Evaluation of bending rigidity behaviour of ultrasonic seaming on woven fabrics

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Abstract. In recent years ultrasonic seaming that is shown as an alternative method to conventional seaming has been investigated by many researchers. In our study, bending behaviour of this alternative method is examined by changing various parameters such as fabric type, seam type, roller type and seaming velocity. For this purpose fifteen types of sewn fabrics were tested according to bending rigidity test standard before and after washing processes and results were evaluated through SPSS statistical analyze programme. Consequently, bending length values of the ultrasonically sewn fabrics are found to be higher than the bending length values of conventionally sewn fabrics and the effects of seam type on bending length are seen statistically significant. Also it is observed that bending length values are in relationship with the rest of the parameters excluding roller type.

1. Introduction

Apparel industry enhancing the added value of products is one of the sectors which has major importance. Various seaming methods are used in conversion into final product of different fabric surfaces produced by different methods. However, seaming process of some types of textile products which requires functional specifications is in need of alternative seaming methods besides conventional seaming methods. One of these alternative methods is ultrasonic seaming which have been used for almost 20 years and was studied intensively and got attention over the past decade.

Ultrasonic seaming method is not only an energy saving method, but also it can perform sewing process without the need for the materials such as needle, thread that have been used in the conventional seaming methods. Ultrasonic seaming is used in wide range of industries such as technical textiles, medical, filtration and automotive [1, 2].

Many studies related to ultrasonic seaming have been made up to date [3-9]. There are studies examining the bending rigidity in these studies. Bending rigidity is very important property in terms of fabric handle [10]. This property is related to fabric stiffness and they are proportional to each other [11]. In Reddy's (2007) study, the effects of various production parameters and material properties on sewing efficiency and fabric stiffness were examined on ultrasonic seaming and compared with conventional seaming. It has been determined that fabric stiffness is higher in ultrasonic seaming when using 100% polyester, 65/35% polyester/cotton and 100% Spectra as material [12]. Appleby (2009) compared conventional and ultrasonic seaming regarding seam strength and stiffness. 100% polyester fabric was used in the study. It is stated that the stiffness of ultrasonic seaming is higher than the stiffness of conventional seaming. High stiffness can be shown as an advantageous feature in sailing and sportswear [13]. Jevsnik et al. (2015) investigated ultrasonic seaming from an aspect of bond strength, seam thickness, seam stiffness and water permeability properties by comparing conventional
They observed that conventional seaming had lower stiffness in comparison to ultrasonic seaming [14].

Our study aims to compare ultrasonic seaming and conventional seaming by using woven fabrics coated with polyurethane membrane which are used as blouson. Fifteen types of sewn fabric were gained by changing the parameters of seaming such as roller type and seaming velocity. Bending length values of the sewn fabrics were compared.

2. Material and Method

In this study, conventional seam and ultrasonic seam were applied to three different woven fabrics and fifteen types of sewn fabric were gained. The properties of fabrics and the seam parameters are characterized in Table 1.

| Fabric code | Weaving structure | Weight in grams per square meter (g/m²) | Thickness (mm) | Raw material | Seam type | Roller / velocity code | Sewn fabric code |
|-------------|-------------------|-----------------------------------------|----------------|--------------|-----------|------------------------|-----------------|
| F₁          | Plain             | 105                                     | 0.366          | Polyester    | Ultrasonic | r₁v₁                   | F₁₁₀v₁         |
| F₁          | Plain             | 105                                     | 0.366          | Polyester    | Ultrasonic | r₁v₂                   | F₁₁₀v₂         |
| F₁          | Plain             | 105                                     | 0.366          | Polyester    | Ultrasonic | r₂v₁                   | F₁₁₀v₁         |
| F₁          | Plain             | 105                                     | 0.366          | Polyester    | Ultrasonic | r₂v₂                   | F₁₁₀v₂         |
| F₂          | Plain             | 170                                     | 0.432          | Polyester    | Ultrasonic | r₁v₁                   | F₂₁₀v₁         |
| F₂          | Plain             | 170                                     | 0.432          | Polyester    | Ultrasonic | r₂v₁                   | F₂₁₀v₂         |
| F₂          | Plain             | 170                                     | 0.432          | Polyester    | Ultrasonic | r₂v₂                   | F₂₁₀v₂         |
| F₂          | Plain             | 170                                     | 0.432          | Polyester    | Ultrasonic | r₂v₂                   | F₂₁₀v₂         |
| F₃          | Twill             | 170                                     | 0.540          | Polyester    | Ultrasonic | r₁v₁                   | F₁₁₀v₁         |
| F₃          | Twill             | 170                                     | 0.540          | Polyester    | Ultrasonic | r₂v₁                   | F₁₁₀v₂         |
| F₃          | Twill             | 170                                     | 0.540          | Polyester    | Ultrasonic | r₂v₁                   | F₁₁₀v₂         |
| F₃          | Twill             | 170                                     | 0.540          | Polyester    | Ultrasonic | r₂v₂                   | F₁₁₀v₂         |
| F₁          | Plain             | 105                                     | 0.366          | Polyester    | Conventional | Lock stitch | F₁₁₀v₁         |
| F₂          | Plain             | 170                                     | 0.432          | Polyester    | Conventional | Lock stitch | F₁₁₀v₂         |
| F₃          | Twill             | 170                                     | 0.540          | Polyester    | Conventional | Lock stitch | F₁₁₀v₂         |

Fabric samples were prepared along the warp direction. Ultrasonic seam process was performed by using Pfaff 8310 ultrasonic sewing machine. Amplitude of the machine was 100% during the sewing process. Two different speeds were performed as 25 dm/min (v₁) and 45 dm/min (v₂). Two rollers were used that across 4 mm (r₁) and 12 mm (r₂) which have the same pattern as shown in Figure 1. Conventional seam process was performed to woven fabrics by using Brother S-7200C-403 electronic lock stitch sewing machine. Stitch length was 2.6 stitches/cm.

All of the sewn fabrics were washed at 30°C with synthetic washing programme without prewashing by using home laundry machine according to TS 5720 EN ISO 6330:2002 test standard [15], 4 g/l ECE non-phosphate reference detergent without optical brightening agent was used for washing processes. Washing process was repeated for five times.
Bending rigidity tests were performed to fabrics before and after washing processes with the instrument designed for bending rigidity test method according to TS 1409:1973 [16]. Five samples were prepared from each sewn fabric having dimensions 2.5x15 cm. The samples were conditioned for 24 hours in standard atmospheric conditions (temperature 20±2 °C and relative humidity 65±2%). The conditioned samples were then tested for both faces and both sides. Twenty falling length values were read on the instrument and the average of these twenty values was divided into two to obtain the bending length value for each sewn fabric. Bending rigidity is formulated in TS 1409:1973 as follows:

\[ G = 0.1 \times W \times C^3 \]

where:
- X = Falling length (cm)
- C = X/2 = Bending length (cm)
- W = Fabric mass per unit area (g/m²)
- G = Bending rigidity (mg.cm)

In the standard TS 1409, bending rigidity is calculated according to above equation for a single layer fabric without any seam. However we used sewn fabrics in our study so we have compared the fabrics in terms of bending length values. Test results evaluated considering fabric type, seam type, roller type, seaming velocity and washing process. To evaluate the importance of test results, SPSS 13.0 programme was used with the analysis of variance (ANOVA). In this way the effects of fabric type, seam type, roller type, seaming velocity and washing process on bending length were analyzed.

3. Results
Bending length values of the ultrasonically and conventionally sewn fabrics before and after washing processes were given in Table 2 and Table 3, respectively.

**Table 2.** Bending length (cm) values of the ultrasonically sewn fabrics before and after washing processes.

| Fabric | R1V1 Before washing | R1V1 After washing | R1V2 Before washing | R1V2 After washing | R2V1 Before washing | R2V1 After washing | R2V2 Before washing | R2V2 After washing |
|--------|---------------------|-------------------|---------------------|-------------------|---------------------|-------------------|-------------------|-------------------|
| F1     | 3.94                | 3.34              | 3.80                | 3.27              | 3.75                | 3.18              | 3.55              | 3.09              |
| F2     | 4.82                | 4.45              | 4.23                | 4.30              | 5.03                | 4.09              | 4.97              | 4.03              |
| F3     | 6.02                | 4.71              | 6.09                | 4.43              | 6.25                | 4.89              | 5.85              | 4.77              |
Table 3. Bending length (cm) values of the conventionally sewn fabrics before and after washing processes.

| Fabric | Before washing | After washing |
|--------|----------------|--------------|
| F1     | 3.03           | 2.92         |
| F2     | 3.28           | 3.20         |
| F3     | 3.72           | 3.62         |

Considering the obtained bending length values; ultrasonically sewn fabrics’ values are found to be higher than that of conventionally sewn. It is observed that the results obtained from the view point of seam type in this research, are in accordance with the studies about bending rigidity of ultrasonic seaming [12, 13, 14]. Taking into account the highest bending length value observed in the ultrasonic seams for each type of fabrics, the bending length value of conventional seam increased by 30% for the F1 fabric, 53% for the F2 fabric and 68% for F3 fabric before washing processes. After washing processes, the amount of these increments varied by 14%, 39% and 35%, respectively. The results show that the impact level of seam type on bending length values varies according to fabric structure.

It is observed that for both of the seam types, before and after washing processes bending length values of F1, F2 and F3 fabrics increases respectively. F1 fabric is lighter in weight than the others so weight increment has an increasing effect on bending length values. Bending property is in interaction with weight of fabric [17]. F2 and F3 fabrics have same weight in grams per square meter and their constructions are plain and twill, respectively. Twill fabric F3 has higher bending value so fabric structure seems to be effective on bending length. Examining Table 4, the differences of bending length values between fabrics are statistically significant.

Table 4. The effects of fabric type on bending length values (Post Hoc).

| Fabric type | N   | Subset   |   |   |   |
|-------------|-----|----------|---|---|---|
|             |     | 1        | 2 | 3 |
| F1          | 48  | 3.3798   |   |   |   |
| F2          | 49  | 4.2404   |   |   |   |
| F3          | 50  | 5.0360   |   |   |   |
| Sig         |     | 1.000    | 1.000 | 1.000 |

Washing process has a decreasing effect on bending length values for both of the ultrasonically and conventionally sewn fabrics. The effects of washing process, seam type and fabric type are found statistically significant on bending length as seen in Table 5.

Table 5. The analysis of variance table for bending length values of the sewn fabrics.

| Factor               | F     | Significance |
|----------------------|-------|--------------|
| Washing process      | 19.098| 0.000*       |
| Seam type            | 43.699| 0.000*       |
| Fabric type          | 64.493| 0.000*       |
| Roller type          | 0.007 | 0.933        |
| Seaming velocity     | 1.362 | 0.246        |

*: Statistically significant for $\alpha = 0.05$
From the standpoint of seaming velocity, it is clear that generally bending length values and seaming velocity are inversely proportional for ultrasonic seam. It is known that ultrasonic seam has an increasing effect on fabric stiffness. Fabric exposes to welding longer time at lower ultrasonic seam velocity. Therefore higher bending length values were obtained at lower seam velocity as expected. On the other hand the effect of velocity on bending length is found statistically insignificant for all fabrics as shown in Table 5. Comparing roller type, bending length values of the ultrasonically sewn fabrics don’t demonstrate regular changes between roller types before and after washing processes and the effect of roller is found statistically insignificant for all fabrics (Table 5).

4. Conclusion

In this study, ultrasonic and conventional seaming were performed to polyester woven fabrics coated with polyurethane membrane which are used as blouson. The effect of ultrasonic seaming parameters and fabric structure on bending property were investigated. The following conclusions can be drawn on the basis of the study:

- Our study demonstrated that bending length values of the ultrasonic seams are higher than the conventional seams in polyester woven fabrics coated with polyurethane membrane.
- In ultrasonic seam process, bending length values decreased with the increase of seaming velocity but no generalization could be made for roller type.
- It is clear from the results that bending length values decreased with reducing of fabric weight. On the other hand, these values in twill structure are superior to plain structure at equivalent weight in grams per square meter. Therefore it can be concluded that fabric structure affected bending length values.
- In addition, bending length values decreased after washing process for both ultrasonic seam and conventional seam.
- After all, the effects of fabric type, seam type and washing process on bending length are found statistically significant, but the effects of roller type and seaming velocity on this property are found statistically insignificant for all fabrics.

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