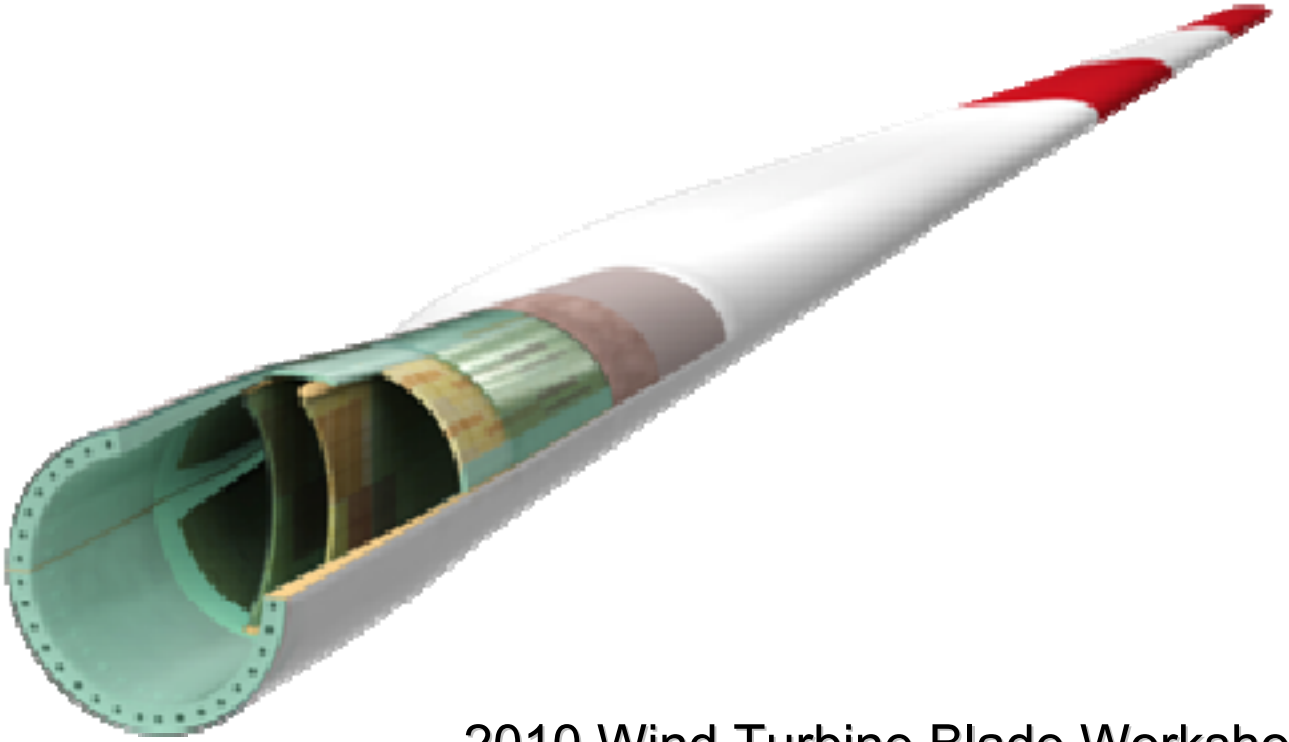
Advanced Material Solutions: Improving Quality & Reducing Cycle Time in Blade Production



2010 Wind Turbine Blade Workshop
July 21, 2010
jay.bhatia@basf.com

BASF
The Chemical Company

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- Product specific data and benchmarks are average values and will vary with spcific production conditions
- Reflections on present and future market trends are presenter‘s personal opinions

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Outline

BASF
The Chemical Company

- BASF - Introduction
- Challenges in Blade Production
- Recent Advances in Materials
- Summary

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BASF – The Chemical Company
At a Glance

- Sales 2009: ~ $ 71 billion
  Sales 2008: ~ $ 90 billion
- Employees 2009: ~105,000
  Employees 2008: ~95,000

- The world's leading chemical company
- Serves all major industries
- Production facilities on 6 continents
- World-class, innovative, high-value products
- Intelligent, sustainable systems & solutions
- *World's Most Admired Chemical Company*: *Fortune* 2010 & 2009

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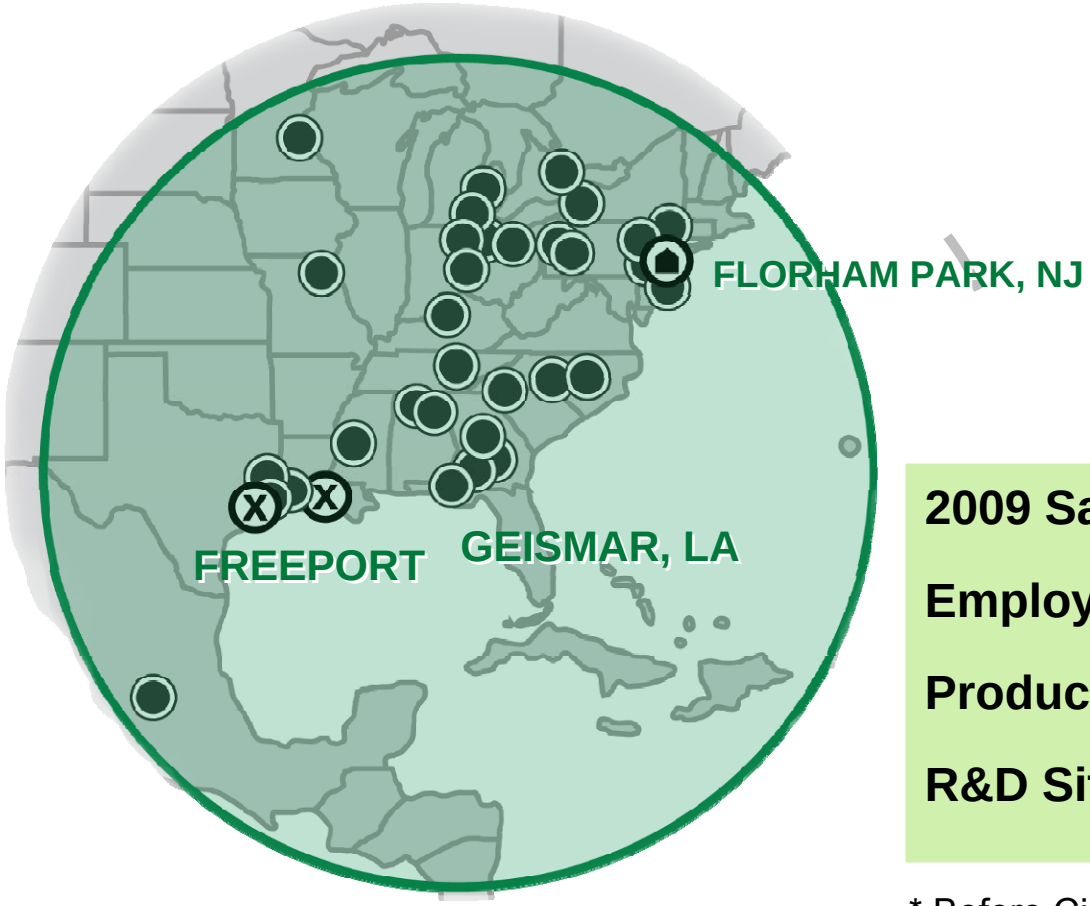
BASF in North America

BASF
The Chemical Company

Regional Headquarters

Verbund Site

Sites with more than 100 employees



2009 Sales: ~$13 B

Employee: ~16,000

Production Sites: 92*

R&D Sites: 24*

* Before Ciba integration

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Eras in BASF's History

April 2009
Integration Ciba

Since 2004
The Chemical Company

1965 – 2004
From Ludwigshafen to the world

1953 – 1965
The beginning of the **plastics** age

1945 – 1953
Reconstruction and new beginning

1925 – 1945
New high-pressure syntheses

1901 – 1925
The age of **fertilizers**

1865 – 1901
Founding of BASF – the age of **dyes**

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BASF in Wind Energy

BASF
The Chemical Company

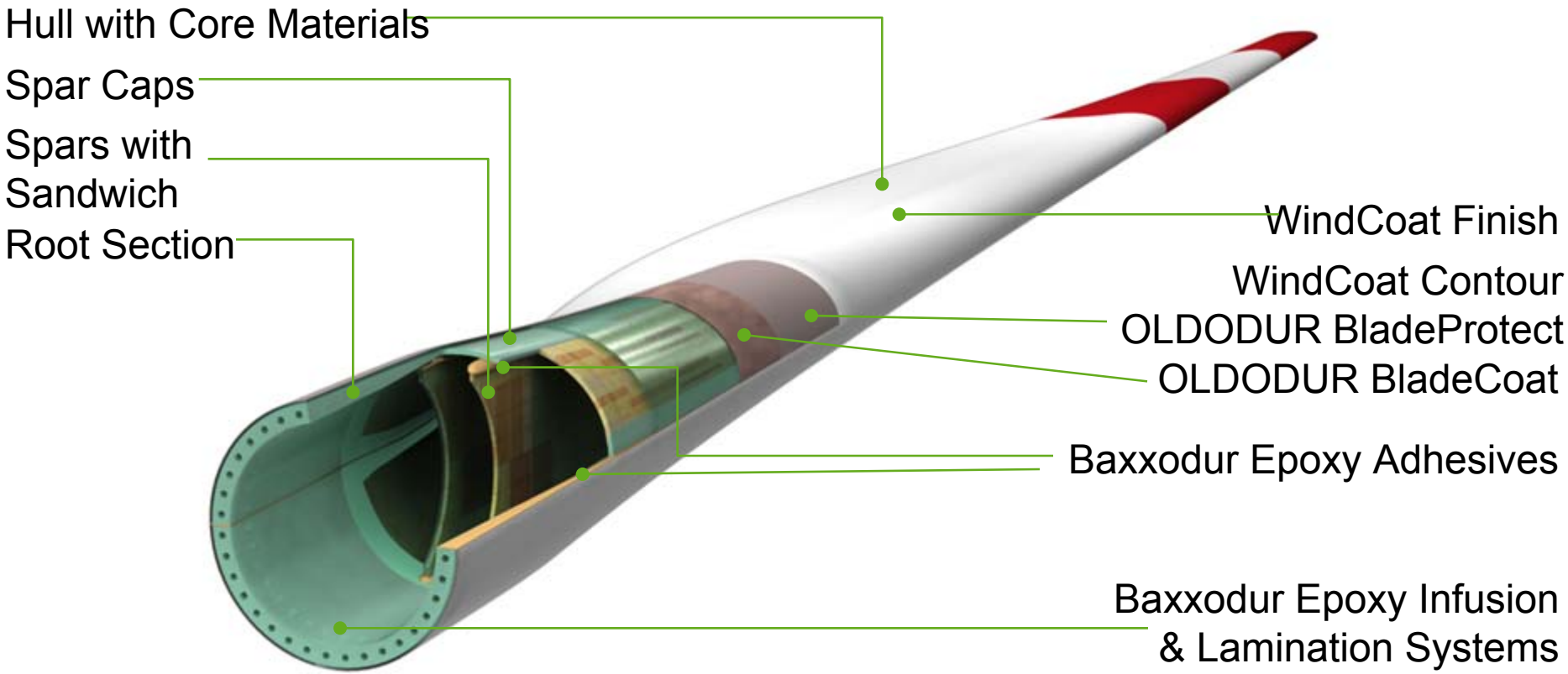
Polyurethanes	Performance Polymers	Construction Chemicals	Intermediates	Coatings	Wind Turbine
Foams	Foams		Epoxy Systems	Blade Coatings	
Adhesive			Adhesive	Tower Coatings	
		Grouts & Admixtures			

in development

Commercial

Copyright: BASF Corporation

Rotor Blade Structure and BASF Portfolio:
Baxxodur® Epoxy Systems and *Relius* Coating Solutions



BASF products play a vital part in rotor blade production and protection

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Epoxy Systems for Wind Turbine Blades

BASF
The Chemical Company

Infusion

- Baxxodur 5300 System (Latent)
- Baxxodur 5400 System (Standard)

Laminating

- Baxxodur 5500 System

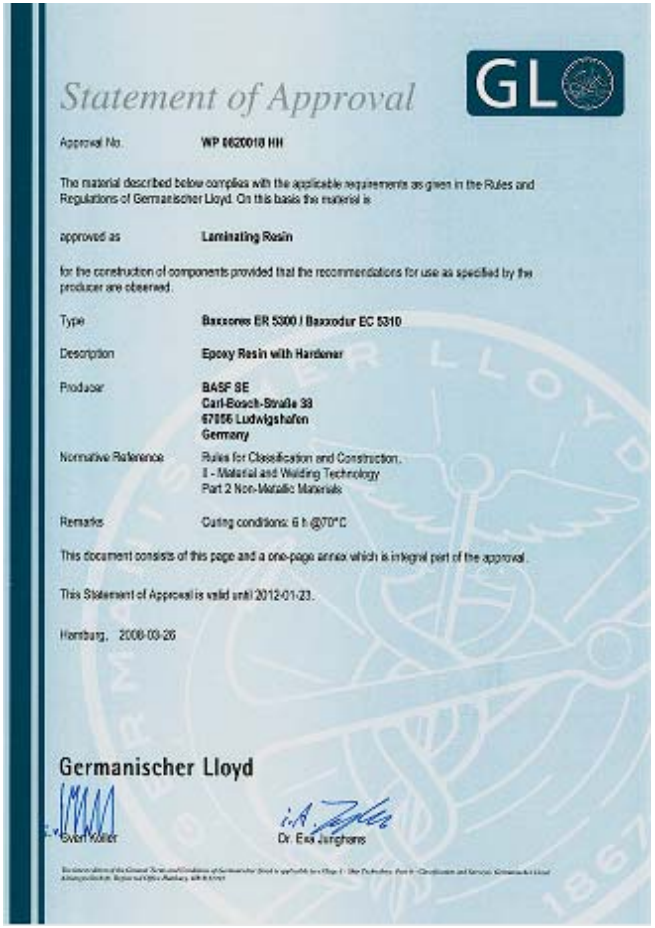
Adhesive

- Baxxodur 4200 System (Latent, new generation)
- Baxxodur 4300 System (Latent)

Tooling

- Baxxodur 3100 System (Infusion)
- Baxxodur 3600 System (Gelcoat)

All Baxxodur systems are GL approved



Statement of Approval

GL

Approval No. WP 0620010 HH

The material described below complies with the applicable requirements as given in the Rules and Regulations of Germanischer Lloyd. On this basis the material is

approved as Laminating Resin

for the construction of components provided that the recommendations for use as specified by the producer are observed.

Type Baxxores ER 5300 / Baxxodur EC 5310

Description Epoxy Resin with Hardener

Producer BASF SE
Carl-Bosch-Straße 38
67056 Ludwigshafen
Germany

Normative Reference Rules for Classification and Construction,
II - Material and Welding Technology
Part 2 Non-Metallic Materials

Remarks Curing conditions: 6 h @70°C

This document consists of this page and a one-page annex which is integral part of the approval.

This Statement of Approval is valid until 2012-01-23.

Hamburg, 2006-03-26

Germanischer Lloyd

Sven Müller

i.A. Dr. Eva Jürgens

Copyright: BASF Corporation

GL Approved Material Testing at BASF Engineering Plastics BU

BASF
The Chemical Company

Statement

GL

Approval No. GL-LZ 1409 HH

In recognition of a successful inspection carried out by Germanischer Lloyd

BASF SE

RBU Engineering Plastics Europe
Materials Testing
E-KTE/MP-F206

is approved as laboratory for technical competence in the field of

Mechanical Testing

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BASF in Wind Energy

Google search: “BASF + Wind Energy Industry” OR

http://www.basf.com/group/corporate/de/products-and-industries/customer-industries/windenergy/index

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Outline

BASF
The Chemical Company

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- Challenges in Blade Production
- Recent Advances in Materials
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Long cycle times due to Significant Labour

Hand lay-up

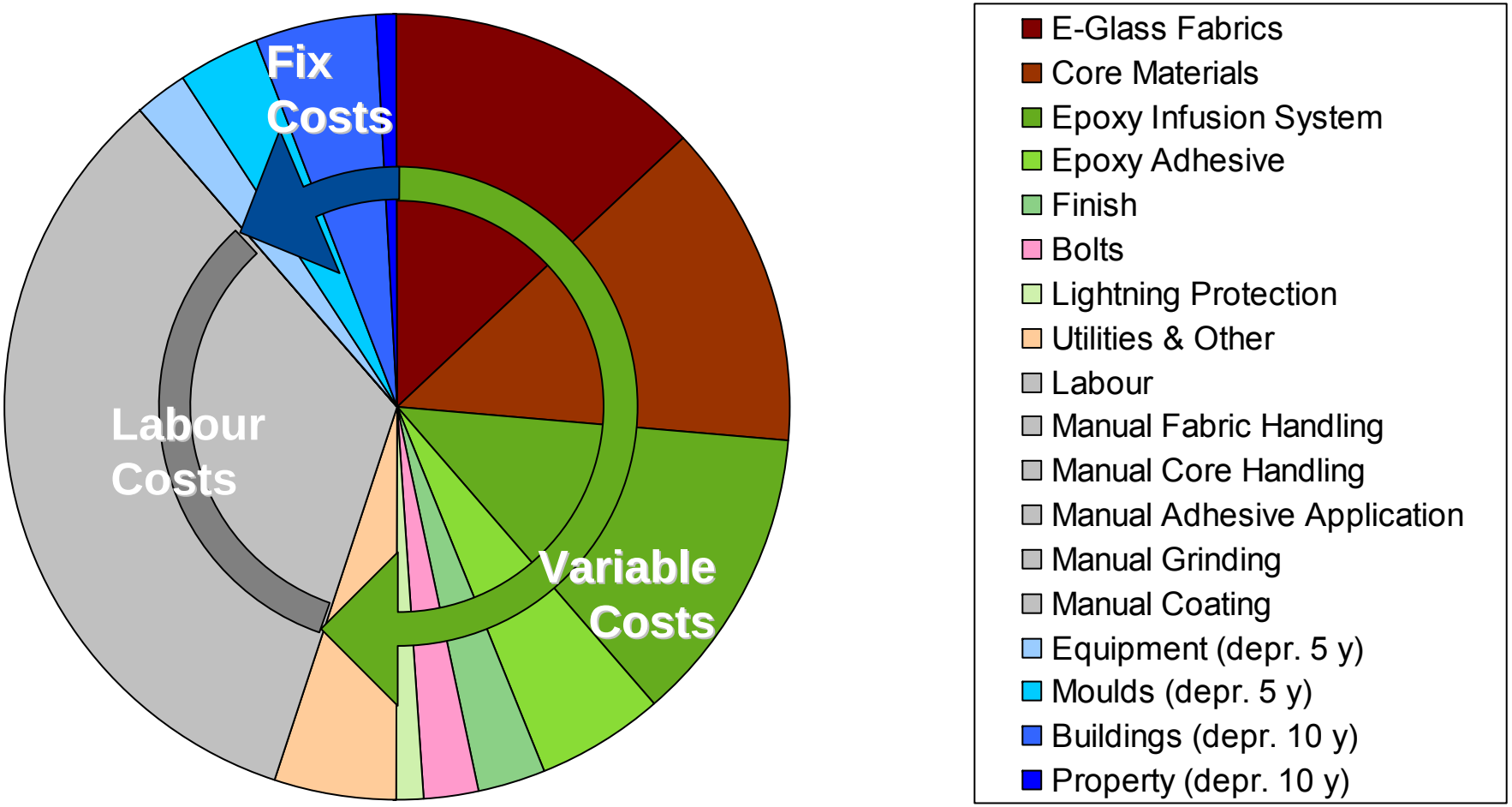
Sanding / Grinding

Painting

Rotor blade production creates jobs!

Copyright: BASF Corporation

Rotor Blade Production
Example Cost Distribution (45 mtr blade)



Rotor blade production in Western countries have large share of labour costs!

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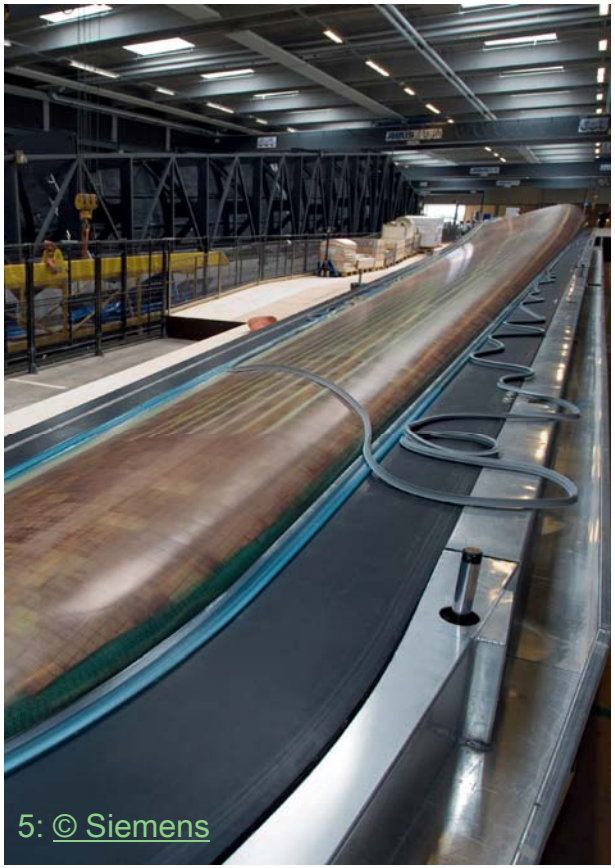
Solution: Automation where makes sense
Examples of Industrial Automation

MAG RPMS

4: © MAG

Siemens Integral Blade



5: © Siemens

ABB IRB 5400

6: © ABB

Automation increases fix costs and drives need for higher throughput.

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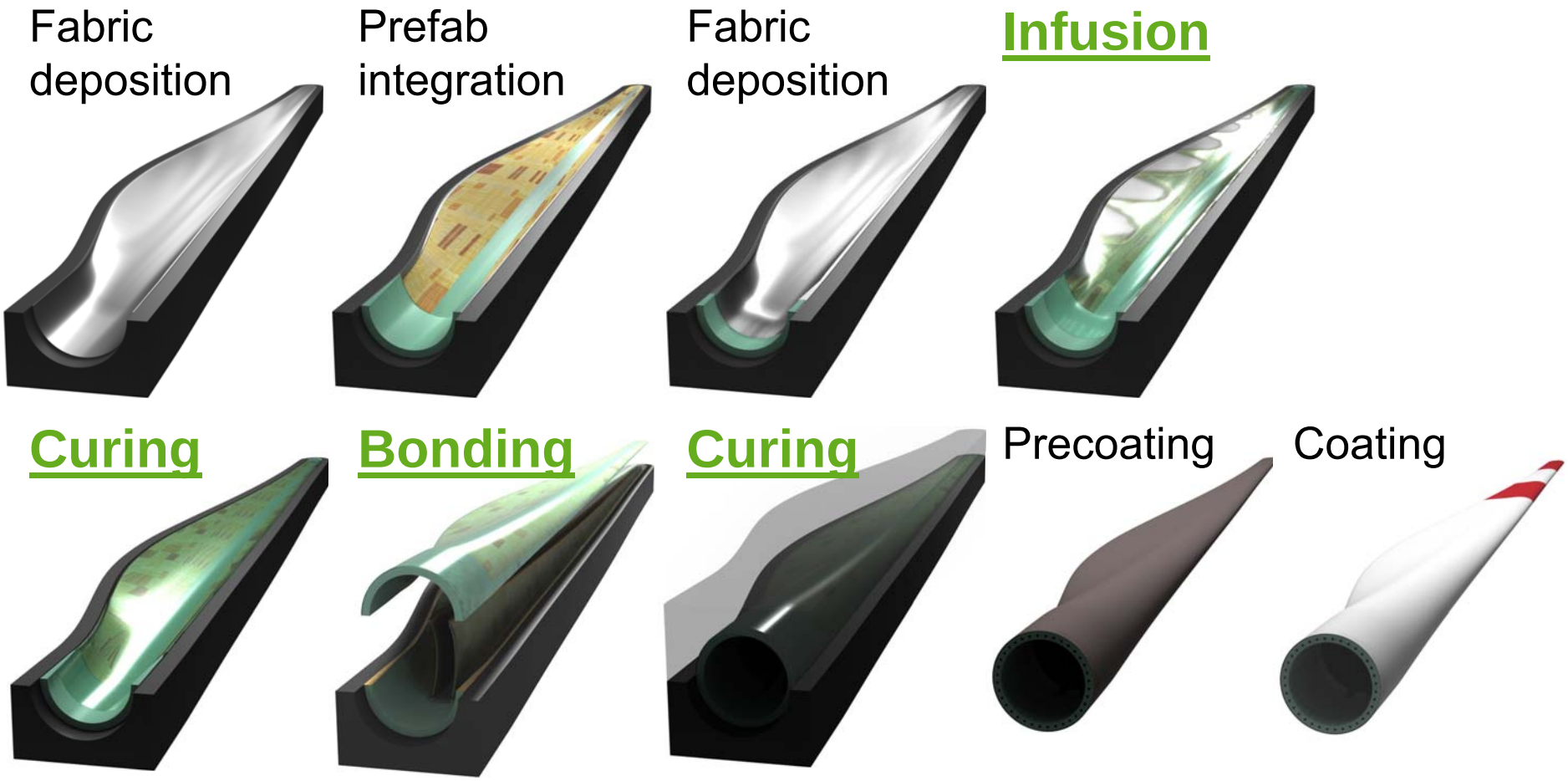
Market Need
Acceleration of Rotor Blade Processing



Infusion, Curing & Bonding steps are driven by chemistry...

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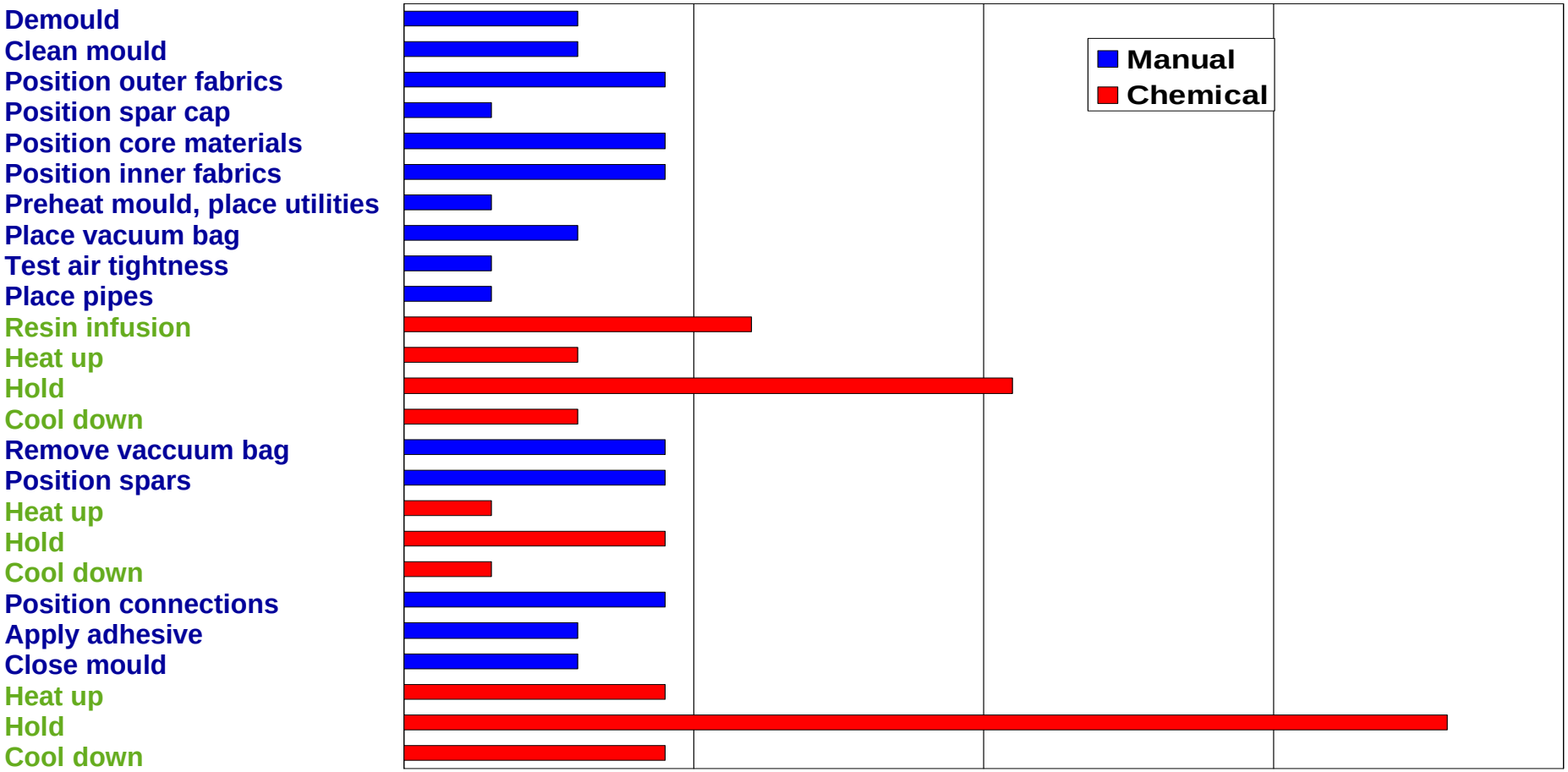
Market Need For Shorter Cycle Times
Rotor Blade Processing Times



Nearly 40% of rotor blade production time is driven by Chemistry!

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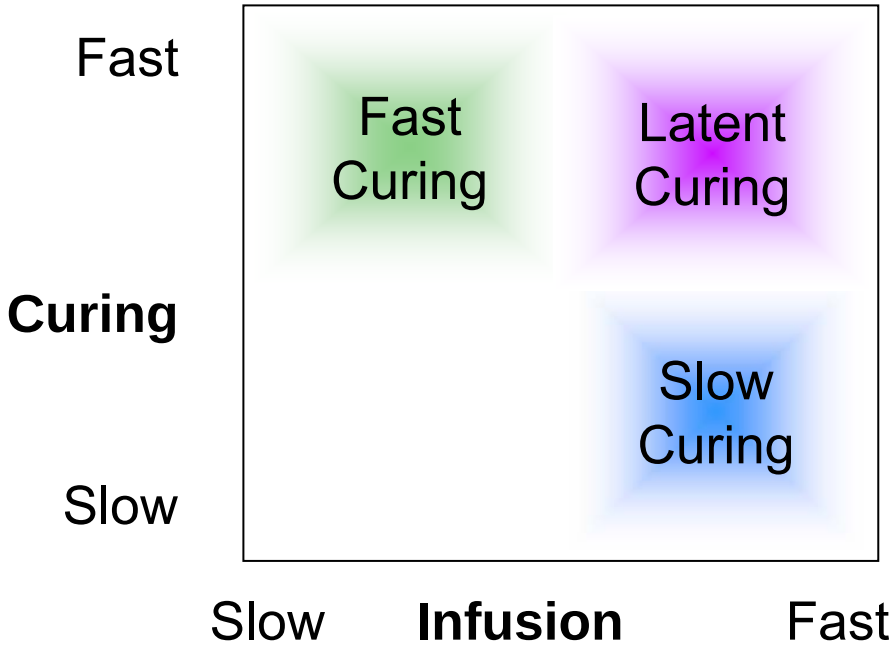
“Reaction Dilemma“ of VARTM
(Epoxy Infusion)

Customers look for a combination of…

- fast infusion with good fibre wetting through low reactivity
- fast polymerization / vitrification through high reactivity



Latent curing systems solves the „reaction dilema“.

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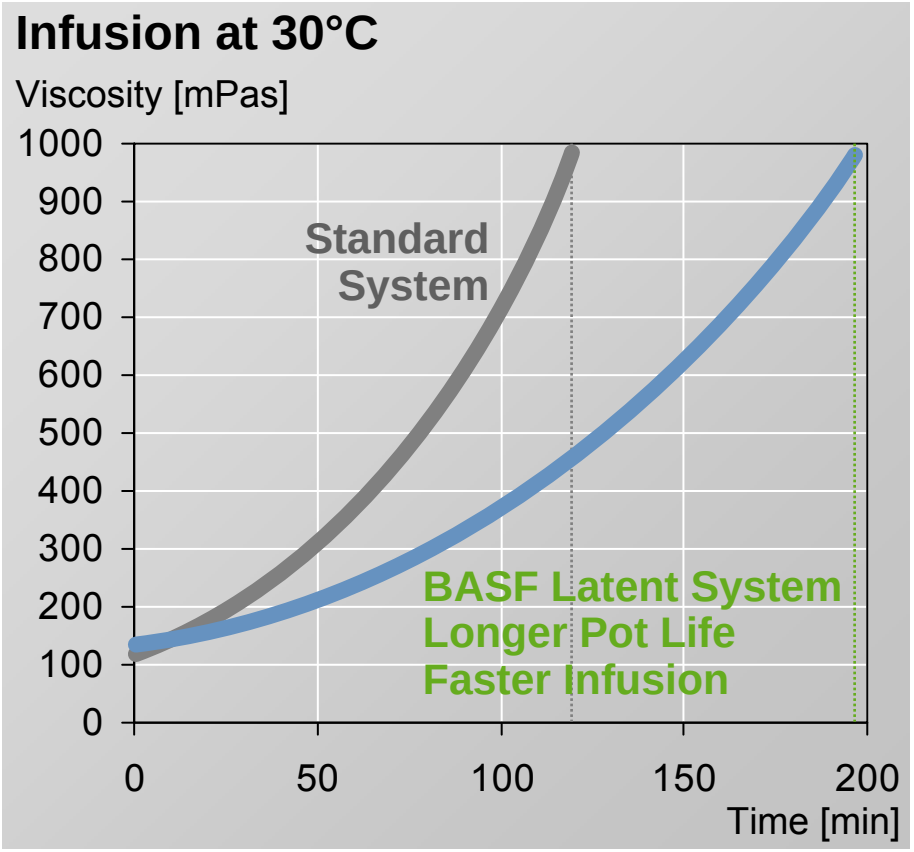
Latent Curing technology is the answer:

- Latent epoxy systems from BASF are less reactive below specific temperature threshold, more reactive beyond threshold temperature
- Wide processing window due to “cure on demand” through latency
- Low viscosity at moderate infusion temperatures (faster infusion)
- Amine based, proprietary cross-linker allows latency without compromising cross-linking properties
- Good overall thermal and mechanical performance
- A simple epoxy system with only one epoxy and one curing agent

Copyright: BASF Corporation

Advantage
Longer pot life, Faster infusion → Better process control

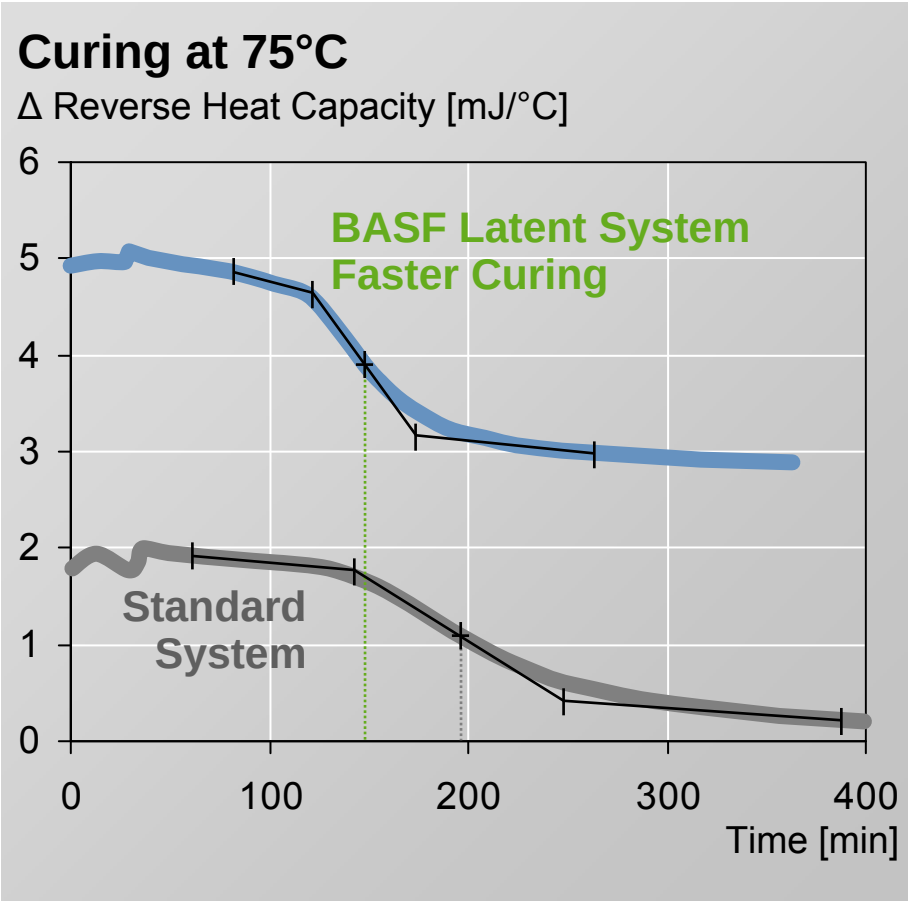


- During infusion at temperatures below 55°C the Baxxodur 5300 system reacts slowly allowing long open time (pot life)
- The lower viscosity at e.g. 40°C with the slow reactivity enables fast infusion and improved fiber wetting

Novel infusion system reduces infusion time around 30 %

Copyright: BASF Corporation

Advantage
Faster Curing → Cycle Time Reduction



- Once the temperature in the mould is increased to 70°C, the latent curing mechanism "kicks in"
- At this temperature System cures faster than the standard system

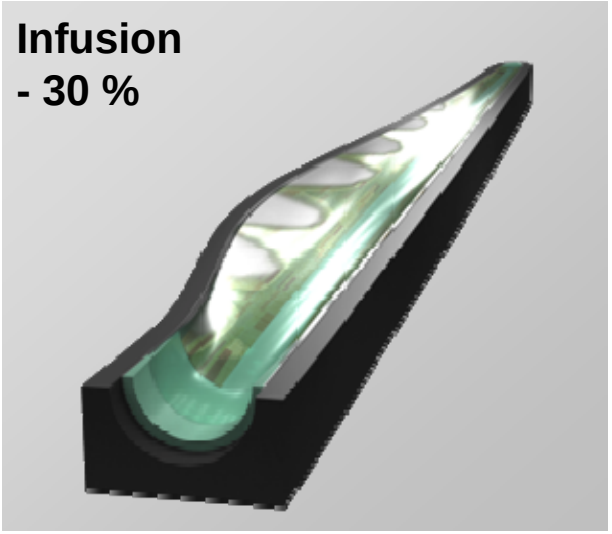
Latent infusion system reduces curing time by 30-40 %

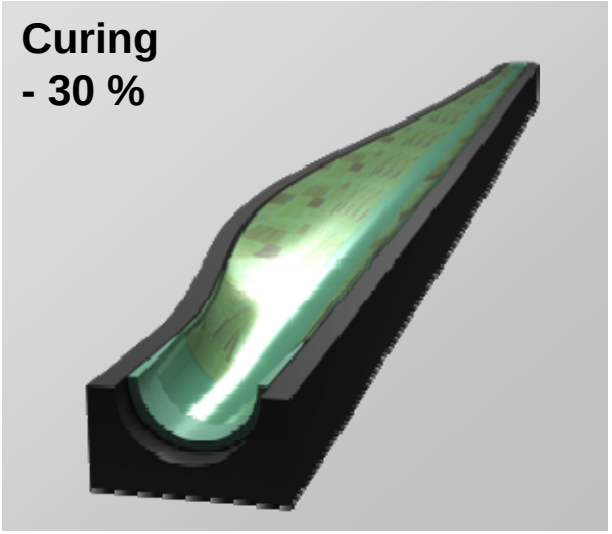
Copyright: BASF Corporation

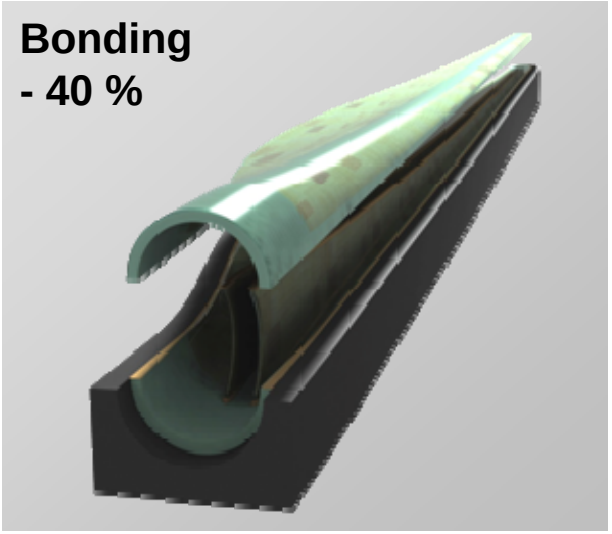
Typical Cycle Time Reductions with Baxxodur® Latent Infusion Systems

BASF
The Chemical Company

Cycle time reduction in rotor blade production







Baxxodur® epoxy systems with latent but fast curing agents enable

- fast infusion at low viscosity with inactive reactants at low temperatures
- fast curing above temperature threshold with activated reactants
- fast bonding based on same principle of temperature activated reactants

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Advantage
Optimal Wetting of Fabrics

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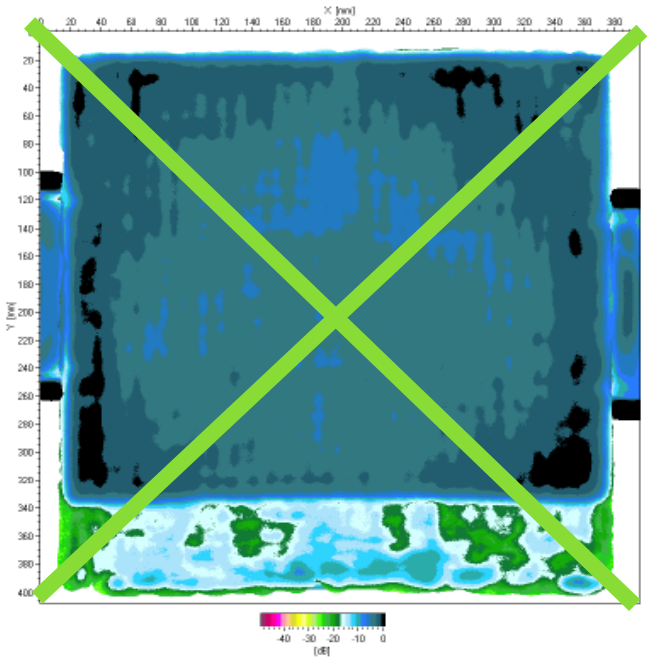
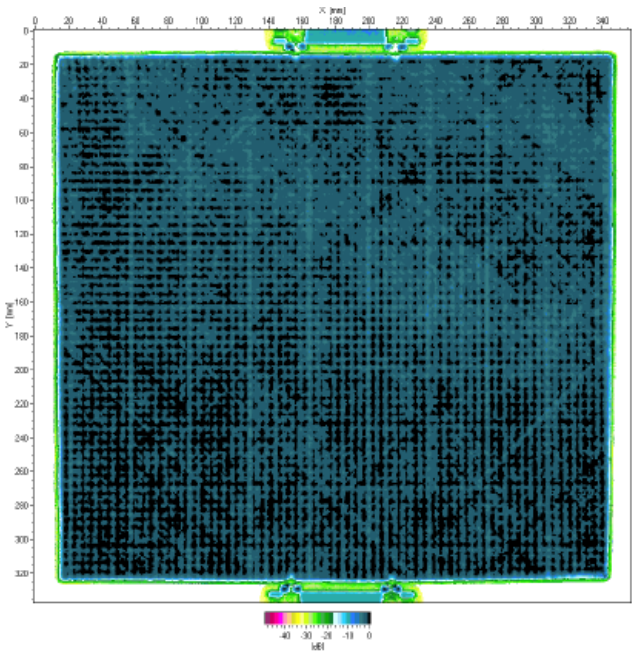
Non-optimal wetting



Optimal wetting



Determination via ultrasound of a GF laminate

Deutsches Zentrum für Luft- und Raumfahrt e.V. in der Helmholtz-Gemeinschaft
DLR

Institut für Faserverbundleichtbau und Adaptronik

Optimal wetting is achieved through low viscosity & long open time.

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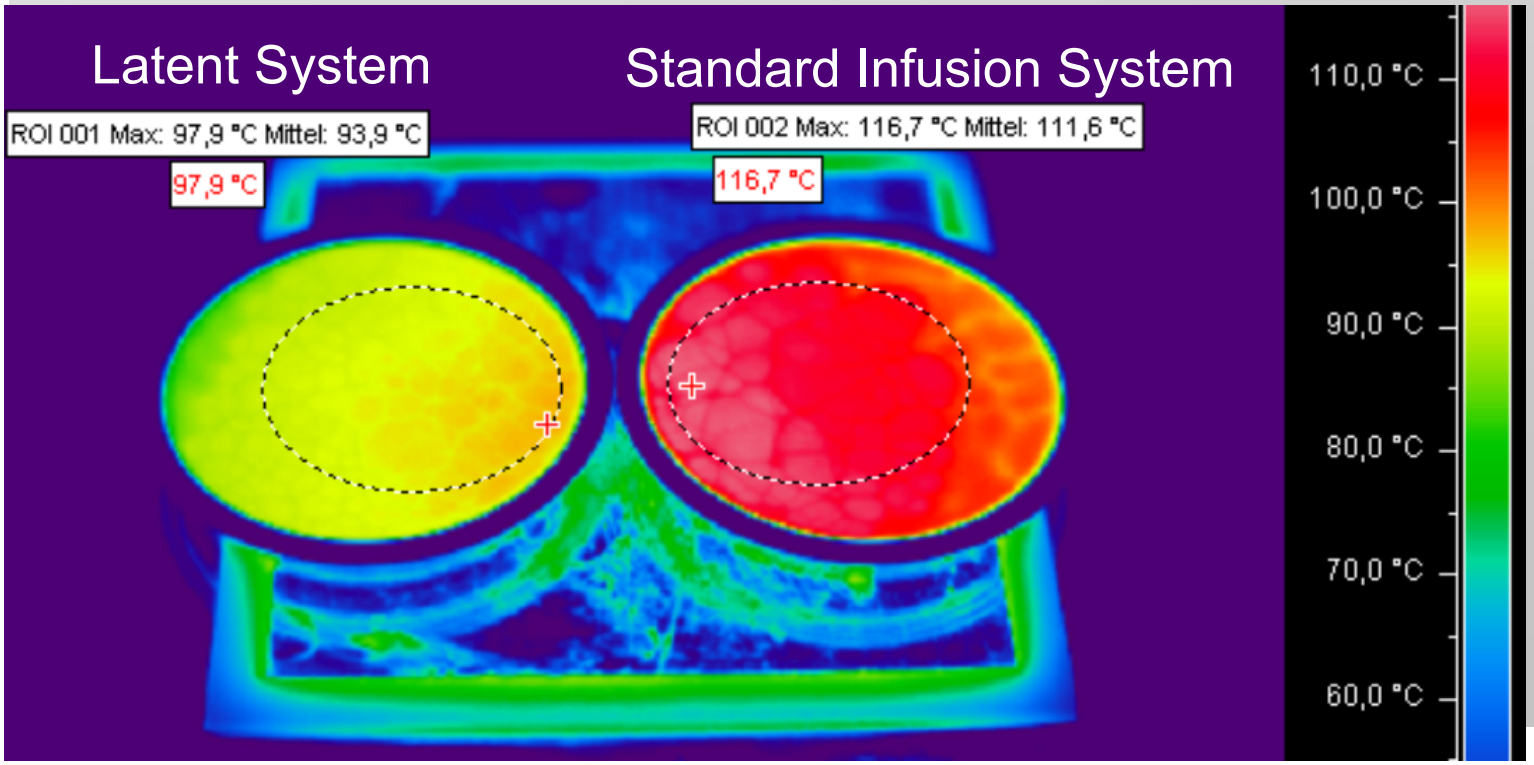
Advantage – Better Reaction Control

Latent system develops exotherm slowly and reaches lower Peak Max temperature

Shortcut to Bhatia_BASF presentation_Jul 21 2010.avi.lnk

Neat Resin Exotherm on 100°C hot B Plate



Better exotherm control of Baxxodur® system can lower peak max.

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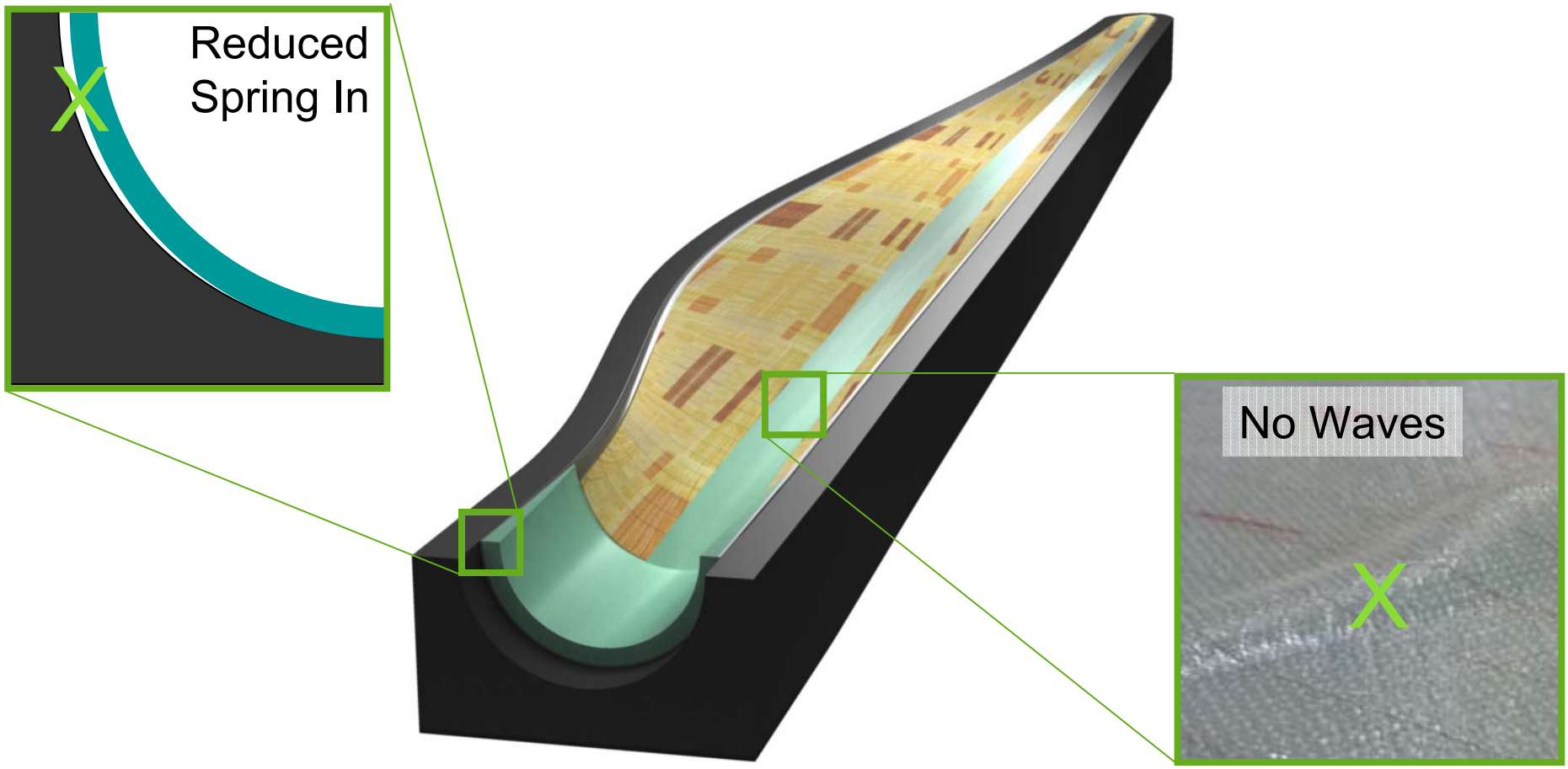
Results From Technical Applications
High Quality Structural Parts



Latent Baxxodur® systems produce high quality composites

Copyright: BASF Corporation

Advantage: All-season Hardner → Simplified inventory, Reduced Costs

- Baxxodur® hardners can be processed at low and high temperatures, eliminating the need for different hardners for different seasons
- Stable Infusion at 40°C (via mould temperature or preheating)
- No onsite hardener blending
- Simplified inventory list

Standard:
Three hardener blends
for different seasons/climates

New:
All seasons/ climates/ regions
hardener **Baxxodur® EC 5310**

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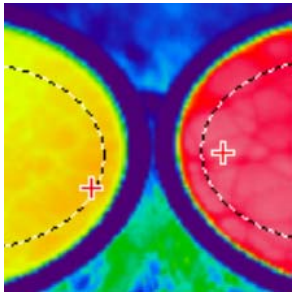
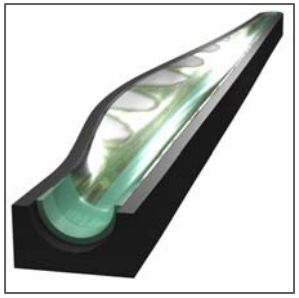
Summary

- Cycle time in blade production drives the factory output, floor plan, capital requirement and labor content
- Cycle time reduction and reducing variability in quality are the two most critical needs in rotor blade production
- As fixed cost in blade production increases due to automation, need for cycle time reductions will be even greater
- BASF's latent curing epoxy systems offer cycle time reductions, quality improvements and scrap reductions





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Sources

Literature

- Schubel PJ, Technical cost modelling for a generic 45-m wind turbine blade produced by vacuum infusion (VI), Renewable Energy (2009), doi:10.1016/j.renene.2009.02.030
- Wittwer G, Production in change: From the manufacture to the serial production at the example of rotor blades for wind turbines, Lecture at Hannover Trade Show, 23.4.2009

Product Information

- www.baxxodur.com

Pictures:

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1. http://www.handelsblatt.com/archiv/wirtschaft-gegen-generelle-40-stunden-woche%3B815947
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