



Complex shaped PMI Foam Cores for highly efficient FRP Composite Sandwich Fabrication for low to high volume applications

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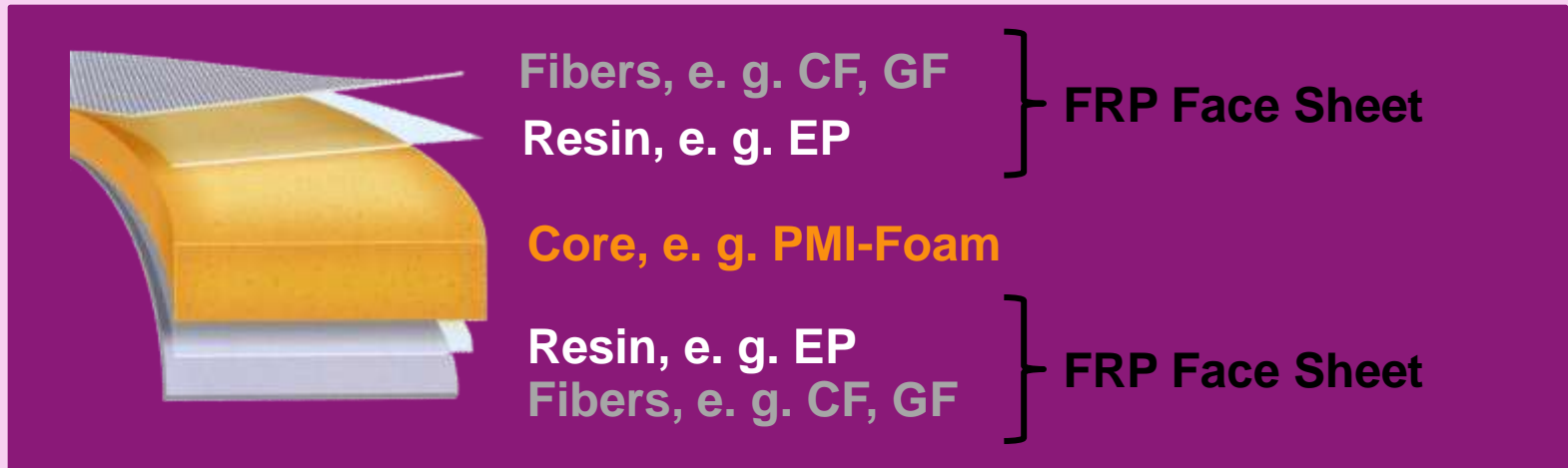


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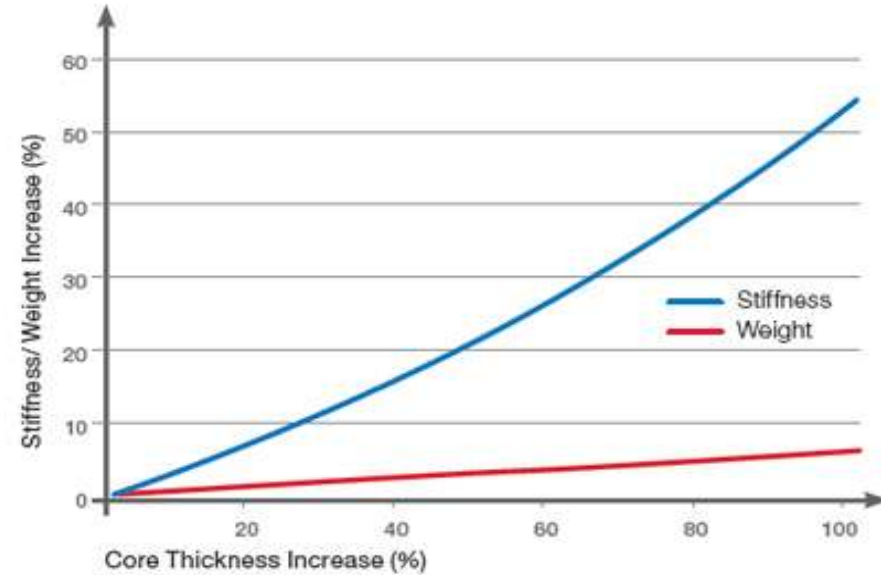
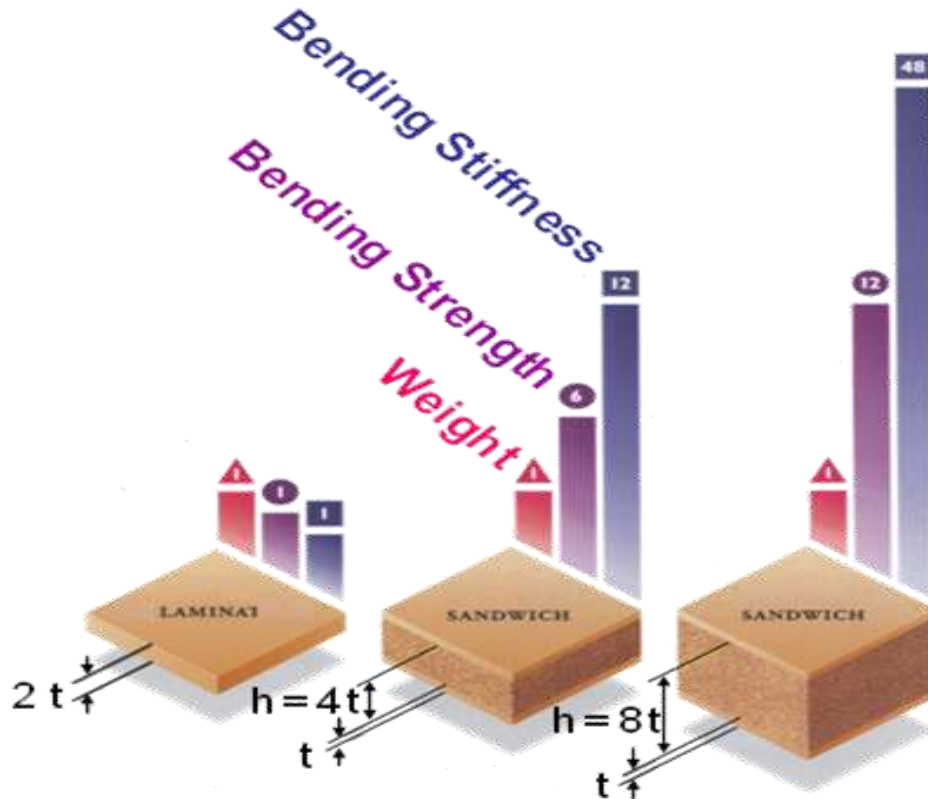
- 1. Sandwich Cores Requirements and Overview**
- 2. Manufacturing Process of PMI Rigid Foams**
- 3. Advantages of PMI In-Mold Foaming (IMF)**

Definition and Layup of Sandwich Structure

A structural **SANDWICH** is a special form of a composite that combines at least two different materials by bonding them to each other so as to utilize the properties of each separate component to the structural advantage of the entire assembly.



The Sandwich Effect



Sandwich Structures are very suitable for bending & axial compressive loaded parts to increase:

- Bending stiffness and strength
- Buckling and crash performance

Lightest Solution!

Max. Bending Stresses Bending Stiffness

$$\frac{\sigma_{\text{Sandwich}}}{\sigma_{\text{Laminat}}} = \frac{2}{3} \left(\frac{t}{h}\right) \quad \frac{D_{\text{Sandwich}}}{D_{\text{Laminat}}} = \frac{3}{4} \left(\frac{h}{t}\right)^2$$

Source of image: http://www.neo.co.th/product_c013%20en1.php, 08/31/2015

Function of Core Material

Mainly:

- Keep Skins at Distance
- Stabilization of Skins (FRP Layers)
- Transferring Shear Forces from one Skin to the other Skin



But also:

- Absorption of Impact Loads
- Thermal Insulation
- Acoustic Insulation
- Vibration Dampening
- ...

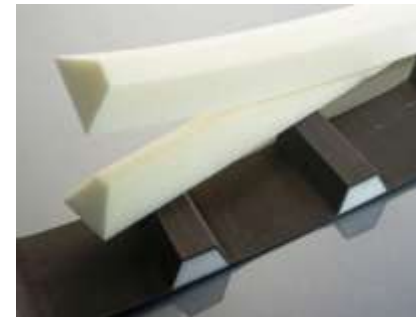


Requirements for Sandwich Cores

Composite sandwich construction is an emerging option to meet innovation demands coming from many industries, from automotive up to sport industry.

It leads to the **lightest** available **final parts** and can also offer significant **cost reduction** in mass production.

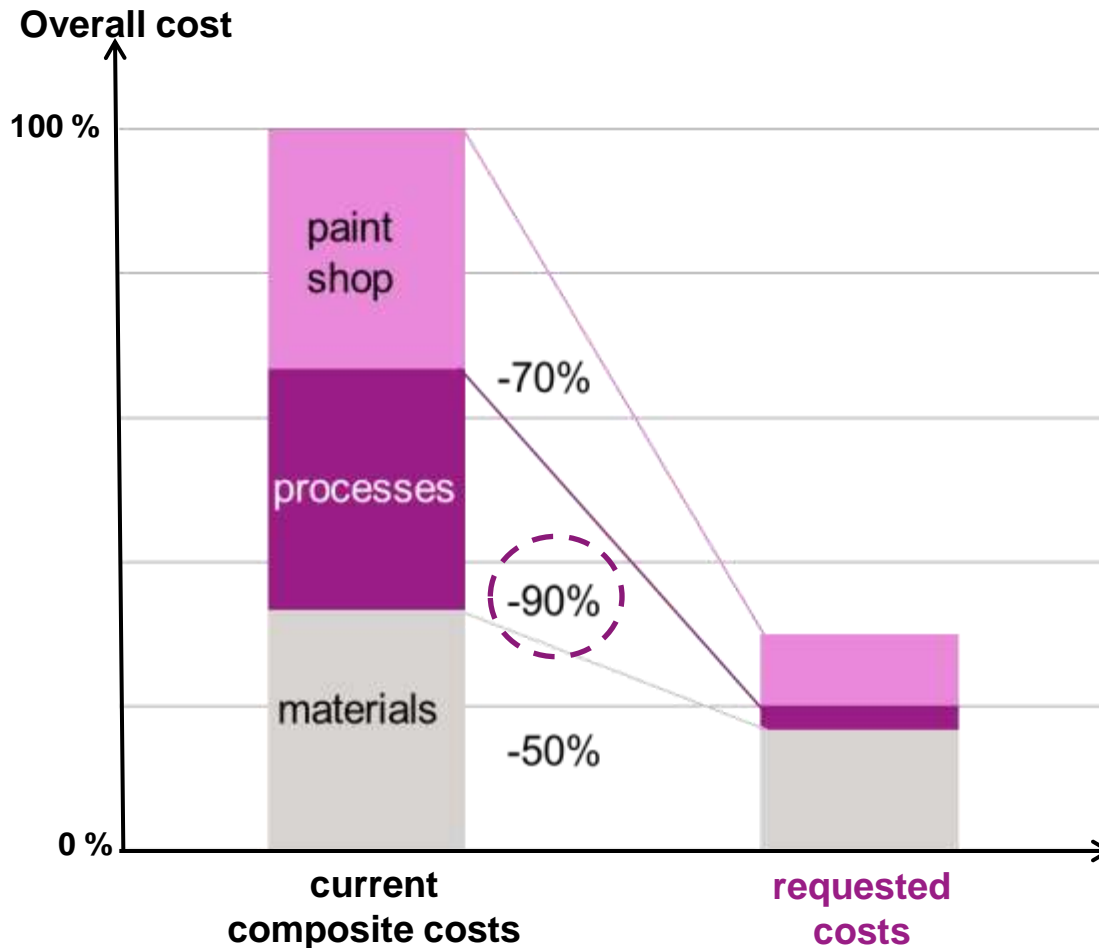
Requirement	Core properties
Lightweight design	High mechanical strength at low density
High surface quality	Fine and closed cell foam
Fast cycle times	High temperature & high compression resistance
Processability	Easy to shape



ROHACELL® is a PMI-based structural foam core that meets all requirements for fast curing processes.

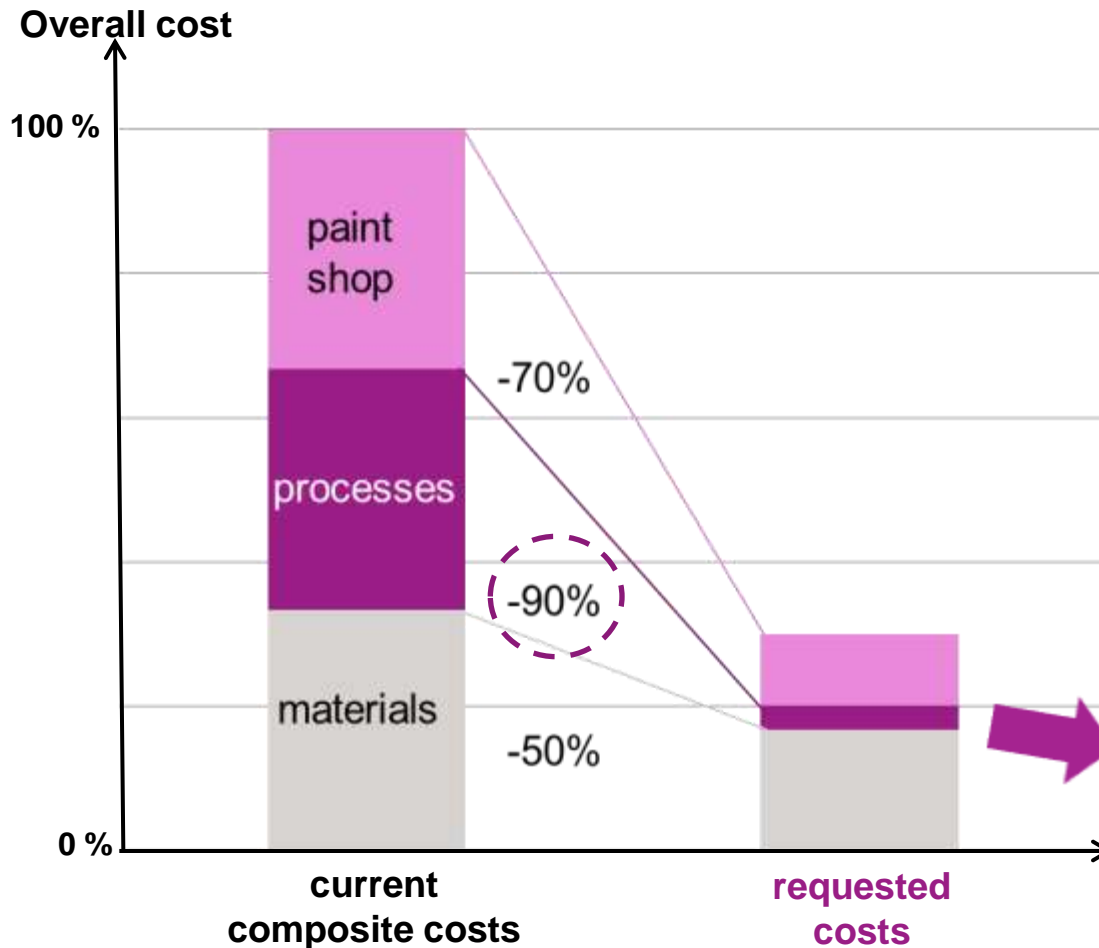
Biggest Hurdle for more Composites: Manufacturing Costs

Requirements from OEMs: “Competitive costs for composites”



Biggest Hurdle for more Composites: Manufacturing Costs

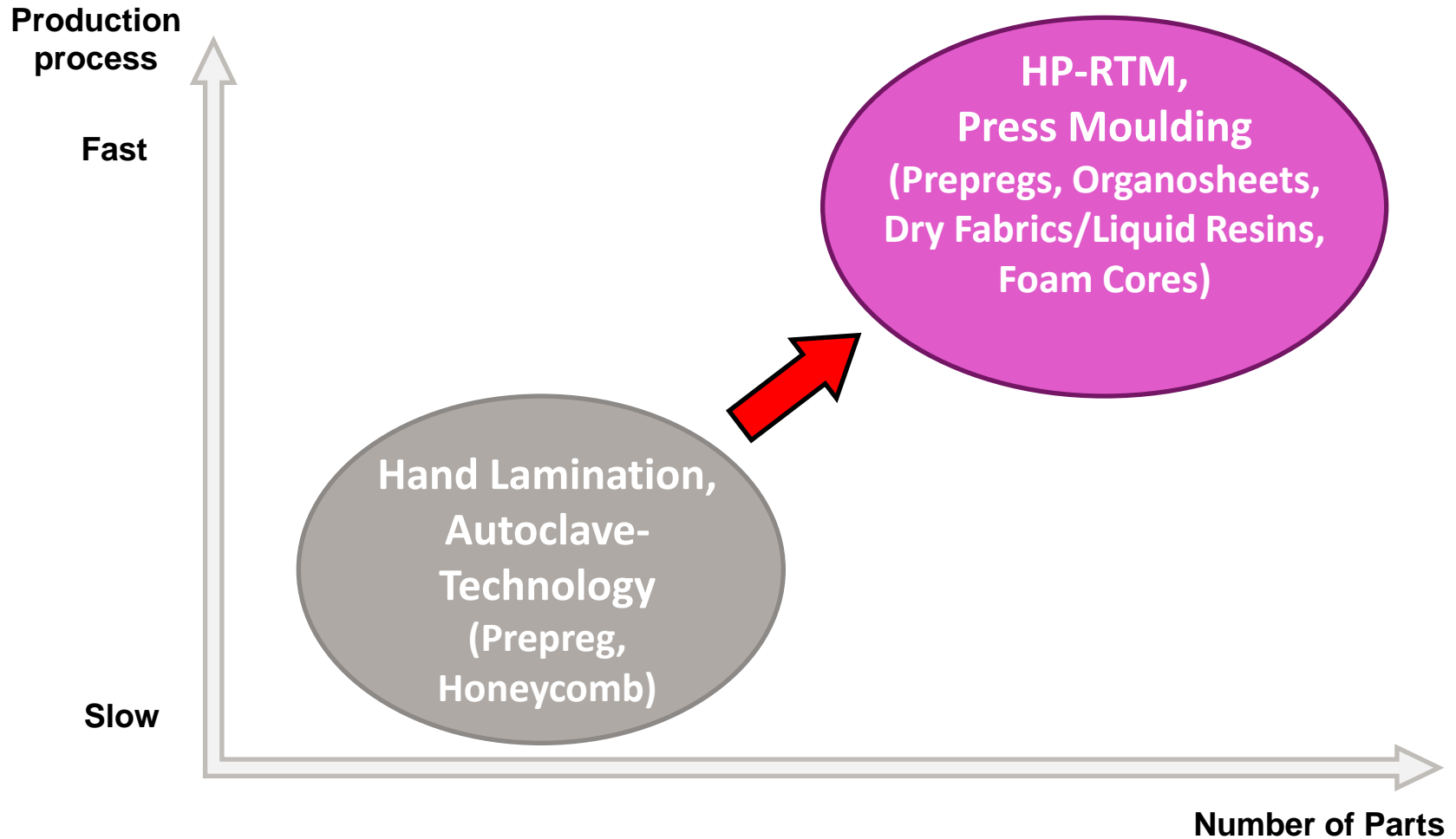
Requirements from OEMs: “Competitive costs for composites”



Production process has the biggest potential to decrease costs!

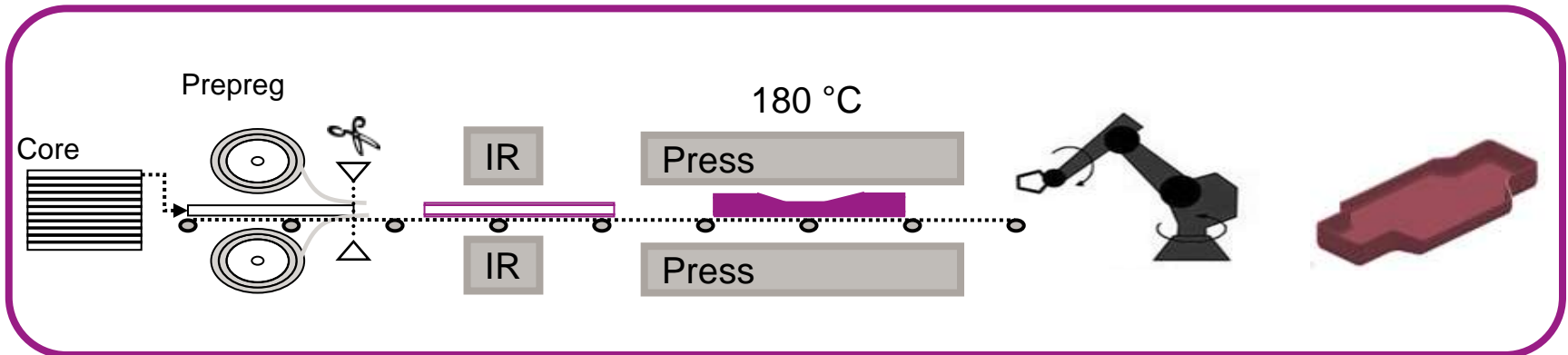
Production Processes

Trend toward mass production

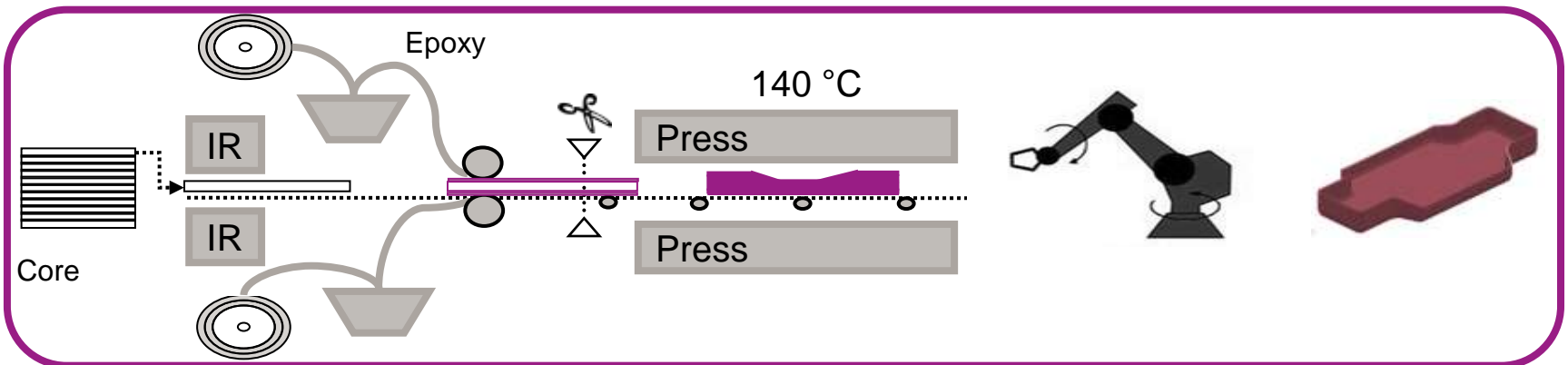


Production Processes

Dry-Compression

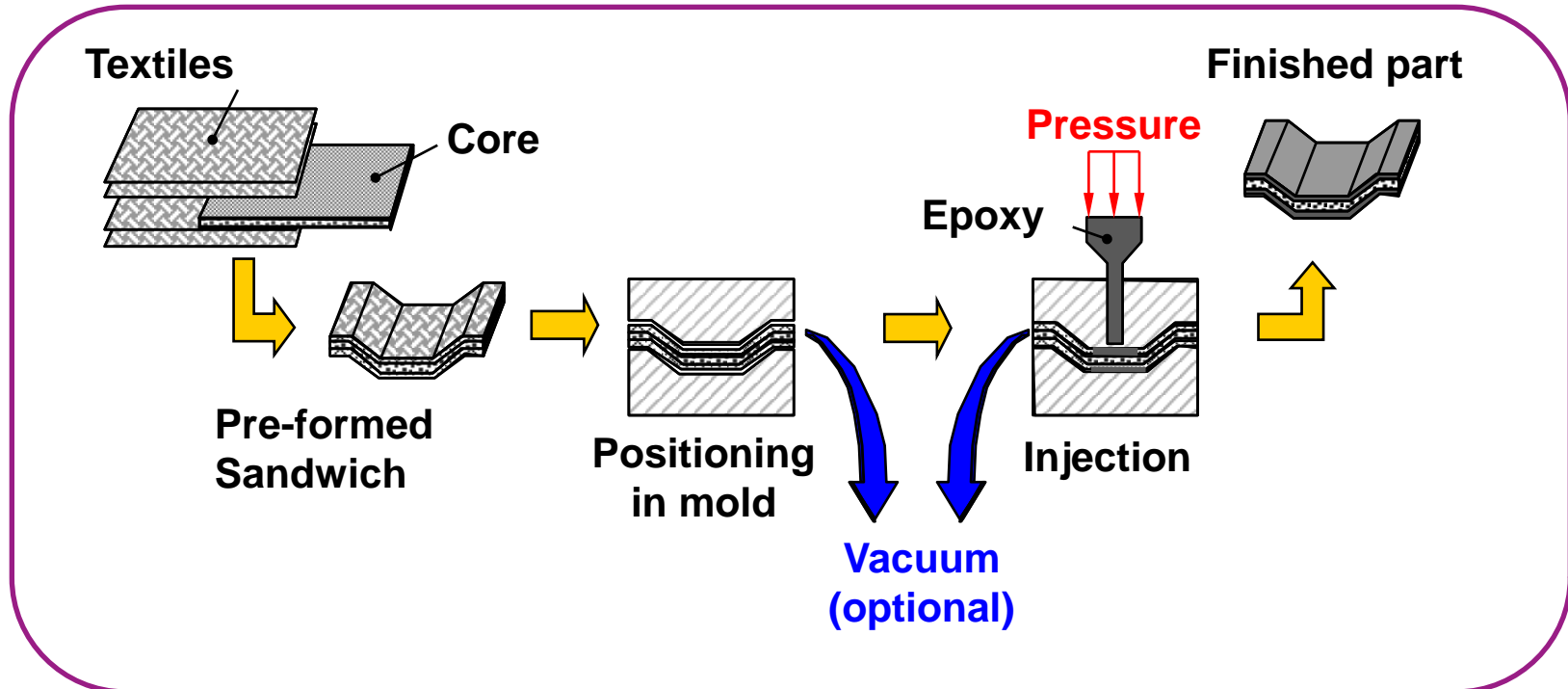


Wet-Compression



shorter production cycle time of composite parts

Production Processes



A fast curing process requires a core to withstand:

- temperatures of 80-140°C
- pressures of 20-80 bars

Production Processes

Requirements of the Core Materials:

- Resistance to Process Pressure
- Resistance to Process Temperature
- Creep Resistance
- Compatibility with any Matrix System
- Closed Cells



Applications

Requirements of the Core Materials:

- High Strength
- High Stiffness
- Fatigue Behavior
- Buckling Behavior
- Crash Performance



- Low Weight = Low Density
- Low Uptake of Resin
- Adhesion to Cover Layers

Source of upper image: <http://www.cbc.ca/news/business/bmw-canada-electric-car-comes-with-solar-panel-discount-1.2700033>, 08/31/2015

Medley of a few Applications with ROHACELL® inside

Aerospace



Radome & Antennas



Automotive



Ship Building



Wind Energy



Consumer Electronics



Medical



Sports



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- 3. Advantages of PMI In-Mold Foaming (IMF)**

Conventional Production of ROHACELL®



2. Co-Polymer Sheet

1. Liquid Monomer Solution

Conventional Production of ROHACELL®



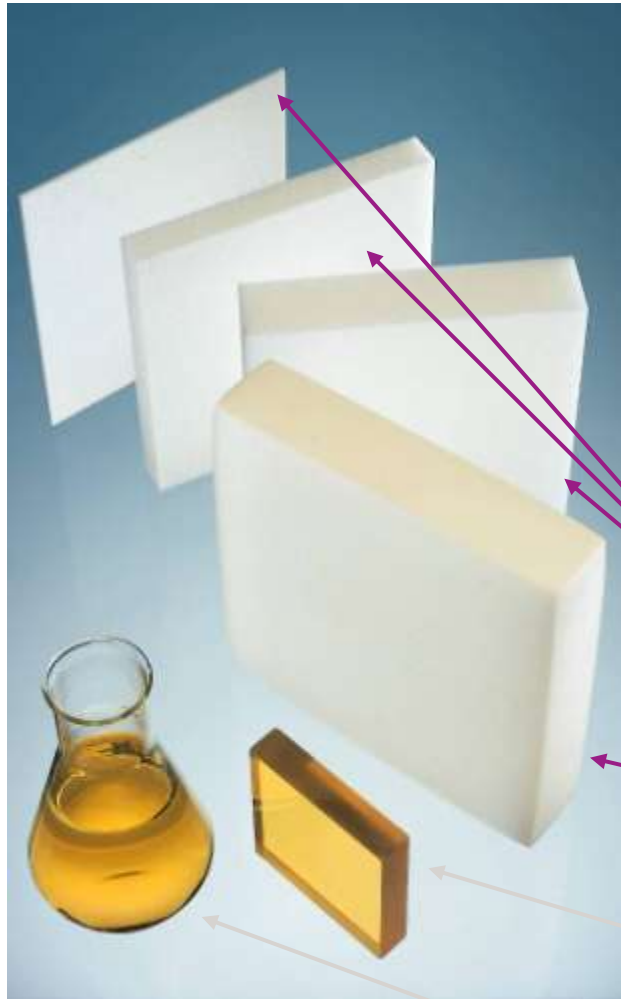
4. Cut-to-Size Foam Sheets

3. Raw Foam Block

2. Co-Polymer Sheet

1. Liquid Monomer Solution

Conventional Production of ROHACELL®



6. Sandwich structure

Customer



5. Net-Shaped cores

4. Cut-to-Size Foam Sheets

3. Raw Foam Block

2. Co-Polymer Sheet

1. Liquid Monomer Solution



Production of ROHACELL® Triple F



2. Co-Polymer Sheet

1. Liquid Monomer Solution

Production of ROHACELL® Triple F



3. Co-Polymer Granules



2. Co-Polymer Sheet

1. Liquid Monomer Solution

Production of ROHACELL® Triple F



4. Pre-foamed beads



3. Co-Polymer Granules



2. Co-Polymer Sheet

1. Liquid Monomer Solution

Production of ROHACELL® Triple F



4. Pre-foamed beads



3. Co-Polymer Granules



5. IMF Complex Core



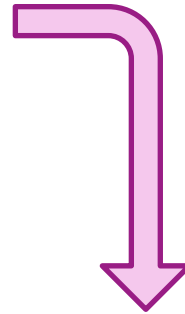
2. Co-Polymer Sheet

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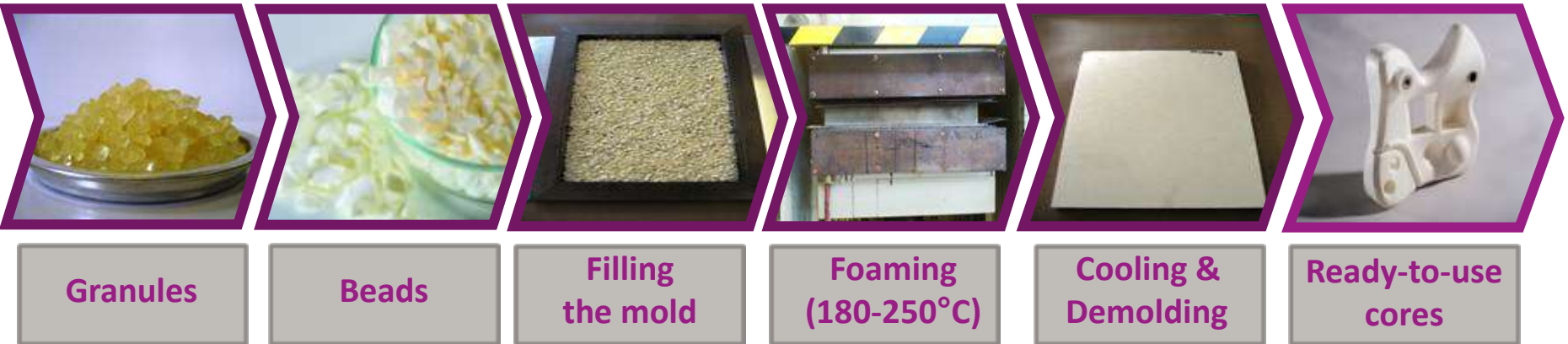
Overview ROHACELL® Triple F



Standard production of ROHACELL® foam sheets

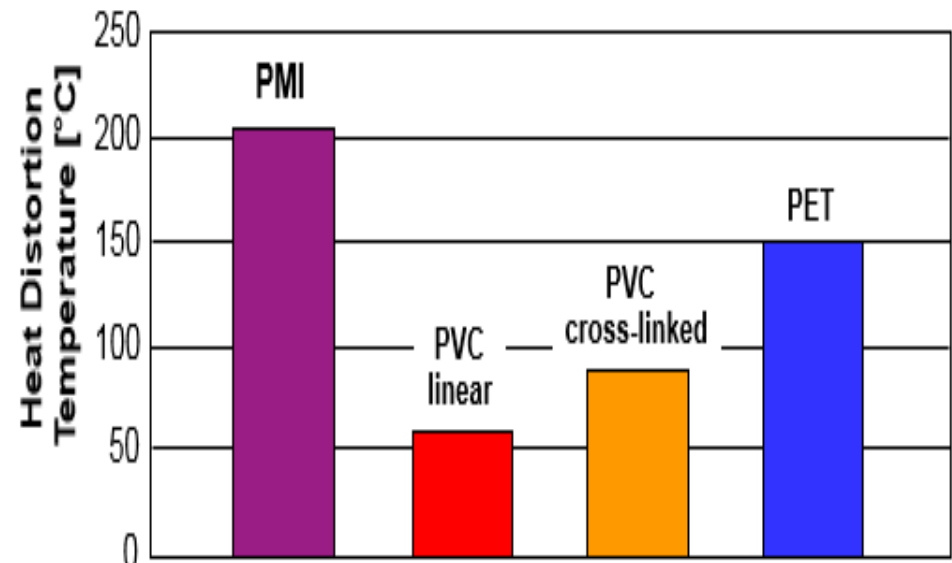
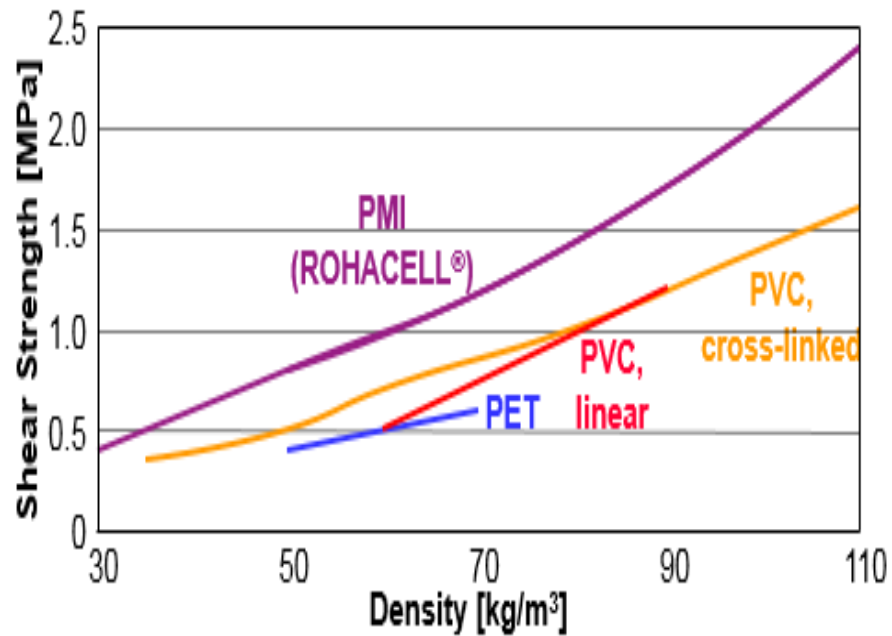


The newest product
ROHACELL® Triple F core

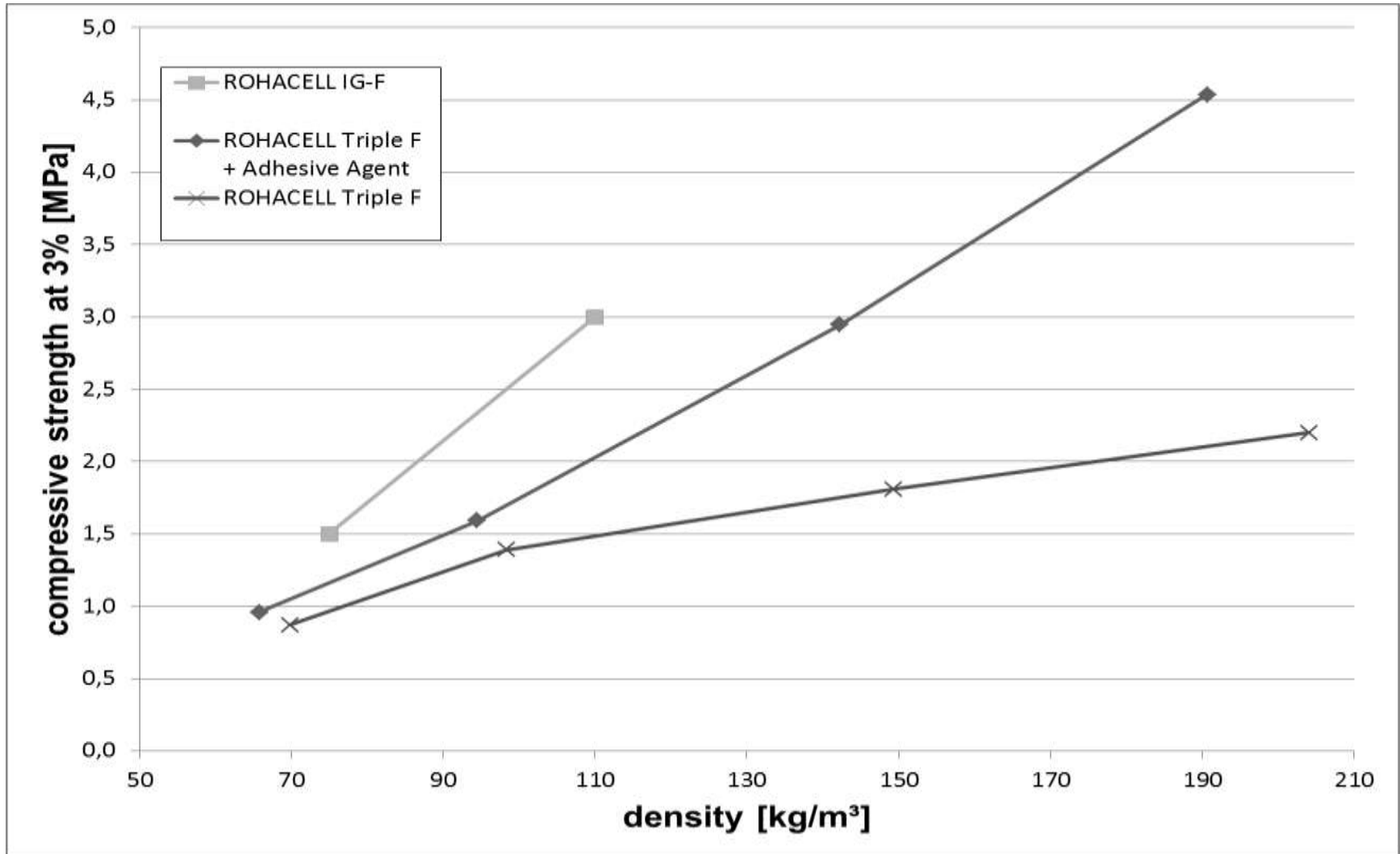


1. **Sandwich Cores Requirements and Overview**
2. **Manufacturing Process of PMI Rigid Foams**
3. **Advantages of PMI In-Mold Foaming (IMF)**

Mechanical/Thermal Properties of PMI foam compared to other polymer foams



Mechanical Properties of conventional PMI foam compared to TripleF



Properties of In-Mold Foamed Cores



- Thermal properties as good as conventional PMI material
- Mechanical properties slightly lower → slight increased density
- Able to withstand fast processes because of high temperature and compressive creep resistance
- No open pores
→ less resin up-take, less adhesion but lower weight and class A surface
- Design: High degree of freedom



Advantages of In-Mold Foaming



Why foaming in a closed Mold?

- Get a final shaped Foam Cores with less production steps and less material consumption but way faster
- Create Complex Shapes in one step technology
- Utilize high degree of integration to eliminate further assembly steps
- Minimize Waste
- More for Less: Save Time & Money

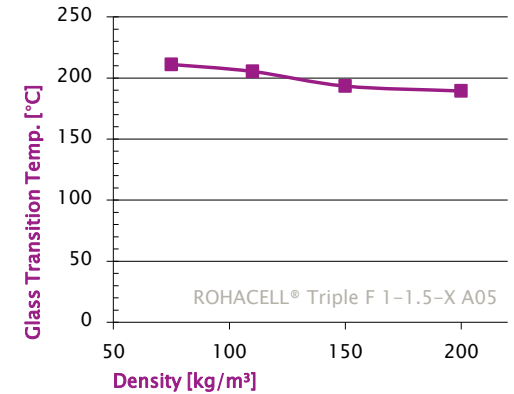
Meet Requests for High Volume Applications

Improve your process with ROHACELL® Triple F core



Use the full temperature performance of the resin.

The T_g of ROHACELL® Triple F (~200°C) is significantly higher than the T_g of all common used resins



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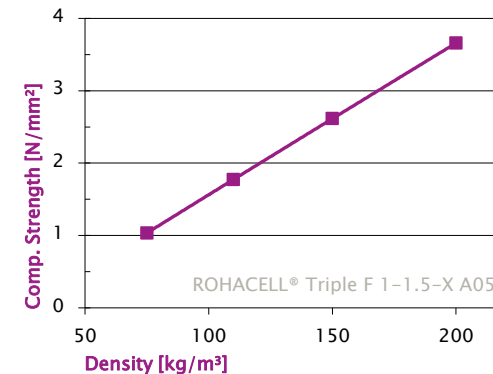
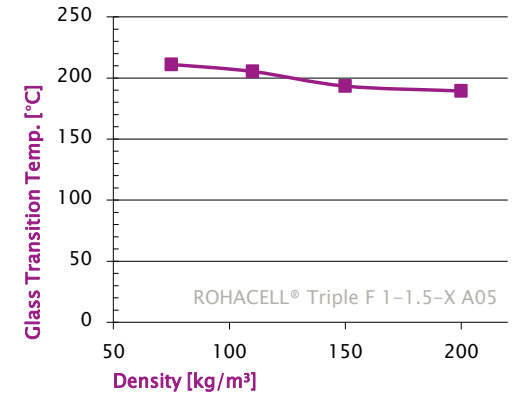


Use the full temperature performance of the resin.

The T_g of ROHACELL® Triple F (~200°C) is significantly higher than the T_g of all common used resins

A strong, but extremely lightweight core.

Depending on the part / process requirements, cores can be produced in a customized density range between 70 – 200 kg/m³ or more



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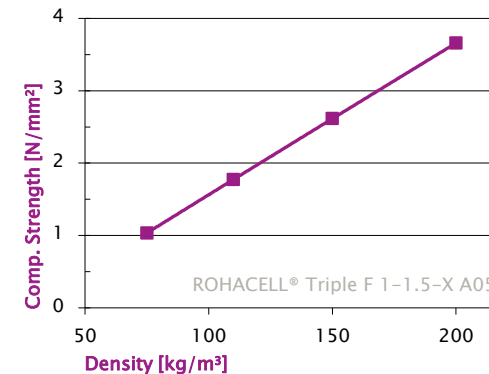
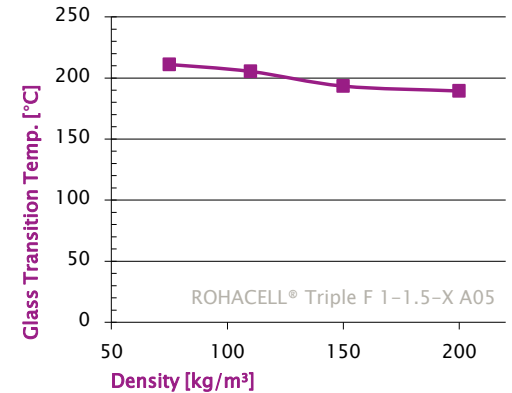
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Speed up the curing process.

ROHACELL® Triple F can be processed up to 140°C and up to 6 MPa



Create geometrically complex parts with very tight tolerances

- No need for evacuation due outgassing
- High Surface Finishing due fine cell structure (no potting and sanding is required) and no outgassing
- Helps to reduce manufacturing costs related to time, materials and processing
- The core is directly foamed in a mold and complex geometries can be produced
- Inserts can be easily integrated into the part during the core foaming process
- No outgassing due to residual chemical reactions that can restrict adhesion of layers

ROHACELL® Triple F cores are ready to use.



Tight tolerances



Integrated inserts

Conclusion

- **Processes** need to be faster
→ **Materials** need to be „faster“
- Sandwich Technology is not cost effective for **Large Scale Production**
- Sandwich Technology is one of the best Design Concepts to achieve **Weight Reduction**
- **In-Mold Foamed PMI Triple F** is a great opportunity to meet these conditions

**Time
Efficient
Process**



**Cost
Efficient
Process**



**High
Quality**



**Light-
weight**



Thank You!

Integrate a bit of Magic...
A kind of Magic for complex automotive part design!!!



It's not Rocket Science...ask our Experts!!!



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