

Dynamic Fluid Compression Molding

A new process for composite mass-production

March 2016

Presentation Contents

1. Composites in mass production
2. Structural composite processing
3. Dynamic Fluid Compression Molding
 - New DFCM process
 - Part quality
 - Industrial fiber processing
4. About HUNTSMAN
5. Summary



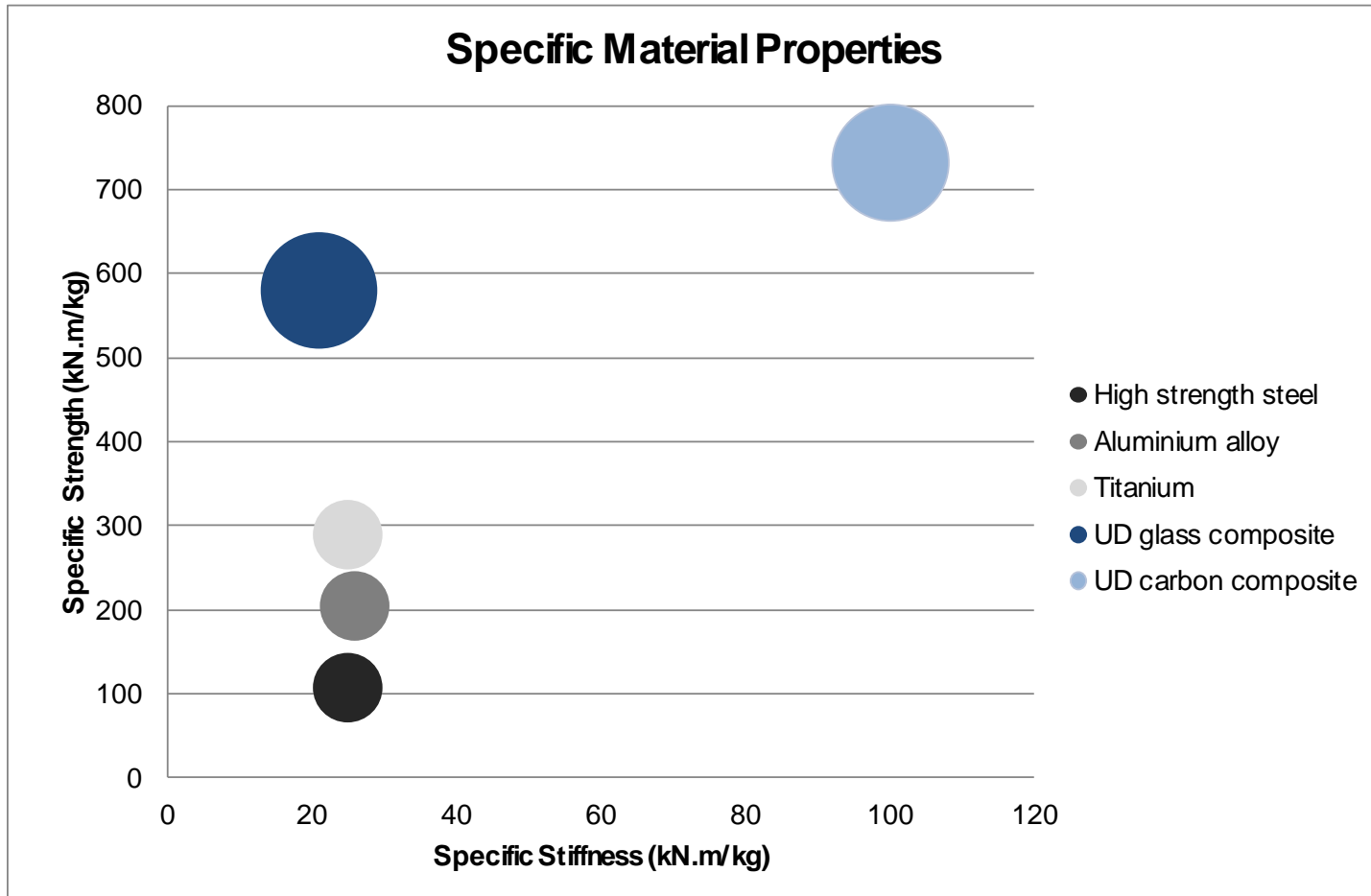
Automotive structural composites

The recent growth in structural composites for automotive applications is driving innovation in both **materials** and **processes**

Composites in Mass Production

Composite properties versus metals

- Composites display outstanding strength / stiffness-to-weight ratio compared to metals



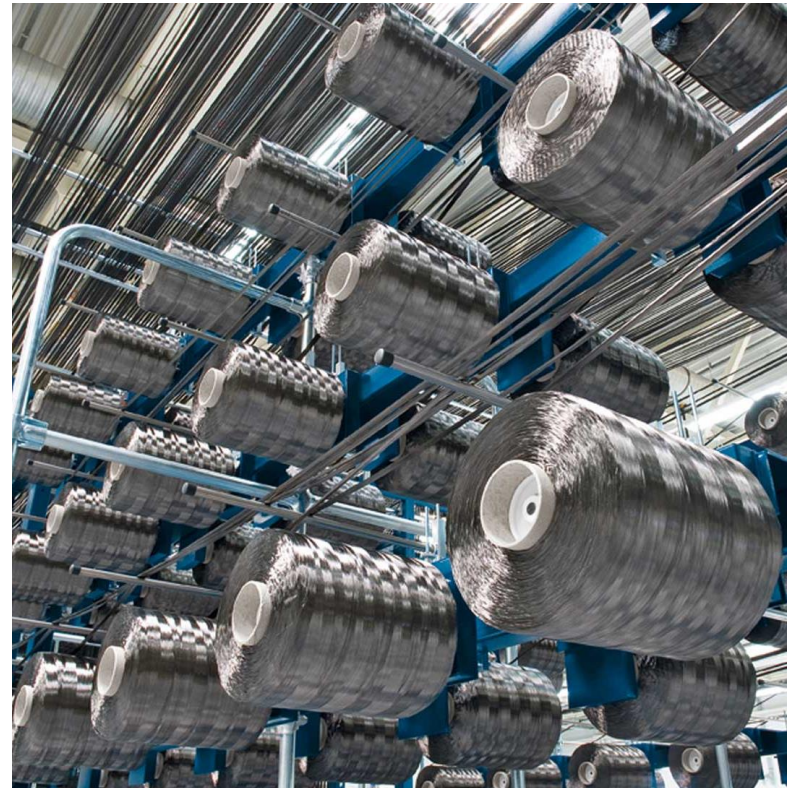
Composites in Mass Production

Composite applications

- Increased usage of composite materials driven principally by **light weight**
- Traditional high-volume composite applications dominated by SMC/ BMC → relatively low mechanical performance
- Current trend towards high-performance structural composites; particularly **carbon fiber composites**

Potential applications for mass-produced structural composites

- Automotive: cars, trucks
- Public transport: buses, trams, trains
- Electronic/ electrical housings: laptops, phones
- Construction
- Sporting goods



Composites in Mass Production

Araldite® Solutions - Case Histories

BMW M3 Roof Parts with ARALDITE® XB 3523 / XB 3458



Benefits

- Low weight, high stiffness and high dimensional stability
- Fashion / aesthetics due to 'carbon look'
- Class 'A' finish
- Low shrinkage

Lamborghini Aventador LP700-4's Chassis with ARALDITE® XB 3518 / ARADUR® 22962



Benefits

- Low viscosity during injection
- Sufficient pot life
- Low shrinkage (surface quality)
- High mechanical properties (good balance Tg / toughness)
- Good hot / wet properties

BMW i3 Life Cell with ARALDITE® LY 3585 / XB 3458



Benefits

- Fast curing
- Versatile for RTM and compression molding
- Low water pick up
- High mechanical performance

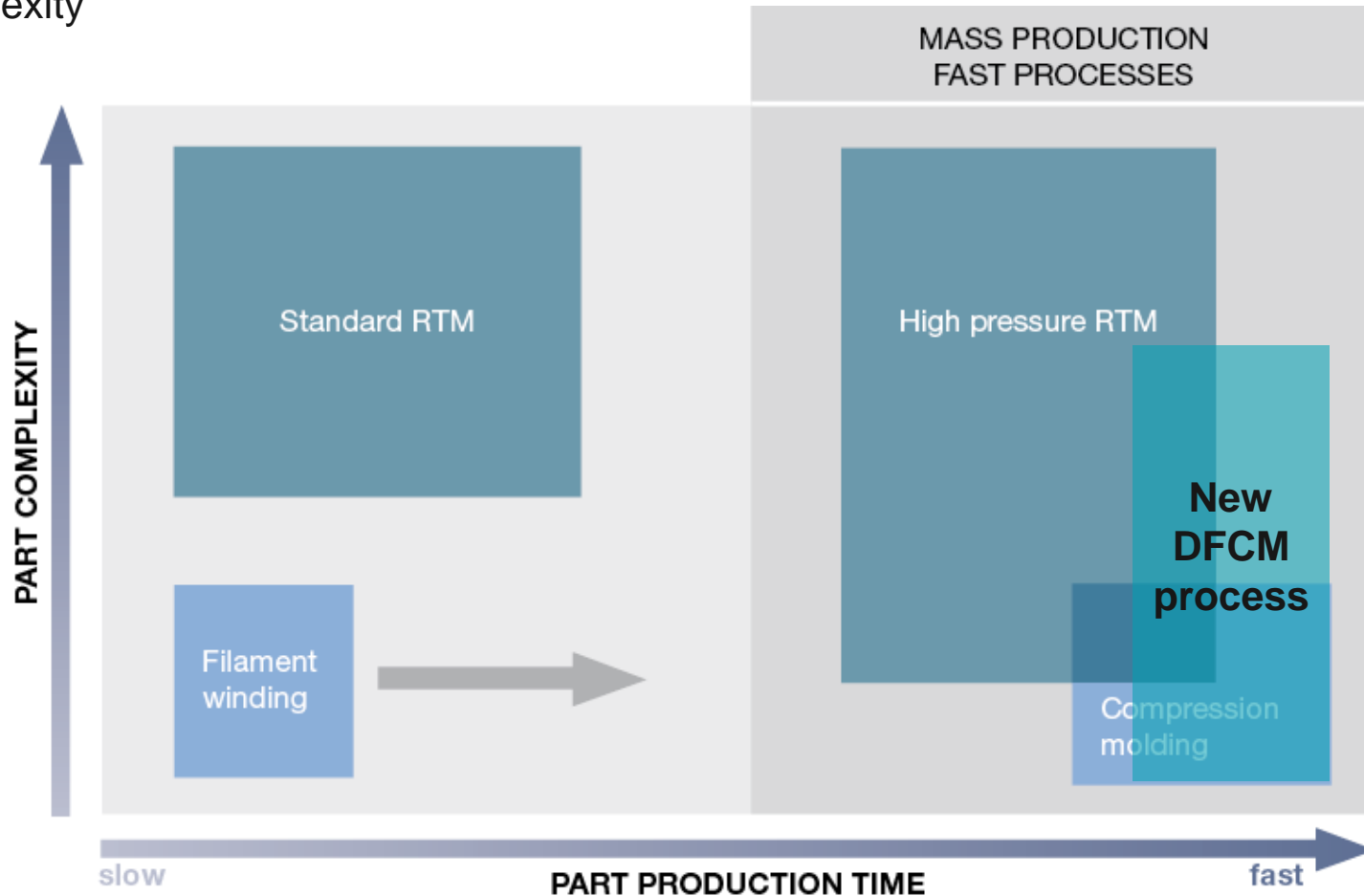
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Structural Composite Processing

Processes for mass production

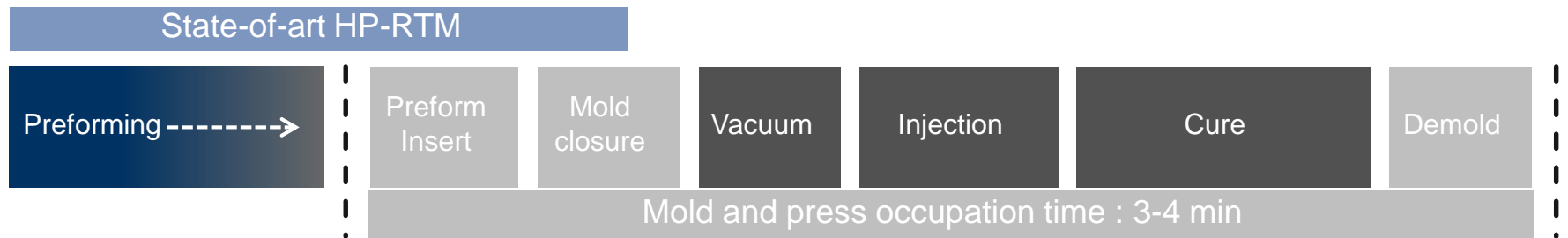
- New processes required to meet needs of mass production
- Huntsman has developed new 'DFCM' process enabling both speed and part complexity



Structural Composite Processing

Process comparison

- Wet compression molding (WCM) is the fastest industrial-scale composite molding process currently available
- Curing with WCM is typically faster than HP-RTM since no latency is required for resin injection
- However, part quality of WCM process is usually inferior to injection processes, with poor surface quality and voids/ porosity

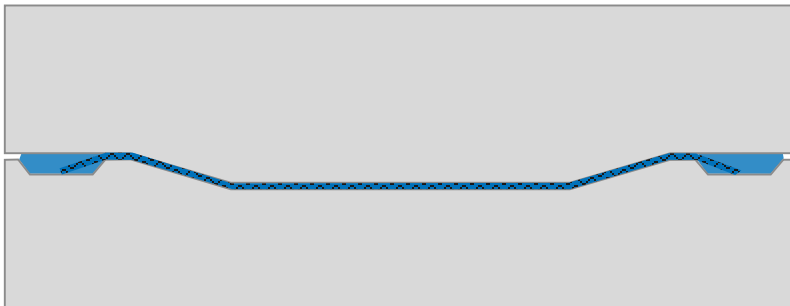
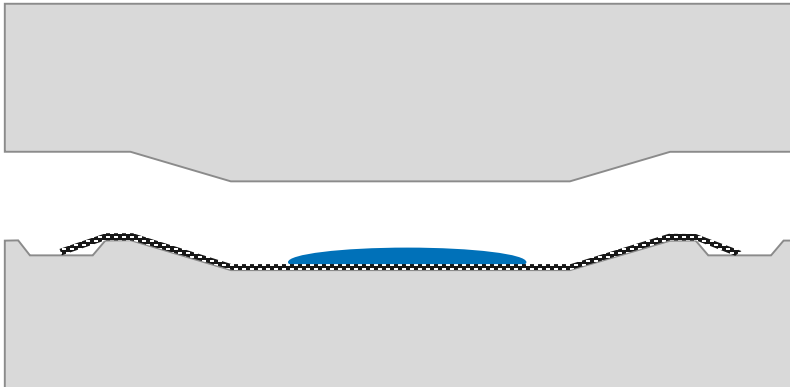


Structural Composite Processing

Wet compression molding

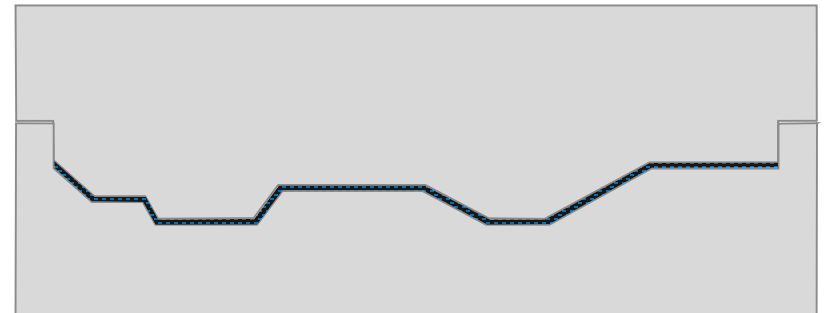
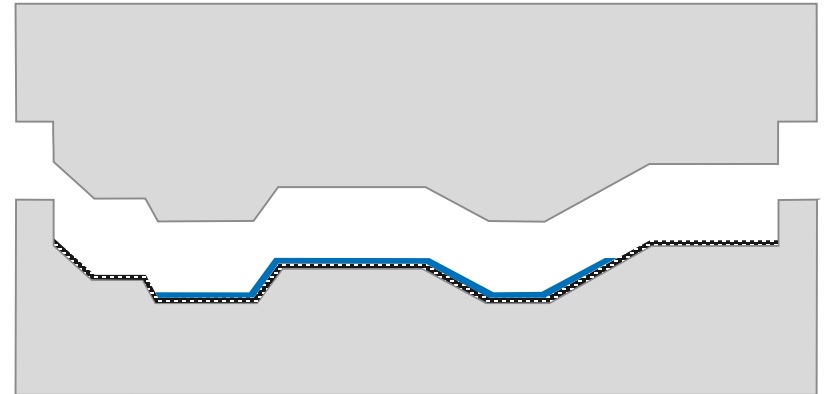
Standard wet compression molding

- Simple process with resin overflows
- Limited to flat parts
- Voids/ porosity in finished part



New DFCM process

- Uses vacuum and mold pressure
- Higher part complexity possible
- Produces 'RTM-like' quality



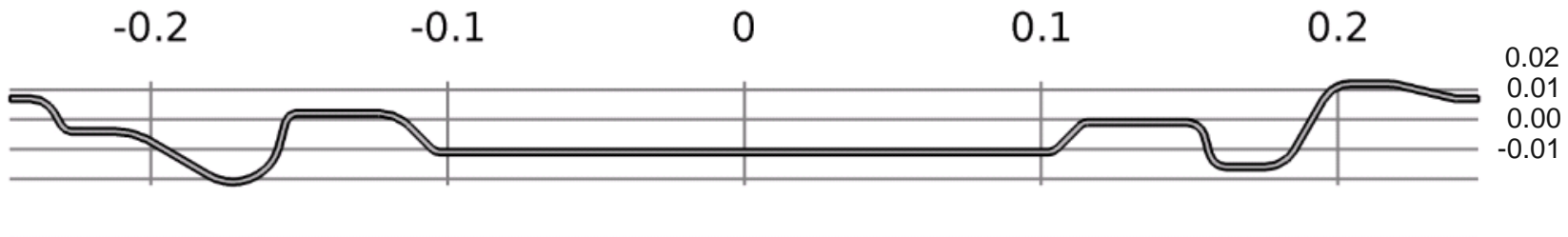
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Dynamic Fluid Compression Molding

DFCM process

- New process developed to combine speed of WCM with quality of HP-RTM
- Combines vacuum and dynamic mold pressure to achieve void-free impregnation
- Pressure enables rapid fiber impregnation, even of deep-draw areas
- Higher part complexity possible compared to standard WCM
- Lower mold pressure/ press force than HP-RTM or standard WCM
- Typically only ~30 bar pressure for high-quality parts
- Industrial demonstrator made with fully integrated mold & press (TRL 5/6)



Cross section of industrial demonstrator part

Dynamic Fluid Compression Molding

Process benefits

DFCM benefits versus standard WCM

- Part quality: near zero void content
- Robust process: consistent quality
- Higher part complexity possible
- Near net-shape part
- Lower pressure = lower investment
- Little resin/ fiber wastage

DFCM benefits versus HP-RTM

- Faster process: reduced press cycle
- Higher fiber content: up to 67%
- Fiber preform less critical
- No fiber movement (fiber wash)
- Lower pressure = lower investment

Dynamic Fluid Compression Molding

New fast-cure ARALDITE® epoxy technology

- New ARALDITE® technology enables a press cycle-time of only 1 minute

Resin: ARALDITE® LY 3031			100 parts	
Hardener: ARADUR® 3032			21 parts	
Internal release agent			1.5 parts	
	Standard	Unit	130°C Cure	140°C Cure
Cure (1)		s	45 s	30 s
DFCM cycle time (2)		s	75 s	60 s
Carbon fiber composite 2mm plate				
Vf	Calculated	%	57	57
Visual aspect			High surface quality / no visible defects	High surface quality / no visible defects
Cure conversion	ISO 11357-2	%	>98	>98
DSC Tg		°C	117	118
DMA Tg onset	ISO 6721-4	°C	104	104
Charpy impact resistance	ISO 179	kJ/m²	147	137
ILSS	ASTM D2344	MPa	64	65

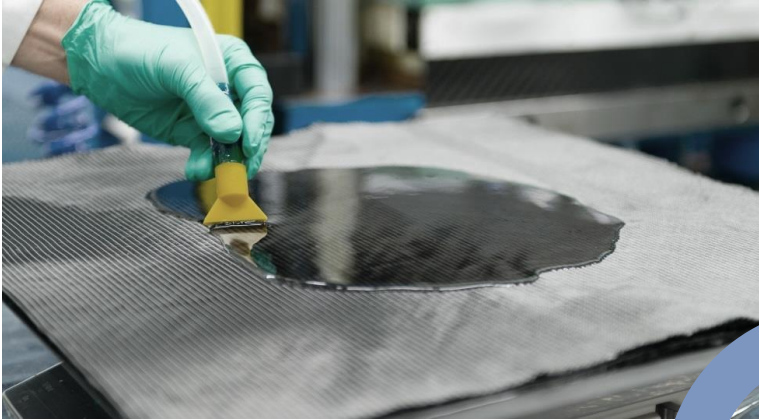
(1) Cure time when press fully closed, (2) Total press occupation time including closure + opening

Dynamic Fluid Compression Molding

Process overview

HUNTSMAN

Enriching lives through innovation



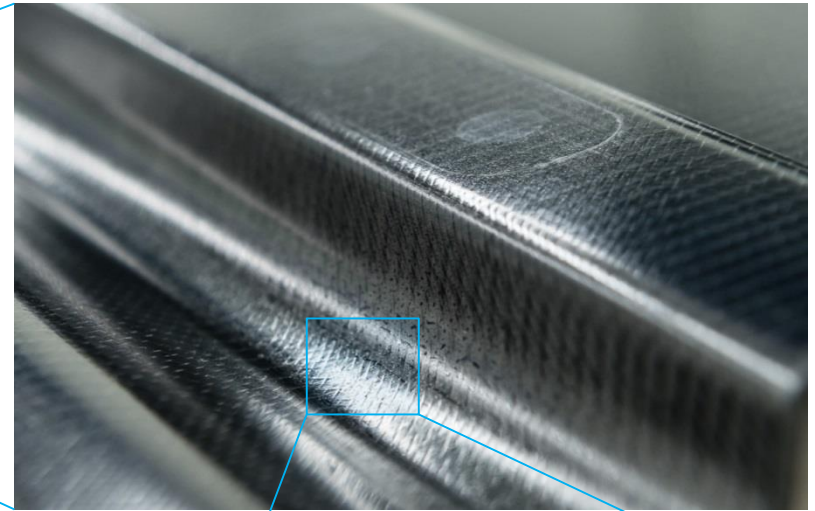
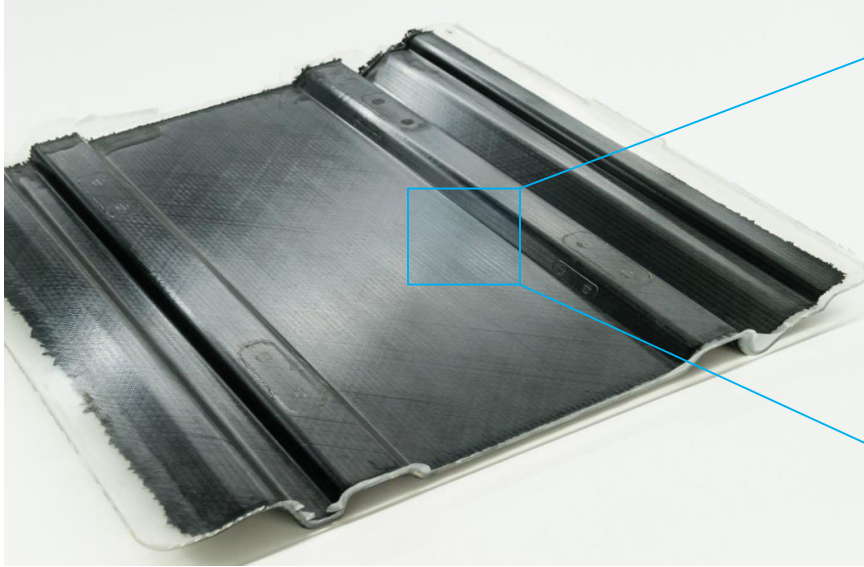
 our customers

Advanced Materials

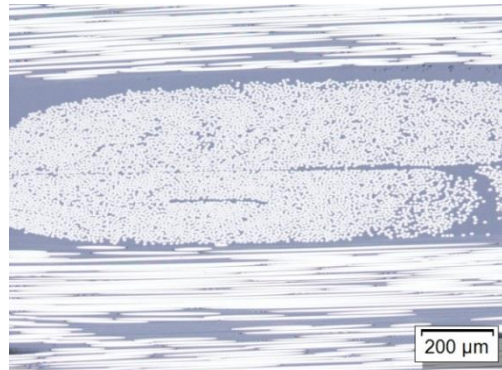
Dynamic Fluid Compression Moulding

Part quality

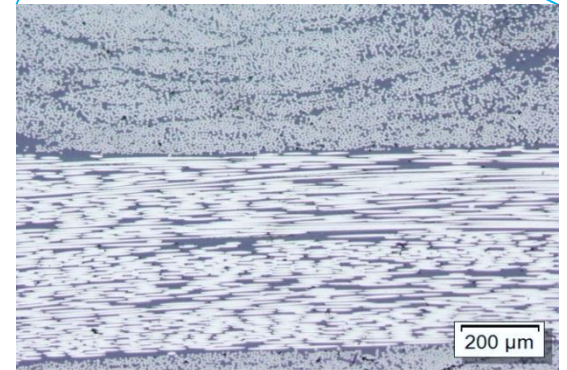
DFCM part made in 1 minute with ARALDITE® 3031 / ARADUR® 3032



Standard WCM Vf = 50%



HP-RTM Vf = 50%



DFCM part Vf = 52%

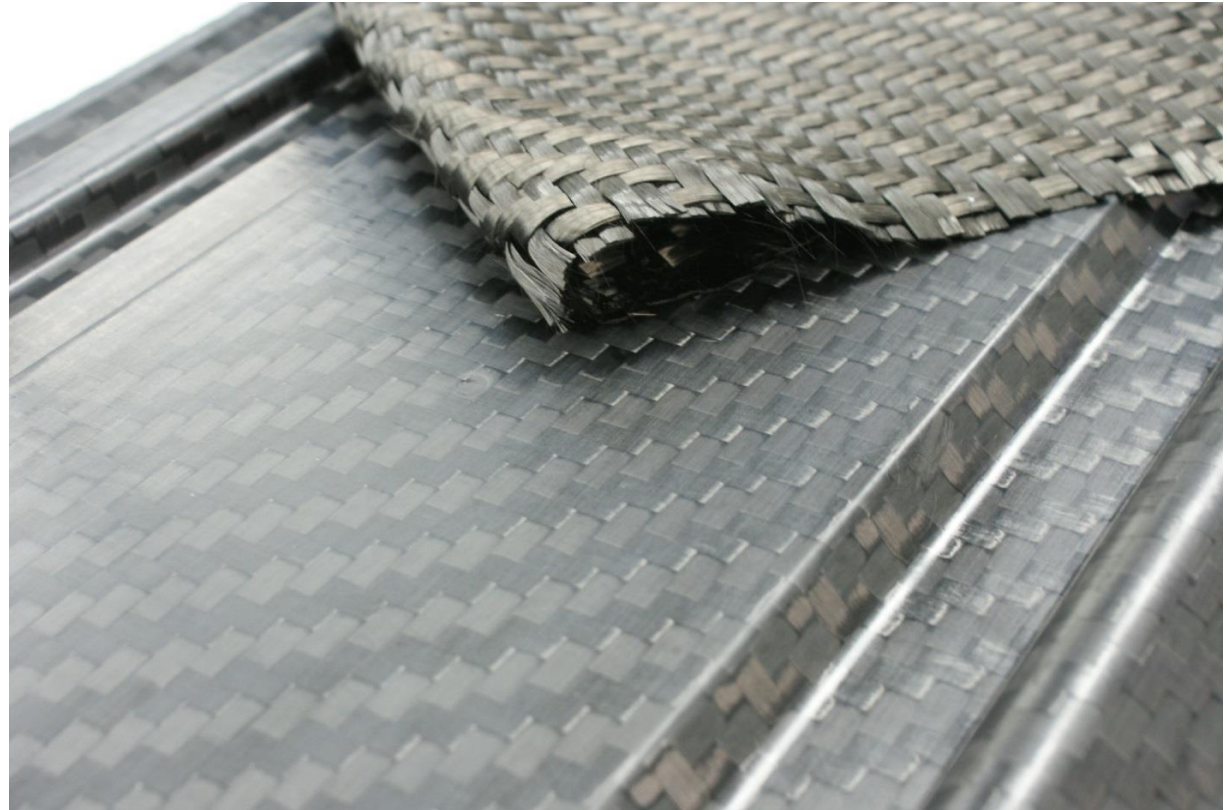
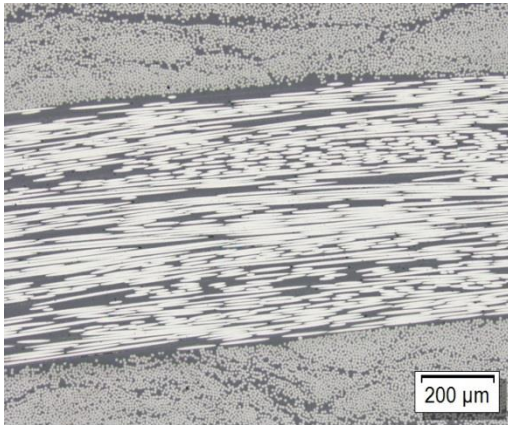
Dynamic Fluid Compression Molding

Industrial fibers

- Recent work shows that DFCM is effective even with heavy, industrial-grade fabrics
- Plate produced in 1-minute at 140°C using industrial 960gsm carbon fabric made with 50K fiber tows
- Void-free laminate: fiber volume fraction $V_f = 53\%$

Plate made with 960gsm
PX35 TW 0960 woven
fabric using PANEX®35
50K carbon fiber

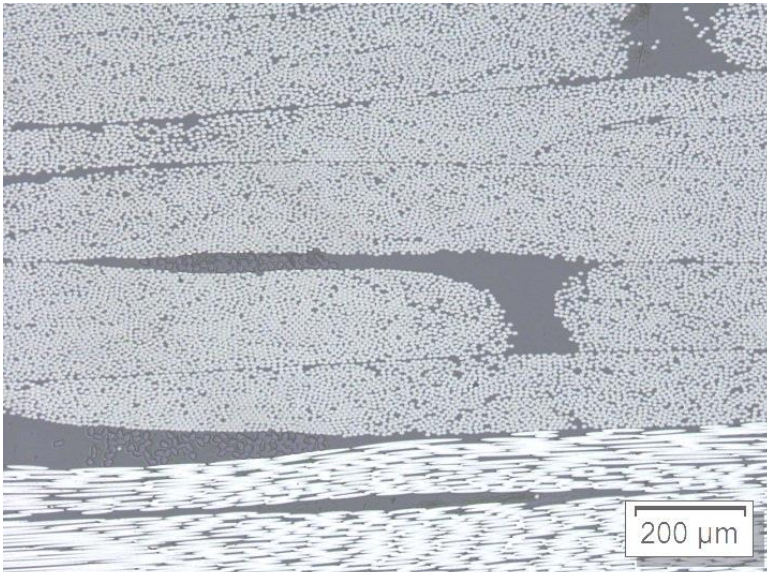
PANEX® is a registered trademark
of Zoltek Corporation



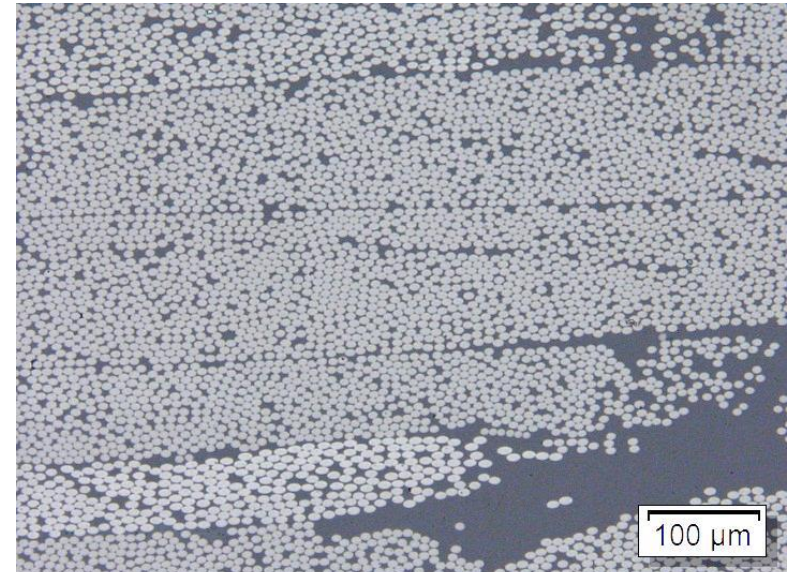
Dynamic Fluid Compression Molding

Fiber content

- Fiber volume content of HP-RTM normally limited to around 50% due to injection permeability
- DFCM enables fiber volume content above 60% without change of process
- Porosity-free laminates up to 67% FVC made with standard DFCM process
→ equivalent to autoclave prepreg quality!



DFCM part Vf = 67% X50



DFCM part Vf = 67% X500

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Huntsman Corporation

We are a global manufacturer and marketer of differentiated chemical products that improve the quality of life for people around the world.

Huntsman Corporation

Our Business Divisions

HUNTSMAN

Enriching lives through innovation

Polyurethanes	Performance Products	Advanced Materials	Textile Effects	Pigments & Additives
<p>MDI Polyols PO/MTBE TPU PU Systems</p>	<p>Amines Surfactants Maleic Anhydride Upstream Intermediates</p>	<p>Systems for Composites Adhesives Resins</p>	<p>Dyes Chemicals Apparel Home & Institutional Technical Textiles</p>	<p>Titanium Dioxide Functional Additives Color Pigments Timber Treatment Water Treatment</p>
				

 our customers

Advanced Materials

Huntsman Advanced Materials

Serving more than 2,000 customers in over 30 countries in three regions



Huntsman Advanced Materials

Our focus industries

HUNTSMAN

Enriching lives through innovation



 our customers

Advanced Materials

Huntsman Advanced Materials

Our core business

HUNTSMAN

Enriching lives through innovation

Base Resins

- Liquid epoxy resins
- Solid epoxy resins
- Epoxy solutions

Our resins include bisphenol-A, F or A/F chemistries.

Speciality Components

- Curing agents
- Matting agents
- Reactive Diluents
- Waterbornes
- Multifunctionals
- BisF/EPN/ECN
- Reactive PAA
- Crosslinkers

Our components give formulators the performance they need.

Formulated Systems

- Adhesives
- Tooling
- Composites
- Laminates
- Encapsulation
- Insulation
- Protection

Our formulations build the products you use every day.

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Summary

- Structural composite parts in less than 1 minute possible (30 sec cure-time)
 - Consistent high surface quality and low void content → **robust process**
 - Higher part complexity possible than standard WCM
 - Low press force required = lower investment
 - Fiber volume content in excess of 60% easily achieved
 - Part quality not sensitive to fiber type – even for heavy industrial fabrics
 - Simpler parts need no fiber preform
- **Cost-effective structural composite production for high-volume industrial applications**

Thank You

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