Advancements In Wet Compression Molding (WCM) For High Speed, Mass Production Of Structural Composite Parts

George Guo
Agenda

• Who is Huntsman?

• Overview of recent advancements in composite processes

• What is Dynamic Fluid Compression Molding (DFCM)

• Benefits of DFCM compared to traditional WCM and HP-RTM

• Application experience

• Summary
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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.
Our Business Divisions
Huntsman Corporation

Polyurethanes
- MDI
- Polyols
- PO/MTBE
- TPU
- PU Systems

Performance Products
- Amines
- Surfactants
- Maleic anhydride
- Upstream intermediates

Advanced Materials
- Composites
- Adhesives
- Resins

Textile Effects
- Dyes
- Chemicals
- Apparel
- Home & institutional
- Technical textiles

Enriching lives through innovation

Advanced Materials
Huntsman Advanced Materials
Pioneering technology for more than 70 years

<table>
<thead>
<tr>
<th>Build</th>
<th>Bond</th>
<th>High performance epoxy resins</th>
<th>Curing agents and accelerators</th>
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<tbody>
<tr>
<td>Formulated systems</td>
<td>Protect</td>
<td>Specialty components</td>
<td>Waterborne resins and hardeners</td>
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<tr>
<td>Ready to use</td>
<td>Insulate</td>
<td>For formulators</td>
<td>Polyimides and Benzoxazines</td>
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<tr>
<td>Encapsulate</td>
<td></td>
<td>Flexibilizers and Tougheners</td>
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</table>
Huntsman Advanced Materials
We operate synthesis, formulating and production facilities around the world
Markets include:

- Adhesives
- Aerospace
- Automotive
- Coatings
- Construction
- Electronics
- Marine
- Power
- Sports and Leisure
- Wind Energy
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In Automotive
Structural Composite Processes

HUNTSMAN is developing towards:
- Increasing productivity of filament winding
- Increasing productivity of HP-RTM
- Increasing productivity & part complexity potential of wet compression molding
## Composite Process Applications

**DFCM**
- Battery box
- Interior Panels / Parts
- Hood / Roof
- Load Floor
- Body in White
- Rear Deck/Rear Seat Wall

**Prepreg**
- Hood
- Trunk Lid
- Roof

**SMC/BMC**
- Hood Inner
- Door Inner
- Liftgate/Decklid Inner
- Body Inner/Outer Panels

**Filament Winding**
- Steering column
- Pressure vessel

**Fabric/RTM**
- Rear Seat Wall
- Roof
- B-pillar
- Load Floor
- Crash Tubes
- Leaf Springs

**Pultrusion**
- Door Sill/Rocker Panel
- Door Inner Support
- Diagonal Engine Strap

<table>
<thead>
<tr>
<th>Composite Process</th>
<th>Exotic</th>
<th>Luxury</th>
<th>Premium</th>
<th>Full-Size</th>
<th>SUVs/Trucks</th>
<th>Mid-Size</th>
<th>Subcompact / Compact</th>
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</thead>
<tbody>
<tr>
<td>SMC/BMC</td>
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<td>✔️</td>
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<tr>
<td>HP-RTM</td>
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<tr>
<td>Prepreg</td>
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What is DFCM?
Structural Composite Processing

Standard wet compression moulding
• Simple process with resin overflows
• Limited to flat parts
• Voids/ porosity in finished part

New DFCM process
• Uses vacuum and mould pressure
• Higher part complexity possible
• Produces 'RTM-like' quality

DFCM Process is Patent Pending
Dynamic Fluid Compression Moulding
DFCM Process

• New process developed to combine speed of WCM with quality of HP-RTM
• Combines vacuum and dynamic mould 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 mould pressure/press force than HP-RTM or SMC
• Typically only ~30 bar pressure for high-quality parts

Cross section of industrial demonstrator part
**Part Production Time**  
**Fast Cure Epoxy Solutions**

<table>
<thead>
<tr>
<th>Wet Compression Molding (WCM) process</th>
<th>Araldite® LY 3031 Resin Aradur® 3032 Hardener</th>
<th>Araldite® LY 3585 Resin Aradur® XB 3458 Hardener</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preform / fabric lay-up set (1)</td>
<td>20-30”</td>
<td>20-30”</td>
</tr>
<tr>
<td>Mold temperature</td>
<td>140°C</td>
<td>140°C</td>
</tr>
<tr>
<td>Injection</td>
<td>No injection</td>
<td>No injection</td>
</tr>
<tr>
<td>Cure</td>
<td>30”</td>
<td>2’00 min</td>
</tr>
<tr>
<td>Demolding</td>
<td>5”</td>
<td>5”</td>
</tr>
<tr>
<td>Part production time (1)</td>
<td>![Timer 1'00]</td>
<td>![Timer 2'30]</td>
</tr>
</tbody>
</table>

(1) Includes preform / fabric lay-up set, mold closure and vacuum
Dynamic Fluid Compression Moulding

Process Overview

60s

Advanced Materials
Dynamic Fluid Compression Moulding
Part Quality

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

Standard WCM Vf = 50%

HP-RTM Vf = 50%

DFCM part Vf = 52%
Dynamic Fluid Compression Moulding
Proven to be Effective on Large Tow: 50k

- Plate produced in 1-minute at 140°C using industrial 960gsm carbon fabric made with 50K fibre tows
- Void-free laminate: fibre volume fraction $V_f = 53\%$

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

PANEX® is a registered trademark of Zoltek Corporation
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## Process Benefits
Dynamic Fluid Compression Moulding

<table>
<thead>
<tr>
<th>DFCM benefits vs standard WCM</th>
<th>DFCM benefits vs HP-RTM</th>
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<tbody>
<tr>
<td>• Part quality: near zero void content</td>
<td>• Faster process: reduced press cycle</td>
</tr>
<tr>
<td>• Robust process: consistent quality</td>
<td>• Higher fibre content: up to 67%</td>
</tr>
<tr>
<td>• Higher part complexity possible</td>
<td>• Fibre preform less critical</td>
</tr>
<tr>
<td>• Near net-shape part</td>
<td>• No fibre movement (fibre wash)</td>
</tr>
<tr>
<td>• Little resin/ fibre wastage</td>
<td>• Lower pressure = lower investment</td>
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Recent Application Experience
Carbon Fiber Body In White Part

• **Challenge:** Enable automotive part maker to achieve high speed production of complex carbon fiber body-in-white part using existing or lightly modified production equipment

• **Target:** Press cycle time < 2 min

• **Approach:** Utilize DFCM process and Araldite® LY 3031 Resin / Aradur® 3032 Hardener

• **Results:**
  • Prototype Phase 1 successfully produced complex, high quality parts
  • Cycle time optimization being addressed in Phase 2

Due to NDA with Customer, Unable to Show Actual Part
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Dynamic Fluid Compression Moulding

- 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
- Fibre volume content in excess of 60% easily achieved
- Part quality not sensitive to fibre type – even for heavy industrial fabrics
- **Simpler parts - fibre preform may not be needed**

→ **Cost-effective structural composite production for high-volume automotive applications**
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