Thermal Comfort Analysis of the Fused Liner

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Thailand is located in the tropics, which is hot and humid across the country. In Thailand, producing handcrafts is one of the largest income sources as well as agriculture (Fujioka, 2002). Handwoven fabrics from natural fibers such as cotton and silk have unique characteristics, a unique feel, and are being produced in many parts of Thailand. Usually, handwoven fabrics are not woven as tightly as machine-produced woven fabrics, resulting in fraying during the construction process. To compensate this weakness, local tailors iron fusible polyester lining fabric onto the back of handwoven fabric before cutting to make the fabrics stiffer and easier to cut and sew. Fabrics from natural fibers are suitable for the tropical weather because of their breathability. The fusible liner would stick to the fabric for a long period of time after many washes and will get softer over time. A few studies have investigated thermal comfort of fabrics fused with liner or multilayered fabric (Shabaridharan, 2012). Therefore, the purpose of this study is to verify if a fusible liner is appropriate in a hot climate by measuring thermal comfort values. Two hypotheses were developed to test and compare the dry thermal resistance (R_{ct}) for thermal resistance and water vapor resistance (R_{et}) for thermal absorptivity among the fabric conditions.

H_1: *The cotton surface with fusible liner produces better dry thermal resistance (R_{ct}) than other fabric combinations; cotton surface only and cotton surface with regular non-fusible liner do.*
H_2: *The cotton surface with fusible liner produces better water vapor resistance (R_{et}) than other fabric combinations; cotton surface only and cotton surface with regular non-fusible liner do.*

Two different 100% handwoven cotton fabrics, which are used commonly in Thailand, were selected as the surface fabrics and tested in three different conditions; 1) cotton surface only (CO), 2) cotton surface with 100% polyester fusible liner (COFL) and 3) cotton surface with 100% polyester regular non-fusible liner (CONFL). All fabric specimens were cut 12 inches in length by 12 inches in width. The fusible liner was ironed onto the inside of each of the cotton fabric specimens. The prepared fabric specimens were pre-conditioned at least 12 hours at the temperature and humidity in accordance with ASTM F1868-09 standard. The Sweating Guarded Hot-Plate (SGHP) manufactured by Measurement Technology Northwest was used to conduct both dry thermal resistance (R_{ct}) and water vapor resistance (R_{et}).

The analysis of variance (ANOVA) by Statistical Package for the Social Sciences (SPSS) software was employed to compare R_{ct} and R_{et} among three fabric conditions. Table 1 showed significant difference R_{ct} among three different fabric conditions; CO, COFL, and CONFL ($F(2, 15) = 5.424$, $p < .019$). The post hoc LSD test in R_{ct} showed that the COFL has its own group and the CO and CONFL were grouped together. The COFL possesses the lowest R_{ct} (.0218) and CO (.0289) and CONFL (.0326) follow. Therefore, H_1 was significantly supported. In the table 2, the result presented no significant difference R_{et} among the three fabric conditions; CO, COFL, and CONFL ($F (2, 15) = 2.660$, $p <.103$). It indicates that all fabric conditions; CO (4.325), COFL (4.402) and CONFL (5.176) possess similar levels of water vapor resistance. There is no significant difference among three fabric conditions, therefore, H_2 was rejected.

Table 1. Dry thermal resistance (R_{ct}) Result of ANOVA

R_{ct}	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.000	2	.000	5.242	.019*
Within Groups	.001	15	.000		
Total	.001	17			

Table 2. Water vapor resistance (R_{et}) Result of ANOVA

R_{et}	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.657	2	1.328	2.660	.103
Within Groups	7.491	15	.499		
Total	10.148	17			

The finding of R_{ct} presents that the cotton surface with fusible liner (COFL) produces better dry thermal resistance than other fabric combinations; cotton surface only (CO) and cotton surface with regular non-fusible liner (CONFL). It indicates that the COFL transfers the heat well from the body to the outside throughout the fabric layer and produces better thermal comfort for the wearers. This finding is consistent with the anticipation that the fusible liner is appropriate in hot weather areas, especially controlling dry thermal resistance. However, the other finding, which related to R_{et}, indicates that all three fabric conditions produce similar water vapor resistance. It means there is no difference in fabric conditions regarding the controlling of sweat.

The fusible liner has a smoother surface and is finer than the handwoven cotton fabrics. Thus, fusing fine liner to cotton provides better comfort and cooling effect than using cotton only, which corresponded with the study of Vivekanadan, Raj, Sreenivasan & Nachane's that finer fabrics showed cooler feeling (2011). Additionally, using non-fusible liner produces two layers, which could create air gap, hence, heat absorption (Wang, Shyr, Jou, & Yao, 2002).

References

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