Journal of Fiber Bioengineering and Informatics 18:1 (2025) 15–28

Cite as: H. Liu et al.
doi:10.3993/jfbim03237

Down Wadding Thermal Insulation Performance in Different Placement Conditions

Han-Xin Liu, Xiao-Xin Yang, Shu-Qi Liu, Jing Guo*

Beijing Institute of Fashion Technology, Heping Street, Chaoyang District, Beijing, 100029, China

Abstract

Warmth is a key consideration for consumers when choosing products. Existing research has mostly focused on testing the warmth performance of down products in a horizontal state, neglecting the non-horizontal state during actual wearing. This study investigates the thermal insulation performance of down waddings under different placement conditions and their interrelationships. Four types of stitching spacing and five types of unit filling amounts are determined through market research, and 20 pieces of down waddings are made. Thermal resistance experiments are conducted in both horizontal placement and 24-hour suspension states. The experimental results show that under 24-hour suspension, the thermal resistance value of down waddings generally decreases; Under the same stitching spacing conditions, the unit filling amount corresponding to the maximum thermal resistance value in the 24-hour suspension state has decreased; There is a significant difference in thermal resistance values between the two placement states, with a Pearson correlation coefficient of 0.939, indicating a strong positive correlation; A mathematical regression model $y = 0.825x + 0.033$ is established through SPSS analysis to describe the relationship between the thermal insulation of down wadding in two different placement conditions. The findings of this study provide an important theoretical basis and practical guidance for further research, design, and production of down products.

Keywords: Down Wadding; Thermal Resistance Test; Thermal Insulation Performance; Placement Condition

1 Introduction

Down products, as an excellent type of warm clothing, are lightweight, warm, and soft [1-4] and have become one of the essential equipment for modern people in severe cold weather. People's requirements for the thermal insulation performance of down products are also constantly increasing. Temperature plays a crucial role in the thermal comfort value [5, 6]. Scholars have found that the main factors affecting the thermal insulation performance of down products include unit filling amount, type of filling material, velvet content, fluffiness, fabric, etc. [7-10]. Gong Yunyu found through experiments that the degree of influence on thermal insulation performance is in

*Corresponding author.
Email address: julia0224163@163.com (Jing Guo).

1940–8676 /
Mar. 2025

the order of unit filling amount, type of filling material, and velvet content [11]. On this basis, some scholars have proposed that factors such as stitch spacing and stitch density also have a significant impact on the thermal insulation performance of down products [12-17], and some studies have found that the influence of stitch spacing is second only to the unit filling amount [17]. The measurement methods for the thermal insulation performance test of down products include the cooling rate method, constant temperature method, warm dummy method, wearing test method, etc. [18, 19]. The latter two methods are mostly used to test the thermal insulation performance of the entire down-product system. As one of the constant temperature methods, the evaporative hot plate method has high accuracy in measuring the thermal resistance value of down flocs and is convenient for in-depth analysis [20]. The research on the thermal insulation performance of down waddings is mostly conducted by conducting thermal resistance experiments in a horizontal placement state. Non-horizontal placement factors of clothing during daily wear can change the down distribution, thereby affecting the insulation effect [21, 22]. Some scholars [12] have also studied the thermal resistance values of down waddings in horizontal and hanging placement states, but only for the stitching factors of down wadding.

Based on literature and market research, this study determined four types of stitching spacing and five corresponding unit-filling amounts for down wadding. Twenty down waddings were made and subjected to thermal resistance experiments in both horizontal and 24-hour hanging states to analyze the effects of different placement conditions on the insulation performance of down waddings and the differences and correlations in insulation performance under different placement conditions. Providing a reference for enterprises in designing and producing down products can help consumers better understand and choose down products with different needs.

2 Method

2.1 Experimental Materials

The experiment uses down wadding as the carrier, composed of fabric and down. Due to the focus of this research on the influence of changes in down indicators on the thermal resistance of down products, a polyester cowhide fabric with a thickness of 0.08 mm and a weight of 60.82 g/m^2 is selected as the fabric for making down flocs. To ensure warmth, goose down with a velvet content of 90% is chosen as the filling material for down wadding. After a literature review and market research found that among various forms of quilting, horizontal quilting is the most common and provides the best insulation for down products. Therefore, the horizontal quilting form is chosen.

2.2 Experimental Equipment

The instruments used in this experiment include the M259B thermal and humidity resistance tester, electronic balance, and suspension device.

The M259B thermal and moisture resistance tester (Fig. 1) simulates the heat and moisture transfer on the surface of human skin. According to the national standard GB/T 11048-2018 “Determination of Thermal and Moisture Resistance under Steady State Conditions of Physiological Comfort of Textiles (Evaporative Hot Plate Method)”, the climate chamber of the equipment is set to 1 standard atmosphere, the temperature of 20 °C, relative humidity of 65%, and wind