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Evolution of Moisture Management Behavior of High-wicking 3D Warp Knitted Spacer Fabrics

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Abstract: Moisture management behavior is a vital factor in evaluating thermal and physiological comfort of functional textiles. This research work studies functional 3 dimensional (3D) warp knitted spacer fabrics containing high-wicking materials characterized by their profiled cross section. These spacer fabrics can be used for protective vest to absorb a user's sweat, to reduce the humidity and improve user's thermal comfort. For this reason, different 3D warp knitted spacer fabrics were produced with functional fiber yarns in the back layer of the fabric (close to the body) and polyester in the front and middle layers (outer surface). Comfort properties such as air and water vapor permeability and wicking and other moisture management properties (MMP) of different fabric samples were measured. It is demonstrated that by using profiled fibers such as Coolmax fiber, moisture management properties of spacer fabrics can be improved, enabling them to be use as a snug-fitting shirt worn under protective vests with improved comfort.

Keywords: Spacer fabric, Profiled fiber, Wicking behavior, Warp knitted fabric, Cooling effect

Introduction

Moisture and heat transfer from the body through clothing is the most important issue in the design and manufacturing of clothing, especially in functional garments such as protective clothing next to the skin or those worn in hot climates. In these situations, clothing layers should absorb large amount of perspiration, draw moisture to the outer surface and keep body dry. In order to optimize these functionalities in protective clothing, it is necessary to investigate the moisture transfer in clothing assembles.

One of the most recently developed structures of clothing assembles for protection clothing is three-dimensional (3D) knitted spacer fabrics. This type of fabrics was introduced a few years ago as a highly interesting structure by forming two textiles stitched by spacer threads in a defined spacing. This structure provides tortuous spaces which allow easy heat and moisture transfer through the fabric. Another main property achieved by this 3D structure is its perfect ventilation during wearing [1].

Warp knitting and weft knitting are the two commonly used methods for producing spacer fabrics. Warp knitted spacer fabrics are knitted with Raschel machines using double needle bars while weft knitted spacer fabrics are knitted on double jersey circular machines having a rotatable needle cylinder and needle dial. Because of these unique characteristics, spacer fabrics are used in many applications including clothing, automobile textiles, composites, medical textile (operation tables, orthopedic) sport wearing, and protective clothing as they have good properties of comfort especially related to heat and moisture transfer [1].

Although most protective garments including ballistic protective gear (bulletproof vest) provide more safety, they also cause some serious problems in comfort for wearers. This type of protective clothing should usually cover a large surface area of user's body according to its level of protection and contain thick padding. Aside from the danger of heat-related injuries, bulletproof vest (BV) may contribute to severe discomfort problems due to the obstruction of water vapor and moisture (sweet) transfer from the body.

Generally, moisture transfer and evaporation in textile materials depend mainly on the moisture absorbency of their fibers and wicking capability which are determined mainly by effective capillary pore distribution, pathways and surface tension, whereas the drying rate of a material is related to the molecular structure and geometrical parameters of the fibers. In the case of protective clothing, such as BV, the most effective mechanism of cooling and keeping the body dry while without dampness feeling is the absorption of perspiration that drives the moisture away from body surface to the outer surface of underwear clothing and evaporates through the mechanism of "Pumping" due to movement of the body [2]. Therefore, there is a need to identify methods to maximize comfort and coolness without compromising safety in the field. Recently protective clothing innovations (Under Armour; Baltimore, MD) intended to improve cooling and achieve greater comfort than natural fiber textiles. It would offer advantages with respect to comfort and cooling, plausibly improving the BV wearer's ability to carry out his/her daily tasks, if this technology is effective. Several researchers are working on improving the comfort feeling of this type of clothing. Results from Yasuda *et al.* [3] showed that clothing

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