Fabric and Garment Shrinkage: Causes, Effects, and Control Measures

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1. Introduction

Shrinkage in the fabric or garment industry refers to the reduction in size of fabric or garments from their original dimensions. It usually occurs during washing, drying, or usage. Shrinkage directly affects customer satisfaction and the financial condition of the industry. If garments do not maintain their intended size for a long time, they may need to be re-marketed or returned.

Shrinkage is mainly of two types:

- **Washing Shrinkage** – Occurs during washing of fabric.
- **Processing or Drying Shrinkage** – Occurs during production processes.

Shrinkage is a natural property of fibers, but it can be controlled using modern processing techniques and proper care instructions. In the garment industry, shrinkage control is an important part of quality management.

2. Causes of Shrinkage

The causes of shrinkage depend on the type of fabric, weaving method, processing, and usage. Major causes include:

1.Fiber Type

- **Cotton:** Natural fiber; swells when it absorbs water, causing fabric shrinkage. Typical shrinkage: 2–5%.
- **Wool:** Sensitive fiber; hot water and friction increase shrinkage. Typical shrinkage: 10–20%.
- **Silk:** Sensitive fiber; hot water or rubber processing can cause shrinkage.
- **Synthetic fibers (Polyester, Nylon):** Shrinkage is relatively low because they are thermoplastic and retain shape under heat.

2.Fabric Weave and Knitting Pattern

- Loose or lightweight fabrics shrink faster.
- Tight weave or dense knitting reduces shrinkage.
- Fabrics blended with spandex shrink less after stretching.

3.Processing and Finishing

- Heat, steam, or roller processes can cause shrinkage.
- Chemical finishing (e.g., resin treatment) can make fibers shrink-proof.

3.Usage Methods

- Hot water, high dryer temperatures, or incorrect washing increase shrinkage.
- Excessive pressure or friction also increases shrinkage.

4.Types of Shrinkage

- **Washing Shrinkage:** Fabric shrinks during washing; common in cotton, wool, and silk.
- **Processing Shrinkage:** Shrinkage occurring during various garment production steps (dyeing, sanforization, printing).
- **Relaxation Shrinkage:** Fabric or fiber returns to its natural size by releasing built-in stress or tension.

5.Comparative Shrinkage of Different Fabric

Fabric Type	Initial Shrinkage	Control Method
Cotton	2–5%	Sanforization, Resin finishing
Wool	10–20%	Felting control, Steam finishing
Polyester	1–2%	Heat setting
Blended	According to cotton	Chemical treatment, Proper

DOI: https://doi.org/10.5281/zenodo.19938367

Fabrics	content	washing

5. Shrinkage Control in Production

To reduce shrinkage, various technologies are used in the garment industry:

- **Sanforization:** Pre-shrinks cotton fabric before washing.
- **Heat Setting:** Stabilizes shape of polyester or nylon at high temperatures.
- **Relaxation Shrinkage:** Allows fabric to shrink naturally without tensile stress.
- **Chemical Finishing:** Resin or cross-linking agents make fibers shrink-proof.

6. Washing and Care Instructions

Shrinkage can be minimized if customers follow proper care instructions:

- Use cold or lukewarm water.
- Avoid tumble dryers; hang-dry garments.
- Use detergent suitable for sensitive fabrics.
- Choose pre-washed or shrink-proof fabrics.

7. Measurement of Shrinkage and Standards

Shrinkage is measured in the industry as:

- **Length-wise shrinkage**
- **Width-wise shrinkage**

Shrinkage is usually expressed as a percentage (%).

Shrinkage formula:

$$\text{Shrinkage (\%)} = \frac{\text{Original Dimension - Finished Dimension}}{\text{Original Dimension}} \times 100$$

Example:

A cotton shirt has a length of 100 cm before washing and 97 cm after washing:

$$\text{Shrinkage (\%)} = \frac{100 - 97}{100} \times 100 = 3\%$$

This way, shrinkage of fabric or garments can be easily calculated.

Acceptable Shrinkage Limits

Fabric Type	Length-wise Shrinkage	Width-wise Shrinkage
Cotton	≤ 3%	≤ 3%
Wool	≤ 5%	≤ 5%
Polyester	≤ 1%	≤ 1%
Blended Fabrics	2–3%	2–3%

Shrinkage above these limits can cause garment fit issues and quality control failure.

8. Shrinkage Testing Methods

The industry follows different standards for shrinkage testing. Common methods include:

1. **ISO Standard Testing**
   - ISO 5077: International standard for measuring shrinkage of fabrics.
   - Procedure: Cut fabric into 20×20 cm, wash and dry under standard conditions, measure shrinkage.

2. **AATCC Standard Testing**
   - AATCC 135: Measures garment shrinkage after washing.
   - Steps: Measure initial size → wash with standard detergent and temperature → dry → calculate shrinkage.

3. **ASTM Standard Testing**
   - ASTM D4970: Determines fabric shrinkage; separate procedure for cotton, wool, and blended fabrics.

4. **Laboratory Measurement**
   - Fabric is washed, dried, and kept under uniform temperature.
   - Shrinkage is calculated using graphical methods.
   - High-end labs use automated shrinkage machines.

9. Case Studies in the Industry

Case Study 1: Cotton Shirt Shrinkage

- A garment company produced 10,000 shirts.
- Customer complaints: 3–5% shrinkage.
- Lab test: Shrinkage exceeded natural cotton limits.
- Solution: Sanforization and Resin finishing applied.

Case Study 2: Wool Sweater Shrinkage

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- Shrinkage: 20% due to hot water and tumble dryer.
- Solution: Cold wash, hand dry instructions for future production.

Case Study 3: Polyester-Blend Fabric

- Initial shrinkage ≤1%.
- Heat setting controlled shrinkage permanently.

These cases show that shrinkage can be controlled by fiber type, processing, and usage methods.

10. Shrinkage Reduction Technologies and Pre-Treatment

Methods to reduce shrinkage include:

- **Sanforization:** Pre-shrink cotton fabric before washing.
- **Heat Setting:** Stabilizes shape of thermoplastic fibers.
- **Resin Finishing:** Reduces shrinkage in cotton and wool.
- **Felting Control:** Makes wool shrink-proof.
- **Mechanical Relaxation:** Relieves tensile stress in fabric.

Example:

- Resin finishing reduced shrinkage of cotton T-shirts below 2%.
- Felting control reduced wool sweater shrinkage from 20% to 8%.

11. Shrinkage Comparison by Fiber

11.1 Cotton Fabric

- Natural shrinkage: 2–5%
- Cause: Hot water and friction increase shrinkage
- Control: Sanforization, Resin finishing

11.2 Wool Fabric

- Natural shrinkage: 10–20%
- Cause: Felting and friction
- Control: Felting control, Hand wash, Steam finishing

11.3 Polyester and Synthetic Fabrics

- Natural shrinkage: 1–2%
- Cause: Heat-sensitive; requires heat setting
- Control: Heat setting, Cold wash

11.4 Blended Fabrics (Cotton-Polyester)

- Natural shrinkage: 2–3%
- Control: Resin treatment, Proper wash instructions

12. Detailed Case Studies

Case Study 1: Cotton T-Shirt Production

- Production: 10,000 T-shirts
- Problem: Shrinkage reported by customers
- Lab results: Length shrink 4%, width shrink 3%
- Solution: Sanforization + Resin finishing + Cold wash & hang dry instructions
- Result: Shrinkage reduced below 2%, customer satisfaction increased

Case Study 2: Wool Sweater

- Initial shrinkage: 20%
- Cause: Hot water & tumble dryer
- Solution: Hand wash, cold water, felting control, steam finishing
- Result: Shrinkage reduced to 8%

Case Study 3: Polyester-Cotton Blend Shirt

- Natural shrinkage: 1.5%
- Heat setting applied: Shrinkage reduced to 1%
- Instructions: Cold wash, standard drying

13. Technical Analysis and Industrial Application

13.1 Mechanical and Chemical Methods

- Mechanical Relaxation: Relieves tensile stress; fabric shrinks naturally.
- Resin Finishing: Shrink-proof agent for cotton and wool.
- Heat Setting: Stabilizes thermoplastic fibers (polyester, nylon).

13.2 Economic Impact

- Pre-treatment or finishing increases production cost.
- Reduces re-marketing risk and increases customer satisfaction.

13.3 Customer Education

- Proper wash instructions and dryer use reduce shrinkage.
- Labeling and instruction guides are important.

14. Future Research and Development

Future research in shrinkage control may include:

- New chemical finishing agents for natural fiber shrinkage reduction.
- Nano-technology for fiber shape stabilization.
- Smart fabrics that are wash-resistant and shrink-proof.
- Educating customers with proper wash instructions.

15. Graphs, Charts, and Data Analysis

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Lab data is usually presented with graphs and charts for comparison.

15.1 Comparative Shrinkage by Fiber

Fiber Type	Length Shrinkage (%)	Width Shrinkage (%)
Cotton	4	3
Wool	12	10
Polyester	1	1
Cotton-Polyester Blend	2	2

Observation: Wool fabric shrinks the most due to felting and hot water. Polyester shrinks the least. Blends show moderate shrinkage.

15.2 Effect of Washing & Drying

Wash/Dry Condition	Cotton Shrinkage (%)	Wool Shrinkage (%)	Polyester Shrinkage (%)
Cold wash, Hang dry	2	8	1
Warm wash, Hang dry	3	10	1
Warm wash, Tumble dry	5	20	1

Observation: Tumble dryer causes maximum shrinkage; wool is most sensitive. Heat-sensitive fibers are affected most by warm wash + tumble dry.

15.3 Lab Result Graph

- X-axis: Wash/Dry condition
- Y-axis: Shrinkage (%)
- Line 1: Cotton
- Line 2: Wool
- Line 3: Polyester

Observation: Wool shrinkage exceeds cotton in all conditions. Warm wash + tumble dry is most harmful for heat-sensitive fibers.

16. Final Case Studies and Examples

Case Study 4: Commercial Garment Line

- Production: 50,000 shirts
- Fabric: Cotton-Polyester blend
- Problem: Customer complaints on length shrinkage
- Lab Test: Average shrinkage 3%
- Intervention: Pre-wash Sanforization + Resin finishing + Cold wash instructions
- Result: Shrinkage reduced to 1.5%, complaints dropped 90%

Case Study 5: Luxury Wool Sweater

- Fabric: 100% Merino wool
- Shrinkage without control: 18% after warm wash
- Control Measures: Felting control, hand wash, cold water, flat dry
- Result: Shrinkage reduced to 7%, quality maintained

Observation: Proper pre-treatment, correct washing instructions, and fiber-specific methods significantly reduce shrinkage.

17. Best Practices for Industrial Shrinkage Control

- **Fiber-specific pre-treatment:**
  - Cotton: Sanforization
  - Wool: Felting control
  - Polyester: Heat setting
- **Chemical Finishing:** Resin treatment, cross-linking agents
- **Mechanical Relaxation:** Keep fabric free of tensile stress
- **Customer Care & Labeling:** Clear wash, drying, and ironing instructions
- **Quality Control:** Pre-production, post-production, lab testing

18. Future Research and Innovation

- Nano-coating & advanced finishing agents for shrink-proof fibers
- Smart textiles responding to temperature or moisture
- AI & data-driven shrinkage prediction based on fiber, weave, and wash
- Sustainable methods: less water, eco-friendly chemicals, reusable processes

19. Conclusion

Fabric and garment shrinkage is a critical quality issue affecting customer satisfaction, financial loss, and quality control.

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- Shrinkage depends on fiber type, fabric construction, finishing process, and wash/dry conditions.
- Pre-treatment like Sanforization, Felting control, Heat setting, and Resin finishing significantly reduce shrinkage.
- Lab testing, quality control, and proper customer instructions are essential.
- Future research with nanotechnology, smart textiles, and AI-based prediction will improve shrinkage control.

Final Advice:

- Apply fiber-specific shrinkage management in all garment production lines.
- Customer education and proper wash instructions reduce shrinkage issues.
- Controlling shrinkage ensures correct garment sizing, business profitability, and environmentally friendly production.

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