



Monolithic

Carbon Fiber Wind Mill Blade



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Innovative composite solutions



Summary

Salient Features

Material & Process

Development

Learning's

Team



Monolithic Carbon Fiber Wind Mill Blade

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Market Scenario

674 Small Wind Turbines

521 Horizontal Axis Wind Turbines (HAWT)

152 Vertical Axis Wind Turbines (VAWT)
and **1** kite



Monolithic Carbon Fiber Wind Mill Blade

Market Scenario

- Machine sizes : 3.4 kW, 5 kW, 8kW, 10kW, 15kW, 20kW, 25kW, 30kW - Offgrid
- Blade sizes : 1.8m to 5.8 m

Reinforcement : Carbon + Glass

Matrix : Vinyl Ester + Epoxy

Process : HLU, Infusion, RTM

- Government Subsidies
- Wind Mill OEM's : Schneider, South West, Altem, Advanced bolting solutions,



Monolithic Carbon Fiber Wind Mill Blade

INDIA's First commercially produced single piece (Monolithic) molded blade of this size till date

The monolithic Carbon Fiber Wind Mill Blade is a unique example of detailed engineering and exquisite craftsmanship.

This blade is 1500 mm long having 3.4 kgs of weight used for 3.5 kW wind mill

It uses Carbon fiber as a reinforcement, structural foam as core and vinyl ester resin as matrix.

The blade is made using Vacuum Assisted Resin Transfer molding

Monolithic Carbon Fiber Wind Mill Blade



Salient Features

- a. Single piece construction :** A specially designed & molded foam is used as an inner core, with appropriate layup to get structural strength & outer shell to get the aerofoil
- b. Optimized Layup sequence :** A mix of unidirectional & multi-axial carbon fiber, Foam layup to get the desired strength with minimum weight for best functional performance
- c. Critical Design optimization :** The best of the CAD & CAE tools were deployed to achieve a critical to function design optimization to get the correct combination of material & process.

Monolithic Carbon Fiber Wind Mill Blade



Salient Features

d. Process optimization : Process designed and developed to get 8 blades / day with only 2 % wastage

e. Indigenous Development : The entire development from design-material selection-optimization-process design-tooling development to production achieved by inhouse Mahindra Composite Team & other Development partners

f. Competitive cost : The development cost for this project was almost 80% less & the product is 40% cheaper than those available from US

g. Mold Development : Mold designed and developed using best of the materials from around the world to suit Indian molding conditions & requirements.

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Material

Reinforcement : Carbon Fiber UD & Combi Matt : **Zoltek**

Matrix : Vinyl Ester Resin : **AOC**

Core : PU Foam & PE Structural Foam : **DIAB**

Process

Vacuum Assisted Resin Transfer Molding

Monolithic Carbon Fiber Wind Mill Blade



Development Process

a. Product Design : Lay up design using UD & Multi Axial Carbon fabric, structural PE foam, Resin. Design optimization for light weight & high strength using best of the CAE tools.

b. Process Design : To cater to the Monolithic – single piece requirement of the molded product, Vacuum assisted RTM process was customized. The correct formulation of Vinyl ester resin to suit the carbon fabric and the foam core was arrived at.

c. Tooling (Mold) Development : Appropriate molds were developed using tool grade resin to suit vacuum molding.

Monolithic Carbon Fiber Wind Mill Blade

Development Process : CAE

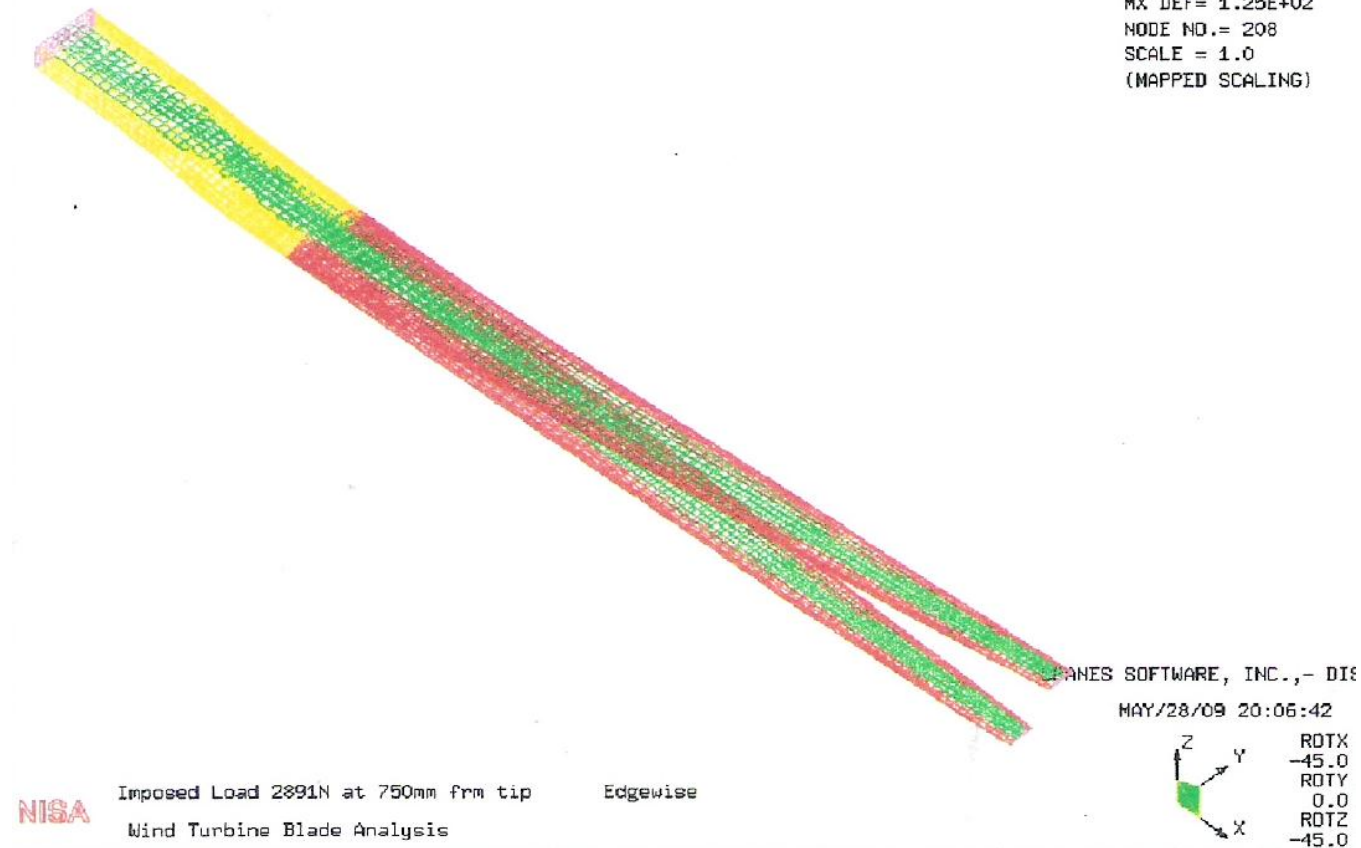


Monolithic Carbon Fiber Wind Mill Blade

Development Process : CAE

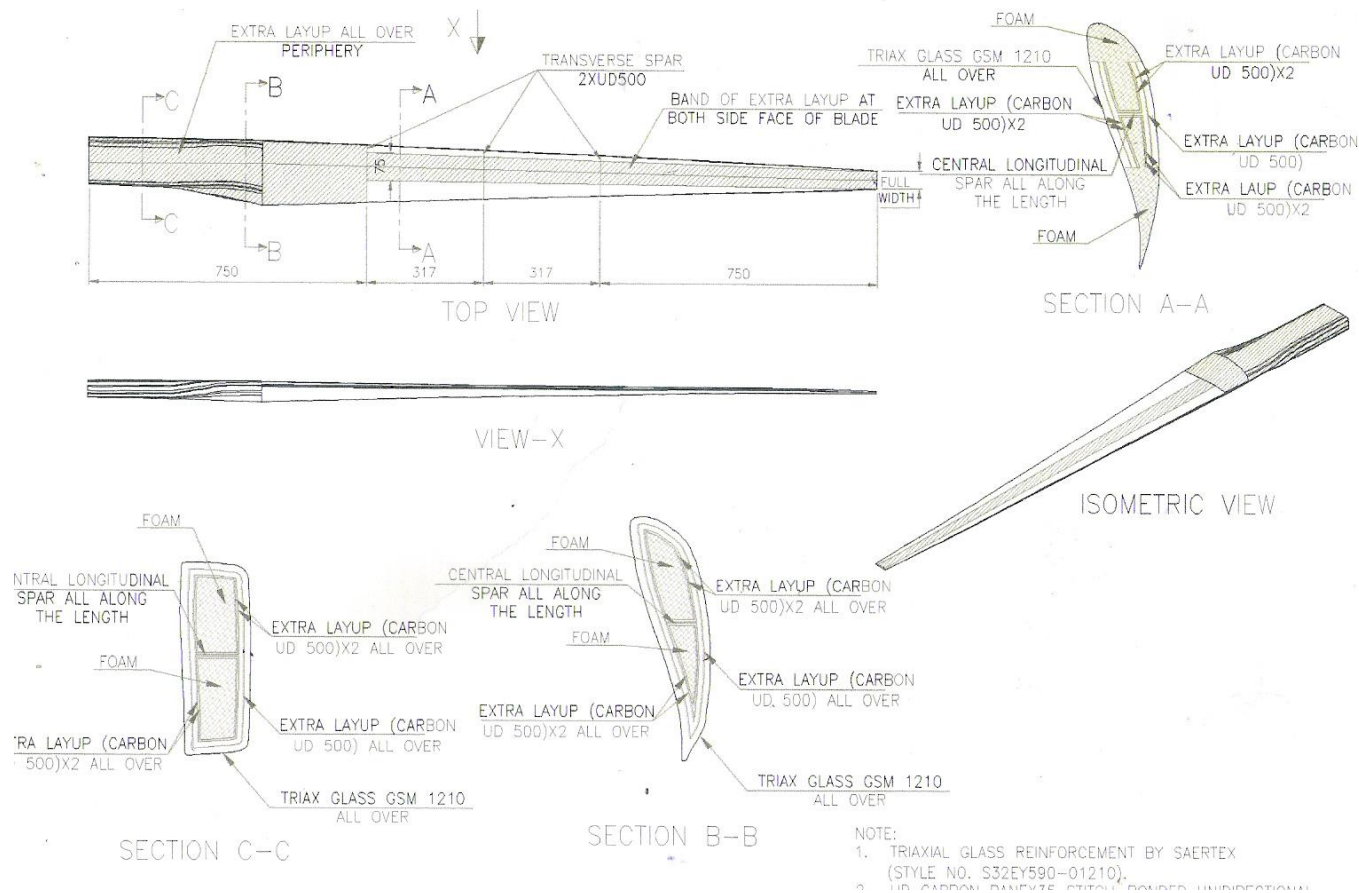
DISPLAY III - GEOMETRY MODELING SYSTEM (15.1.1) PRE/POST MODULE

DISPLACED-SHAPE
MX DEF= 1.25E+02
NODE NO.= 208
SCALE = 1.0
(MAPPED SCALING)



Monolithic Carbon Fiber Wind Mill Blade

Development Process : Final Design of the Blade



Monolithic Carbon Fiber Wind Mill Blade



Development Process

d. Part molding : To get the required weight of the component various optimization techniques were deployed. We achieved a wastage of only two percent of the raw material before starting serial production

e. Balancing : A unique 2 component balancing technique was evolved using lead pallets.

f. Production : The facility is designed for making 5 blades a day, which is a landmark

Monolithic Carbon Fiber Wind Mill Blade

Development Stages



Foam Core



Monolithic Carbon Fiber Wind Mill Blade

Development Stages



Pre Cut Reinforcement

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Development Stages



Mold

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Development Stages



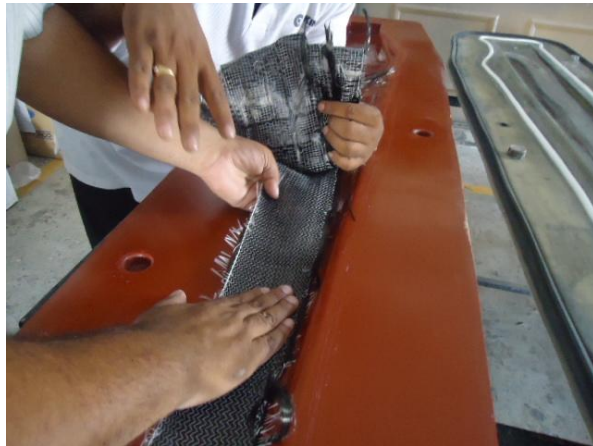
Mold preparation



Gel coat application

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Development Stages



Lay-up sequence



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Development Stages

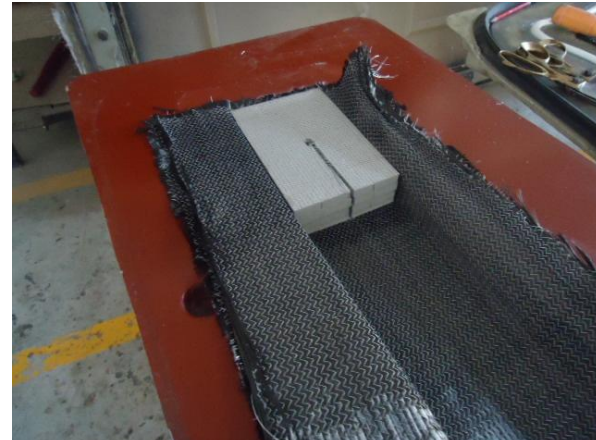


Lay-up sequence



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Development Stages



Lay-up sequence



Monolithic Carbon Fiber Wind Mill Blade

Development Stages



Lay-up sequence



Monolithic Carbon Fiber Wind Mill Blade

Development Stages



**Mold Closure –
Vacuum Application**

Resin catch pot



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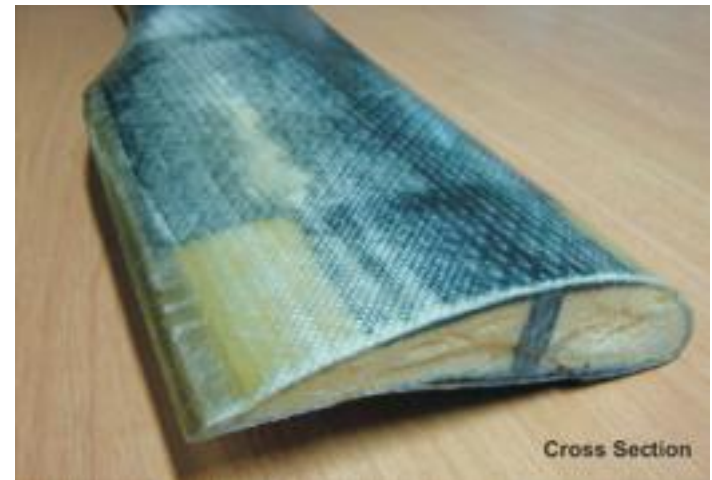
Serial Production



150 blades per month

Monolithic Carbon Fiber Wind Mill Blade

Final Blade



Monolithic Carbon Fiber Wind Mill Blade



Learning

1. Appropriate material
2. Correct material specs
3. Design & Validation Tools
4. Persistence
5. Methodological approach
6. Collaborative efforts



Monolithic Carbon Fiber Wind Mill Blade



Team

1. Mahindra Composites

Pravin, Sachin, Kiran, Yogesh

2. Zoltek – Akhil Hebbar

3. Epsilon Composites Solutions : ADC Resin & Engineering

Vijay Deshpande, Perera, Sanjay Rade



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ICERP 2011

International Conference and Exhibition on Reinforced Plastics
2 - 4 March, Mumbai

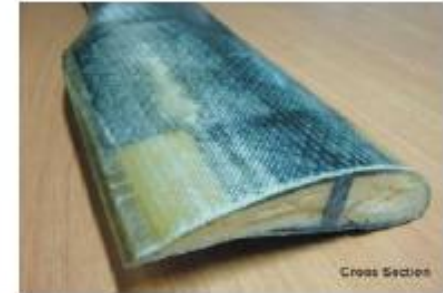
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Awards and Recognitions

Monolithic Carbon Fiber Wind Mill Blade



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Thank You

Thank You



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