Composite Materials

Mary P. Shafer
Fabric Development, Inc.
Quakertown, PA 18951

Composite Material

Two inherently different materials that when combined together produce a material with properties that exceed the constituent materials.

Composites Offer

- High Strength
- Light Weight
- Design Flexibility
- Consolidation of Parts
- Net Shape Manufacturing

Fiber Reinforced Polymer Matrix

Matrix

- Transfer Load to Reinforcement
- Temperature Resistance
- Chemical Resistance

Reinforcement

- Tensile Properties
- Stiffness
- Impact Resistance

Design Objective

- Performance: Strength, Temperature, Stiffness
- Manufacturing Techniques
- Life Cycle Considerations
- Cost

Matrix Considerations

- End Use Temperature
- Toughness
- Cosmetic Issues
- Flame Retardant
- Processing Method
- Adhesion Requirements

Matrix Types

Polyester

Polyesters have good mechanical properties, electrical properties and chemical resistance. Polyesters are amenable to multiple fabrication techniques and are low cost.

Vinyl Esters

Vinyl Esters are similar to polyester in performance. Vinyl esters have increased resistance to corrosive environments as well as a high degree of moisture resistance.

Matrix Types

Epoxy

Epoxies have improved strength and stiffness properties over polyesters. Epoxies offer excellent corrosion resistance and resistance to solvents and alkalis. Cure cycles are usually longer than polyesters, however no by-products are produced.

Flexibility and improved performance is also achieved by the utilization of additives and fillers.

Reinforcement

Fiber Type

- Fiberglass
- Carbon
- Aramid

Textile Structure

- Unidirectional
- Woven
- Braid

Fiberglass

E-glass: Alumina-calcium-borosilicate glass (electrical applications)

S-2 glass: Magnesuim aluminosilicate glass (reinforcements)

Glass offers good mechanical, electrical, and thermal properties at a relatively low cost.

	E-glass	S-2 glass
Density	2.56 g/cc	2.46 g/cc
Tensile Strength	390 ksi	620 ksi
Tensile Modulus	10.5 msi	13 msi
Elongation	4.8%	5.3%

Aramid

Kevlar™ & Twaron™

Para aramid fiber characterized by high tensile strength and modulus

Excellent Impact Resistance

Good Temperature Resistance

Density	1.44 g/cc
Tensile Strength	400 ksi
Tensile Modulus	18 Msi
Elongation	2.5%

Carbon Fiber

PAN: Fiber made from Polyacrylonitrile precursor fiber

High strength and stiffness

Large variety of fiber types available

	Standard Modulus	Intermediate Modulus
Density	1.79 g/cc	1.79 g/cc
Tensile Strength	600 ksi	800 ksi
Tensile Modulus	33 Msi	42 Msi
Elongation	1.8 %	1.8 %

Weight Considerations

Aramid fibers are the lightest

1.3-1.4 g/cc

Carbon

1.79 g/c

Fiberglass is the heaviest

2.4 g/cc

Strength Considerations

Carbon is the strongest

600-800 ksi

Fiberglass

400-600 ksi

Aramids

400 ksi

Impact Resistance

Kevlar is the toughest

Fiberglass

Carbon

Stiffness Considerations

Carbon is the stiffest

30-40 msi

Aramids

14 msi

Fiberglass

10-13 msi

Cost Considerations

Fiberglass is cost effective

$5.00-8.00/lb.

Aramids

$20.00/lb

Carbon

$30.00-$50.00/lb

Fabric Structures

Woven: Series of Interlaced yarns at 90° to each other

Knit: Series of Interlooped Yarns

Braided: Series of Intertwined, Spiral Yarns

Nonwoven: Oriented fibers either mechanically, chemically, or thermally bonded

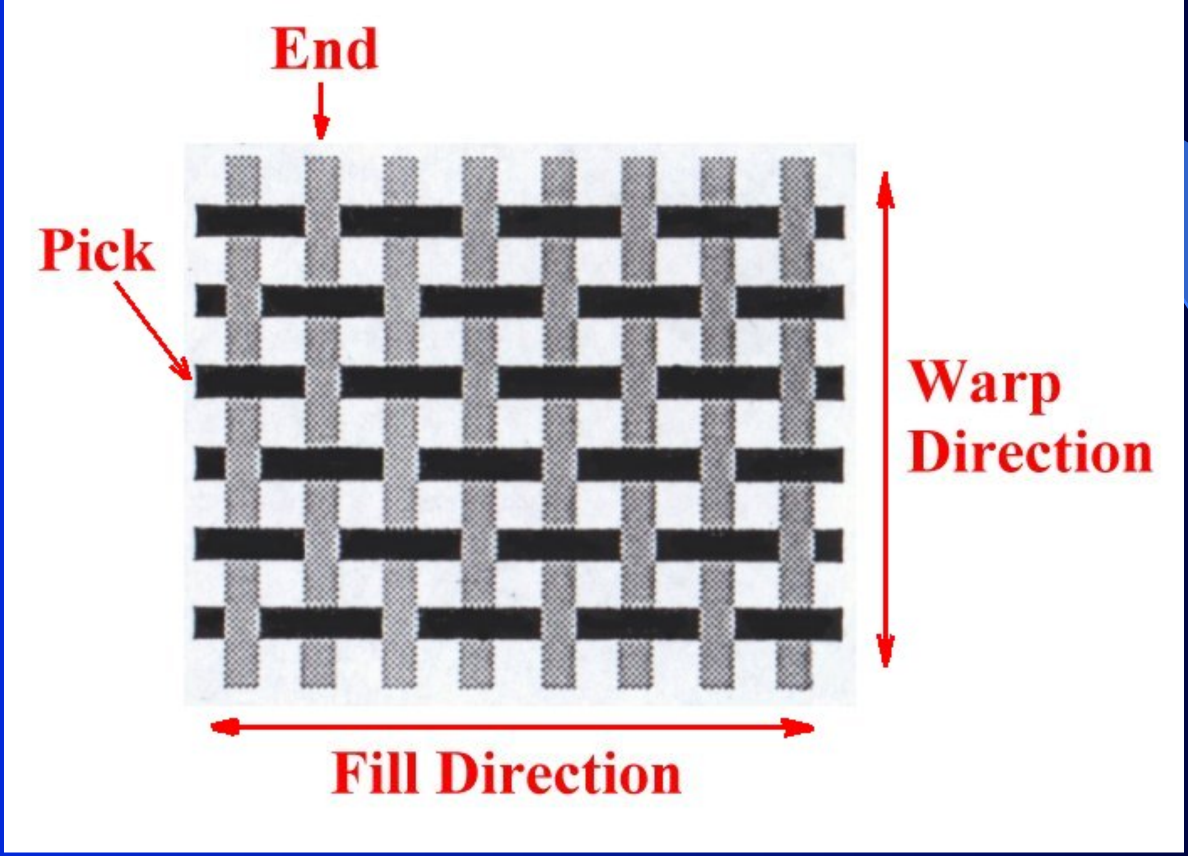
Woven Fabrics

Basic woven fabrics consists of two systems of yarns interlaced at right angles to create a single layer with isotropic or biaxial properties.

Physical Properties

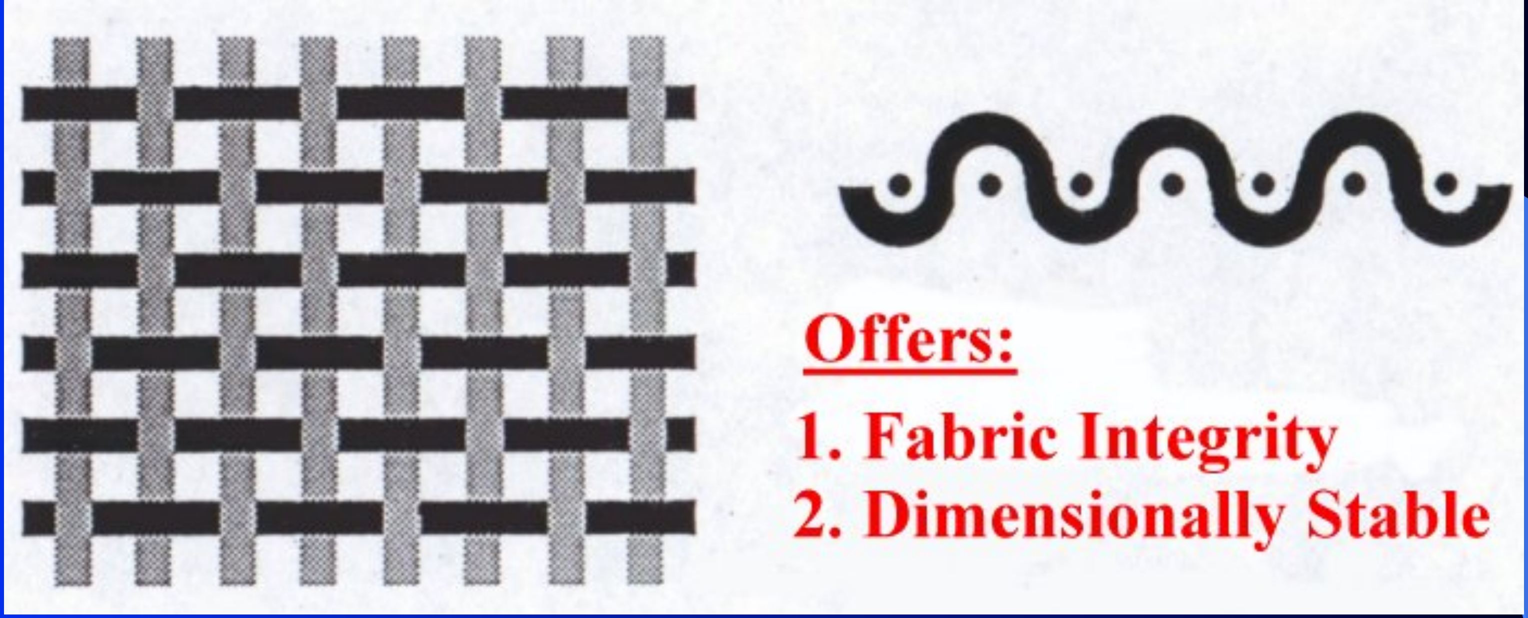
- Construction (ends & picks)
- Weight
- Thickness
- Weave Type

Components of a Woven Fabric



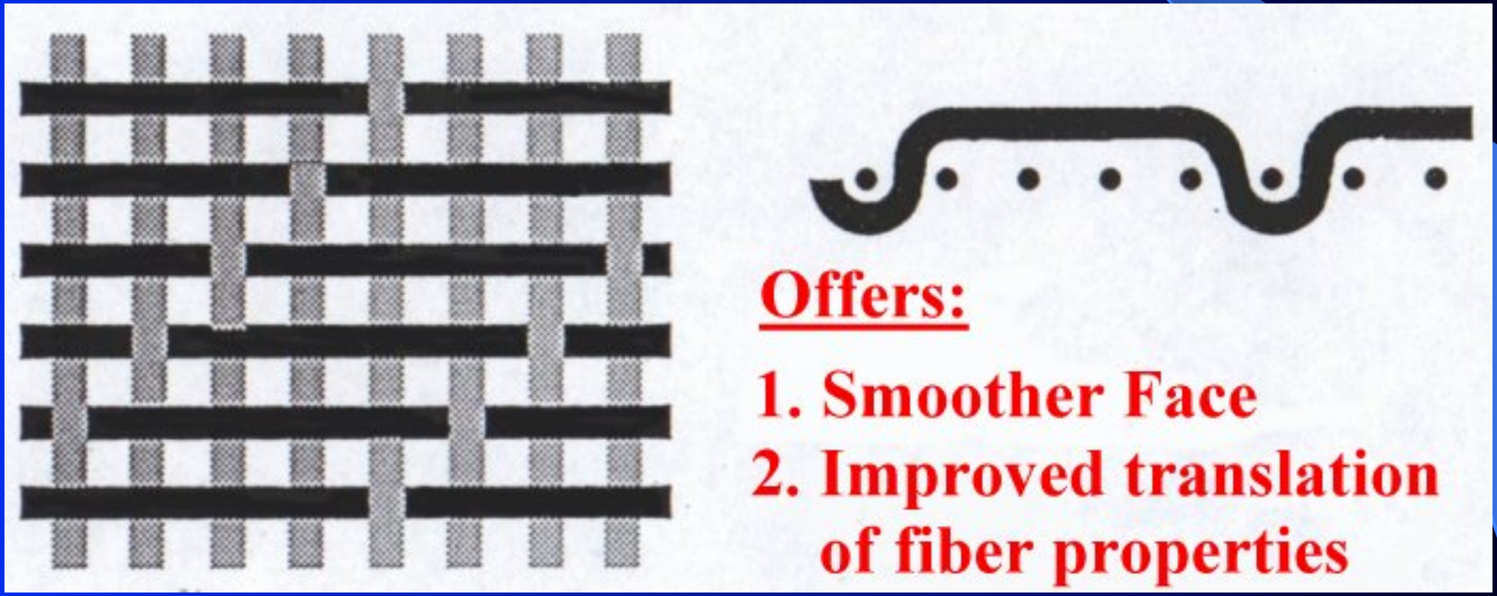
Basic Weave Types

Plain Weave



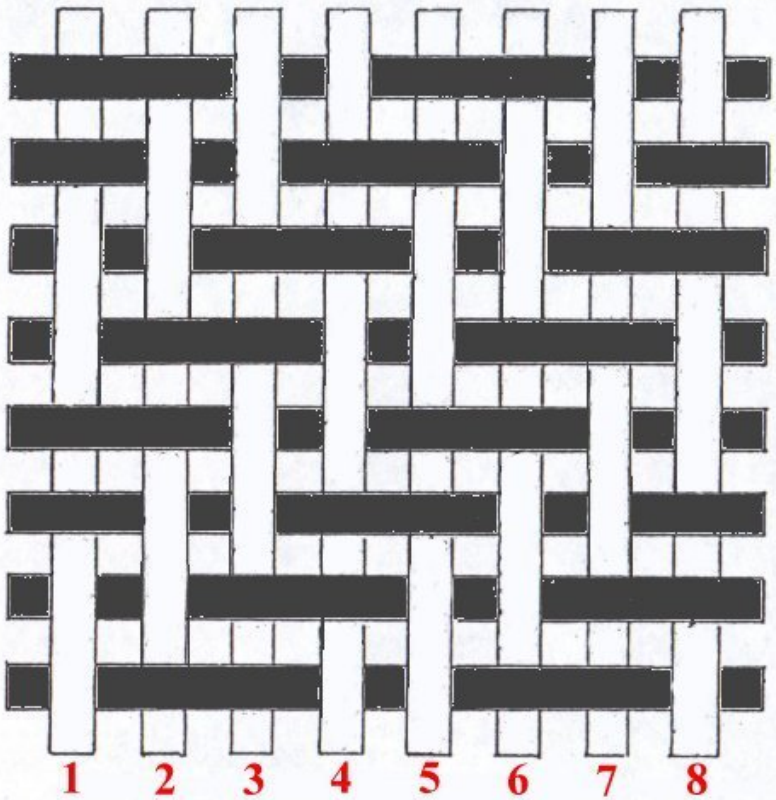
Basic Weave Types

Satin 5HS



Basic Weave Types

2 x 2 Twill

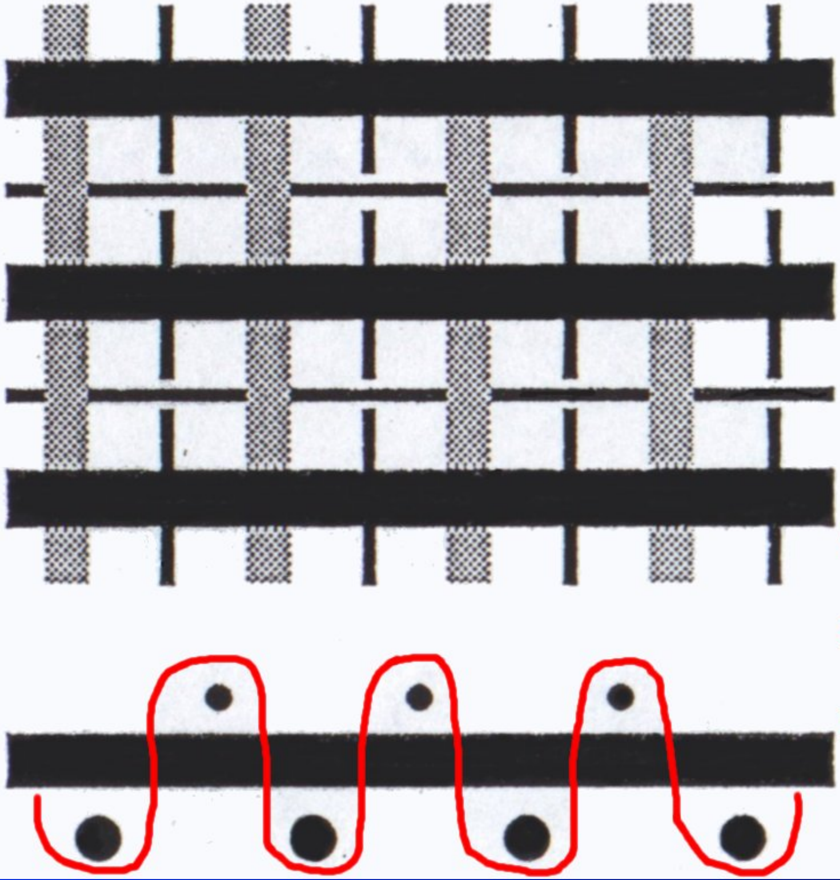


Offers:

Excellent drapeability, conformability

Basic Weave Types

Non-Crimp



Offers:

Minimum crimp in yarns.

Dimensioally stable.

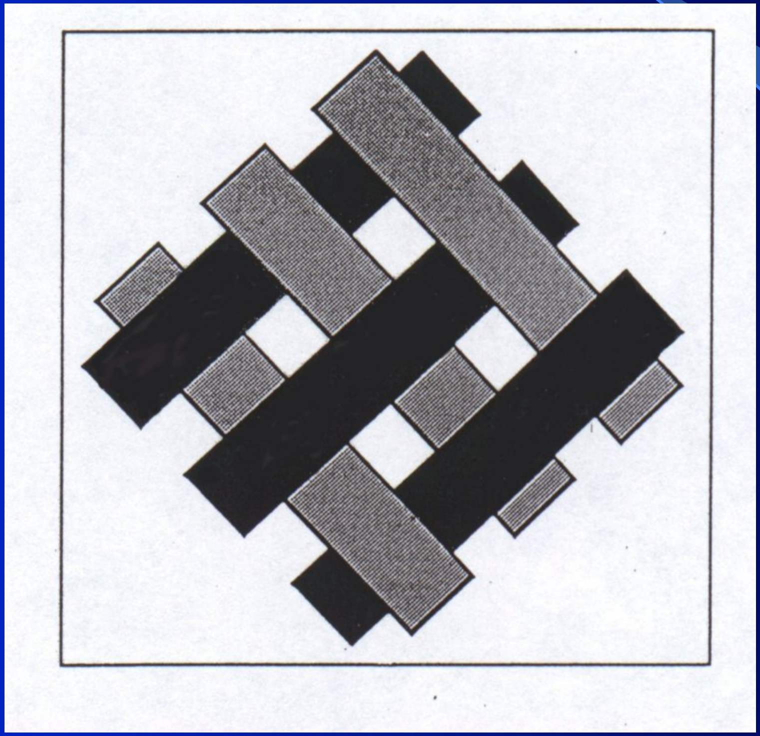
Braiding

A braid consists of two sets of yarns, which are helically intertwined.

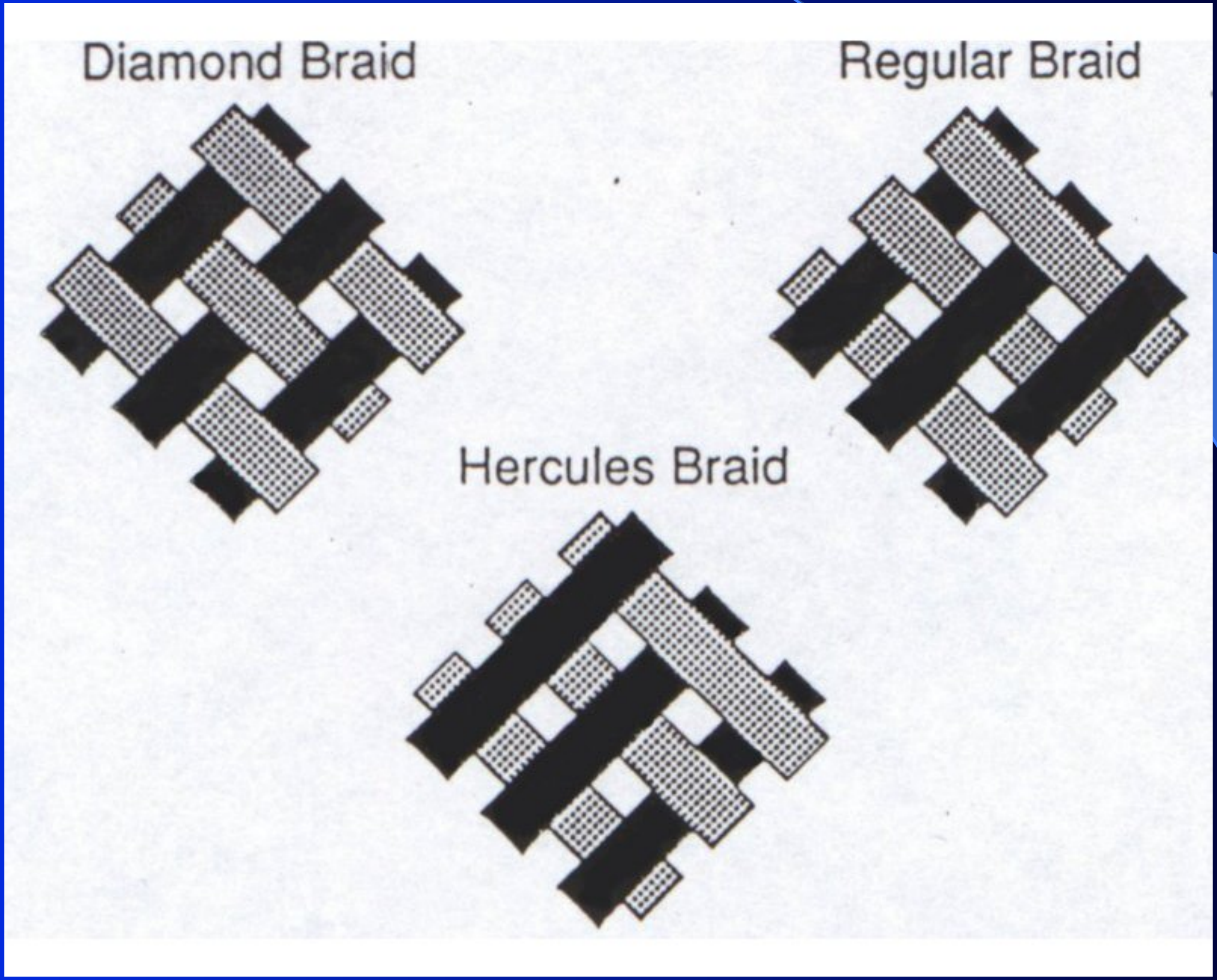
The resulting structure is oriented to the longitudinal axis of the braid.

This structure is imparted with a high level of conformability, relative low cost and ease of manufacture.

Braid Structure



Types of Braids

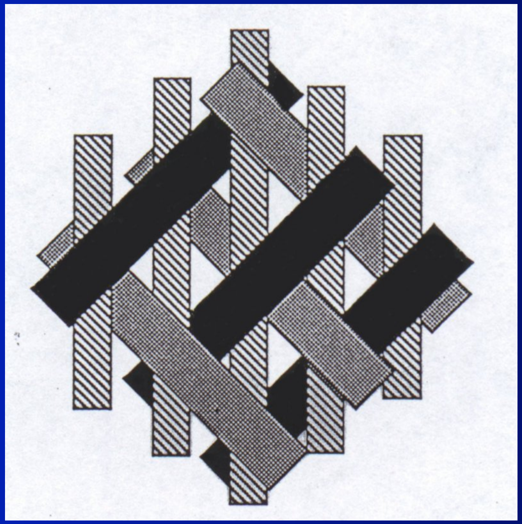


Triaxial Yarns

A system of longitudinal yarns can be introduced which are held in place by the braiding yarns

These yarns will add dimensional stability, improve tensile properties, stiffness and compressive strength.

Yarns can also be added to the core of the braid to form a solid braid.



Conclusions

Composite materials offer endless design options.

Matrix, Fiber and Preform selections are critical in the design process.

Structures can be produced with specific properties to meet end use requirements.