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ULTRASONIC WELDING AS SUSTAINABLE TEXTILE JOINING METHOD

Research paper

Ineta Nemeša[1], Marija Pešić[2], Danka Đurđić[3], Valentina Bozoki[4]
[1,2,3,4]University of Novi Sad, Technical Faculty, Zrenjanin, Serbia

Abstract: Ultrasonic technology is successfully used manufacturing wide variety of apparel and technical textile goods.It is suitable for synthetic fabrics due to their low melting points and ability to absorb ultrasonic energy efficiently. Two main types of ultrasonic textile equipment used are: roll seam machines and platen presses. Using ultrasonic technology can be performed textile seam welding, cutting, lamination, punching, embossing, lacing, riveting, inserting. Comparing with traditional sewing method ultrasonic technology can ensure several advantages: higher processing speed, higher strength of seams, and ability to create waterproof and airtight seams. Advantages that support sustainable garment manufacturing goals are: reduced waste and energy use, improved fabric recyclability, improved workplace environments for the industrial workforce.
Key words: textile joining methods, ultrasonic welding, waste reduction, textile recycling

INTRODUCTION

Ultrasonic technology has been used to weld thermoplastic materials in industrial applications since the 1950s. Since then, it is improved and has become an important and widely used industrial process. In nowadays ultrasonic technology is also successfully used manufacturing wide variety of apparel and technical textile goods (Jones, 2013; RINCO Ultrasonics, 2026. -b) (see Fig.1).
By help of ultrasonic equipment water and wind proof seams are created for outdoor and special performance wear. In lingerie, sportswear and seamless underwear this technology creates highly elastic, smooth, threadless seams that significantly improve wear comfort. Hygienic bonding and durability got by help of ultrasound are very important in medical and protective clothing (Hyusonic, 2025).
In the group of technical textile goods: filters, filtration bags, waterproof bags, canvas covers, awnings, tents, geotextiles, car interior trim components, airbags, seat covers, acoustic soundproofing materials and many others products are manufactured using ultrasound technology (Jones, 2013; RINCO Ultrasonics, 2026. -b; Hyusonic, 2025).



a **b**

Fig.1 *Jacket (a) created from textile material embossed by ultrasound (b)*

[1] Corresponding author, inetavil@gmail.com, ORCID: 0000-0003-2552-3097
[2]marija.pesic@uns.ac.rs, ORCID: 0000-0002-3745-7771
[3]danka.dordic@uns.ac.rs, ORCID: 0009-0003-4369-8306
[4]valentina.bozoki@uns.ac.rs, ORCID: 0009-0000-4045-3539

THE MAIN CHARACTERISTICS OF TEXTILE ULTRASOUND WELDING TECHNOLOGY

Ultrasonic textile welding process

Ultrasonic textile welding uses high-frequency acoustic vibrations to generate frictional heat. This heat melts synthetic origin materials, fuse and join them together at the molecular level. The welding process consists on several work steps (Jones, 2013; RINCO Ultrasonics, 2026. -d; Dizo Global, 2026. ; MURISCUT, 2026.):

- ultrasonic generator produces high-frequency sound waves typically in the range of 20–40 kHz.
- The sound waves are directed to processed material through a sonotrode, also called a horn. The sonotrode vibrates at high frequency, creates molecular friction and heat in fabric layers.
- Synthetic fibers soften and melt. The molecules from both layers of material are intermingled by the diffusion process and a weld is formed.
- When ultrasonic vibrations are stopped, the melted materials cool down and create durable bond.

Textile materials used for ultrasonic welding

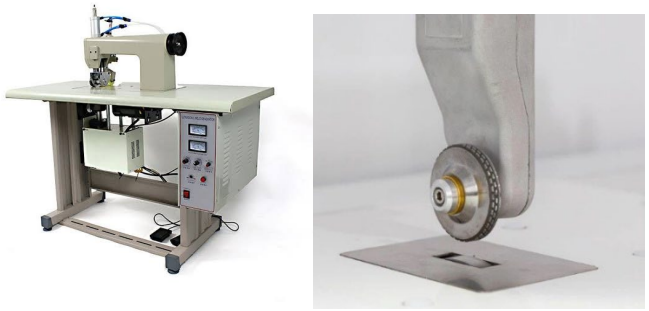
Ultrasonic welding is suitable for synthetic fabrics due to their low melting points and ability to absorb ultrasonic energy efficiently. The most commonly processed materials are: 100% synthetic origin textiles (polyester, nylon, polypropylene, polyvinylchloride, polyethylene, polyurethane, spandex/elastine) and mixed synthetic and natural origin fabrics (textiles with at least 60% synthetic fibers content). Ultrasonic welding cannot be performed for natural origin textiles, glass fibres and high-heat polymers (RINCO Ultrasonics, 2026. -d; MURISCUT, 2026.).

ULTRASOUND TEXTILE WELDING EQUIPMENT

The various types of ultrasonic textile equipment are primarily categorized by how the sonotrode moves related to the material. Two main types are: roll seam machines and platen presses (MURISCUT, 2026. ; Sonomax, 2026.).

Roll seam welding machines (ultrasonic sewing machine)

A machine operates similar to a traditional sewing machine. Continuous weld seams are created by the rotating (driven) circular sonotrode paired with an anvil roller (see Fig.2). As a processed material passes in between a sonotrode and an anvil, vibration created by ultrasonic weaves welds them together. The interchangeable sonotrodes and anvils can be differently designed and patterned to perform seaming, cutting and embossing operations (MURISCUT, 2026. ; Cheersonic, 2026. ; SONOTRONIC, 2024).



a b

Fig.2. *Roll seam welding machine (a) and a circular anvil paired with a sonotrode roller (b)*

Platen ultrasound welding presses

During the work process the textile material is held stationary on a fixed anvil (see Fig.3). The sonotrode of the machine moves downwards to apply pressure and ultrasonic energy and perform the needed operation – welding, cutting or embossing (MURISCUT, 2026. ; Sonomax, 2026.).



Fig. 3. *Platen ultrasound welding presses*

ULTRASOUND WELDING OPERATIONS

Using ultrasonic weave technology can be performed following textile treatment operations: seam welding, cutting, lamination, punching, embossing, lacing, riveting, inserting (MURISCUT, 2026. ; Raytech, 2026. ; RINCO Ultrasonics, 2026. -c).

Seam welding

Ultrasonic seam welding is used to join two or more plays of fabric together. Depending on equipment continuous welds, spot welds and seams of free geometry are created. Continuous welds are processed by roll seam machines. Spot welds and small size welds with a certain fixed geometry are created byplaten welding presses (see Fig.4).



a b

Fig.4. *Continuous welding (a) and spot weld (b)*

Cutting

Ultrasonic technology can be also used to separate thermoplastic materials. In cutting applications a shape of cutting tool is a sharp blade (for roll seam machines), guillotine, or knife-edge. When thermoplastic textiles are cut, their edges are sealed and protected against material frying (6).
Material edge cutting and joining of components can be also performed simultaneously using a roll seam welding machine with a single anvil wheel or a double tool anvil (see Fig.5).

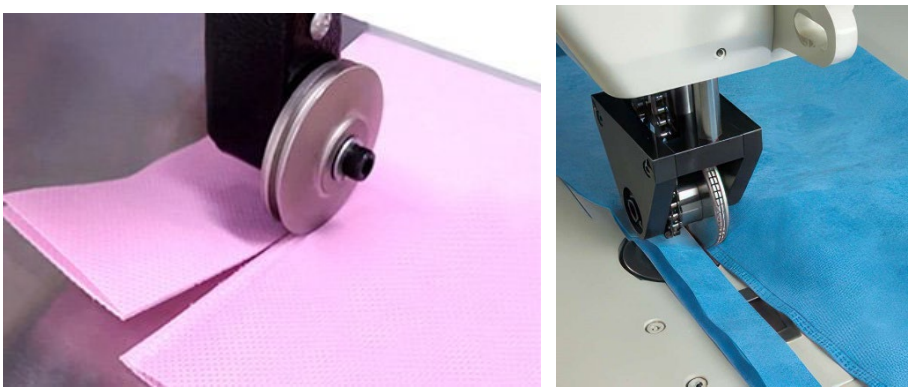


Fig. 5. *Sharp blade anvil wheel of a roll seam machine to cut and join material*

Ultrasonic lamination, embossing and quilting

All three processes refer to continuous joining of multiple flat layers of fabric together across their entire surface to create a single composite material. Often in professional literature terms lamination, embossing and quilting are used with a single meaning. However, there are three different processes.
During the lamination process two or more plays of material is joined in single one. Embossing adds texture to the material surface - three-dimensional patterns or logos. Quilting process connects three material layers - top fabric, filling, and back fabric together and creates a padded composite fabric with 3D texture (MURISCUT, 2026. ; SONOTRONIC, 2026.) (see Fig.6).



Fig.6. *Textile material with embossed pattern (a) and quilted pattern (b)*

Ultrasonic lacing

Ultrasonic textile lacing is a manufacturing process that cuts, joins, and embosses textiles (see Fig. 7). Lace machines can be designed like a traditional sewing machine or wide high productivity special purpose machines (MURISCUT, 2026. ; Alster Industry, 2025).

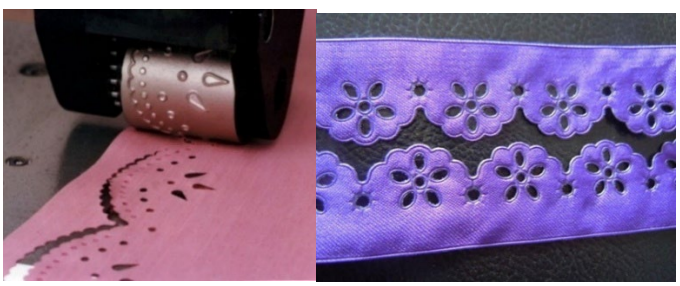


Fig. 7. *Lace formation by an ultrasonic welding machine*

SUSTAINABLE BENEFITS OF TEXTILE ULTRASOUND WELDING

Ultrasonic welding as an alternative to traditional fabric sewing method can ensure several advantages: higher processing speed, higher strength of seams, and ability to create waterproof and airtight seams (Miller Weldmaster, 2025). There are also advantages that support sustainable garment manufacturing goals - reduced waste and energy use, improved fabric recyclability, as well as, improved workplace environments for the industrial workforce (RINCO Ultrasonics, 2026. -b; Sonic Italia, 2026. ; Sonomax, 2026.).

Reduced use of raw materials and their potential waste

Reduced use of auxiliary materials

Sewing threads and chemical adhesives used by other textile joining methods are not needed performing ultrasonic welding. The components are mutually joined in molecular level by help of ultrasonic energy only.

Reduced amounts of chemical origin waste

Not using sewing threads and chemical adhesives in textile component join process, their production and further chemical waste at the end of the life cycle of textile goods is lowered.

Waterproof and airtight seams without use of auxiliary materials

By help of ultrasonic welding technology seams can be created fully waterproof and even airtight. Using traditional sewing method a needle makes holes in processed material and a seam created by threads is not air and waterproof. Additional work steps, equipment and auxiliary materials (tapes, glues, equipment, and energy) are used to create fully sealed seams (Hyusonic, 2025).

Less waste from used ultrasonic equipment

Ultrasonic welding equipment has less mechanical parts comparing with standard sewing machine. No needles, drive belts, tension mechanisms that can wear out, have to be changed and at the end of their use wasted.

Improved recyclability of textile goods

Sorting of textile waste on the bases of their fiber origin, separation of contaminants like zippers, buttons, and labels is the first and very important work step performing textile chemical recycling process. The quality of regenerated fibers obtained in chemical recycling process depends on a large extent on purity of textile waste processed.
Recycling of textile goods manufactured by ultrasonic technology (cutting and joining their components) gives higher quality regenerated raw material as they do not contain mixed origin materials - different origin thread types and glues which are used in traditional sewing process and are impossible to separate from textile goods before their recycling (Nemeša et al., 2024; Nemeša et al., 2025).

Sustainable energy practices

Only molecule frictional heat is generated

The ultrasonic technology uses high-frequency mechanical vibrations to generate localized molecular friction directly inside the synthetic fibers, meaning it does not waste energy heating the entire equipment or ambient air.

Extra work steps are eliminated

Ultrasonic welding equipment can cut, seal, and join synthetic textiles in a single work step, without need for secondary finishing or thermal sealing operations that consume extra energy.

Higher processing speed

Ultrasonic welding is up to 70–80%faster than traditional sewing. It can ensure joining of 10 to 20 meters per minute while sewing typically can reach 3 to 6 meters per minute. Reducing processing time, energy consumption spend to manufacture a single textile product is reduced too (Miller Weldmaster, 2025).

Improved workplace conditions for the workers

Work environments with reduced contaminant levels

Performing ultrasound cutting thermoplastic textiles melt and their edges are sealed. This prevents dust generation during cutting process of textile material, as well as, during other manipulations with cut components as fabric edges cannot fry anymore (Nemeša et al., 2024). The same time, there is no contamination of half-finished and ready textile goods and production premises with sewing thread ends and fried fibers of textile materials as they do not exist in the manufacturing process.

No hazardous evaporations

As processing airtight and waterproof seams chemical adhesives are not used, their evaporations cannot contaminate environment.

No temperature increase

Using ultrasound technology the heat is generated locally - only inside the processed workpieces by help of high-frequency mechanical vibrations and friction. The welding tools (a sonotrode, an anvil or others) do not heat up. Thus there is no temperature increase in environment because of heated up work process machinery.

A lower-stress work environment for machine operators

As material joining is performed without sewing threads, tapes, glues there is no needed additional attention of the operator for thread and a tape fixing, changing during the working hours. Accidental thread breakage, seam quality problems connected with of threads and their sewing parameters does not exist. Operators of welding machines work in more relaxed conditions with less mental tension.

CONCLUSION

Ultrasonic welding has become important textile goods manufacturing method that can ensure several important advantages comparing with other traditional textile joining methods, such as, sewing, fusing, thermal welding, laser cutting, others. The wide application of ultrasound technology mostly is based on its ability to ensure very high processing speeds and with it high productivity, high quality of created seams and current wide use of thermoplastic textiles in different industries.
Additionally, ultrasonic technology facilitates sustainable manufacturing practices, aligning with the heightened industrial demand seen over the last ten years – reduction of raw material use, textile waste, and energy consumption.

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