Journal of Fiber Bioengineering and Informatics 14:2 (2021) 113–126

Cite as: Q. Huang et al.
doi:10.3993/jfbim00368

Influence of Fabric Properties on Clothing Thermal Comfort under Different Environmental Temperatures ⋆

Qing-hong Huang [a], Zhang-chi Liu [a], Tim Jun Li [b], Yi Li [a,*]

[a] *Department of Material, The University of Manchester, Oxford Rd, Manchester, M13 9PL, UK*

[b] *Digital Clothing Limited, Unit 503, 5/F, Silvercord Tower 2, 30 Canton Road, Tsimshatsui, Hong Kong*

Abstract

Temperature greatly influences the choice of clothing type. It is difficult to study the effect of temperature on the performance of a garment and the used fabric, as changes in temperature varies significantly within a year, a season or even a day. This research paper studied the effect of fabric properties on human thermal comfort under different environmental temperatures. The main methodology entails using a CAD software to simulate clothing thermal comfort value of a garment made of 6 fabric types, then conducting analysis on the simulation results. The results indicate that fabrics perform better within a range of temperature. The further they stray from the range, the smaller the impact of the fabrics on human comfort. The results from the methodology also demonstrates that activity types and temperature greatly affect the comfort value.

Keywords: Textile CAD technology; Mathematical modeling; Mathematical analysis; Big data model

1 Introduction

Clothes have played an indispensable role in people's daily life, they not only protect the human body from injuries, they also help people adapt to stress in varying and extreme temperatures (i.e., the cold or the heat).There is a demand for a software tool that can predict which garment is suitable for a person to wear in relation to the local weather and climate. Clothing companies are also interested in a software tool that can help them predict the thermal comfort demand of customers.

A key factor that influences the decision-making process of the consumer when choosing clothes is the comfort experience. Thermal comfort value plays a key role in a person's comfort experience and is susceptible to the environmental thermal condition (i.e., temperature, wind velocity,

⋆Project supported by EU Horizon 2020 and University of Manchester through the project entitled "Fashion Big Data Business Model" (project No. 761122).

*Corresponding author.

Email addresses: qinghong.huang@postgrad.manchester.ac.uk (Qing-hong Huang), henry.yili@manchester.ac.uk (Yi Li).

humidity). To acquire information on the best physiological fit of a garment for a particular consumer group, the software is designed to predict the comfort value of a clothing given a set of environmental thermal condition.

The environmental thermal condition is prone to change, in many cases a significant change can take place within a day. Take the environmental temperature as an example, In the example shown in Figure 1, the temperature ranges from 21 °C to 9 °C within 17 hours. indicating that the data which the software needs to deal with are tremendous. With a generic temperature setting based on climate, it will be difficult for people to clearly assess the comfort temperature range. Hence, this dissertation simplifies and quantifies the changeable temperature condition for evaluating clothing comfort.

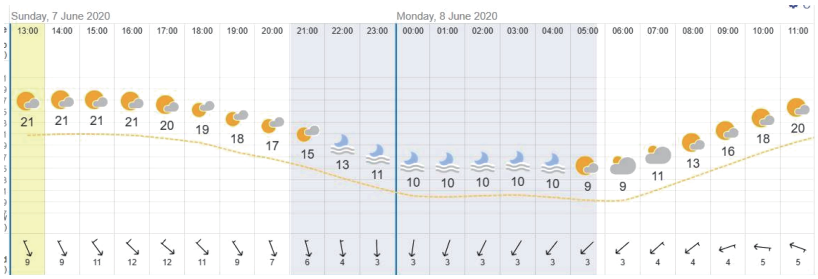

Fig. 1: A hour-by-hour forecast in London[1]

2 Methodology

This experiment uses the "e-thermal CAD" website and "s-smart" software to simulate the thermal environment of the human body[2]. The clothing thermal CAD system is based on a multidisciplinary math model and previous clothing thermal CAD systems[3-6]. The *Introduction for E-thermal Simulation* manual is available on the e-thermal website[7].

The s-smart software has an algorithm that takes into consideration the wind speed, relative humidity, and temperature to simulate the environmental condition. Wind speed is the velocity of air relative to a fixed point on earth, and relative humidity is the ratio of the vapor partial pressure in the air to the saturation vapour pressure of water under the same temperature condition[8]. Relative humidity impacts whether people feel dry or wet physiologically.

In this study, there are 6 fabric types and 3 temperature condition, each type of fabric will be simulated in each temperature condition once, with a total of 18 times of simulations. Figure 2 shows the simulation result of Fabric ID 007. A single simulation has a set of 6 graphs as follows: comfort value, dampness sensation, thermal sensation, skin relative humidity, core temperature and skin temperature. Each simulation has one set of graphs for each temperature condition, so there in total are 18 sets of graphs, as shown in Figure 4 to 21.

Besides the environmental condition, the software also requires input of other data.

2.1 The settings of fabric

Table 1 is a list of all the fabric types and their respective properties. Figure 2 are images of the 6 fabric types. These 6 fabric types are all suitable for making the same clothing style, and the