One Step Hybrid Molding Process - A Cost Effective Manufacturing Technique for Composite Parts

Pal Swaminathan
What kind of manufacturing process will help me to target a variety of automotive parts?

What does it take to produce composite parts in mass production???

What will be my capital investment?

There are so many manufacturing processes in the market - which one I should choose?
Equation for a successful mass production in automotive industry

Material
- availability for mass production

+ Process
  - feasibility
  - reliability
  - cycle time

= Successful mass production
Tepex® a woven thermoplastic composite laminate

- Continuous-fiber-reinforced sheets in thermoplastic polymer matrix
- Reinforcement is a fabric or continuous fiber made of glass, carbon, carbon + glass
- Sold as semi-finished sheets - Material is fully impregnated and consolidated
- Parts can be made by thermoforming or one step hybrid molding process
- Sheet thickness as low as 0.5mm and up to 6.0mm
- Standard polymer matrixes are PA6, PA66, PP, TPU and PC
Continuous production of Tepex® on an advancement of the Double Belt Press

Polymer  Impregnation + consolidation  Cutting + Packaging
Textile
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### Processes available for manufacturing composite parts

#### Thermoset composites
- Hand layup
- Filament winding
- Resin transfer molding (High pressure, Low pressure, vacuum assisted)
- Pultrusion
- Compression molding (SMC)
- Resin film infusion (RFI)

#### Thermoplastic composites
- Injection molding
- Compression molding
- Automated tape laying
- Automated fiber placement
- Resin Injection Molding (RIM)
- Pultrusion

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**The list of manufacturing process for composite parts is long!**
Processing of thermoset composites

- **Hand layup and Resin film infusion** are attractive for low volume applications with low to medium cost tooling along with medium to high investment in infrastructure.

- **Compression molding** requires medium investment and is suitable for high volume applications with medium to high energy cost and cycle time.

- **Pultrusion** requires medium investment but is constricted to making constant cross-section parts with medium to long cycle times.

- **Filament winding** requires medium investment but is constricted to making cylindrical parts with longer cycle times.

- **HP-RTM** have relatively low cycle time and can be a good candidate for high volume part production but cycle times $>$ 1 min and complexity is higher with thermoset.

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**Hand layup**

- Resin
- Roller
- Laminate
- Mould


**Resin film infusion**

- Vacuum bag
- Pre-cured resin in sheet form


**Compression molding**

- Bonding components
- Tactile sense


**Pultrusion**

- Doctor blade
- Head-off gripping
- Pultruded sections


**Filament winding**

- Winding supply
- Resin bath


**Resin transfer molding**

- Polymerization
- Cure


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**Highlights**

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Processing of thermoplastic composites

Injection and compression molding are the most common manufacturing processes in the industry that is suitable for high volume production with relatively low investment.

Automated tape layup is relatively slow process with high investment.

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HP-RTM have relatively low cycle time and can be a good candidate for high volume part production with cycle times>>1min.
### Processing properties of Thermoset and Thermoplastic Composites

<table>
<thead>
<tr>
<th>Feature</th>
<th>Thermoset Composites</th>
<th>Thermoplastic Composites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass production feasibility</td>
<td>Low to Medium volume</td>
<td>High volume</td>
</tr>
<tr>
<td>Processing time</td>
<td>Medium to Long</td>
<td>Short</td>
</tr>
<tr>
<td>Processing Skill Level</td>
<td>Medium to Difficult</td>
<td>Easy adaptation</td>
</tr>
<tr>
<td>Energy costs</td>
<td>High</td>
<td>Medium to Low</td>
</tr>
<tr>
<td>Design feasibility</td>
<td>Low to Medium</td>
<td>High</td>
</tr>
<tr>
<td>Recycling</td>
<td>Difficult</td>
<td>Possible</td>
</tr>
<tr>
<td>Shelf life</td>
<td>Limited</td>
<td>Unlimited</td>
</tr>
<tr>
<td>Weldability</td>
<td>Not Possible</td>
<td>Possible</td>
</tr>
</tbody>
</table>
Processing of thermoplastic composites

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# Processing steps of Thermoset and Thermoplastic Composites

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<th>Process of Thermoplastic composites</th>
<th># of steps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Preg Process</td>
<td>Semi finished sheets precut to the initial blank shape</td>
<td>6</td>
</tr>
<tr>
<td>Hand Lay-up</td>
<td>Thermoforming &amp; over molding</td>
<td>1</td>
</tr>
<tr>
<td>Curing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cutting</td>
<td></td>
<td></td>
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<tr>
<td>Applying Adhesive</td>
<td></td>
<td></td>
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<tr>
<td>Over-molding</td>
<td></td>
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**One Step Hybrid Part manufacturing**
One step hybrid molding process
Thermoplastic composites in injection molding process

- Functional Integration
- One shot hybrid molding process (thermoforming + injection molding in one step)
- Rib structures can be injection molded to reinforce the part
- Relatively low investment cost
- Cycle times < 60 seconds
- Higher repeatability
- Higher geometric accuracy
- Suitable for complex parts
- Easy adaptation

During the manufacturing no chemical reaction occurs, a very reproducible process is obtained.
One step hybrid molding process
Thermoplastic composites in injection molding process

Advantages

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One step hybrid molding process
Thermoplastic composites in injection molding process
One step hybrid molding process
Thermoplastic composites in compression molding process

Advantages
- Large parts with strong structural requirements
- High performing material in outer layer → stiffness/toughness
- One-step process allows many different material combinations for versatile part properties
One step hybrid molding process
Injection molding + In Mold Decoration (IMD)

Advantages

- Cost effective process
- Combination of three processing steps in one shot process
  - Thermoforming of Tepex®
  - Injection Molding
  - In-Mold-Decoration (IMD)
- Fully automated process
- Short cycle times: ~ 60 s
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### Mass production components with Tepex®

**Automotive**
- Carrier
- Seat pan/structure
- Door module
- Pedal / Pedal box
- Trunk well
- Frontend
- Rear Bumper
- Underbody protection

**Non - Automotive**
- Smartphone casing
- Shoe Soles
- Ski Boot

- Many projects in development and several mass productions targeted in 2019, ranging between 5000-300,000 parts/yr
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Successful mass production

✅ + ✅ = ✅
Usage of composites is on the rise in automotive industry
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