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Mathematic Model for Predicting Average Pressure of Man's Socks Based on Elastic Potential Energy of Fabrics

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Abstract

In this research, a mathematic model for predicting the average pressure at the lower leg caused by socks has been built. This research establishes a relationship between the average pressure of socks, the potential energy of fabrics and the shape of the lower leg section based on the law of conservation of energy. On the basis of the result, the mathematic model has also been built up to predict average pressure, and the model was proved by both the data of experiments and the relation between the average pressure, the shape of the lower leg section and the elastic potential energy of the fabrics. The results has shown that the average pressure caused by the socks at the lower leg is related to the circumference of the welt as well as the circumference of calf and elasticity of the welt. The testing result shows that this model can be used to predict the pressure. This model will simplify the calculation method, and provide a theoretical foundation for the accurate prediction of the pressure at any given positions.

Keywords: Socks; Pressure; Elastic Fabrics; Elastic Potential Energy; Energy Conservation

1 Introduction

Research on clothing pressure and its comfort spans only the recent decades. Researchers have already obtained many important research achievements in the field of clothing pressure comfort by designing and improving pressure test instrument and evaluating clothing pressure, developing medical pressure garments [1-3] via various subjective and objective experiments [4-6]. Salim M. Ibrahim [7] raised the concept of clothing pressure for the first time in 1968 and gained the magnitude and distribution law of dynamic and static pressure on human body generated by shape-keeping apparels through the pressure sensor. At the end of the last century, many scholars had already carried out dynamic test and comfort evaluation researches of clothing pressure by the analysis of women's tights and underwear [8-10]. Literature [11, 12] also discusses various effects of clothing pressure on the human body. In Deepti Gupta's [13] research the relation between

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the pressure and the extension of pressure garment was found. With continuous development of the researches, study on comfort of clothing pressure has also become one of the hot issues in clothing researches.

Study on clothing pressure of socks is always the research hot-spot of scholars at home and abroad. The main reason is that leg surface at the welt is not that complicated, similar to elliptic cylinder, which is convenient for test and research. Besides, the research results at welt can be applied to other positions. At present, research achievements of clothing pressure at welt mainly focus on clothing pressure test, clothing pressure simulation, test method of clothing pressure and clothing pressure comfort at welt [14-16]. In 2011, DAN Rui conducted finite element simulation analysis on clothing pressure at welt, and pointed out that clothing pressure at welt is closely related to displacement at the leg, and constructed a prediction model [17-19]. However, the previous research achievements still cannot fully reflect the complicated relation between clothing pressure, human body and apparel.

This paper mainly discusses the relationship between elastic potential energy and average pressure at welt and establishes a prediction mathematical model of average pressure at welt, which provides a new method for prediction of pressure at welt and a theoretical foundation for constructing accurate pressure prediction model.

2 Theoretical Analysis on the Model

According to the energy conservation law, the work produced by volume expansion and pressure change will be absolutely converted into elastic potential energy of the material, so the work of volume is equal to that of surface material tension, i.e.:

$$\Delta W_{\mathrm{P}} = \Delta W_{\mathrm{T}}$$

W_{P} represents the work of pressure and W_{T} denotes the work of tension; unit: J.

Differentiation element model is established, as shown in the following:

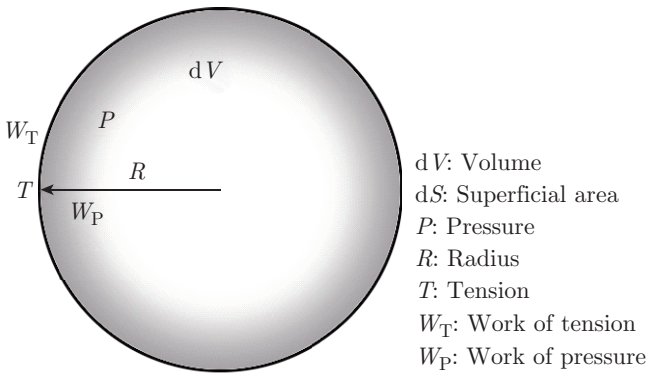

Fig. 1: Schematic diagram of differentiation element

The work of pressure is equal to that of tension, so $\mathrm{d}\Delta W_{\mathrm{P}} = \mathrm{d}\Delta W_{\mathrm{T}}$; it can be known according to the analysis in the figure:

$$T\mathrm{d}S = \Delta P\mathrm{d}V, \text{ then } \Delta P = T\mathrm{d}S/\mathrm{d}V$$