Application of vacuum-assisted high-pressure RTM-process for the series production of CFRP components for car bodies

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Overview of presentation

- Motivation for the use of CFRP parts in the automotive industry
- The vacuum-assisted high pressure RTM press process
- Press technology for the high pressure RTM process with example of supplied presses 36,000 kN – 3.6 x 2.4 m
- System overview of complete RTM process
- New development of press technology
Light weight design in the automotive industry - Motivation

Future of mobility

- Energy costs will rise
- Fuel consumption and emissions will be increasingly financially punished.
- Laws concerning emissions influence mobility (E-mobility, etc.)
- For development of new vehicles there is a challenge of balancing safety, efficiency (environment) and joy of driving.
Light weight design in the automotive industry - Potential

Potential of various materials with regard to light weight design

Source: Audi AG

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**Press processes for fiber reinforced plastic**

<table>
<thead>
<tr>
<th></th>
<th>Thermosetting plastics</th>
<th>Thermoplastics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Long fibers</strong></td>
<td><strong>SMC / D-SMC</strong></td>
<td><strong>GMT / LFT / LFT-D</strong></td>
</tr>
<tr>
<td>&lt; 50 mm arbitrary</td>
<td>e.g. deck lid, bumper...</td>
<td>e.g. spare wheel well, front end...</td>
</tr>
<tr>
<td><strong>Endless fibers</strong></td>
<td><strong>RTM / HP-RTM</strong></td>
<td><strong>Organic sheet</strong></td>
</tr>
<tr>
<td>&gt; 50 mm Dedicated</td>
<td>e.g. passenger cell, roof...</td>
<td>e.g. seat shell, front end...</td>
</tr>
<tr>
<td><strong>fiber orientation</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: BMW AG and BASF
The vacuum assisted high pressure RTM press process

1. Preform placement
2. Press closing, start apply vacuum
3. Resin injection, with position control
4. Curing with compression force

Force up to 36.000 kN
The vacuum assisted high pressure RTM press process

Mold opening

Press opening

Unload part

Mold cleaning

Mold break open force
Up to 5.000 kN
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CFRP sample parts produced on Schuler presses

- BMW i3 – passenger cell

- BMW M3 – roof

Source: BMW AG, www.bmw.de
Requirements for the RTM press

- Uniform wall thickness of the pressed part
- Maintaining of resin injection position for gap-injection
- Minimizing of non-productive time for mold cleaning / handling
- Reliable media supply to the molds
- Short pressure build-up and efficient energy use
Requirements for the RTM press

- Uniform wall thickness of the pressed part
  - Press statics with congruent bending lines of slide and table
  - Parallelism of slide to table also at high eccentric load
Press design with congruent bending lines

Traditional design

Wall thickness non-uniform

Design with congruent bending lines

Uniform wall thickness

Raising deviation of bending lines

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Requirements for the RTM press

- Uniform wall thickness of the pressed part
  - Press statics with congruent bending lines of slide and table
  - Parallelism of slide to table also at high eccentric load
Hydraulic slide parallelism control

- Eccentric load for the slide results from the process
  - Non-symmetric part geometry = eccentric center of force load
  - The liquid / pasty-like resin compound flows arbitrarily, when closing the mold

![Diagram of hydraulic slide parallelism control]
Requirements for the RTM press

- Uniform wall thickness of the pressed part
- Maintaining of resin injection position for gap-injection
- Minimizing of non-productive time for mold cleaning / handling
- Reliable media supply to the molds
- Short pressure build-up and efficient energy use
Maintaining injection position of the slide

**Task:**
- Maintaining of injection position against rising internal resin pressure and rising eccentrical load.

**Solution:**
- Closed-loop control for position + parallelism with set value position of parallelism cylinders and actuating value slide force.
Requirements for the RTM press

- Uniform wall thickness of the pressed part
- Maintaining of resin injection position for gap-injection
- **Minimizing of non-productive time for mold cleaning / handling**
- Reliable media supply to the molds
- Short pressure build-up and efficient energy use
Design with 2 moving bolsters

- Two lower molds and one shared upper mold
  - Part loading and unloading during the secondary processing time
  - Cleaning of the lower mold during the secondary processing time
Requirements for the RTM press

- Uniform wall thickness of the pressed part
- Maintaining of resin injection position for gap-injection
- Minimizing of non-productive time for mold cleaning / handling
- Smooth mold opening
- Reliable media supply to the molds
- Short pressure build-up and efficient energy use
Requirements for the RTM press

- Uniform wall thickness of the pressed part
- Maintaining of resin injection position for gap-injection
- Minimizing of non-productive time for mold cleaning / handling
- Reliable media supply to the molds
- Short pressure build-up and efficient energy use
Short pressure build-up time and efficient energy use

- **Accumulator drives**
  - Charging pumps continuously charge with low power
  - Temporarily a high volume flow with nominal pressure is available for a working speed of 30 mm/s at 36.000 kN

Charging pump units
2 x 55 kW
Noise < 75 dB(A)
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- System overview of complete RTM process
- New development of press technology
System overview complete HP-RTM process
From carbon fiber mats to a finished part
System overview complete HP-RTM process

Technology partners Schuler and Frimo

1. Provision of garments
2. Production of preform
3. Trimming of preform
4. Handling of preform
5. RTM-press
6. RTM-mold
7. Mixing / Dosage technology
8. Handling of cured part
9. Machining of cured part
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Short stroke press – Function principle

1. Slide starts moving downwards (parallelism controlled)
2. Slide reached working position
3. Slide is locked by split nuts
   - Press plate starts movement upwards (parallelism controlled)
4. Working stroke with press plate from bottom
Short stroke press – Parallelism control

- Individual setting of press force between cylinders
  - Parallelism control integrated
  - Bending line of press table can be influenced
  - Congruent bending lines of press table and slide

Two central positioned cylinders

Four edge-positioned cylinders
Short stroke press – Technical innovation

- Reduction of machine height
- Easy accessibility
- Integrated parallelism control
- Short pressure build up time
- Reduced energy consumption
Please visit us at our booth 6/D10

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