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Experimental Analysis and Modeling Research of the Morphological Structure of the Weft-Knitted Loop

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Abstract

To address the limitations of the traditional idealized loop model, this study conducted experimental analysis and mathematical model for the morphological structure of the weft-knitted loop, and research on the method for describing the weft loop's structure and parameters. Because the features of the loop's structure is consistent with the Non-uniform Rational Basis Spline (NURBS), three degree NURBS curve was used to establish the model of the weft loop, and the corresponding value points' coordinate can be obtained by the experimental analysis of the effect of the fabric structure from the structure parameters. In addition, based on the features of the different weft-knitted structure, the models of plain and pattern stitch have been established. Research shows NURBS curve modeling can be applied to a more complex weft tissue as well as the basic and variation tissue.

Keywords: Weft Loop's Structure; Morphological Structure; Non-uniform Rational Basis Spline; Experimental Analysis; Loop Structure's Modeling

1 Introduction

There are many different varieties and patterns of the weft-knitted fabric, and weft CAD technology can greatly improve the design and the production efficiency of the weft-knitted fabric. However, due to the complexity of the weft-knitted structure, it is difficult to use mathematics to accurately describe the loop model [1]. As a result, further development of the weft CAD technology has been constrained. Limitations of the traditional models can no longer meet the requirements of the modern weft CAD technology. Therefore, it is important to establish the corresponding loop model, and at the same time realize the simulation of the fabric structure. Based on the analysis of the morphological variation of the weft-knitted loop structure, this study uses NURBS' curve to establish a model for the weft knitted structure.

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2 The General Mathematical Description for Ideal Loop Model of Weft Knitting

The complexity of the morphological structure of the weft is caused by many factors. The unit of the knitted structure is the loop. Its morphological structure is created by the variation at which the yarn is space bended [2]. When each section of the loop is under a force, the yarn moves which leads to the instability of the morphological structure of the weft-knitted fabric.

In the traditional research on the weft-knitted structure, hypotheses were made to reduce the complexity of the mathematical description. Based on characteristics of the loop structure of the weft-knitting, the ideal loop model can be established as shown in Fig. 1. The unit loop's structure consists of a head and two side limbs or legs. The main structure parameters include the width of loop W, the height of loop H, the height of the leg loop h, the length of the leg loop l, the whole length of loop L (L_1 is the length without considering the separation distance, L_2 is the length with considering the separation distance). In the ideal loop model, the head loop and the sinker loop are considered as circular, the leg loop is considered as linear, and the yarn a cylinder in which its diameter is labeled as$d$. The relation between the loop structure parameters can be calculated [3]:

$$\begin{aligned} &W = 4d \qquad h = \sqrt{(4d)^2 - (2d)^2} = 3.464d \\ &l = \sqrt{h^2 + d^2} = \sqrt{13}d = 3.606d \\ &H = h + 4d = 7.464d \\ &\begin{cases} L_1 = 2 \times 1.5d\pi + 2 \times 3.606d \approx 16.64d \\ L_2 = 2p + w + 5.94d \end{cases} \end{aligned} \tag{1}$$

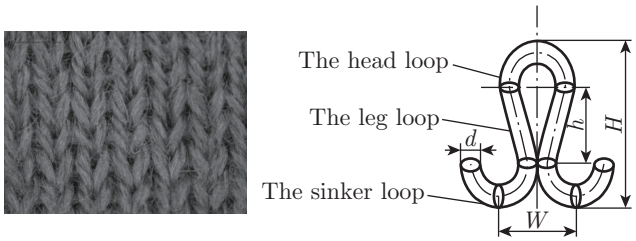

Fig. 1: The structure of plain and the ideal loop model

Therefore, the size performance of the weft-knitting depends on the length of the loop in its relaxed state. The morphological features of the different fabrics depend on the fabric structure and the length of the loop.

3 Experimental Analysis of the Actual Loop Morphological Structure

Based on the analysis of the loop morphological structure, to establish a loop model consistent with reality, the limitations of the traditional loop model must be addressed. The limitations include: the model curve is discontinuous and there is a mismatch with the actual yarn's structure;