Journal of Fiber Bioengineering and Informatics 13:2 (2020) 89–99
doi:10.3993/jfbim00341

Thermal and Mechanical Characteristics of Cotton Knitted Fabric Made of Non-twisted Hollow Yarn for Inner Wear

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Abstract

The characteristics of a weft knitted fabric made of new cotton non-twisted hollow yarn targeting an inner wear product were investigated. The weight, thickness, thermal characteristics, tensile, shear properties, bending properties and surface properties of the knitted fabric and four commercially available inner wear fabrics were measured using a KES-FB system. The measured properties were examined to examine the usefulness of the new fabric for inner wear. Fabric characteristics were compared in a multiple comparison test. The knitted fabric made of non-twisted hollow yarn is lighter and fuller than commercially available inner wear fabrics. The shear stiffness and bending rigidities of the knitted fabric were similar or lower than ones of commercially available cotton inner wear fabrics. The surface properties of the new fabric were similar to ones of commercially available inner wear fabrics. The fabric also has a lower Q-max value (the peak value of heat transferred), lower thermal conductivity, and higher heat retention rate and is therefore warmer than the commercially available fabrics. It is thus considered that knitted fabric made of new cotton non-twisted hollow yarn is suitable for inner wear.

Keywords: Weft Knitted Fabric; Non-twisted Hollow Yarn; Inner Wear; Thermal Properties

1 Introduction

Cotton knitted fabrics have been widely used for many clothing items, especially for innerwear. To improve the handle of cotton fabric, yarn manufacturing processes such as carding and combing, and finishing treatments such as mercerization are carried out [1-3]. Thermal and mechanical properties are considered as important characteristics for the comfort of cotton knitted fabrics. Many researchers investigated the relationship between thermal comfort taking into account knitting structure and yarn properties [4-6]. On the other hand, synthetic fibers with excellent functionality have been developed in recent years [7] and many fabrics are used for inner wear [8].

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Jun. 2020

Meanwhile, several studies on skin damage caused by clothing have been reported [9-11]. Ohkawa [9] reported skin problems caused by clothes. In the study, a questionnaire survey was conducted for a total of 2386 men and women, ranging from infants to elderly people, throughout Gunma Prefecture in Japan. Most skin problems were caused by inner wear. Iwaki et al. [10] investigated the consciousness of the elderly towards inner wear. They reported that the elderly believe that skin problems may be due to synthetic fibers although there is no evidence for this. Kawai [11] summarized the cases of skin disorders caused by textile products. That study found that skin damage occurred through physical irritation due to textiles having poor moisture permeability or through the pressing and rubbing of textiles on the skin. Rietschel [12] reported that sweat-resistant nylon products cause sweat rashes. The First Research Group of Japanese Society [13] conducted experiments on the irritation of skin due to clothing. They clarified that as the fiber becomes thicker, the bending stiffness and the compression recovery increase and skin irritation increases. They also found that the skin irritation becomes more evident as the number of twists of the yarn increases when the fiber thickness is constant.

On the above basis, it is considered that ideal inner wear will generate less pressure when a material that is soft and generates less friction is used. In addition, to reduce skin irritation, it is considered that a thin thread with a small number of twists is preferable.

As a fabric for inner wear, a knitted fabric made of a new cotton non-twist hollow yarn has been developed as shown in Fig. 1. The untwisted cotton fiber bundle is wrapped with covering cotton fiber. The knitted fabric is expected to be soft, have excellent heat retention, and be light and thin [18]. These properties could be suitable for inner wear. Andrysiak et al. [19] investigated the thermal resistance of woven fabrics made of a cotton hollow yarn. However, it used woven fabric made of twisted hollow yarn. The thermal and mechanical properties of the knitted fabric will be different from those of the woven fabric. The present study investigated the properties of the developed knitted fabric and compared them with the properties of commercially available inner wear to examine the usefulness of the developed knitted fabric for inner wear.

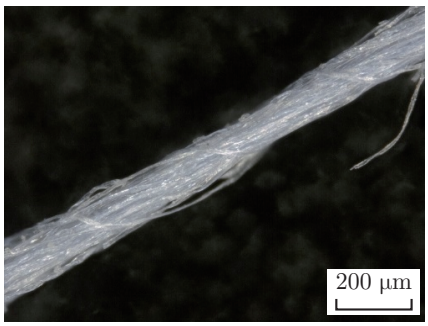

Fig. 1: Cotton non-twist hollow yarn

2 Experiment

To investigate the characteristics of knitted fabric made of cotton non-twist hollow yarn, we measured the weight and thickness at 50 gf/cm^2 using a KES-FB3 compression tester [14]. Tensile, shear, bending and surface properties were measured using KES-FB1-4. Thermal characteristics (i.e., the peak value of heat transferred (Q-max), thermal conductivity, and heat retention rate) were also measured using a KES-FB9 device [15,16]. Ventilation resistance was also measured