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Dye Shade Optimisation for Batch-to-Batch Consistency in Braided Surgical Textiles

Executive Summary

Batch-to-batch consistency is a critical requirement in braided surgical textile manufacturing, where visual appearance, dimensional accuracy, and mechanical performance must remain tightly controlled across production runs.

This project was initiated after introduction of a new dye batch resulted in a lighter appearance compared with previously approved production material. Although the braid remained structurally compliant, the visual deviation created a risk to customer acceptance and production consistency.

The objective was to optimise dye concentration to restore visual alignment while maintaining braid integrity, dimensional control, and mechanical performance.

Through controlled adjustment of dye formulation and validation against established production standards, the programme successfully improved colour consistency without compromising product performance.

The Challenge

The existing braid remained mechanically compliant but exhibited visible shade variation following introduction of a new dye batch.

In braided surgical textiles, small changes in finishing conditions can influence product attributes beyond appearance.

Key engineering challenges included:

- Restoring colour consistency across production batches
- Maintaining braid diameter and dimensional stability
- Preserving tensile and extension performance
- Avoiding changes to handling characteristics
- Supporting repeatable manufacturing outcomes
- Maintaining compliance with colour requirements

The challenge required optimisation of the finishing process while preserving established product performance and manufacturing repeatability.

Engineering Objectives

The programme focused on:

- Restoring approved colour appearance
- Maintaining mechanical equivalence
- Preserving dimensional consistency
- Improving process repeatability
- Reducing risk or customer rejection
- Establishing a controlled dye operating window

Development Approach

Controlled Dye Optimisation

A structured development programme evaluated the impact of small dye concentration adjustments on braid performance.

The investigation focused on:

- Dye uptake behaviour
- Colour depth consistency
- Surface appearance
- Process repeatability
- Dimensional stability
- Mechanical integrity

Multiple trial samples were produced and visually assessed against retained reference batches and approved production standards.

Final optimisation involved a controlled 0.02% increase in dye concentration.

Validation & Performance Assessment

Performance was assessed using standard production quality criteria:

- Runnage
- Break load
- Extension
- Diameter
- PPI
- Visual shade comparison

Results confirmed improved alignment with historical production appearance while maintaining acceptable mechanical and dimensional performance.

No significant impact was observed in:

- Structural stability
- Tensile performance
- Process handling
- Finished braid consistency

Process Control & Repeatability

Repeatability was supported through control of:

- Dye concentration verification
- Standardised processing conditions
- Visual comparison against retained standards
- Post-dye dimensional and mechanical validation

The project demonstrated that small formulation changes can create measurable appearance differences, reinforcing the importance of controlled finishing windows.

Engineering Outcome

The programme successfully restored batch-to-batch visual consistency without requiring changes to braid architecture or material selection.

Key engineering outcomes included:

- Improved colour consistency
- Preserved braid performance
- Reduced manufacturing variability
- Lower customer acceptance risk
- Improved process robustness

The work demonstrated how controlled finishing processes contribute directly to quality and repeatability in braided medical textile production.

Application Relevance

Surgical Sutures & Closure Systems

Relevant to braided surgical products where colour consistency supports product identification, handling, and manufacturing quality

Orthopaedics & Sports Medicine

Applicable to braided fixation systems requiring repeatable appearance and consistent production output.

Soft Tissue Repair & General Surgery

Supports applications where visual uniformity and manufacturing consistency contribute to reliable product performance.

Key Takeaways

- Colour consistency is a controlled manufacturing outcome, not purely a cosmetic attribute.
- Small finishing adjustments can significantly influence final product appearance.
- Dye optimisation restored visual alignment without affecting braid performance.
- Process control supports repeatability and reduces downstream manufacturing risk.

“Consistency in medical textiles is defined not only by structure, but by control of the processes that shape the final product.”



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