Long Glass Fiber-Polypropylene Light Weight Instrument Panel Retainers & Door Modules

Matthew Marks
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History: 2002 to present

Comments at that time:

This is for the Ford Fiesta.

Why are there no other cars?

Disbelief in door module concept.

It is an extra part.

Assembly outside current line considered complicated
Situation 2008 - LGF-PP Door modules

*in production or development*

Ford
VW
Skoda
Hyundai
Kia
Fiat
Mercedes
Chrysler
BMW
Jaguar

... and injection molded hatchback doors
Dashboards examples LGF-PP

Standard Injection Molding

**VW:**
Golf, Golf Plus, Touran, Bora, Jetta

**Skoda:**
Octavia, Superb

**Audi:**
A4

**Ford:**
Fiesta, Focus, Fusion

**Mercedes:**
A, B, C, M, R

**Volvo:**
S40, V50

**Opel:**
Vectra
2. Materials

Both dashboards carriers and door modules:
- Good flow
- High stiffness
- Safe fracture
- Dimensional stability

and more recently: **Light weight (why more recently?)**

High impact strength is not required, but good crash behavior is. Example: Dashboard carriers don't need Charpy notched > 10 kJ/m², E.g. short glass mSMA can be OK
Material choice IPs

20% long glass PP

+ thin-wall possible (t=1.7mm, 2000 ton)
0 needs thorough knowledge of warpage predictions to guarantee correct shape.

PP talc 20%
- low stiffness/strength at 80° C (2.5mm PP/talc = 1.8mm LGF-PP)
+ material price/kg (not per part?!) 

SMA short glass 12%
- poor flowability (2.5mm, 4000 ton)
0 same mechanical properties as LGF-PP 20%
+ warpage OK, foam adhesion easy
3. Costs

Cost price calculation example IP carrier

Calculations basis is design / development for 3 different OEM dashboards:
## Calculated weight factor IP-carrier

<table>
<thead>
<tr>
<th></th>
<th>mSMA-SGF 12%</th>
<th>PC/ABS unfilled</th>
<th>PP-LGF 20%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density</td>
<td>1.15</td>
<td>1.15</td>
<td>1.05</td>
</tr>
<tr>
<td>Density factor</td>
<td>1.10</td>
<td>1.10</td>
<td>1.00</td>
</tr>
<tr>
<td>* mSMA min wall thickness = 2.2mm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Density factor x Wall thickness</td>
<td>1.34</td>
<td>1.52</td>
<td>1.00</td>
</tr>
<tr>
<td>Weight of Instrument Panel of 2900 cm3 [kg]</td>
<td>3.97</td>
<td>4.57</td>
<td>3.0</td>
</tr>
</tbody>
</table>

\[
\text{Density factor} = \frac{\rho_{\text{Material}}}{\rho_{\text{PP-LGF}}}
\]

\[
\text{Stiffness factor} = \frac{E_2 \times (t_2)^{2.2}}{E_1 \times (t_1)^{2.2}}
\]
Cost Price Calculation IP - Assumptions

Machine size equal  *
Cycle time equal
Energy consumption equal
Mold investment equal
Number of operators equal
Assembling cost equal

Unfavorable assumption for part cost price PP-LGF

Flame treatment cost for PP-LGF ~ $0.50 / part (incl. investment)

* Conservative assumptions:
- Typical PP-LGF clamp force = 1600 ton, amorphous 2500 ton.
- Typically wall-thickness much thinner for PP-LGF, faster cooling/energy.
### Material Cost Price IP

*Calculated weight factor IP*

<table>
<thead>
<tr>
<th>Material</th>
<th>mSMA-SGF 12%</th>
<th>PC/ABS unfilled</th>
<th>PP-LGF 20%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material weight [kg]</td>
<td>3.97</td>
<td>4.57</td>
<td>3.0</td>
</tr>
<tr>
<td>Material price / kg [$]</td>
<td>110%</td>
<td>125%</td>
<td>100%</td>
</tr>
<tr>
<td>Material cost per part [$]</td>
<td>145%</td>
<td>190%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Including delta for flame treatment.

Low density  
High stiffness (high temperature)  
Low weight  
Low material cost
4. Thin wall design

"Light weight design" has been a topic on all international congresses for years.

Is it becoming more of a new requirement? Differentiator?

=> Solution: Materials + Engineering

1. Molding thin walls

2. Design optimization
Filling example

$t = 1.7 \text{ mm}$
Design optimization – 1 clever design

Example door module

From "metal" design

To plastic

+ Wall-thickness optimization
  typical 1.0-1.5 to max. 3-4 mm
Effect clever design

Front-end structure

Clever design

Factor 4 increase in stiffness, just by design.
Or 2 kg = 33% weight + cost saving on total front-end.
Design optimization, Anisotropic

Use fiber orientation from flow.
Design optimization, Anisotropic

Using anisotropy! Up to 20% weight saving compared to isotropic.

example fiber orientation core layer example E-modulus distribution

But still hardly used for IP/door modules
5. Warpage control

Filling is not the issue, large IP can be filled with one gate!

=> One important issue: **Warpage control**.

- Effect fiber length on fiber orientation.
- Long fiber $C_l/D_z/\lambda$ coefficients as $f(\text{glass\%}, \text{length}, \text{thickness})$
- Effect gating strategies, spring-forward predictions, etc.

Default result:

LGF result:

Own SABIC Moldflow version and knowledge developed and still ongoing.
Developments in simulations

*Dashboards/IP-carriers*

1. Warpage of both "as molded" and "trimmed" dashboard.
Developments in simulations
Dashboards/IP-carriers

2. Warpage of assembly in car:
   + vibration welded air ducts, glove box, etc.
   How does it fit into the car and when mounted?

   z-deflection, nice fit

   y-deflection, OK in assembly

Thin-wall dashboard is flexible. Out of the mold shape may be quite different compared to assembled shape.

Note:
Special method developed for vibration welded assembly warpage.
6. Trends

1. Only recently first examples of weight and wall-thickness optimization in door modules.

2. Structural upgrade of dashboard carriers

   Cross car beam

3. Other light weight alternatives?

   Foaming?
   Injection-compression?
Cross car beam 1 to 1 replacement

Steel -> STAMAX:

STAMAX beam only weighs ca. 2 kg, at t=3mm.

diameter 150mm!

=> Integration with carrier.
Needs validated impact simulation

Single Element Validation
LS-DYNA

+ test bar validation
+ component validation
Example of dynamic validation

*Component test, beam compression*

Impactor:
\[ m = 4.47 \text{ kg} \]
\[ v_{\text{initial}} = 9.409 \text{ m/s} \]

Foundation: beam fully constrained

Only half of the beam is being tested, this is done to prevent instable collapse.
Example of dynamic validation
Component test, beam compression

Test data supplied by Faurecia
Measurement vs. calculation unfiltered

Measurement peaks due to oscillations in impactor, force sensor location

quite good agreement in failure progression

Variations in damage evolution, compression vs. tension and fiber pull-out length.
Side impact crash simulation

S, Mises
SNEG, (fraction = -1.0)
(Ave. Crit.: 75%)

[Color bar with values]

Scale Factor: +0.00

EBQ EERAPE Seite AM 50t-01
ODB detaill93.02.02 - NTIET ELPLICIT Version 6.5  Wed Sep 13 09:38:2
2
Step: 1, 1, Step-1
Increment = 0.0025, Step Time = 6.0801E-02
Primary Var: S, Mises
Deformed Var: U  Deformation Scale Factor: +1.000e+00
Conclusions

- Door modules/IP-carriers in LGF-PP have become common practice. Reasons: Low weight, low cost.

- Thin wall molding is state of the art, but weight optimization is just getting accepted. => large cost/weight saving potential.

- Warpage control knowledge key to success for LGF-PP.

- Trends for more structural dashboard carriers.