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Development of Dynamic Drape Measurement of Fabrics using a Reciprocating-Motion System

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ABSTRACT

With the advancement of three-dimensional virtual fitting technologies, the fashion industry faces increasing demands for highly realistic digital garment simulations that faithfully reproduce fabric motion. However, conventional static drape measurements—such as the Cusick method—are limited in their ability to capture dynamic behaviors or structural responses that occur during actual wear. In response, various dynamic drapability measurement techniques using rotational or vibrational motions have been proposed, but these methods remain insufficient in replicating everyday handling of fabrics. This study therefore aims to develop a dynamic drape measurement system based on a reciprocating motion that more closely reflects real-use conditions.

A total of 19 woven and knitted samples were selected, representing a broad range of static drape coefficients (10.16–94.73%), weights (63.8–305.12 g/m²), and thicknesses (4.22–32.79 mm). Each fabric was prepared in 50 cm and 100 cm lengths and 20 cm widths, with warp aligned to the lengthwise direction. Dynamic drape evaluations were conducted using a reciprocating-motion apparatus. After fixing the upper edge of the specimen, the displacement amplitude (25–100 mm) and speed (50–200 rpm) were controlled, and movement was recorded for 5 seconds. Motion data were analyzed using TEMA Motion and ImageJ software to extract five quantitative indicators: (1) number of nodes, (2) position of the first node, (3) amplitude, (4) total movement length, and (5) movement area. The clearest and most reproducible drape patterns were obtained at a specimen length of 100 cm, displacement of 100 mm, and speed of 150 rpm. Lower-intensity conditions (e.g., 25 mm, 50 rpm) produced minimal drape formation, whereas excessively high speeds (200 rpm) resulted in unstable motion and increased measurement errors. Among the five indicators, the position of the first node showed the strongest and most consistent relationship to visual drape patterns and fabric properties, indicating high reliability. Amplitude and total movement length also demonstrated coherent trends, while the enclosed area was highly sensitive to experimental conditions and exhibited strong discriminative power between samples. Notably, fabrics with similar static drape coefficients displayed markedly different dynamic drape behaviors, confirming that static measurements alone are insufficient to represent fabric performance during motion. Knitted fabrics, characterized by high extensibility and flexibility, formed first nodes near the lower end of the specimen (≥75 cm) and exhibited large, complex movements. In contrast, woven fabrics showed first nodes concentrated near the upper region (50–65 cm), with smaller amplitudes and simpler shapes. Increases in fabric weight led to downward shifts in node positions and greater amplitudes and movement lengths, suggesting that higher mass enhances curvature and deformation through increased kinetic energy. However, knitted structures partially offset these effects due to their inherent flexibility.

This study establishes a reciprocating-motion-based dynamic drape system that better mimics real-use handling. The first node position emerged as the most reliable indicator, closely linked to structural and mechanical properties. The findings emphasize the need to use both static and dynamic indicators to capture the full spectrum of fabric behavior. Further study may incorporate bias and weft-direction analyses, real-time movement tracking during wear, and predictive modeling based on fabric physical properties.