Light Weight, Spread Filament, Multilayer Composite Technology

Presented by Chris Adams
Technology Manager Composite Fabrics, DSM Dyneema B.V.
Where have you seen Dyneema®?

When ropes with Dyneema® lifted the Costa Concordia

When the net with Dyneema® caught the parachute-free jumper

When sails with Dyneema® won the Volvo Ocean Race

When NYPD needed new bullet resistant vests
Press Release

DSM Dyneema, Press Office
press.dyneema@dsm.com
www.dyneema.com

DSM DYNEEMA ACQUIRES CUBIC TECH AND EXTENDS DYNEEMA® BRAND INTO HIGH-PERFORMANCE FABRICS

The Netherlands, 13 May 2015 - DSM Dyneema, the inventor and manufacturer of Ultra High Molecular Weight Polyethylene (UHMwPE) fiber, branded as Dyneema®, today finalized the acquisition of Cubic Tech Corporation. This privately owned company, based in Mesa (Arizona, USA), has specialized for more than 23 years in the custom design, development and production of innovative high performance ultra-lightweight flexible laminates and fabrics — most of them based on Dyneema®.
CubicTech Integration

In 1992 Flexible Composite fabric was developed for the America3 team who would go on to win the America’s Cup.

By 2003, Cubic Tech Corporation was producing flexible composites for airships, outdoor products, medical devices, inflatable structures and beams, parachutes, large kites, balloons, flexible circuits and space applications.

Cubic Tech was acquired by DSM Dyneema in 2015. The integration expands the product portfolio, adds complementary knowledge to current offerings and enhances and accelerates the company’s innovation pipeline.
What are Dyneema® Composite Fabrics

We produce flexible composite fabrics from oriented fiber layers, high performance matrix, and high performance films or other surface coatings.

- Multiple oriented fiber layers may be positioned at any angle having an unlimited range of fiber areal weights and unlimited fiber choices and combinations
- Composite may be tailored and optimized for strength, stretch properties, weight, and minimum thickness for local and global needs, including specific locations or along predetermined load paths
- Customizable weights from 11gsm to over 500 gsm
- Flexible composites constructed from high modulus fibers have predictable and linear properties for engineering designs
DSM Dyneema offers different Dyneema® Composite fabrics to tailor tensile and tear strength for the intended application. With tensile strength measured in lbf/in or N/5cm you can select a material with just the right amount of strength and weight to meet your goal.

- Dyneema® Composite Fabric offerings start around 4.4kN/m and can go up to ~260kN/m. The tradeoff here is the higher strength means adding weight.
- Standard High Bias (HB) strength materials add +/- 45 deg fiber layer increasing tear and tensile strength.
- Fabrics can be made in equal strength in all directions.
Internal/Surface Coating Options

Surface coating properties add customizable properties including toughness, low gas permeability, low/high temperature operating capability, visible/UV/IR protection, surface texture, weldability, waterproofness, breathability.

- Polyesters PET, PEN
- Fluoropolymers - PVF, ECTFE, ETFE, E-PTFE
- Urethanes - TPU, PU, PUR
- Wovens
- Non-wovens
- Waterproof Breathable Membrane

15x stronger than steel

Ultralight
Dyneema® offers the option of customized prints (pattern and/or color). There are 2 different ways of coloring Dyneema® Composite Fabrics, each with its own look and feel:

- **Solid Color process:** Adding dye to the inside layers of the composite. Lighter fabrics will have lighter color and saturation; heavier fabrics will have deeper color saturation.

- **Sublimation printing:** Currently only for fabrics with K.18, WOV6 and WOV32c (polyester surfaces). Colors: Black, Tree-leaf Camo, Olive Drab, Blue, Orange and Gray.
How are Dyneema® Composite Fabrics Different?

Traditional Woven Fabrics
- Use many tows
- Exhibit non linear stress-strain properties due to ‘crimp’ in weave
- Tensile loading induces transverse stresses in fibers at crimp points under load.
- Translation of fiber strength to fabric strength, fatigue life and creep rupture performance are reduced.
- Crimp related reduction in properties is particularly pronounced with higher performance engineering fibers

Dyneema Composite Fabrics
- Mechanical Properties can be directionally oriented and tailored.
- Mechanical Properties can be analytically predicted and modeled
- Low to no crimp improves property translation, structural performance and resistance to creep rupture
- Can use high denier tows which eases manufacturability and cost
Why Dyneema® Flexible Composites?

Customers choose Dyneema® Flexible Composites when they need a low weight, high tensile strength, high modulus material for the most demanding applications ranging from Alpine climbing to medical device components.

Dyneema® Flexible Composite’s low stretch materials have been employed at the highest levels of sport including the America’s Cup, Tour De France and the NFL.
PROPERTIES
Lightweight Strength Example Materials

- Higher performance alternative to nylon and polyester woven materials
- Applications include parachutes, parafoils, balloons, or others where very thin, lightweight, strong, and tear resistant material is required
- Compared to 1.3 oz/yd\(^2\) Silicon Coated Woven Nylon of similar weight and thickness, a Non-Woven UHMWPE Laminate (CT1.5) is 80% stronger, has 10x higher modulus, 4x higher tear strength
- A 0.5 oz/yd\(^2\) ultra-light CT UHMWPE Laminate (CT0.3) has comparable strength to the 1.3 oz/yd\(^2\) Silicon Coated Woven Nylon
- Woven fabrics have very little strength/modulus in the bias directions, the CT0.3 and CT1.5 UHMWPE Laminates have been designed with quasi-isotropic properties. Shear properties of CT composites also significantly outperform woven fabrics.

<table>
<thead>
<tr>
<th>Product</th>
<th>Silicone Coated Woven Nylon</th>
<th>CT1.5 UHMWPE Composite</th>
<th>CT0.3 UHMWPE Composite</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (oz/yd(^2))</td>
<td>1.3</td>
<td>1.2</td>
<td>0.5</td>
</tr>
<tr>
<td>Thickness (in)</td>
<td>0.002</td>
<td>0.002</td>
<td>0.001</td>
</tr>
<tr>
<td>Tensile Strength (lbf/in)</td>
<td>48</td>
<td>87</td>
<td>41</td>
</tr>
<tr>
<td>Theoretical Strength @ 23°C (lbf/in)</td>
<td>--</td>
<td>75</td>
<td>28</td>
</tr>
<tr>
<td>Conversion Efficiency @ 23°C (%)</td>
<td>--</td>
<td>116</td>
<td>146</td>
</tr>
<tr>
<td>Modulus ((lbf/in)/(in/in))</td>
<td>237</td>
<td>2774</td>
<td>1670</td>
</tr>
<tr>
<td>Strain to Failure (%)</td>
<td>33.0</td>
<td>3.2</td>
<td>2.9</td>
</tr>
<tr>
<td>Slit Tear Strength (lbf)</td>
<td>26</td>
<td>108</td>
<td>38</td>
</tr>
<tr>
<td>Bias Tensile Strength (lbf/in)</td>
<td>--</td>
<td>87</td>
<td>41</td>
</tr>
<tr>
<td>Bias Modulus ((lbf/in)/(in/in))</td>
<td>--</td>
<td>2774</td>
<td>1670</td>
</tr>
<tr>
<td>Helium Gas Permeability (L/m(^2)/24hrs)</td>
<td>--</td>
<td>&lt;0.2</td>
<td>&lt;0.2</td>
</tr>
</tbody>
</table>

Figure 9. Properties of Silicone Coated Woven Nylon and CT Lightweight Composites
Composite thickness variation

- 6 plies in laminate of total thickness 240μm = ~40 μm per ply
- Small range of thickness
  - (95% of data points fall between 9mil and 11mil = 222μm to 279μm)
- Low variation -> 5% CoV
- 120 data points from a 9m x 1.37m finished sheet
- ~210kN/m warp tensile, ~75kN/m weft tensile

Thickness data histogram
APPLICATIONS
Stone Island Prototype Research Series

- The brand is holding an exhibition of 50 garments made in 50 different colors.
- Series 02 features a reversible jacket made from Dyneema, the strongest and most durable lightweight fibre in the world, and nylon tela, which takes the dye.
- The 100-piece limited edition collection will be on sale from the end of April at the Stone Island website.
SPEZIALIZED S-Works 6  Explosive speed and superior comfort

- The Specialized S-Works utilizes a 4 directional Dyneema composite to eliminate stretch in the heel and counter area.
- The Dyneema composite uses TPU faces to allow the material to bond to a multitude of substrates using a hot-melt adhesive
- By eliminating stretch the shoe is able to fully employ the BOA system and carbon sole for maximum power transfer to the pedal.
Inflatable Gear

AIRE Backraft Expedition

- The Bakraft uses a impregnated woven Dyneema® fabric for ultimate durability.
- Total fabric weight is 175 gsm.
- Lightweight, packable and simplified in-field repairs
Tents and Shelters

LOCUS GEAR

- Easy Bonding with Pressure Sensitive Tapes. No Sewing or Waterproof Sealing
- With CT1K.18, weight is almost Half of a regular 30den coated nylon fabric
- With Waterproof & Breathable Dyneema® Composite Materials, condensation can be eliminated in cold weather conditions
**New developments in safety**

**THE NEXUS BY INDEMNIS**
Focused on making safe, regulated commercial flight over people possible

This system works by rapidly inflating the tubular apparatus and launching the chute up to 50 feet away from the aircraft at 100+mph, clearing it from the aircraft and preventing entanglement.

**Bonding of Dyneema - Patent Pending**
- Developed patent pending technology to bond the ultra-lightweight Dyneema Composite Fabrics to a strength greater than the base material. This process allows us to achieve weight efficiency and is used in all Indemnis designs.

**Spot Coating - Patent Pending**
- Allows for the lightest possible combination of the Dyneema composite fabrics with an ultra high strength seam.
- Internal State of the Art Tooling
- Ability to create high pressure structures (100+PSI) in complex shapes and angles that allows for product advancements that have never been done before
Plate carrier

Laser cut solutions for lightweight vests

- Point Blank Enterprises launched 7 vests at 2017 Shot Show in Las Vegas
- 10-30% weight savings
- Significant labor savings and C&S simplicity
Parachutes

- **Large Lightweight Canopy** - In 2010, Cubic Tech demonstrated our ability to reduce weight and packing volume over traditional materials having equivalent mechanical specifications by developing a parachute material that afforded a significant weight savings for the system and reduction in packing volume (Figure 6).

- “The use of lightweight fabric by Dyneema® has brought the 62.2 ft canopy assembly weight down from approx 42 lb to approx 32 lb - a saving of 23% in canopy assembly weight.

- This significant weight reduction leads to a reduced pack volume, easier packing of existing canopies or the ability to provide larger parachutes within an existing airframe compartment to accommodate air vehicle weight growth over time. The advantages for use of this material in spacecraft application parachutes include the ability to provide significant weight and /or volume savings in these mass-critical applications.”

![Lightweight Packed Parachute Comparison](image)
Inflatables

Amorphic Robot Works Inflatable Sculptures
Lift bags

Produced and delivered 3-D shaped lift-bags to US Airforce
Future product-application options

Capable of producing 3D Integrated Structure Panels with Internal Reinforcement & Complex Geometries
Future? Flexible Electronics

- Internal and external lamination of flat-wires and etchable foils (copper)
- This may be useful technology for power transfer or storage
- Potential to incorporate flexible antennas, and other sensors and smart structures into the fabric shell
Conclusion

We are developing materials to meet the challenges of current and future technologies.

- Flexible multidirectional flexible fabric using high performance engineering fibers and engineered environmental surface coatings
- Customizable flexible or rigid composites for optimum mechanical properties
- Dyneema Composites Fabrics can be produced in weight ranging from 11gsm to over 500gsm
- Material properties can be tailored for strength and modulus in multiple directions
- Seamless 2D flat or 3D complex curved structures are possible
- Composites can be designed for pressure retention, breathability, environmental resistance, abrasion resistance, adhesion, aesthetics, and haptics
Find out more at our booth:

Hall 4 Level 1 Stthand G19
Questions and Answers