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Investigation on the tension and stretch distributions of textile assembled with seam in virtual garment simulation

Sanal giysi simülasyonunda dikişle birleştirilmiş tekstillerin gerilme ve esneme dağilimlarinin incelenmesi

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Abstract

In decade, clothing comfort and sustainability has attracted more attention in the clothing industry. Garment fit is a key factor of clothing comfort. The garment fit of the assembled garment mostly depends on fabric properties and the elasticity of the seam. Assembling the fabrics in clothing manufacturing is usually provided with sewing process. Durability required for sustainability of a textile item, depends on the strength of seam and efficiency of the sewing process, as well as on the properties of fabrics. The seam is mostly not enduring part because it is located at the joint part of garment where is exposed to multiaxial forces. Therefore, the tension and stretch values causing deformation in garment and nearby seam line should be given importance. This study aimed to investigate the tension and stretch distributions of the sewn garment pieces in Virtual Garment Simulation. Four different sewn garment pieces were created in Virtual Garment Simulation according to their mechanical properties. A non-contact assessment method was obtained by combining Virtual Garment Simulation and Image Analysis. The tension and stretch distributions maps were compared and analyzed.

Keywords: Seam, Virtual garment, Comfort, Sustainability, Sewn garment

Öz

Son on yılda giyim konforu ve sürdürülebilirlik, giyim endüstrisinde daha fazla ilgi görmektedir. Giysinin vücuda oturması, giysi konforunun önemli bir faktörüdür. Birleştirilen giysinin vücuda uyumu çoğunlukla kumaş özelliklerine ve dikişin esnekliğine bağlıdır. Konfeksiyon imalatında kumaşların birleştirilmesi genellikle dikim işlemi ile sağlanmaktadır. Bir tekstil ürününün sürdürülebilirliği için istenen dayanıklılık, kumaşın özelliklerine olduğu kadar dikişin sağlamlığına ve dikiş işleminin verimliliğine de bağlıdır. Dikiş, giysinin çok eksenli kuvvetlere maruz kalan birleşim kısmında yer aldığı için çoğunlukla dayanıklı değildir. Bu nedenle giyside ve dikiş çizgine yakın yerlerde deformasyona neden olan gerilim ve esneme değerlerine önem verilmelidir. Bu çalışma, Sanal Giysi Simülasyonunda dikilmiş giysi parçalarının gerilim ve esneme dağılımlarını araştırmayı amaçlamıştır. Sanal Giysi Simülasyonunda mekanik özelliklerine göre dört farklı dikilmiş giysi parçası oluşturulmuştur. Sanal Giysi Simülasyonu ve Görüntü Analizi birleştirilerek temassız bir değerlendirme yöntemi elde edilmiştir. Gerilim ve esneme dağılım haritaları karşılaştırılmış ve analiz edilmiştir.

Anahtar kelimeler: Dikiş, Sanal giysi, Konfor, Sürdürülebilirlik, Dikişli giysi

1 Introduction

Sewing process is a complicated production section in garment manufacturing. During sewing process, the textile material to be assembled is exposed to many mechanical deformations (bending, shear, stress, strain) [1]. In this case, fabric properties (composition, structure, thickness, tensile etc.) effect sewing process and efficiency [2]. Seam stability depends on the bending and shear rigidity of material and the deformation of sewn fabrics during sewing process [3-4]

Stretch fabrics are more preferred in casual wear with its comfortable body fitting structure. A stretch garment would adapt to the movements of the wearer and is subjected to some forces while this adaptation to the body. The tension in the fabric that occurs at taking shape also causes stretching of the seams [5]. The seams are not enduring part of garment because they are located at the joint parts of garment where the multiaxial forces are occurred [6-7]. High stretching of the seams would cause a seam deformation and defect spots in garment. So, it is important to acquire a sufficient tension and stretch distribution on garment.

Virtual garment simulations have become a part of design and marketing from personal use to professional designs. It provides the textile producers and fashion designers with benefits in terms of product variety, giving fast result and not consuming time. When the literature studies are examined, it is seen that the simulations in which the fabric mechanical and physical properties are defined, present a great virtual realism [8-10].

Rogina-car et al., investigated mechanical properties of sewn woven fabric used for male jacket in different test conditions. By preloading the seam fabrics for a 3-h period, the effect on mechanical properties were tested and the differences in pre-stretching intensity and stress distribution were observed because of various material properties (fabric structure, seam properties, material properties) [11].

Lange et al., investigated the influence of the material type in fabric and fabric cutting direction on the strength of upholstery covers. They managed an objective evaluation of the strength of fabric to identify the most optimal fabric–seam joints. They obtained that the material type and sample cutting direction effect the strength of upholstery cover and seam failure form [12].

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Admassu et al., researched the effect of fabric structure, sewing yarn seam types, type of needle on sewing performance. They investigated the effect of these parameters on different weft knitted fabrics. They observed that the structure and type of fabric have considerable influence on seam strength and sewing performance [13].

İftikhar et al., researched the influences of fabric structural and sewing parameters on the seam strength and sewing performance. They found that weave design significantly affects the seam strength and the direction of stitch is most important for seam efficiency [14].

Kara evaluated the influence of different stitch types and their combinations on the workwear seam strength and efficiency. They observed that both fabric strength and seam properties are affected from the yarn and fabric structural parameters in warp and weft directions [15].

Gribaa et al., investigated the effect of sewing process on the tensile behavior of a sewn textile when sewing yarn, seam density, seam type, needle properties would be changed. In this experimental research, it verified the high influence of yarn type in seam and showed the relations between factors in sewing process, especially that the relation between stitch density and the edge of seam would be important [16].

From literature review, it is observed that fabric structural and sewing parameters have great influence on the seam strength and sewing performance. In literature experiments, they showed that mechanical measurement of textile assembly (assembly with seam) would be time-consuming, high cost and hard to repeat. In this study, a non-contact assessment method was obtained by combining Virtual Garment Simulation and Image Analysis The tension and stretch distributions maps were compared and analyzed.

2 Materials and Methods

2.1 Materials

Four stretch warp knitted fabrics consisting of polyamide, polyester and elastane fibres were provided from sports garment supplier. The fabric weights were determined according to the TS 251 standard. The fabric thicknesses were determined according to ASTM D1777-96 standard. Their Characteristics are given in Table 1.

Table.1. Characteristics of fabrics

Fabric Code	Materials	Structure	Weight (g/m^2)	Thickness (mm)
A	75% polyester, 25% elastane	warp knitted	160	0.35
B	70% polyamide, 30% elastane	warp knitted	170.7	0.45
C	90% polyester, 10% elastane	warp knitted	195.7	0.40
D	80% polyamide, 20% elastane	warp knitted	336.1	0.75

2.2 Methods

Fabric mechanical properties have been measured in Fabric Assurance by Simple Testing (FAST) system. The fabrics have been conditioned and measurements were performed in a standard laboratory environment.

The fabric parameters: weight, thickness, tensile, bending and shear rigidity converted via Fabric Editor (Figure 1) were inputted into the Virtual Garment Simulation's database to simulate the fabric behaviours properly.

Figure 1. Fabric Editor converting the fabric parameters (showing the fabric parameters for Fabric code A)

Four garment pieces were created in sleeve forms to simulate and predict fabric dynamic behaviours via Virtual Garment Simulation. In figure 2, it shows the garment piece in sleeve form and the cylinder that would be worn with garment piece. The cylinder has a height of 30 cm, perimeter around cylinder is 23.17 cm and its radius is 3.69 cm.

Figure 2. The garment piece in sleeve form and the cylinder

3 Results

The fabric measurements (Bending rigidity, shear rigidity and tensile strain) measured in FAST testing system were shown in Table 2.

Table 2. The fabric measurements measured in FAST testing system.

Fabric code	Bending rigidity B, 10^{-6} Nm		Shear rigidity G, N/m		Tensile strain E100 %	
	column	row	column	row	column	row
A	1.58	0.48	56.1	56.1	51.0	114.0
B	1.26	0.78	55.2	55.2	70.6	86.3
C	4.70	4.00	211.1	211.1	31.6	56.3
D	19.23	3.82	146.4	146.4	49.0	18.8

Four garment pieces in sleeve form were created respectively. They were worn around the cylinder and their tension and stretch maps showing the distribution on garment surfaces were obtained via Virtual Garment Simulation (Optitex). The colors changing blue (low) to red (high) gradually in tension and stretch distribution represent the changes (low to high) of tension and stretch value.

The proportion of coloured areas (%) in tension and stretch distribution map were measured via Image Analysis (Digimizer).

The tension distribution in Y direction on each fabric surface (fabric code A-B-C-D respectively) were shown in Figure.3.

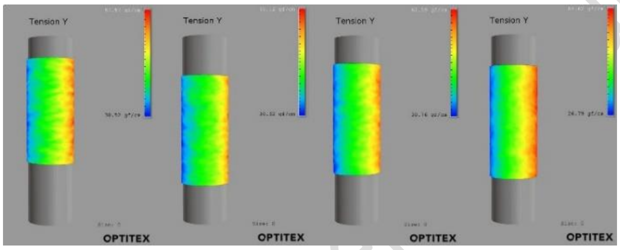

Figure 3. Tension distribution on fabric surfaces

The stretch distribution in Y direction on each fabric surface (fabric code A-B-C-D respectively) were shown in Figure.4.

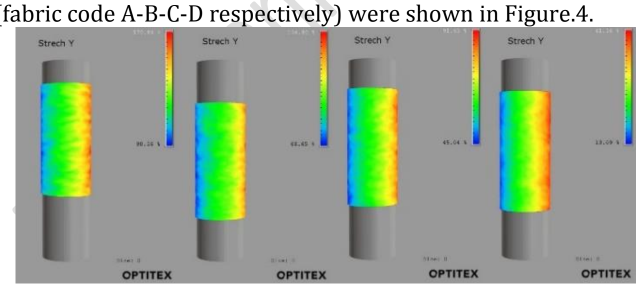

Figure 4. Stretch distribution on fabric surfaces

The proportion of colored areas (%) in tension distribution map shown in Figure 3. on each fabric surface (fabric code A-B-C-D respectively) were shown in Figure 5.

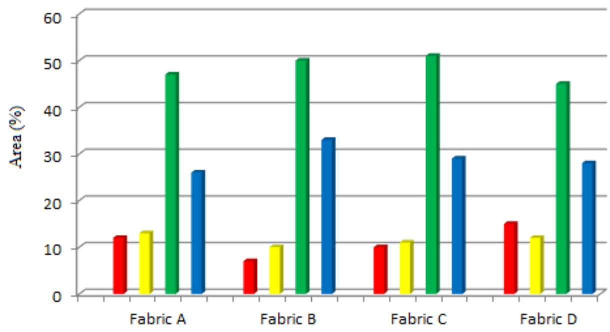

Figure 5. The proportion of colored areas (%) in tension distribution map

The proportion of coloured areas (%) in stretch distribution map shown in Figure 4. on each fabric surface (fabric code A-B-C-D respectively) were shown in Figure 6.

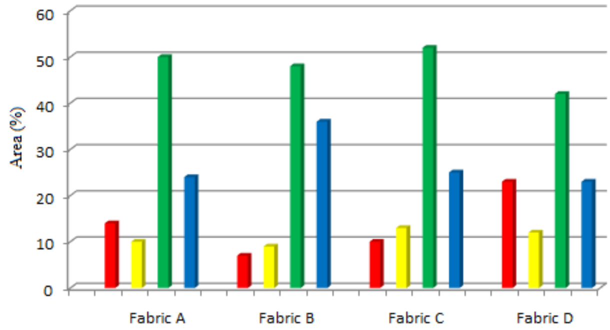

Figure 6. The proportion of colored areas (%) in stretch distribution map

4 Discussion

The seam is mostly not enduring part because it is located at the joint part of garment where is exposed to multiaxial forces. As seen in tension and stretch maps for all fabrics, the distribution having highest values (red colored area) was obtained nearby the seam line. The high values nearby seam line means that it would force the seam to deform.

The highest value of tension in Y direction and the proportion of red colored areas (%) in tension distribution map were obtained in Fabric code D because of its high bending rigidity and low tensile stain. Fabric code D has high fabric weight and fabric thickness, so it caused lowest fabric performance. For other remaining fabrics, almost the same tension values were seen nearby seam line. But a smaller proportion of red colored area (%) in tension distribution map was obtained nearby seam line for Fabric code B because of its low bending and shear rigidity.

The highest value of stretch in Y direction was obtained in Fabric code A because of its high tensile stain. Fabric code A has low fabric weight and fabric thickness, so it enables high stretch. Fabric code D shows the lowest value of stretch in Y direction and a bigger proportion of red colored areas (%) because of its high bending rigidity and low tensile stain.

5 Conclusion

Assembling the fabric in clothing manufacturing is usually provided with sewing process. Seam line is usually not enduring location on the clothing, especially when the uniaxial or multiaxial forces are present at that location. Durability required for sustainability of a textile item, depends on the strength of seam and efficiency of the sewing process, as well as on the properties of fabrics.

In this study, a non-contact assessment method was established by combining Virtual Garment Simulation and Image Analysis in such a way to consider how the fabric properties affect the tension and stretch distribution nearby fabric–seam joints. The results verified the investigations done in the past researches. But it still has some deficiencies because virtually all 3D garment simulations disregard most of the mechanical behavior of seams, and just use them simply as joint edge. Nevertheless, this assessment method can give us information about seam strength, durability and to improve the virtual accuracy in Virtual Garment Simulation.

6 Author contribution statements

Author 1 contributed to the article by establishing a non-contact assessment method to eleminate the disadvantages of mechanical assessment in experiments and tests, evaluating the results and writing the manuscript.

7 Ethics committee approval and conflict of interest statement

"There is no need to obtain permission from the ethics committee for the article prepared".

"There is no conflict of interest with any person / institution in the article prepared".

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