Recent Thermoplastic Composites for Automotive Applications

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Contents

1. Introduction

2. Applications of Thermoplastic Composites
   - High Flow TPO
   - Long Glass Fiber Reinforced PP
   - Glass Microsphere Filled PP
   - Nonoclay Filled PP
   - PP-LFT by Direct Compounding

3. Concluding Remarks
The United States, the European Union and Korea are re-establishing Green House Gas reduction targets for vehicle operation, which makes it increasingly challenging to find cost effective solutions.

**CAFE (U.S.A.)**
- '08: 28.2 mpg
- '16: 35.5 mpg
- 35.5 mpg (15.1 km/ℓ)
- Passenger Vehicle 39 mpg (16.6 km/ℓ)
- Light Truck 30 mpg (12.8 km/ℓ)

**CO₂ Regulation (EU)**
- '08: 147 g/km
- '12~'15: 130 g/km
- (Annual Phase-in)
- Monetary penalty if unsatisfactory

**CAFE (Korea)**
- '08: 12.3 kpl
- '12~'15: 140 g/km
- (Annual Phase-in)
- 2012 30%, 2013 60%, 2014 80%, 2015 100%

* CAFÉ (Corporate Average Fuel Economy)
• Usage of plastics in passenger cars is 12% by weight
• Among them PP and PA compounds are around 65%

More than 70% of plastics is used in the form of composites
  - Talc reinforced PP & TPO mainly for exterior and interior parts
  - Glass fiber reinforced PA mainly for chassis and powertrain parts

* 2008 Internal Report
Weight Reduction

• How can we reduce part weight with polymer composites?

- New Materials
  - High Modulus & Strength
  - High Impact Strength
  - High Processability

- New Processing Techniques

- New Design Concepts

• Issues: Cost, Performance, Quality Control
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3. Concluding Remarks
Exterior Part

• Rear Bumper Cover: Non-Paint High Flow TPO

<table>
<thead>
<tr>
<th>Test Item</th>
<th>Units</th>
<th>General</th>
<th>High Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific Gravity</td>
<td>g/10min @230°C</td>
<td>25</td>
<td>40</td>
</tr>
<tr>
<td>Melt Flow Index</td>
<td>J/m @-30°C</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>Flexural Modulus</td>
<td>MPa</td>
<td>1,800</td>
<td>2,100</td>
</tr>
<tr>
<td>Thickness</td>
<td>mm</td>
<td>3.0~3.5</td>
<td>2.8~3.2</td>
</tr>
</tbody>
</table>

• Issues: Larger Bumper Area, Weld Line, Sink Mark, Weatherability

• Challenges: Lighter Material (ex: Nanocomposite)
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3. Concluding Remarks
• Manufacturing Process: Glass Fiber Content (20~70wt%)

• Issues: Screw and Die Design, Full Impregnation, Fiber Length after Injection Molding
Chassis Part

• Front End Module (FEM) Carrier: PP-LFT

Previous – Steel/Plastic Hybrid

New Concept – Plastic

PA 6+GF 30%
* PA: Polyamide

• Issues: Stiffness, Hood Latch Strength, Low Speed Impact Toughness

• Challenges: Apply to Bigger Cars (ex: Premium Sedan)
Body Part

• Door Module Plate (DMP) : PP-LFT

Previous – Steel

New Concept – Plastic

PP-LFT
Two Cavities Injection Molding

* PP-LFT (PP-Long Fiber Reinforced Thermoplastics)

• Issues : Part Integration, Warpage and Deformation, Impact Toughness
• Challenges : Lower Glass Fiber Content (ex : 30~40% → less than 25%)
Material Preparation (II)

- Manufacturing Process: Continuous Fiber + Long Fiber

→ Injection-Compression Molding

Polypropylene & Additives
Glass Fiber Rovings

Impregnation Die

LFT (Long Fiber Reinforced Thermoplastics)
CFT (Continuous Fiber Reinforced Thermoplastics)
WCFT (Woven Continuous Fiber Reinforced Thermoplastics)
WLFT (Woven and Long glass Fiber Hybrid Thermoplastics)
Exterior Part

• Rear Bumper Back Beam : PP-WLFT

Previous – GMT
New Concept – WLFT

• Issues : Drapability of WCFT, Safety, Reparability (IIHS)
• Challenges : Apply to Other Parts (ex : Front Bumper)
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• High strength hollow glass microsphere can provide weight savings

Previous – Talc Filled

PP/Rubber/Talc 10~25%
(sp.gr. = 1.0~1.1)

New Concept – Microsphere Filled

PP/Rubber/Talc/glass Bubble 3%
(sp.gr. = ~0.93)

• Issues : Breakage during Compounding, Impact Strength, HDT
  • Challenges : Increase Glass Bubble Loading (ex : 5%)

* Collaboration with 3M and Hyundai EP

* Specific Gravity : 0.60
* Size : 15 ~ 40 μ
* Wall Thickness : 1.3 μ
• SEM (scanning electron microscope) Investigation

Talc Filled

Microsphere Filled

• Recent Application

HG Grandeur 2011
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**Material Preparation**

- **Preparation of PP Based Nanocomposite**

  - **MMontmorillonite (MMT)**
    - Organic modifier: alkyl ammonium
    - Surface Treatment
    - gallery ~0.2 nm

  - **Organo-clay (O-clay)**
    - gallery 2~3 nm

  - **Compatibilizer**: MA-g-PP

  - **Compounding**
    - Matrix: PP
    - Rubber: EOR

  - **Nano clay**
    - 0.1 μm

  - **MMT**: Montmorillonite, $\text{Al}_4\text{Si}_8\text{O}_{20}(\text{OH})_4$
  - **TPO**: ThermoPlastic polyOlefin
  - **PP**: Polypropylene
  - **MA-g-PP**: Maleic Anhydride-grafted-Polypropylene
  - **EOR**: Ethylene-Octene Rubber

- **Issues**: Intercalation or Exfoliation of Clay, Dispersion in Polymer matrix
- **Challenges**: Cost Effective Processing (ex: without Compatibilizer)
Exterior Part

• In spite of lower filler content, nanocomposite showed good dimensional stability at a high temperature as well as weight reduction by about 20%

Previous – Talc Filled
PP/Rubber/Talc 30~40%
(sp.gr. = 1.14~1.26)

New Concept – Clay Filled
PP/Rubber/Clay 4%
(sp.gr. = ~0.92)

* Collaboration with LG Houses and Samsung Total

• Issues : CLTE, Processability, Surface Quality
• Challenges : Apply to Non-Paint Parts (ex : Cowl Top Cover)

* CLTE : Coefficient of Linear Thermal Expansion
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LFT-D

- Extrusion + Compression: Longer Fiber Retention (~25mm)

- Issues: Quality Control, High Investment Cost, Design Restriction
Exterior Part

• Floor Under Cover: PP LFT-D

HMC i40
(2011 Seoul Motor Show)

Old Concept – GMT

- Front: 840mm x 570mm, 2.4kg (1.2kg x 2)
- Rear: 590mm x 570mm, 1.5kg (0.75kg x 2)

New Concept – LFT-D

• Advantages: Cost Down, Weight Down, Higher Surface Quality, Easy Thickness Control (1.6~1.8mm)
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• Thermoplastic composites will be used much more than today in automotive industry, which should be clearly connected to the fuel efficiency issue.

• Glass fiber reinforced polypropylene (PP) will be continuously needed to satisfy weight reduction as well as cost competitiveness.

• Hyundai·Kia will endeavor to support the development of innovative composite materials and parts.
Thank You!