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SCIENTIFIC APPROACH TO CONSIDERING PROPERTIES IN THE DESIGN OF GARMENTS MADE FROM KNITTED FABRICS

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Abstract: In the design of knitted garments, twisting (torsion)—a tendency of the fabric edges to curl or distort—is considered one of the most important physical-mechanical properties. This phenomenon arises from the structural characteristics of knitted fabrics, yarn interlooping, yarn tension, and elasticity, and is particularly visible in thin, highly elastic, direction-sensitive knits. Excessive twisting results in deformation of garment shape and negatively affects fitting and appearance. This article analyzes scientifically-based approaches to reducing the twisting property during the engineering and design of knitted products.

Keywords: Knitted fabric, twisting, torsion, structural stability, physical-mechanical properties, garment design, elasticity, sewing technology.

Introduction. Knitted fabrics are widely used in the modern garment industry due to their comfort, elasticity, and aesthetic appearance. However, one of the major challenges encountered during construction and production is the twisting phenomenon (torsion, D_s) [1]. It refers to the spontaneous curling or rotation of the fabric edges caused by the unbalanced structure of loop formations, yarn twist, and non-uniform distribution of strength in the fabric [2].

Methodology & Empirical Analysis.

1. Twisting Property and Its Causes

Knitted yarns are **highly orientation-dependent**, and internal structural stresses formed during the loop formation process lead to **edge curling or inward rotation** of the material [3]. Because of their specific loop structure and intermeshing method, knitted fabrics are inherently **elastic and susceptible to torsional deformation**. The twisting behavior typically arises under the influence of the following structural and environmental factors [4]:

Primary causes of twisting:

- **Yarn twist and elasticity:**

The degree of yarn twist and its elastic recovery strongly affect torsion. Yarns with higher elasticity exhibit more pronounced edge curling.

- **Knitting direction anisotropy:**

The arrangement of yarn loops predominantly in one direction results in **asymmetric tension distribution**, contributing to twisting.

- **Differences in surface tension by direction:**

Directional variations in loop density or stitch tightness create **non-uniform relaxation**, leading to deformation.

- **Fabric structure type:**

Unbalanced single-jersey structures (e.g., **plain knit, jersey**) are more prone to twisting compared to **balanced rib or interlock knits**.

- **Insufficient post-knitting stabilization:**

Lack of **proper steaming, heat-setting, or mechanical stabilization** allows internal stresses to remain active, increasing fabric distortion.

- **Environmental influences:**

Changes in **humidity and temperature** accelerate the relaxation of loop structures and intensify curling.

Xu, Li, and Song conducted a scientific study on factors influencing **laddering and structural instability** of knitted fabrics. The results demonstrated that **loop length** is the dominant factor influencing stitch deformation **regardless of fiber composition**, and optimizing loop length significantly reduces distortion risks in garment applications [5].

To minimize twisting in knitted products, the researchers proposed utilizing **transversely knitted, highly extensible, double-layer fabric structures**, with the following combined design solutions [6]:

- ⊙ The first rib course formed using **low-stretch yarn**, while the transverse plain (jersey) course positioned on face or back side is knitted with **high-shrinkage yarn**.
- ⊙ Courses produced from **partial-tuck stitches** using low-stretch yarn on face or back side to ensure structural balance.
- ⊙ Additional rib courses created with **low-stretch yarn** positioned at the back to enhance dimensional stability and reduce torsion.
- ⊙ A four-course system designed to combine **elastic stability and directional counterbalance**, preventing edge curling at both sides.

2. Scientific Approaches for Reducing Twisting in Knitted Fabrics

Approaches	Description
Structural design	Modifying the structural composition of the fabric; using balanced and double-knit constructions to neutralize internal torque.
Material selection	Choosing low-elasticity and low-twist yarns ; natural fibers are generally less prone to curling than synthetic fibers.
Stabilization treatments	Applying thermal setting, pressing, steam relaxation and other finishing processes to relieve internal stresses.
Pattern engineering corrections	Designing symmetrical cutting lines , adding compensation allowances , and using supportive fusible interlinings to reinforce garment edges.
Modification of knitting technology	Using bi-directionally balanced knitting , inserting stabilizing yarns , and developing innovative loop structures to minimize torsion.

Material and Structural Selection

The primary factor in designing knitted products with **reduced twisting tendency** is the correct selection of raw materials. Natural fibers such as **cotton** exhibit **lower torsional deformation**, while synthetic fibers—with higher elasticity and shrinkage—are generally **more prone to curling** [7]. (*Cotton remains the most important raw material in the global textile industry, with an average annual production of approximately 23–24 million tons.*) In addition, **double-knit (interlock or rib) structures** significantly decrease twisting because they provide **balanced reinforcement in both wale and course directions**, ensuring uniform stress relaxation throughout the fabric.

3. Considerations in Garment Design. When designing knitted garments to minimize twisting, the following factors should be taken into account:

- **Orientation of yarn in pattern placement:** Ensure that the **direction of the yarn loops** aligns properly with the garment model to reduce torsional stress.

- **Compensatory adjustments at angular sections:** Introduce **correction allowances** at corners, edges, and curved seams to counteract potential curling.

- **Reinforcement of high-stress areas:** Strengthen parts of the finished garment that are subject to **pressure or tension** using **stable or supportive materials**, such as interfacing or additional layers, to preserve shape and dimensional stability.

II. Results. Scientific Approach. The scientific approach to minimizing twisting in knitted garments involves measuring, analyzing, and mathematically modeling the physical-mechanical properties of each fabric type—such as elasticity, tensile strength, and torsion angle—and incorporating these parameters into the design process.

Measurement of physical-mechanical properties. These parameters are critical for evaluating material elasticity and structural characteristics. For example, the twisting coefficient (Ds) can be calculated as follows:

$$D_s = \Delta\theta L D_s = L \Delta\theta$$

Where:

- $\Delta\theta$ — torsion angle in degrees
- LL — length of the fabric sample in centimeters

Based on the measured values, the garment pattern can be adjusted, and necessary design corrections can be applied.

Processing methods. Thermal treatment and mechanical pressing stabilize the knitted structure and reduce twisting. Techniques such as steam relaxation or thermal pressing help to fix the yarn arrangement and relieve internal stresses.

Design adjustments. Maintaining symmetry in pattern pieces, adding compensation allowances at corners and seam lines, and incorporating interfacing layers effectively minimize torsional deformation in the final product.

Conclusions. To reduce twisting in knitted garments, the following measures are recommended:

1. Modification of fabric structure — using balanced or double-knit constructions.
2. Appropriate yarn selection — low-twist and low-elasticity yarns, preferably natural fibers.

3. Design corrections — incorporating symmetry, compensation allowances, and reinforcement layers.

4. Application of finishing techniques — thermal setting, pressing, and steam relaxation to stabilize the fabric.

Implementing these approaches ensures:

- Shape retention of the garment
- Improved comfort and fit
- Enhanced durability and wear resistance

A scientific, property-based approach allows designers to analyze material characteristics, select suitable structures, and introduce effective constructive and technological solutions. Considering twisting during the design process is essential for product quality, aesthetic appearance, and user comfort. By applying these strategies, the twisting problem can be effectively mitigated, resulting in more reliable and competitive knitted products in the textile industry.

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