innoTRAC Journal
Volume 3 (2024), pp. 102–107
https://doi.org/10.14464/innotrac.v3i1.787

Rapid testing of textile structures with TSA and DynaWash

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Received 16 September 2024; Accepted 16 September 2024; Available online December 2024

ABSTRACT The rapid and precise evaluation of textile structures is crucial to ensuring quality and functionality across various industries, including fashion, automotive interiors, and healthcare. This study explores the use of the Tactile Sensation Analyzer (TSA) and DynaWash system for testing textiles under different conditions. The TSA objectively measures key tactile properties such as softness, roughness, and stiffness, providing an accurate representation of how textiles will feel in real-world applications. The DynaWash system simulates repeated washing cycles, assessing the durability and resilience of textiles by replicating mechanical stresses over time. Tests conducted include measurements of tensile strength before and after washing cycles, with textiles being stretched to their breaking point using a tensile testing machine. The results indicate that textiles subjected to the DynaWash process retain high tensile strength and demonstrate significant resistance to wear and deformation. This combination of rapid testing methods contributes to improving sustainability by optimizing textile production processes, reducing resource consumption, and ensuring long-lasting product quality. The findings provide valuable insights into enhancing textile performance for industrial and commercial applications.

KEYWORDS textile testing, TSA, DynaWash, tensile strength, durability, sustainability

1. Introduction

Textiles play a critical role in a wide array of industries, including fashion, automotive interiors, and medical applications, where the quality and longevity of materials are paramount. Ensuring the durability and maintaining the tactile properties of textiles are essential factors in meeting industry standards for functionality, comfort, and aesthetic appeal. Traditional textile testing methods, while effective, often lack the precision and speed required to meet the demands of modern manufacturing processes.

Recent advancements in textile testing technologies, such as the Tactile Sensation Analyzer (TSA)(Fig. 1) and the DynaWash (Fig. 2) system, offer new opportunities to evaluate textile properties more efficiently and accurately. The TSA objectively measures tactile properties like softness, roughness, and stiffness, parameters that were previously difficult to quantify with consistency. On the other hand, the DynaWash system simulates mechanical stresses caused by repeated washing cycles, allowing manufacturers to predict a textile's performance and durability over its lifecycle.

This study aims to assess the performance of these advanced testing methods in both enhancing textile quality and supporting sustainability initiatives by reducing resource consumption. By applying these technologies, we aim to bridge the gap between tactile performance, mechanical durability, and sustainability. The findings presented in this work could provide valuable insights into optimizing textile production, ensuring both high-quality outputs and minimal environmental impact.

2. Methods

2.1. Testing Protocols

This study utilized the Tactile Sensation Analyzer (TSA) and DynaWash systems to evaluate the tactile properties and durability of textiles. Each system focuses on different aspects: the TSA measures haptic parameters (softness, roughness, and stiffness), while the DynaWash assesses the mechanical durability of textiles through simulated washing cycles.

2.1.1. TSA Testing Method

The Tactile Sensation Analyzer (TSA) utilizes a two-step process to evaluate key haptic parameters of textiles: sound analysis and deformation measurement, providing a comprehensive assessment of softness, roughness, and stiffness.

Step 1: Sound Analysis

The first stage of the TSA process involves measuring roughness (TS750) and softness (TS7) through the analysis of vertical and blade vibrations, respectively.

- Roughness (TS750): The vertical vibration of the textile sample is directly influenced by its surface structure. Rougher surfaces produce higher levels of vibration, which the TSA quantifies to provide an objective roughness value (Fig. 3).
- Softness (TS7): Blade vibrations are used to measure softness. The softness of the fibers affects the blade's movement, with softer materials generating more vibration. This allows for precise softness quantification (Fig. 4).

The results of this sound analysis are presented on a noise spectrum, where the y-axis indicates noise intensity and the x-axis represents frequency. Peaks in the spectrum correspond to the measured roughness and softness values (Fig. 5).

Step 2: Deformation Measurement

The second stage of TSA testing involves measuring in-plane stiffness (D) through controlled deformation of the fabric.

- In-plane stiffness (D): The depth of deformation is recorded when mechanical pressure is applied to the textile. Stiffer fabrics show less deformation, providing a clear indication of the material's resistance to folding or handling (Fig. 6).

By analyzing the roughness, softness, and stiffness values, the TSA provides an objective Hand Feel (HF) score, which reflects the material's tactile properties and can be correlated with human perception. This systematic approach offers precise and repeatable results, making it more reliable than traditional hand-feel evaluations.

2.1.2. DynaWash Testing Method

The DynaWash system simulates multiple washing cycles to test the durability of textiles under conditions of mechanical stress. It is particularly useful for evaluating the effects of repeated laundering on fabric performance. Key parameters tested include:

- Water temperature and time control: The system heats water to a predefined temperature and agitates the fabric using an impeller. This simulates the mechanical agitation found in standard washing machines.
- Mechanical stress simulation: By replicating the stresses of washing, the DynaWash tests how well textiles maintain their integrity under long-term use. The system measures changes in fabric properties after multiple wash cycles.

Relevant tests conducted using the DynaWash include:

- Print durability: Evaluates how well printed designs remain intact after multiple washes.
- Pleat retention: Assesses whether pleats or folds hold their shape after repeated laundering.
- Wrinkle and pucker resistance: Measures the fabric's ability to resist wrinkling and puckering after mechanical agitation.
- Differential shrinkage: Tests for inconsistencies in shrinkage across different sections of the fabric, ensuring the material retains its size and shape uniformly

2.2. Figures, Tables and Equations

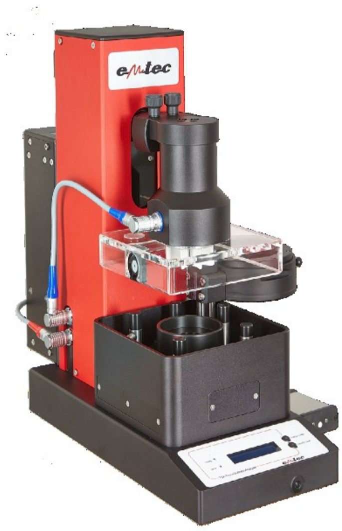

Figure 1: TSA - Tissue Softness Analyzer from emtec

Figure 2: Dynawash from James Heal

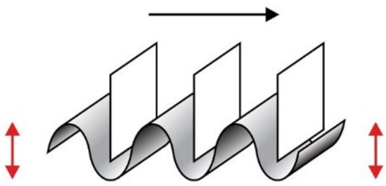

Figure 3: This isvertical vibration of tissue samples varies according to surface structure / roughness (TS750).

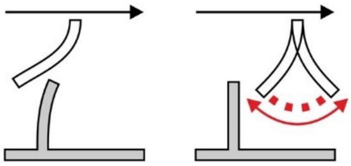

Figure 4: Blade vibration varies according to fiber softness (TS7).

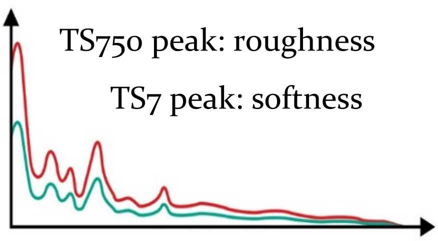

Figure 5: The noise spectrum shows the results of the sound analysis. y: noise intensity x: frequency

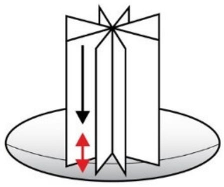

Figure 6: The deformation depth varies according to the in-plane stiffness.

3. Results

The results from both the TSA and DynaWash testing systems provided clear insights into the textile samples' performance, particularly in their tactile properties and long-term durability. The Tactile Sensation Analyzer (TSA) revealed key differences in how fabrics felt to the touch, providing objective data for what is traditionally considered a subjective experience. The TSA successfully quantified the softness and roughness of the materials, correlating these measurements with the way humans typically perceive textiles. This analysis proved particularly useful, as the variation in softness and roughness across the different samples was significant, and the TSA was able to isolate these factors, giving a clear picture of how each textile would feel in various applications.

In addition to softness and roughness, the TSA also measured in-plane stiffness, an important factor for understanding how fabrics handle mechanical stress. The results showed that some textiles were much stiffer and resisted deformation more effectively than others. This is a critical finding for industries where the behavior of the fabric under handling, folding, or movement is essential, such as in fashion or upholstery.

On the other hand, the DynaWash system simulated the effects of repeated laundering, and the results highlighted substantial differences in how well the fabrics maintained their structural integrity. Several fabrics demonstrated excellent print retention, meaning that their designs remained intact after multiple wash cycles, while others showed signs of degradation. Pleat retention was also tested, with some textiles able to maintain folds and shapes better than others. Additionally, the tests on wrinkle resistance and pucker resistance showed that certain materials were more resilient in maintaining their appearance after mechanical stress.

The study also revealed notable findings in shrinkage behavior, where some fabrics displayed differential shrinkage across different sections. This finding is particularly relevant for manufacturers aiming to produce textiles with consistent performance across the entire fabric surface. These results underscore the importance of optimized manufacturing processes to prevent undesirable distortions after washing.

4. Discussion

The combination of TSA and DynaWash testing provided comprehensive data on both the tactile properties and mechanical resilience of textiles. The TSA results are particularly noteworthy, offering an objective measure of softness, roughness, and stiffness. These metrics eliminate the variability introduced by subjective human testing, aligning well with the goals of precision in product development. By isolating each haptic parameter and generating a unified Hand Feel (HF) score, the TSA effectively addresses a key limitation in traditional textile evaluation, where multiple factors often influence human perception.

The DynaWash results affirm the system’s utility in simulating long-term use and assessing how textiles hold up under repeated laundering. This is particularly relevant in an industry where the durability of fabrics is increasingly scrutinized, both for consumer satisfaction and sustainability purposes. Compared to other systems, DynaWash demonstrated improved efficiency in resource use—notably, water and energy—while maintaining stringent performance standards. The print and pleat retention tests, alongside the wrinkle and shrinkage analyses, provide a clear indication of which materials are best suited for high-performance applications, such as workwear or technical textiles.

5. Conclusion

This study underscores the value of objective, quantifiable testing methods in evaluating textiles. The TSA's ability to accurately measure haptic properties and the DynaWash system's effectiveness in replicating long-term wear highlight the significant advancements these tools bring to textile manufacturing. Together, they enable a more nuanced understanding of material behavior, leading to better product optimization and quality control. Looking ahead, refining these methodologies and expanding their scope will further enhance the textile industry’s ability to meet growing demands for sustainability, performance, and consumer satisfaction.

Acknowledgement

The authors would like to thank their colleagues for their valuable contributions to this work. Special thanks to Ms. Isabelle Grimm, Dr. Ulrike Klobes, Ms. Sandra Haase, and Mr. Kay Ulrich for their support in various aspects of this research, including technical guidance and administrative assistance. Their help was instrumental in carrying out the experiments and completing this project successfully.

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