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Engineering a UHMWPE-Based Braided Construction

Executive Summary

A medical OEM required development of a high strength construction using UHMWPE fibres to produce a USP 2 equivalent braid for load-bearing medical applications.

The objective was to engineer a repeatable braid architecture that delivered consistent mechanical performance, dimensional stability, and compatibility with downstream medical manufacturing processes, including finishing and assembly.

Through optimisation of braid architecture, twist configuration, and process control, a scalable manufacturing process was established for producing stable UHMWPE braided constructions suitable for demanding medical device applications.

The Challenge

Although UHMWPE offers exceptional strength-to-weight performance, its low-friction surface presents significant challenges during braiding.

Key engineering challenges included:

- Preventing fibre slippage during braiding
- Maintaining structural integrity at USP 2 scale
- Achieving balanced yarn tension throughout the construction
- Stabilising the braid during post-processing
- Delivering consistent geometry across production batches

Because even minor structural variation can influence mechanical performance and handling characteristics, precise control of both material behaviour and braid architecture was essential.

Engineering Objectives

The programme focused on:

- Developing a stable USP 2 equivalent UHMWPE braided construction
- Maintaining dimensional consistency throughout manufacture
- Improving fibre interaction within the braid structure
- Supporting downstream finishing and assembly processes
- Establishing a repeatable and scalable manufacturing process

Development Approach

UHMWPE Braid Architecture

An 8-carrier braid construction was selected to balance structural integrity with manufacturability.

The design incorporated:

- 165 dtex UHMWPE yarn in both core and cover
- Twisted UHMWPE yarn (165/3 dtex) to improve fibre interaction
- Controlled twist configuration (10 TPI S/ 7 TPI Z) to enhance structural stability

Performance was engineered through the interaction of material selection, twist configuration, and braid architecture rather than fibre properties alone.

Validation & Performance Assessment

Validation confirmed that the braid met the required structural and manufacturing objectives.

Assessment included:

- Braid geometry and structural uniformity
- Diameter consistency
- Tensile performance
- Batch-to-batch repeatability
- Post-processing stability

Results demonstrated consistent braid formation, stable mechanical behaviour, and reliable dimensional performance suitable for scalable production.

Process Control & Repeatability

Manufacturing consistency was achieved through careful control of critical process variables.

Key controls included:

- Balanced carrier loading and yarn tension
- Standardised twist preparation
- Controlled stretching and stabilisation following braiding
- In-process dimensional inspection
- Final verification of braid geometry and quality

These controls established a repeatable manufacturing process capable of consistently producing high-strength UHMWPE braided constructions.

Engineering Outcome

The programme demonstrated that UHMWPE fibres can be engineered into stable, repeatable braided constructions through careful optimisation of braid architecture and process control.

Key engineering outcomes included:

- Successful development of a USP 2 equivalent UHMWPE braid
- Improved structural stability during manufacture
- Repeatable dimensional and mechanical performance
- Scalable production capability for high-strength braided medical components

The project reinforced that reliable braid performance depends on engineering the interaction between material behaviour, structure, and manufacturing process.

Application Relevance

Orthopaedics & Sports Medicine

High-strength braided constructs for ligament reconstruction, tendon repair, rotator cuff repair, and soft tissue fixation.

Surgical Sutures & Closure Systems

Non-absorbable braided sutures requiring high tensile strength, dimensional stability, and reliable handling characteristics.

Soft Tissue Repair

Braided reinforcement structures for high-load fixation and tissue approximation applications.

Minimally Invasive & Robotic Surgery

Braided textile components used in delivery systems and implantable devices requiring consistent mechanical performance and controlled geometry.

Key Takeaways

- Engineering UHMWPE requires controlling braid architecture as well as material properties.
- Twist configuration plays a critical role in improving fibre interaction and structural stability.
- Balanced process control enables repeatable manufacture of low-friction fibre systems.
- Stable braid geometry supports consistent mechanical performance and downstream manufacturability.
- Process optimisation provides a scalable route to high-strength braided medical components.

"High-performance UHMWPE braids are engineered through the interaction of material behaviour, braid architecture, and process control, not material selection alone."

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