Ultrasonic Sewing of Clothing Accessories as an Environmental Approach to Green Manufacturing

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Abstract:
Manufacturing and the environment have a strong mutually beneficial relationship that is crucial for productivity. Using green manufacturing in production processes have gained popularity among researchers and owners of multinational corporations. A "green" alternative to traditional sewing i.e. using ultrasonic technology has piqued the interest of ready-to-wear manufacturers to reduce the environmental impact. The goal of this paper is to improve the performance of sewing garment accessories "zippers" by drawing a comparison between the traditional method and ultrasonic welding method of installing zippers. To study relationship between two methods experiments made on fabrics to measure the laboratory characteristics of knitted fabrics (weight per square meter, thickness, etc.). a comparison was made between the samples through tests (tensile strength and elongation, Crease, appearance (before/after) washing). The results demonstrated differences in favor of ultrasonic welding [USW], which helped to reduce the waste of sewing threads and contributed to environmental preservation.

Keywords:
Ultrasonic Welding (USW) Traditional Sewing, Garment Accessories, Green Manufacturing.

Paper received June 19, 2023, Accepted September 17, 2023, Published on line November 1, 2023

1. INTRODUCTION:
Today's consumers are more conscious of the need to safeguard the environment, as a result, businesses utilize labels like "green environment" and "environmentally friendly" to market their products or services. They have been apprehensive about using industrial items due to the technology' role in the increased unsustainable use of natural resources. The principles of the environmental movement were made known in order to address these circumstances.

In the late 1970s, consumer demand for environmentally friendly products led to the emergence of the environmental movement, which has had a significant impact on the fundamental beliefs of modern society (30, 31). In response to the demands of the sustainable environment movement, eco-friendly clothing has been manufactured.

The design, production, and commercial use of environmentally friendly materials and products that are cost-effective, sustainable, and pose the fewest dangers to both human health and the environment are collectively referred to as "green manufacturing". Green manufacturing is a global trend that many nations and international organizations are interested in because it serves as a way to achieve sustainable development and gain a competitive advantage. Green manufacturing is more of a philosophy than a process or an accepted standard (32) as it focuses mostly on the manufacturing industry, the modernization of production processes and the establishment of environmentally friendly processes (33).

In terms of sewing looks, tensile strength, elongation, and wrinkles, USW is superior to traditional sewing. By using USW, the clothing sector reduces detrimental environmental waste, increases the quality of sewing accessories, complies with the widespread trend of using contemporary sewing technologies to make sportswear accessories, helps maintain environmental protection and sustainable growth, and examines how ultrasonic sewing affects the tensile strength and sewing elongation, efficiency, and look of running garments.

The contributions of this paper are:

- Using ultrasonic to improve sewing of garment accessories.
- Finding a relationship between traditional sewing and modern sewing.
- Reducing the consumption of natural materials used in weaving.
- Estimating how USW affects garments tensile strength, elongation, efficiency, and look.

2. LITERATURE REVIEW
Many clothing brands and manufacturers around the world have focused on reducing pollution caused by manufacturing processes, as well as using alternatives to raw materials that cause increased environmental damage. The study of Nayak, R., Panwar, T., & Nguyen, L.V.T. (2020) presents concepts of sustainability in the production of fashion and textiles from fibers to the garment industry. The study shows that large fashion

organizations are embracing fashion sustainability due to global competition, consumer awareness, management policy, while Small and Medium-sized Enterprises (SMEs) struggle to survive in the global market due to limited access to finance, lack of competencies and lack of consumer awareness[1]. The clothing industry is traditional, globally competitive and customer-centric. The clothing industry generally includes a large number of industrial processes, and sewing is one of the most important of these processes [2].

The clothing industry is linked to global technological developments, as many technologies have emerged that help preserve the environment and reduce environmental exhausts that are emitted from ready-made garment factories. The term "ultrasound" refers to sound frequencies above the range audible to humans [3]. Ultrasound was initially used to weld plastics then used in the automotive, electronics, electrical, instrumentation, filtration, packaging, and astronaut clothing industries[4]. Ultrasonic sewing offers many advantages, including its use as an alternative to bonding fabrics made of polymers containing synthetic fibers that do not require the use of needles, and are characterized by efficiency, low cost, energy conservation, and product recycling. The defects of traditional sewing are represented by the intermittent connections that produce perforated layers, which deteriorate over time, leading to the failure to maintain the aesthetic and functional values that the designer seeks in his works as they lie in the unity of the artwork resulting from the close connection of all its elements together, as well as the designer's nature of aesthetic value[5]. There is a possibility of benefiting from ultrasonic sewing in enriching the functional aspect of leather clothing as ultrasonic sewing has a high tensile strength for sewing, in addition the fabric becomes less permeable to air and water compared to traditional sewing (Elbarbary, A. F., 2021)[2].

Different types of clothing seams can be created using ultrasonic technology, which is an existing technology that has not been fully used and its associated advantages in the clothing industry hasn't been fully introduced (Seram, N., & Cabon, D., 2013)[4]. The ultrasonic sewing of non-woven fabrics is possible after drawing a comparison between the properties of non-woven fabrics when ultrasonic is used (Manal A. Seif, 2016) [6]. In an attempt to measure the effect of ultrasonic roller sewing patterns on the microstructure and peeling strength of ultrasonic welding joints of non-woven fabrics, 8 patterns of ultrasonic sewing machines rollers were manufactured, the results showed that no weld defects appeared on the anterior or posterior side or the cross section of SEM images (Nguyen Van, A, 2020)[7]. Identifying the dominant factors affecting the damage of sewing garments as well as the different explanations for the defects of sewing in garment production (Choudhary, A. K., Sikka, M. P., & Bansal, P., 2018)[8]. The defects occurring during the sewing of pieces of clothing were analyzed and classified and the decisions made by production manager when these defects occur were questioned (Tarafder, N., Karmakar, R., & Mondal, M., 2007)[9]. Green manufacturing involves the control and reduction of hazardous substances in the design, manufacture and application of products or processes that cause global warming. In recent years, a great deal of research has been done in studying the impact and reducing the carbon footprint in the various manufacturing industries[10].

3. RESEARCH PROBLEM:

The research problem is described through the following questions:

- What benefits might ultrasonic sewing offer for making clothing accessories?
- Can ultrasonic sewing make a substantial contribution to green manufacturing?
- How to utilize ultrasonic sewing to improve the knit quality of clothing accessory?
- How to evaluate the efficiency of ultrasonic sewing in comparison to traditional sewing?
- How to reduce the damage traditional sewing causes to the global warming?

4. METHODS

This research paper used both qualitative and quantitative methodological approaches. For the qualitative approach, literature review and some of the used methods will be explained in detail in the next section. For the quantitative approach, fabric samples were tested in the lab to determine the weight per square meter, thickness, tensile strength of the individual piece, kg, and elongation of sewing fabrics. Zippers were installed using both the traditional sewing method and the ultrasonic sewing method, and comparisons were made. Tensile strength, sewing efficiency, elongation, wrinkle, and appearance tests [before/after] were used to compare samples. Practical applications will be explained in section 4.2.

4.1 Qualitative Approach

4.1.1 Ultrasonic sewing:

The term "ultrasound" refers to sound frequencies above the human audible range[11]. Human hearing is normally between 16 Hz and 16 kHz, but ultrasound frequencies are typically thought to be between 20 kHz and 500 MHz[12]. Instead of using needles to connect fabrics comprised of polymers with synthetic fibers, ultrasonic technology can be used for its various benefits including effectiveness,

low cost, energy-saving, and product-recycling. The defects of traditional sewing are represented by the intermittent connections that produce perforated layers, which deteriorate over time, leading to the failure to maintain the aesthetic and functional values that the designer seeks in his works as they lie in the unity of the artwork resulting from the close connection of all its elements together, as well as the designer's nature of aesthetic value[13]. The term "ultrasound"[13, 14] refers to sound waves that vibrate at a frequency that is higher than that of human hearing (more than 20,000 Hz)[14]. Materials having thermoplastic coatings such as polyvinyl chloride (PVC), polyurethane (PU), polyethylene (PE), and polypropylene (PP) can be used on fabrics[15]. Ultrasonic welding equipment produces strong and secure sewing, moreover, it lengthens the product's shelf life across all packaging and material types[16].

The process of ultrasonic sewing is performed as follows:

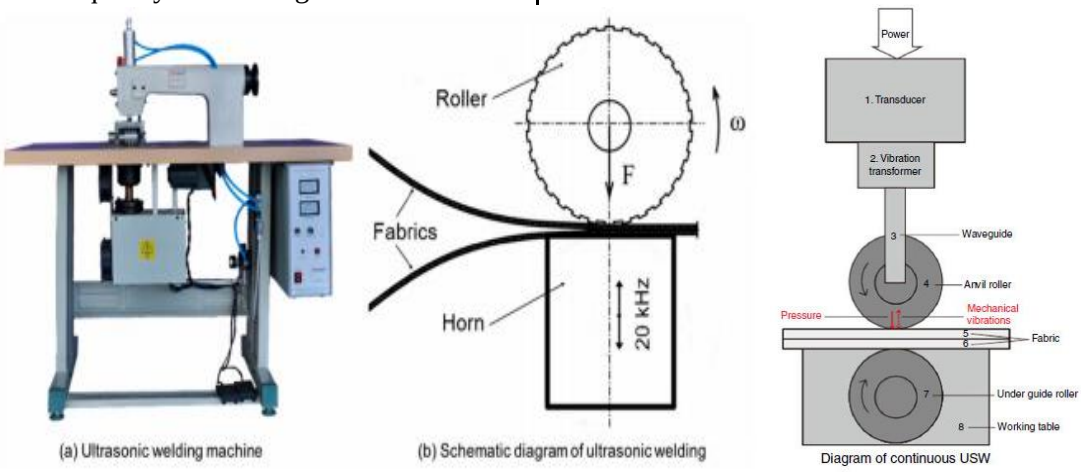


Fig. (1) Scheme of the USW sewing machine mechanism, and conversion sequence

Figure (1) illustrates the working principle of continuous USW machine in which the system provides line power at 50-60 cycles and transmits it to high ultrasonic wave with frequency at 20000 cycles/sec by transducer 1 and vibration transformer 2 containing waveguide 3, and dissipates the input electrical signal to mechanical vibrations of the same frequency, which is delivered to the fabrics by means of an anvil roller 4, resulting from the molecular and surface friction of the heat generated by the mechanical vibrations as it causes the materials to soften and weld between the adjacent layers. As shown in Figure (1), the ultrasonic welding machine consists of four components: power, transducer, power booster, and machine head [7, 17].

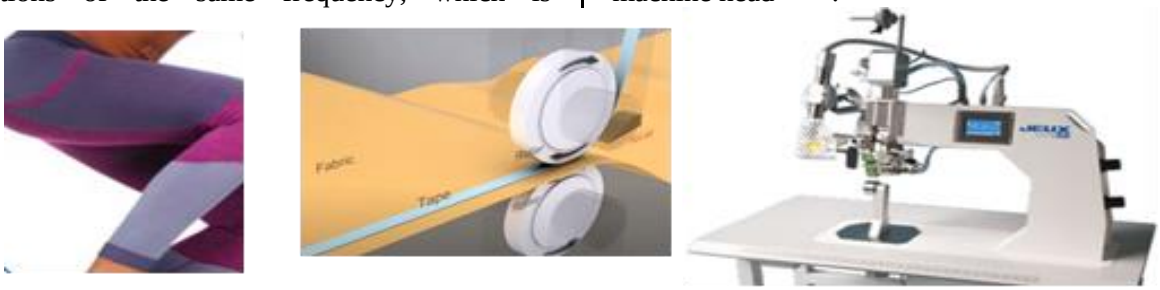


Fig. (2) Ultrasound sewing using Tape Bonding / Seam Sealing

Figure (2) depicts the mechanism of ultrasonic sewing with tape bonding/seam sealing, in which hot air activates the bonding tape's adhesive to embed the tape on the fabric. The tape can also be placed on regular stitching layers to be more endurable and waterproof.

Fig. (3) Ultrasonic Welding

Figure (3) illustrates the mechanism of ultrasonic sewing using Ultrasonic Welding, where ultrasonic vibration leads to heating and fusion of the material as it causes stress within the materials that releases thermal energy making connection points soft and binds the materials together. Bonding only occurs at the connection points between horn and anvil. Polyester, nylon, polypropylene, polyethylene, PVC, urethane fabrics can be ultrasonically bonded.

Fig. (4) Press Bonding (1, 18)

Figure (4) illustrates how ultrasonic sewing works with press bonding technology. This sort of sewing employs pressure waves to knit a single layer or two layers of fabric together using tape.

4.1.2 Traditional Sewing

Sewing was defined according to the British Standard (BS) No. 3870 of 1965 as the process of joining or connecting two layers of cloth. As for the term "stitch", it was used in the case of a single layer of cloth whose edges were to be cleaned or to be decorated by sewing. And through the BS No. 3870 of 1983, Part II, a classification was developed for different sewing patterns and stitches, then sewing was redefined again as a process of succession of a series of stitches in one layer of cloth or to connect several layers of cloth[19].

Sewing is the basic component of the piece of clothing. Different components of the garment are linked together through sewing, which is responsible for giving the appearance of the wear [20]. The sewing stitch, which was known by different trade names before 1921, was defined as the repeated unit that is formed and shaped by sewing threads [21]. Stitching can contribute to the economic production of clothing by achieving various process at one time e.g. cleaning and assembly of fabrics [22].

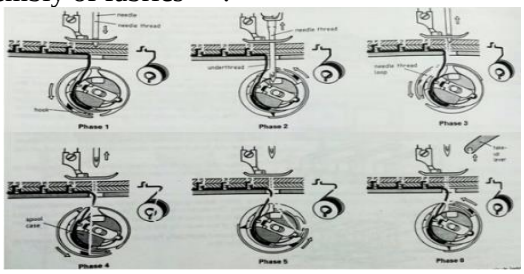


Fig. (5) Stages of sewing stitch (23)

Types of Traditional sewing:

Sewing is classified based on the kind and quantity of its components. According to ISO 4916:1991, there are eight different classifications. In the past, sewing was described as flat or overlapping, then contrasting, other types are seamless or decorative.

1- Superimposed Seam (SS):

This type of sewing typically starts with two or more pieces of cloth layered on top of each other and linked close to the edge with one or more rows of stitches. The overlap edges can then be stitched together with stitch types 301 or 401 as seen in Figure [6].

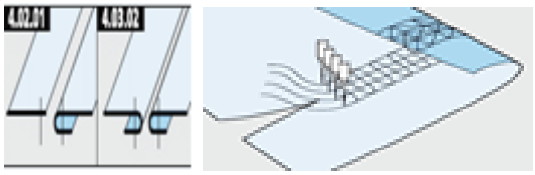


Fig. (6) Superimposed Seam (SS) sewing

2- Lapped Seam (LS):

In this type of sewing, a group or more of cloths with single, or folded edges are overlapped. They are often knitted using chain stitch 401, which is preferred for textiles like denim due to its sturdy construction as seen in Figure [7].

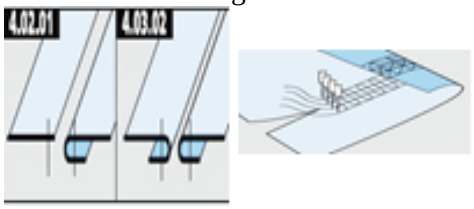


Fig. (7) Lapped Seam (LS) sewing

3- Bound Seams (BS):

They are created by folding a strip over the edge of the fabric and sewing it together with one or two stitches. There are various types of bound seams e.g. 301 lockstitches or 401 chain stitch as seen in Figure [8].

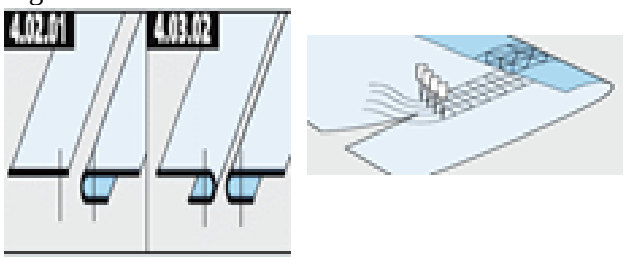


Fig. (8) Bound Seams (BS) sewing

4- Flat Seams (FS):

The fabric's two edges, whether they are folded or flat, are brought together and stitched (zigzag lock stitch, chain stitch, etc.) as seen in Figure[9].

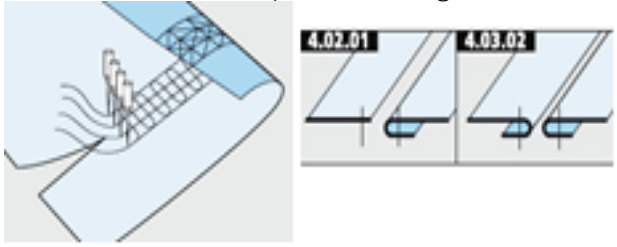


Fig. (9) Flat Seams (FS) sewing

5- Ornamental Seam/ Decorative Sewing (OS):

It is a series of stitches along a straight or curved

line or following a certain design on a single layer of fabric as seen in Figure [10].

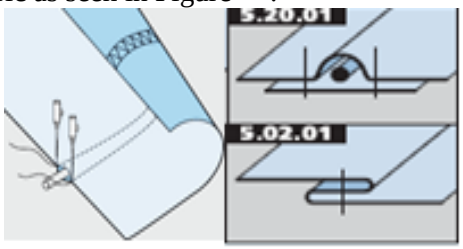


Fig. (10) Ornamental Seam (OS) sewing

6- Edge Finishing / Neatening (EF)

It is the place where the edge of a single layer of fabric is folded over as seen in Figure [11].

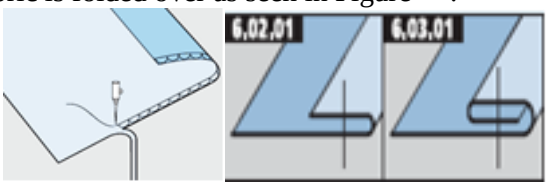


Fig. (11) Edge Finishing (EF) sewing

7- Attaching of Separate Items (AS)

This type of sewing includes layers that require the addition of another component on the edge of a piece of fabric, for example, elastics materials.

8- (SC) Single-Ply Construction sewing:

A single piece of fabric is turned over on both edges. It is most common in belt loops [24].

4.1.3 Seam Efficiency:

Sewing quality standards are an important factor in the quality of clothes. The total quality assessment includes certain evaluation tests that depend on the aesthetic appearance of the piece of clothing (25). There are many factors that affect the quality of sewing clothes, including the optimal choice of fabric, sewing threads, artificial stitches, and the shape of the model (26). The efficiency of sewing performance is assessed by several elements: tensile strength, flexibility and elasticity, durability, sliding, safety and comfort. There are also factors affecting the efficiency of sewing performance such as: the pattern of sewing threads, stitch pattern, stitch-link pattern, needle pattern, and feeding system (27).

4.1.4 Green Manufacturing and Clothing Industry

There is no doubt that most consumer goods negatively affect the environment, however, the garment industry causes many environmental damages due to the rapid changes of fashion from season to season, as consumers are tempted to buy clothes to keep up with it. -- . Purchasing clothes affects the size of the carbon emissions that they release, as researchers believe that online purchasing reduces carbon emissions, but at the same time it encourages the consumer to buy quantities that exceed their needs and then return large quantities of them after trying them on. The fashion industry is one of the most industries in the world that pollute the environment as the production and distribution of crops, fibers and clothing used in fashion contribute to various forms of environmental pollution, including water, air and soil pollution. Pollution occurs as a result of some of the main factors in industry, such as overproduction of garments and the use of synthetic fibers (28). The clothing industry produces many wastes that affect the environment as defined by the Environmental Affairs Agency in the handbook issued in January 2003. Table (1) shows that there are many effects that help increase environmental pollution rates from the clothing industry.

Table (1) Classification of clothing industry waste according to the handbook issued by the Environmental Affairs Agency in January 2003

Process	input	function	product	air emissions	solid waste	work environment
Straighten the cloth	Garment fabric and linings	Making a large number of fabric layers	Preparing the fabric for the cutting process	-	-	-
Cutting	Multilayer assembly	Cutting fabric according to the pattern	Parts of garment, lining, and padding	Yarn waste	Leftover of fabrics and linings. Packaging wastes	Yarn waste, fabric scraps and linings
Paste the lining	Parts of garment, linings and padding	Pasting the padding by pressure and heat	Garment parts are attached to the padding	Chemical adhesive fumes	-	Adhesive heat and fumes
sewing	Garment parts, linings, sewing buttons	Assembling garment parts and linings to form a product	Integrated clothing	Yarn waste	thread waste	Yarn waste
Ironing	integrated clothing	Processing appearance	Fitted clothes	Fumes	-	Fumes

4.2 Practical Applications

The study samples were carried out by the two researchers, who applied traditional sewing to 9 samples and ultrasound sewing to 1 sample with fixed pressure and temperature factors. The practical applications were covered through four

axes as follows:

The first axis is an **analysis of research samples**, the second axis is **applications of research samples**, the third axis is an **analysis of tests practical outcomes**, and the fourth axis is **a comparative study to achieve green manufacturing**.

4.2.1 Axis (1): Analysis of Research Samples:

a) Laboratory Tests of The Study Samples:

The preliminary tests of the study samples are as follows:

Fabric tensile strength test (kg), fabric elongation test (%), durability (mg. cm), sample thickness (mm), weight (g/m2). The preliminary tests' results of the study sample were as shown in Table [(2)].

Table 2: Lab tests to describe the study samples

sample code	sample type	weight (g/m2)	sample thickness (mm)	durability (mg/cm)	tensile strength (kg)	elongation (%)
1-1	Single jersey lycra	173	0.61	110	28	220
2-1	Single jersey lycra	173	0.61	110	28	220

B. Criteria Affecting Traditional sewing: (Variable Factors)

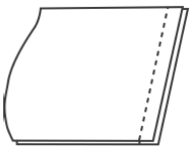
There are many factors that affect the quality of sewing to give a good appearance to the pieces of clothing, including sewing performance, and tensile strength. Moreover, there are a number of difficulties that occur during the application of sewing including stitch formation, ruffles and denting of the material, damage to the material along the sewing line.

Table (3) Variable and invariable factors for traditional and USW knitting

Code	Stitch Density	Needle Size	Fixed Variable
1	3	12	Thread Number: Ne 42/2
2	4	14	Connector Type: SSA-1 301
3	5	16	Pressure / Temperature USW
4	-	-	Jersey Fabrics (Lycra)

Table (3) shows the variables that were applied in the research, where three types of stitch densities were used in order to ensure the strength of sewing during the lab tests of the samples, as well as three types of needles (12, 14, 16) were used.

Table (4) A description of the traditional sewing for the implementation of the study research samples

Link Type	Knitting	Thread Type	Thread Number	Needle Size	Sewing Type	Stitch Density / cm	Number of Needles
Closed Stitch		Spun 100% Polyester	Ne 42/2	-12 -14 -16	301	-3 -4 -5	1

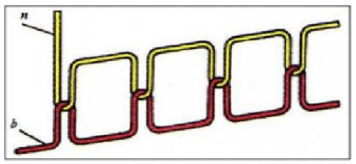
C. Specifications of Traditional Sewing Machine and Ultrasonic Sewing

Tables (5) and (6) show the technical specifications of the sewing machines used in the application of the USW research samples used in the installation of zippers using the traditional sewing technique and producing the closed stitch of CLASS 301 and USW sewing.

Table (5) Specifications of ultrasonic sewing machines for zipper installation

Specifications	Electromotive Force	Machine Speed	Ultrasound Frequency	Machine Speed Limit
Ultrasonic Welding	220V 50/ 60Hz	Meter/ Min 2.5-1.8	40khz	10m/min

Table (6) Specifications of the traditional sewing machine for zipper installation

Machine Model	Machine Speed	Number of Needles	Machine Type Is Larger	Stitch Width
JK-F4	5,000 Stitches/Min	DB×1needle1	Semi-automatic	 5 mm

D. Description of clothing accessories used in the study sample

A zipper is a device fastened and operated using two parallel rows of plastic or metal teeth on either side interlocking closed by a sliding tab called a zipper. The teeth are carried in two of the fastening strips that run the length of the zipper and are commonly sewn into clothing and textile products.

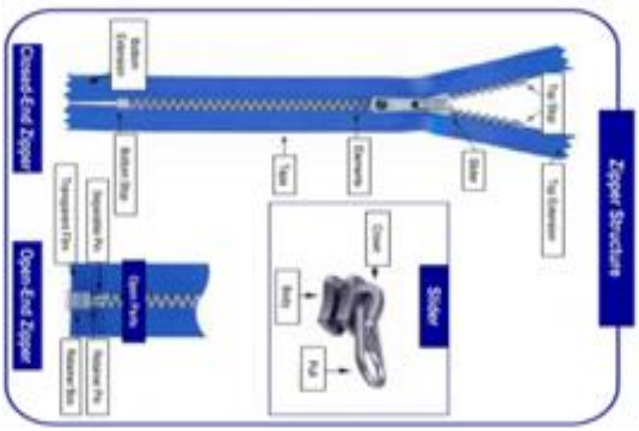


Fig. (12) Description of the zipper used in research applications

Figure (12) shows a description of the zipper used in the sample applications for traditional sewing and USW knitting, where the zipper consists of the stop area, the sliding part, the body, the textile tape made of polyester, the teeth and the bottom stop area.

4.2.2 Axis (2): Applying Samples Using Traditional Sewing Techniques

a) Applications of research samples for installing zippers using traditional sewing

Fig. (13) Applications of research samples for installing zippers using traditional sewing closed stitch SSA-1

b) Application of Samples Using Ultrasonic Sewing Techniques:

Table (7) shows the use of ultrasonic sewing for sewing zipper on sportswear, where the zipper was sewn using the USW pressing method. A promotional tape for JUKI was used, and the research sample was implemented at Musa Amin Machinery Company, Egypt.

Table (7) Applications of research samples for sewing zippers using ultrasonic welding

Sample Code	Sewing Type	Material 2-1
2-1	Ultrasonic Welding	Front view of the sample  Back view of the sample 

4.2.3 Axis (3): Results

4.2.3.1 Laboratory Tests:

A set of tests was determined in order to analyze the physical and mechanical properties of the study samples i.e. sample's weight of the square meter, thickness (mm), tensile strength (kg), elongation 100%, thickness, appearance, and seam efficiency (%).

All tests were carried out using standard test methods at the Textile Laboratory of the National Research Center according to specifications (Attmd 1683), standard atmosphere 20 °C ± 2 and humidity of 65% ± 2. The appearance test of the samples was carried out with the help of 10 specialized professors, who observed the samples and gave each a score of (1:5).

4.2.3.2 Results of USW and traditional Sewing Sample Test:

In the light of the research objectives and questions, the two researchers applied tests for knitting, traditional connections, and ultrasonic sewing (USW) on 10 pieces; 9 samples used traditional method and one sample used the USW method. The samples were coded according to the numbering pattern of 1-1 to 1-9 for traditional connections and 1-2 for USW, where the variables were the number

of stitches density (3 stitches/cm, 4 stitches/cm, and 5 stitches/cm), the needle sizes (12/14/16) and the thread number was invariable as shown in the analysis of research samples. A pressure cylinder was used to fasten the zipper sample (1-2USW). Through the following results, the comparison of sewing zipper using the traditional method and the USW tells the difference.

Table 8. Results of lab tests of the effect of zipper sewing by traditional and USW methods

Sample Code	Link Type	Stitch Density	Needle Size	Thickness (mm) Before sewing	Thickness (mm) After sewing	square meter weight (g)	Tensile Strength (kg)	Performance %	Elongation %
1-1	SSA-1 301	3 stitches/cm	16	0.61	1.71	173	18	64.29%	22.23
1-2		4 stitches/cm	16	0.61	1.71	173	15	53.57%	23.25
1-3		5 stitches/cm	16	0.61	1.71	173	25	89.29%	25.22
1-4		3 stitches/cm	14	0.61	1.71	173	26	92.85%	22.24
1-5		4 stitches/cm	14	0.61	1.71	173	24	85.71%	23.25
1-6		5 stitches/cm	14	0.61	1.71	173	25	89.29%	25.44
1-7		3 stitches/cm	12	0.61	1.71	173	25	89.29%	23.20
1-8		4 stitches/cm	12	0.61	1.71	173	22	78.57%	24.28
1-9		5 stitches/cm	12	0.61	1.71	173	17	60.71%	25.50
2-1	welding	0	Compressor cylinder	0.61	0.98	173	27	96.43%	33.03

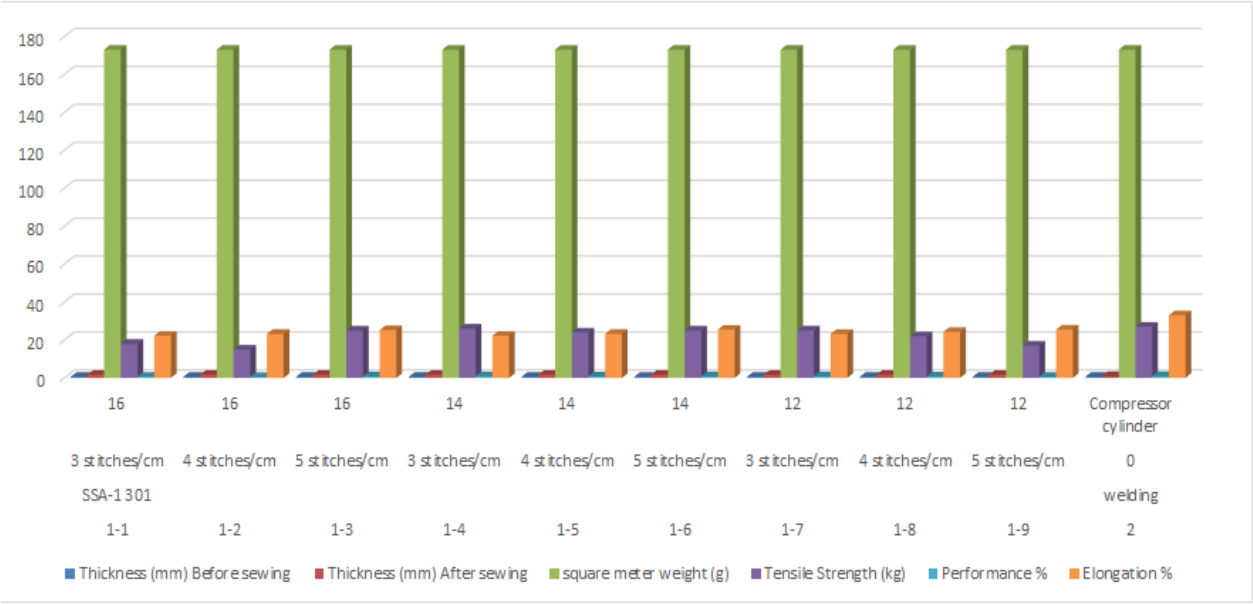


Fig. (14) Results of testing zipper sewing with traditional and USW method

By comparing the results in Table (8) and Fig. (14) to measure the effects of traditional sewing of zipper on variables (stitch density and needle size) used in the installation of zippers and comparing these effects to the use of ultrasonic knitting. It becomes clear, as shown in Table (8) and Fig. (14), that the results of sample (1-4) were better than the of other samples, as the tensile strength of sewing was (26 kg), the performance efficiency was (92.85%), but the elongation was less in the results (22.4%). The results show that tensile strength of samples (1-6) and (1-7) is 25 kg for each, and the samples are similar in the results of performance efficiency (89.29%). However, results show that there is a difference between the samples in elongation, as the results of the sample (1-6) were higher than the results of the sample (1-7), which indicates that there is an effect on the difference in stitch density and the needle on the elongation of knitting. The results also show that the sample (1-2), upon which ultrasonic sewing was used with invariable of temperature and pressure coefficient, that tensile strength of the zipper sewing and the pressure exerted on it is 27 kg. The performance efficiency was 96.43% and the elongation was 33.03% as shown in Table (8) and Fig (14).

Table (9) A comparison between the results of zipper knitting; sample (1-4) for traditional method, and sample (2-1) for ultrasonic method

Sample Code	Link Type	Stitch Density	Needle size	Sample Thickness (mm) Before Knitting	The thickness of the sewing sample after knitting	Square Meter weight (g)	Sewing Tensile strength (kg)	Sewing Performance %	Sewing Elongation %
1-4	SSA-1 301	3 stitches / cm	14	0.61	1.71	173	26	92.85%	22.24
2-1	Welding	0	Compressor cylinder	0.61	0.98	173	27	96.43%	33.03

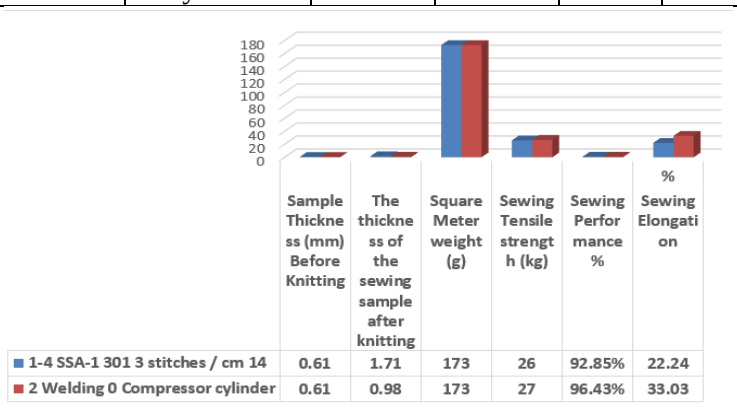


Fig. (15) Results of testing zipper sewing with traditional method (sample 1-4), and USW method (sample 1-2)

4.3.3 Results of appearance degree of zipper installation:

The appearance of the zipper was evaluated due to the amount of wrinkle measured using the (Level) method, by presenting the samples executed using traditional sewing and USW to a group of arbitrators to measure the appearance on a scale of 1: 5, where 1 represents the lowest degree and 5 represents the highest degree in evaluating structure appearance of zippers by the traditional and ultrasound methods.

Table (10) Relative differences in appearance level of traditional and USW methods for study samples

Sample Code	Type of Knits	Link Type	Appearance Degree
			Sample 1
1-4	SSA-1(301)	Traditional Weaves SSA-1(301)	20%
2-1	Ultrasonic Welding	Ultrasonic Welding	96%

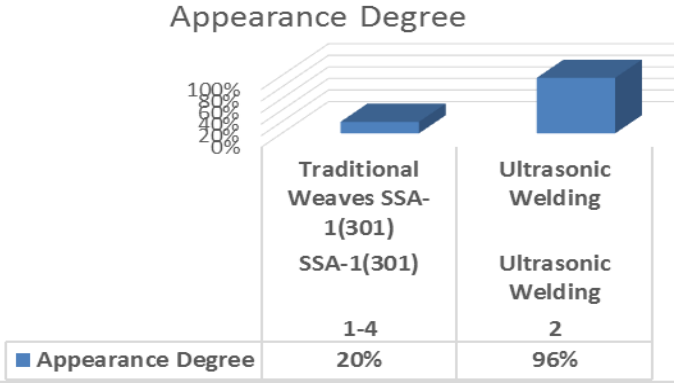


Fig. (16) A graph of the relative differences in appearance level of the traditional and USW sewing methods

4.2.4 AXIS (4): The Results of Achieving the Research Hypotheses, Green Manufacturing:

Table 11 shows a comparison between the quantities of thread consumption in traditional sewing with the sewing machine producing stitch 301 and USW, after applying the law of calculating

the quantities of thread consumption per stitch and the total consumption for the total distance, where the total distance for the length of the zipper was (33 cm), in order to measure the extent of yarn consumption in the SSA-1 (301) stitch-producing sewing machine.

Table (11) Comparison between thread consumption with traditional sewing and USW to achieve green manufacturing

Sample Code	Type of Knits	The Amount of Yarn Consumption of Traditional Knitting
1-4	SSA-1(301)	366,3/ 33 cm
2-1	Ultrasonic Welding (USW)	0

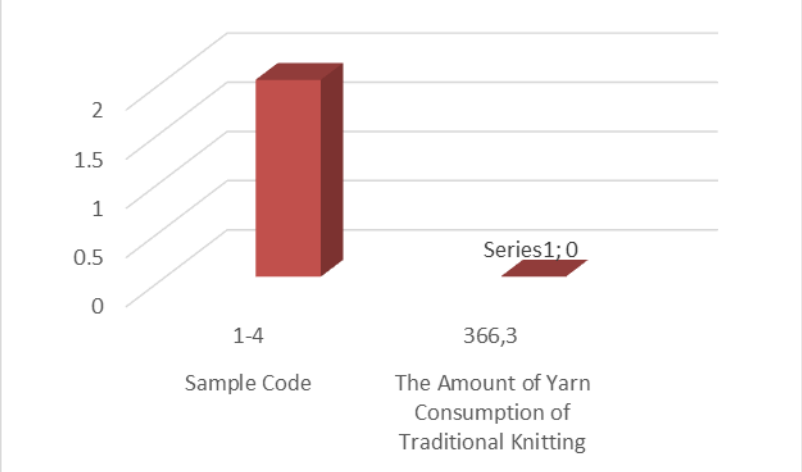


Fig. (17) Results of measuring thread consumption for zipper installation by traditional methods and USW ultrasonic sewing to achieve green manufacturing

Table (11) and Figure (17) show that the use of traditional sewing in sewing the zipper consumes an amount of 366.3 / 33 cm yarns according to the executed sample, while the quantities for installing zipper using USW is 0/33 cm due to the use of the welding method, which confirms the researchers' vision that the use of ultrasonic sewing has many benefits, including:

1- Reducing the economic cost of using threads.
2- Reducing the proportions of exhausts and waste resulting from the use of threads.
3- Improving the outer appearance of garments by using ultrasonic sewing to sew clothing accessories.

5. ANALYSIS AND DISCUSSION OF THE RESULTS:

Knits are the basic requirements in the garment industry in general. The aesthetic and functional form of sewing has a great impact on apparel products. The execution and appearance of knits depend on the stitch and types of knits. Sewing at the present time depends on the uses of advanced technology, whereas the mechanisms of sewing and clothing accessories were done in traditional ways by doing a set of adjustments on sewing machines, including the thread tension regulator, the stitch length regulator, and determining the type of foot that facilitates the sewing operations to install clothing accessories (zipper). Then the era of technologies began with the new millennium, using ultrasonic knitting, as heating mechanisms are adopted in industrial materials. Nine samples of traditional sewing consisting of 3, 4 and 5 stitches / cm with different sewing needle size (12/14/16) were carried out using USW, and preliminary tests were carried out to determine the specifications of the material used (fabric weight, thickness, durability (cm/mg), tensile strength (kg), and elongation (%)).

Parametric tests were carried out after sewing zippers on 9 predetermined samples, and a set of tests related to sewing were determined (tensile strength (kg), efficiency (%), elongation (%), and appearance).

The research proved the existence of differences between sewing methods in favor of USW sewing in terms of tensile strength, elongation and efficiency as shown in Table (8), Figure (14), Table (15) and Figure (16), for sewing garment accessories produced from industrial materials using ultrasonic waves.

A test was conducted for the appearance of the sewing used in the research, and the results showed the efficiency of the appearance of the sewing by ultrasound compared to sewing by the traditional method, as shown in Table (10) and Figure (16).

With a technological analysis to measure the consumption of yarns for the life expectancy of zippers sewn by traditional and ultrasonic methods to achieve green manufacturing by reducing the consumption of yarns and the percentage of environmental waste that occurs as a result of the

use of yarns, as shown in Table (1) classification of clothing industry waste according to the handbook issued by the Environmental Affairs Agency in January 2003.

It is clear from the research that sewing clothing accessories using traditional methods consumes more threads than sewing with USW as shown in Table (11) and Figure (17), which proves the objectives and hypotheses of the research.

6. CONCLUSION

The study demonstrated the differences between traditional sewing and ultrasonic welding [USW], which helped to reduce the use and waste of sewing threads and contribute to environmental preservation. The findings of the research can be implemented in clothing manufacturing facilities to raise the quality of clothing accessories "zippers". To fulfill the objectives of sustainable development and rationalize resource usage, it was suggested to improve the production method without threads in order to achieve green manufacturing. The research reached the following conclusions:

- The use of USW to sew clothing accessories increases the aesthetic aspect of the clothing items.
- Laboratory tests confirm that using USW is safe for clothing accessories.
- USW of clothing accessories increases the strength and efficiency of sewing.

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