



DELIVERING
COMPOSITE
SOLUTIONS

Commercial Blade Developments at TPI Composites, Inc.

2008 Wind Turbine Blade Workshop

Hosted by:

Sandia National Laboratories

Co-Hosted by:

National Renewable Energy Laboratory (NREL)

And supported by

The US Department of Energy

Stephen C. Nolet
Principal Engineer
TPI Composites, Inc
Warren, Rhode Island

May 12, 2008



Wind Energy Development Programs Discussed at the Highest Levels of Government



- President Bush explains the clear advantage of bend/twist coupling to senior officials.
- Here the President is showing how the TPI TX-100 design optimizes the use of carbon fiber in the skin to maximize the coupling coefficient.

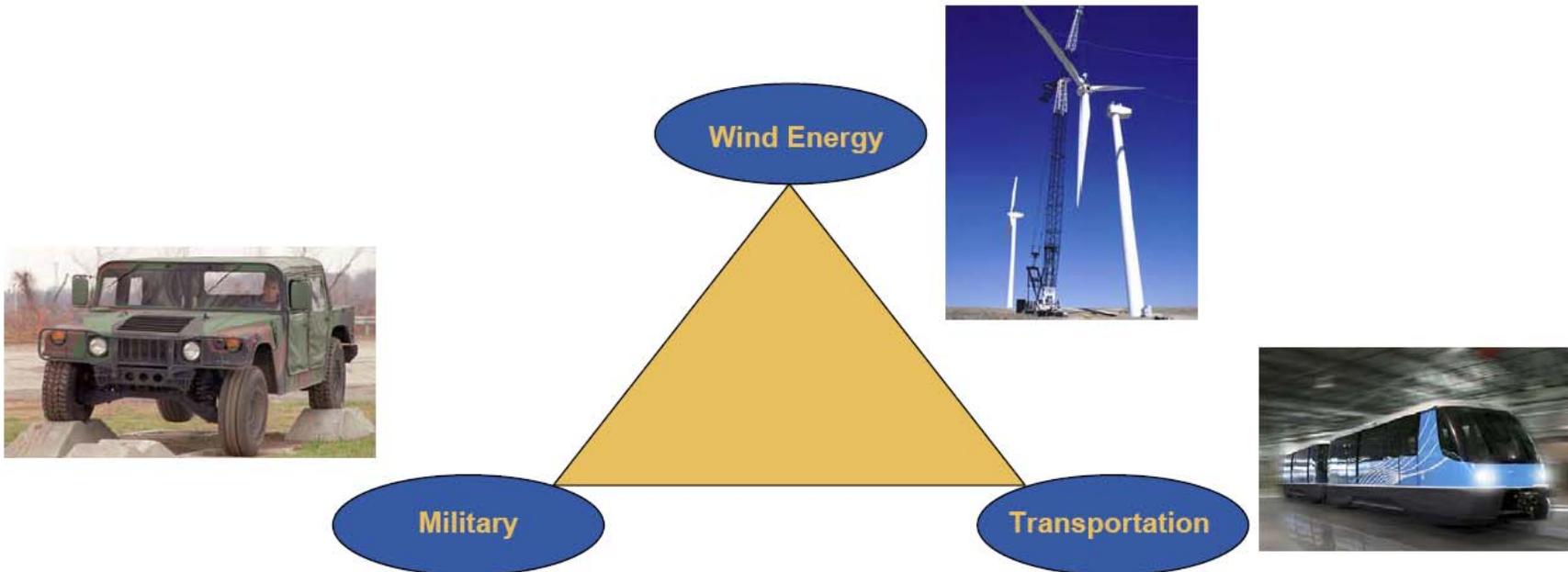


DELIVERING
COMPOSITE
SOLUTIONS

INTRODUCTION TO TPI COMPOSITES

TPI Composites, Inc.

Deliver structural composite solutions in volume to the wind energy, military and transportation markets. Solid growth through long term partnerships with major players in each of these industries.



Military Vehicle Applications

- > Weight reduction of structural composites enables improved armor & mine blast capability
- > Improved durability - corrosion and fatigue
- > Migrate from components such as hoods to cabs to full vehicle bodies



Transportation Applications



BOMBARDIER



Military Applications – Facilities Springfield, Ohio



**TPI Composites, LLC, Springfield, OH
96K sq ft, Military and Transportation
Manufacturing**

Wind Turbine Blades

- › Blades 29-50 meters long, weighing 10-20K pounds
- › Cost-efficient, long-term partnership models with key turbine makers
- › Factories located in a manner to optimize labor and transportation cost, providing competitive advantage
- › Custom designs, tailored to customers machine



VienTek

**MITSUBISHI
POWER SYSTEMS**



Wind Energy – Commercial Products Mitsubishi Heavy Industries



MHI 1MW Class 1
26.8M Blades



MHI 1MW Class 2
29.5M Blades



Wind Energy – Commercial Products Mitsubishi Heavy Industries (continued)



- MHI's 2.4 MW wind turbine
 - MWT92/2.4 and MWT 95/2.4
- 44.7m WTB Class II Service
- 46.2m WTB Class III service



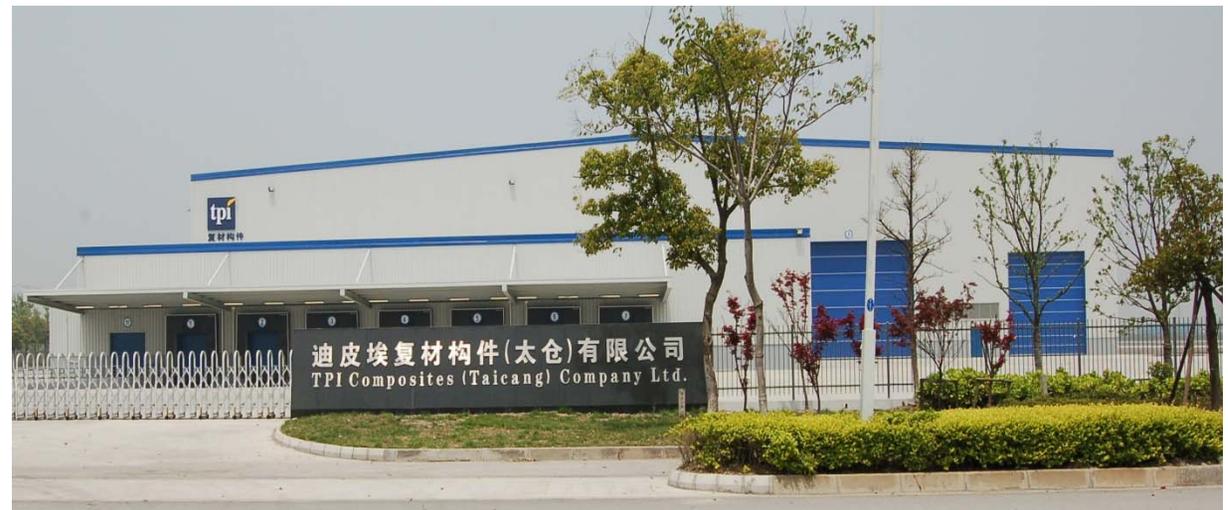
Wind Turbine Blade Production World-Wide Facilities



Juarez Mexico
“Vientek” JV between
TPI Composites and
Mitsubishi Heavy Industries
Plant 2 opened December 2007



Taicang Port, China
Facility opened January 2008
Blades built for GE Wind.



Wind Turbine Blade Production Newton, Iowa Opening June 2008



- 316,000 sq ft production facility
- GE Wind Energy 37m and 40m blades for 1.5MW Turbines.
- GE Wind 48.7m blades for 2.5MW Turbines (soon!).
- Newton is home of former Maytag Appliances w/strong manufacturing base



TPI Composites Newton, Iowa – Progress April 2008

1.1M Sq Ft of Manufacturing Space

Warren, RI, 60K sq ft, Development Center, Manufacturing



Taicang Port, China, 190K sq ft to supply wind blades to GE



Newton, Iowa, 316K sq ft to supply wind blades to GE



Juarez, Mexico, 2 Plants 477K sq ft, Wind blade JV with Mitsubishi



Springfield, OH - 66K sq ft, Military and Transportation Mfg



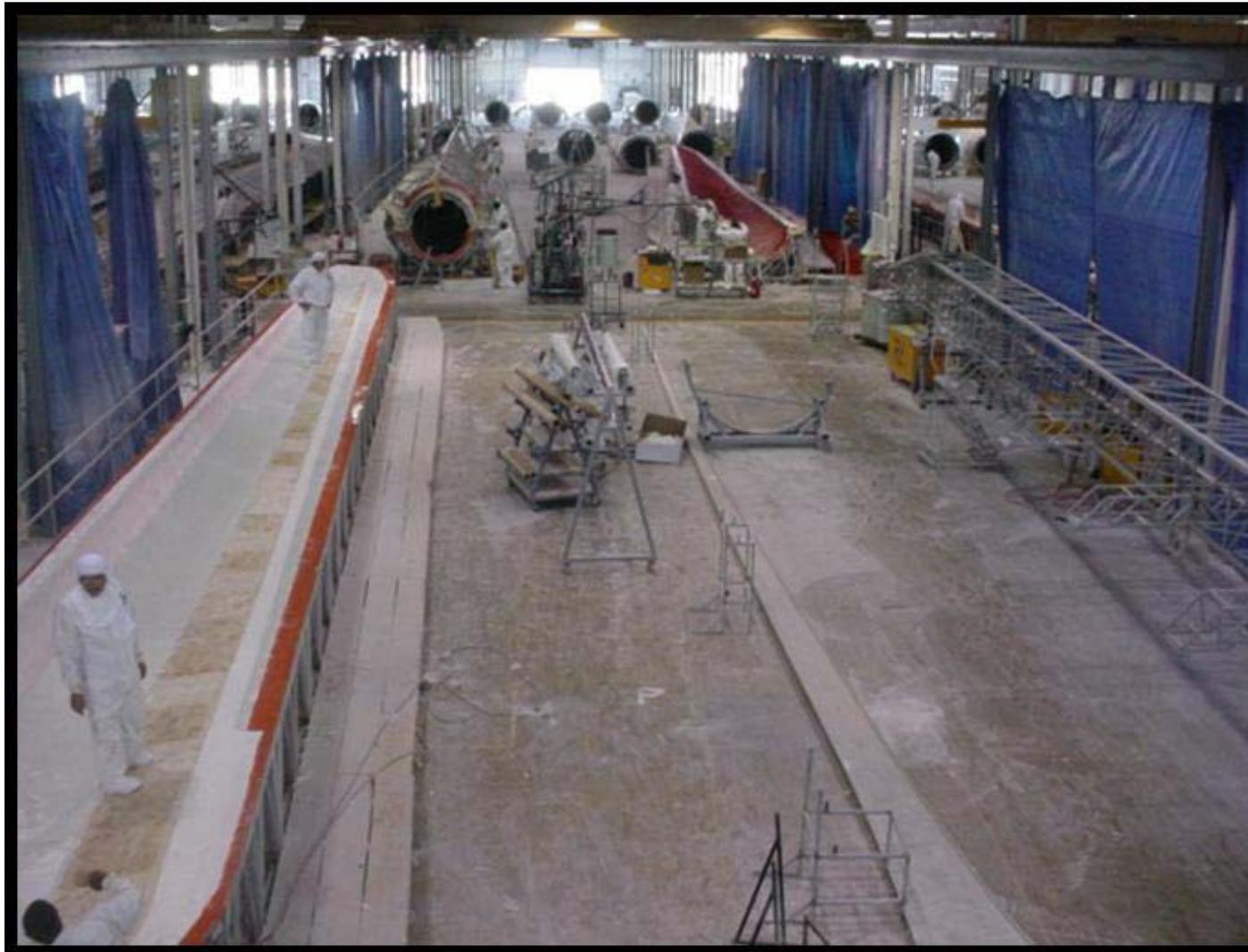
DELIVERING
COMPOSITE
SOLUTIONS

BLADE MANUFACTURING



DELIVERING
COMPOSITE
SOLUTIONS

Skin Lay-up with Reinforcements and Core



Wind Blade Manufacturing: Infusion, Demolding, and Assembly



Blade Assembly and T-Bolt Drilling



Blade Testing, Inspection & Storage



Blade Transportation





DELIVERING
COMPOSITE
SOLUTIONS

APPLIED TECHNOLOGIES

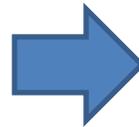
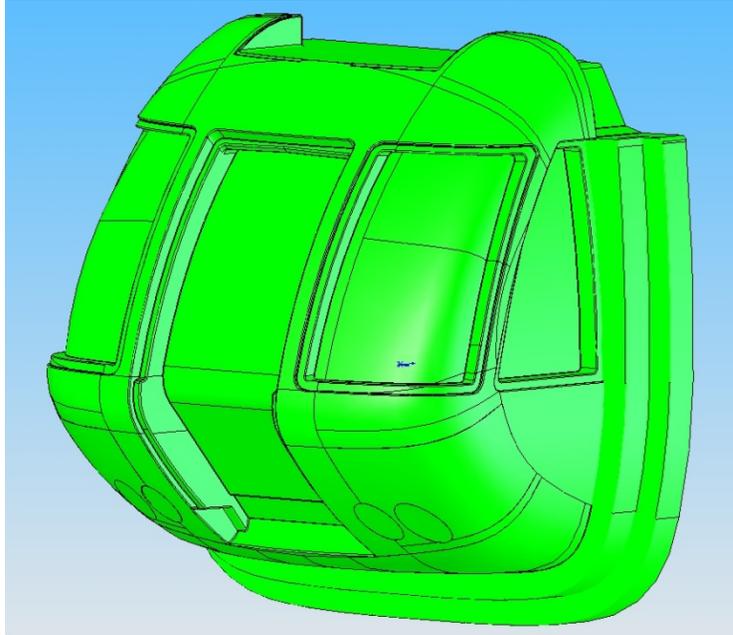
Reusable Silicon Bag Technology for SCRIMP



- Silicone bags are rapidly fitted to the infusion tool
- Feed lines, vacuum lines and embossed distribution channels are integrated into the bag improving the repeatability of the process
- Setup time and process robustness greatly improved



•3D Solid Modeling From CAD to Plug



- CAD models uploaded to 3 and 5 axis machine centers for plug fabrication.
- Multiple mold sets pulled from machined plugs to build final product structure



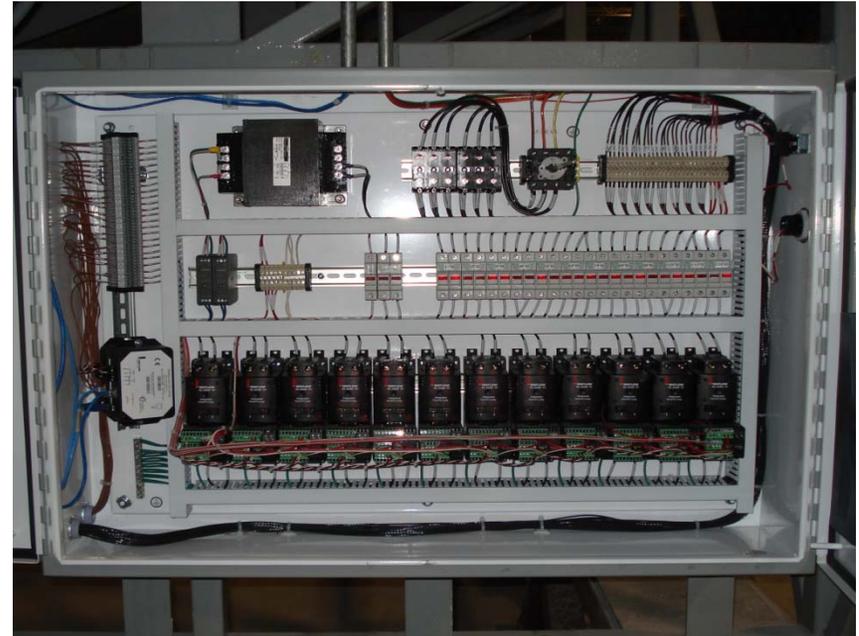
- Catia V5 solid modeling is now applied for design of all geometric surfaces.
- Applied to both structural analysis and surface generation for tooling.

Hydraulic “Power Hinges” for Blade Assembly



- Hinges eliminate flip fixtures and HP or LP Skin demolding prior to bonded assembly
- Greatly reduces assembly time
- Improves accuracy
- Eliminates risk of damage to either skin as a result of handling

Electro-Resistive Heating for Epoxy Matrix Molded Blades



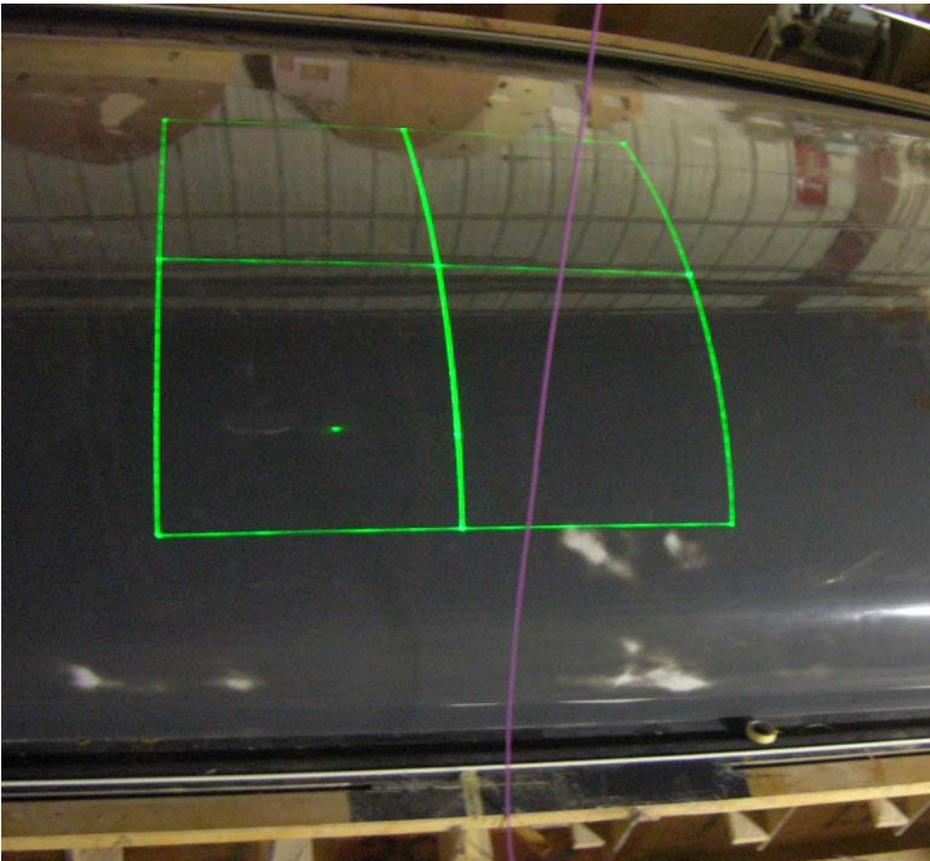
- In-house fabrication with proprietary ER cables and fit for purpose laminate design.
- Dedicated multi-zone PID temperature control with supervisory control via TCP/IP based remote SCADA for set point control, production monitoring and logging.

Webcore Technologies, TYCOR Sandwich Core Materials



- TYCOR material applied to shear webs in production blades for multi-megawatt scale turbine.
- Very low weight, high performance core at a highly competitive price.
- Kitting and assembly in mold has proven to be faster and more accurate than balsa and foam materials.

3D Laser Projection Systems



- Laser Projection Systems for real time tool based projection of ply locations, bonding adhesive outlines and shear web location.
- Ceiling mounted laser projectors. Up to five “ganged” together to provide full coverage across a single pair of 47.2m molds.
- Technology is now applied to all 2.4MW blade production



DELIVERING
COMPOSITE
SOLUTIONS

DEVELOPING TECHNOLOGIES

Global Energy Concepts DOE Ph II SBIR



- Build of megawatt scale vinyl-ester blade with carbon fiber spar caps
- Broad use of Webcore Technologies TYCOR sandwich core product in skins and shear webs.
- Resulted in > 20% weight reduction in comparison to same glass/polyester design.
- Effort directly lead to application of sandwich core materials to TPI production.

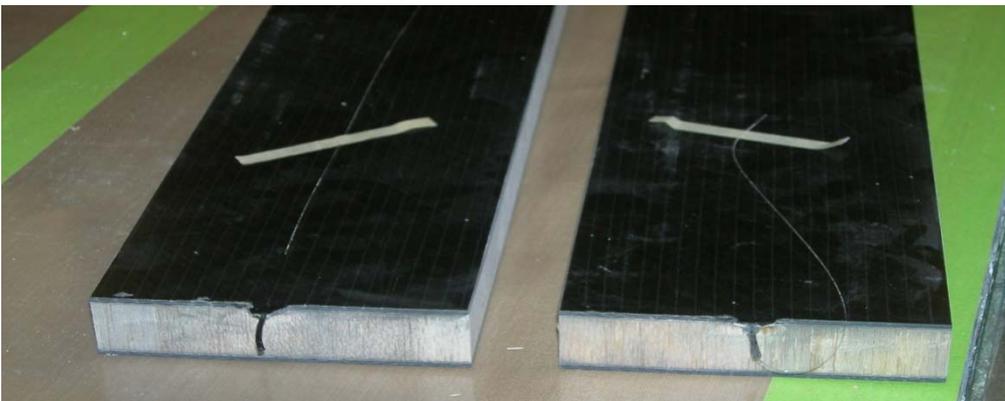
- US Department of Energy (Sandia) Blade R&D at TPI:
 - 9 Meter Blade Program
 - ERS-100/NPS Blade: Baseline
 - CX-100 Blade: Carbon Spar Cap Epoxy Blade
 - TX-100 Blade: Bend-Twist Coupled Epoxy Blade for load mitigation
 - BSDS Blade: Thick Airfoil / Carbon Spar Cap Epoxy Blade



CX-100 Development Continues



- This month TPI, Aither Engineering and Purdue University with support from Sandia labs will build a new CX-100 with fully integrated FBG strain instrumentation and accelerometers for real time measurement on a NWTC test turbine at Bushland, Texas.
- Test panels with embedded fibers as well as mechanical testing for characterization of material systems completed to provide analytical predictive capability.





DELIVERING
COMPOSITE
SOLUTIONS