and nonwoven. Polyester became popular in apparel when it was used to create men's suits in the 1970's. The first use of polyester filaments was in knit shirts for men's shirts and women's blouses (Kadolph, 2007). However, the most common and popular use of polyester is for the creation of plastic water & soda bottles, because these polyesters can be recycled.

Polyester/Cotton Blends

This blend combines the softness and moisture absorption of cotton with the dimensional stability, hard-wearing, and easy care qualities of polyester. The complex shape of the cotton fibers gives products greater bulk and cover, compared to 100% PET. Blends are produced to balance technical properties for a particular textile product, to produce a cheaper product by blending a low cost fiber with a more expensive one, or to produce special color effects by blending fibers with different dyeing characteristics (Reddy, 2007).

PET/cotton blends are popular for apparel fabrics, particularly woven dress wear and light weight suiting. These rich blends (55/45) are usually designed to exploit luster, drape, and softness of the regenerated fiber, whereas in cotton rich mixtures the strength, wash-ability and durability of the natural fiber make important contribution (Charankar, Gupta, and Verma, 2007).

METHODOLOGY

In this design experiment, samples of each fabric were sewn using a sewing machine and the ultrasonic seaming machine. Results were compared to determine the best seam strength. When the best results are determined, a garment will be created using the ultrasonic seaming machine.

Hypothesis

The fabrics that will have the best seam strength will be 55% cotton / 45% PET, and 100% cotton with low-melting polymer tape. The 55/45 blend is believed to have stronger seam strengths than a sewn sample sewn with needle and thread, because it is composed of a thermoplastic and natural fiber. One-hundred percent (100%) cotton is also believed to have stronger seam strengths than needle and thread, because the low melting polymer tape will have a stronger bond that reinforces the seams of the sample/garment.

Materials used in this study

The materials used in this study were polyester, polyester-cotton blends, and low melting point polymers. The equipment used in this study was the Chase FS-90 Ultrasonic Sewing Machine and the Tensile Testing Machine for Textiles.

Polyester (PET)

Polyester was chosen for this study because of its characteristics and its ability to withstand heat, its light weight, and its strong fibers.

Cotton/Polyester Blends

In this study two different blend ratios were used: a 65/35 and a 55/45 cotton/polyester blend, two of the most common blends manufactured.

Ultrasonic Seaming Machine

The machine used in this study was the Chase FS-90 Ultrasonic sewing machine, shown in Figure 2. The producer of the machine states that the "Chase Machine's FS-90 Ultrasonic Fabric Sealing System 'sews' and/or slits knitted, woven, and non-woven man-made thermoplastic materials without needle or thread. It seals edges with no stitch holes – unlike conventionally stitched edges – prevent penetration of chemicals, liquids, blood pathogens, or particulates" (chasemachine.com).

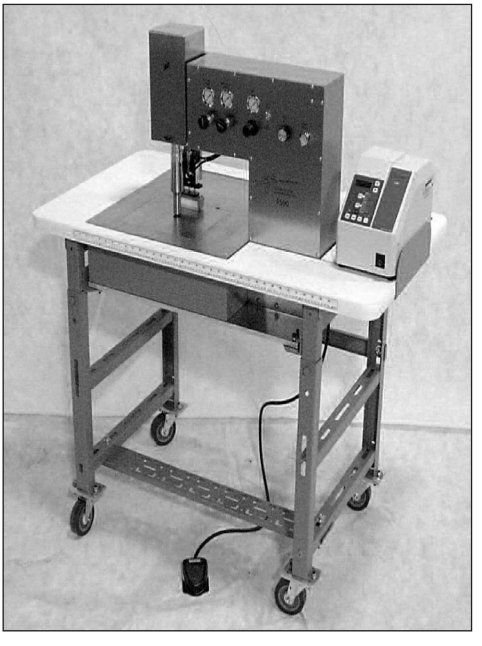

Figure 2. Chase Machine's FS-90 Ultrasonic Fabric Sealing System (www. chasemachine.com, n.d.).

This machine has many features and benefits. This stand-alone system enables flexibility and tight turns in sealing and/or cutting, and provides an unobstructed view of fabric in the processing area, giving the seam a much-improved hand. The FS-90 has a two-position foot switch that facilitates operation. Its first position raises and engages the rotary wheel, applying force to the material being processed. The second position activates ultrasonic and wheel rotation. The operator-selectable maximum operator speed enables the operator to set maximum feed speed at the fully depressed foot switch position setting. The FS-90 is designed for operator safety ¾ no needles or other moving parts are placed above the work surface. The variable speed drive motor provides continuous operation at speed ranges of 0 to 60 feet per minute and 7 to 123 feet per minute. Operator controls are conveniently located on the control panel, which includes a pneumatic pressure regulator, on/off switch, power-on indicator and a nip control. It offers various sealing patterns, including the standard single stitch, right or left slant, zigzag and custom-designed patterns. Typical applications include protective garments, disposable hospital gowns and shoe covers, face masks, infants' nursery garments, filters, bags, curtains, sails, lingerie and web splicing (Ghosh & Reddy, 2009; www.chasemachine.com, n.d.).

MTS Tensile Testing Machine

Test Procedure: Standard Test Method for Failure in Sewn Seams of Woven Apparel Fabrics, ASTM D 1683-81 (American Society of Testing and Materials, 1981). This test method is used to measure the maximum sewn seam strength that can be achieved in woven fabrics when a force is applied perpendicular to the seam. This test method is also used to measure the seam strength of ultrasonically joined seams.

Specimen Size and Number: Two pairs of fabrics, each measuring 4 x 4.5 inches, were cut, with the longest length parallel to the warp for every condition in each fabric.

Apparatus: Constant Rate of Extension (CRE) type MTS Tensile Testing Machine, with 25 mm. x 25 mm. top and bottom jaws, an Industrial Sewing Machine, Branson Ultrasonic

Fabric Sealing System, model F-90, and a Branson Ultrasonic Assembly System, model 2000d/aed.

Calibration: A 75mm. distance between the upper and lower jaws and a jaw speed of 2 in./min. was maintained.

In this experiment, traditionally sewn seams were contrasted with ultrasonic seams, using the Grab Test Procedure. This test method measures the maximum sewn seam strength that can be achieved in woven fabrics when a force is applied perpendicular to the seam. This test method is also used to measure the seam strength of ultrasonically joined seams. This method determines the damage to sewn seams in stable or stretch woven fabrics. Samples sized 4.5 inches by 4 inches of each fabric were used.

***Procedure*:**

1. Cut each fabric into 4 in. x 4.5 in. rectangular samples creating 20 rectangles of each fabric, or 10 samples of each fabric.
2. Using a regular sewing machine, sew 1 sample of each fabric with 12 stitch per inch, with a seam allowance of ½ in. Stitch: Lockstitch 301. Seam: Plain seam. Thread poly-cotton poly filament covered with cotton.
3, Take 12 samples of each fabric and sew them using the ultrasonic sewing machine, each time using different parameters (speed, amplitude, and pressure). Use the truncated male knurl pattern wheel. Seam type: plain. Seam allowance: ½ inch.
4. The parameters used for thread seam were determined based on ASTM standardized methods, and should find optimal ultrasonic seams, using designed experiment.

Each Fabric will be tested under 3 different parameters. The parameters used were:

Pressure: 100 lbs. (low) / 200 lbs. (high)
Speed: 1 (slow), 2 (medium), 3 (fast)
Amplitude: 60 hz. (low) / 90 hz. (high)

RESULTS

55% Cotton / 45% PET

Figure 3. shows that the 55% cotton / 45% PET fabric blend formed the strongest seams under higher pressure, medium speed, and high amplitude. Compared to the seam strength of the sewn sample, the sewn sample had the best seam strength results.

Pressure	Speed	Amplitude	Seam Strength in lbs.
100	1	60	No Seam Formation
100	2	60	No Seam Formation
100	3	60	No Seam Formation
100	1	90	0.69
100	2	90	0.509
100	3	90	No Seam Formation
200	1	60	6.962
200	2	60	3.199
200	3	60	1.238
200	1	90	11.837
200	2	90	13.105
200	3	90	7.459
		Sewn Sample	**49.694**

Figure 3. Seam Strength of 55% Cotton / 45% PET Using the Parameters of Pressure, Speed and Amplitude.

65% Cotton / 35% PET

Figure 4. shows that the 65% Cotton / 35% PET fabric blend formed the strongest seams under high pressure, medium speed, and high amplitude. Compared to the seam strength of the sewn sample, the sewn sample had the best seam strength results.

Pressure	Speed	Amplitude	Seam Strength in lbs.
100	1	60	0.244
100	2	60	No Seam Formation
100	3	60	No Seam Formation
100	1	90	5.199
100	2	90	0.474
100	3	90	No Seam Formation
200	1	60	11.645
200	2	60	9.27
200	3	60	7.302
200	1	90	10.771
200	2	90	12.125
200	3	90	10.936
		Sewn Sample	**52.948**

Figure 4. Seam Strength of 65% Cotton / 35% PET, Using the Parameters of Pressure, Speed and Amplitude.

100% Polyester

Figure 5. shows that 100% Polyester fabric forms the strongest seams under high pressure, high speed, and high amplitude. Compared to the seam strength of the sewn sample, the sewn sample had the best seam strength results.

Pressure	Speed	Amplitude	Seam Strength in lbs.
100	1	60	No Seam Formation
100	2	60	No Seam Formation
100	3	60	No Seam Formation
100	1	90	1.121
100	2	90	0.158
100	3	90	No Seam Formation
200	1	60	7.965
200	2	60	6.997
200	3	60	2.816
200	1	90	7.854
200	2	90	9.061
200	3	90	10.03
		Sewn Sample	**13.987**

Figure 5. Seam Strength of 100% Polyester, Using the Parameters of Pressure, Speed and Amplitude.

100% Cotton

Figure 6. shows that 100% Cotton fabric forms the strongest seams under lower pressure, high speed, and low amplitude. Compared to the seam strength of the sewn sample, the sewn sample had the best seam strength results.

Pressure	Speed	Amplitude	Seam Strength in lbs.
100	1	60	4.992
100	2	60	5.311
100	3	60	6.572
100	1	90	4.899
100	2	90	5.772
100	3	90	5.795
200	1	60	4.53
200	2	60	4.471
200	3	60	4.519
200	1	90	3.904
200	2	90	4.832
200	3	90	4.591
		Sewn Sample	**50.08**

Figure 6. Seam Strength of 100% Cotton, Using the Parameters of Pressure, Speed and Amplitude.

CONCLUSION

One-hundred percent (100%) Cotton, using low melting polymer tape, and a 55% Cotton/45% PET fabric blend, were expected to have the best seam strength properties of the four fabrics. However, neither sample held seams stronger than the machine-sewn samples. The hypothesis was proven to be incorrect.

The 55% Cotton/45% PET samples sewn with the ultrasonic sewing machine produced the strongest seam at 13.105 lbs. of pressure. This could be compared to the 100% Polyester (PET) needle and thread sewn sample, at 13.987 lbs. of pressure. Further research should investigate blended fabrics of similar weight, given the comparison of strength between the two samples. A fabric containing more PET may have stronger seam strengths.

Another suggestion would be to investigate different types of low-melting polymer tape in different settings such as fabrics, speed, amplitude and pressure. The use of blended cotton/polyester fabrics along with low melting polymer tape would be ideal for producing stronger seam properties.

REFERENCES

American Society of Testing and Materials. (1990). ASTM D 1683-81. Standard test method for Failure in Sewn Seams of Woven Fabrics. 355-361. Philadelphia, PA:ASTM.

Afma.org (1953) *Polyester Fiber* [online] Available at: http://www.afma.org/f-tutor polyester.htm [Accessed: 09 Feb 2012].

Chase Machine & Engineering. *Chase Machine & Engineering: Expect to Be Impressed!*.N.p.,n.d.Web. 8 Jan. 2012. <http://www.chasemachine.com>.

DeMeis, R. (1995, August). Laser-enhanced bonding produces strong seams. In *LaserFocusWorld*. Retrieved February 02, 2012, from http://www.laserfocusworld.com/content/lfw/en/ articles/print/volume-31/issue-8/world-news/world-news/laser-bonding-produces-strong-seams.html

DeWitt, J. W. (1994). Sewing machines show few advances in 160 years. *Apparel Industry Magazine, 55*(9), 38-39.

Eryuruk, S. H., & Kalaoglu, F. (2010, March). The Effecrs of Different Amounts of Lubricant Application on the Sewing Thread Performance Properties [Electronic version]. *Textile Research Journal*, *80*, 1232-1242. doi:10.1177/0040517509355350

Forsdyke, G. (n.d.). A Brief History of the Sewing Machine. In *www.ismacs.net*. Retrieved March 10, 2012, from http://www.ismacs.net/sewing_machine_history.html

Charanka, S., Gupta, M., & Verma, V. (n.d.). GROWING IMPORTANCE OF COTTON BLENDS IN APPAREL MARKET. *Google Scholar*. Retrieved February 18, 2012, from http://scholar.googleusercontent.com/scholar?q=cache:q0Ob7-uqDNkJ:scholar.google.com/&hl=en&as_sdt=0,23

Hecht, J. (1995, July). Laser banishes leaky wellies and wetsuits. *New Scientist, 147*, 21.

Hou, M., & Friedrich, K. (1998). Adjustable Forming of Thermoplastic Composites for Orthopaedic Applications. *JOURNAL OF MATERIALS SCIENCE: MATERIALS IN MEDICINE*. Retrieved February 9, 2012, from www.springerlink.com/content/rt61x0711425p219/fulltext.pdf

Jones, I. (2005, May). Improving Productivity and Quality with Laser Seaming of Fabrics. *Technical Textiles International*, *14*(3), 35-38. Retrieved March 5, 2012, from GoogleScholar.

Ibar, J.P. (1998). Control of polymer properties by melt vibration technology: A review. *Polymer Engineering and Science, 38*(1), 1-20.Kadolph, Sara J. *Textiles*. 10th ed. Upper Saddle River: Pearson Prentice Hall, 2007. 131-44. Print.

Reddy, R. (2007) *Ultrasonic seaming of PET, PET* . Eastern Michigan University.

Reddy, R., & Ghosh, S. (2009, April 2). Ultrasonic sealing of polyester and spectra fabrics using thermoplastic properties. In *Journal of Applied Polymer Science*. Retrieved December 8, 2011, from http://onlinelibrary.wiley.com/doi/10.1002/app.30050/full

Shaeffer, C. (2001). *Sewing for the apparel industry.* Upper Saddle River, NJ: Prentice Hall.

Shi, W., & Little, T. (2000, February). Mechanisms of ultrasonic joining of textile materials. *International Journal of Clothing Science and Technology*, *12*(5), 331-350. Retrieved March 12, 2012, from GoogleScholar.

Tolunay, M. N., Dawson, P. R., & Wang, K.K. (1983). Heating and bonding mechanisms inultrasonic welding of thermoplastics. *Polymer Engineering and Science, 23*(13), 726-733.