Development Of Special PVC Resins For Long Glass Fibres Reinforced Sheets

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Brighton, April 2008
Introduction: what and how?

- The aim:
  - Offer to the market the possibility to have access to a new high performance PVC material: homogeneous long glass fibres reinforced PVC plates

- The question:
  - How to manufacture homogeneous long glass fibres (50 mm) PVC plates without damaging the fibres

- A possible process: Fibroline
  - In this process, the polymer doesn’t pass through a mixing step → no shearing on the material → no damage of the fibres

- The challenge
  - How to quickly gelate PVC without going through a shearing step?
Introduction: Classical Manufacturing Processes

- Extrusion or Injection molding
  - Passing through extruders ⇒ shearing stress on the material
  - Breaking of the fibres
  - Orientation of the fibres
  - = to the addition of short glass fibres

- Pultrusion
  - The fibres are pushed together with the polymer through the die and are then completely “drown” into the matrix
  - Use of very long fibres
  - Orientation of the fibres ⇒ anisotropic properties
  - Necessity to have very low viscosity materials ⇒ not so much for PVC
Content

- Introduction
- Fibroline Process
- Developments and results
- Markets
- Conclusions
FIBROLINE Process

The patented FIBROLINE Process is a dry process allowing the impregnation of fiber structures with powders

- Cut Fibres are placed on a conveyor belt
- The powder is scattered on it
- The material passes between 2 plane electrodes

Creates ions that collide with the grains of powder and charge them electrically, allowing them to penetrate into the fibre support

The fibre support and the polymer are then pressed between hot cylinders
FIBROLINE Process: the principle

- Initial surface distribution
- Ionization and impregnation phenomena
- Homogeneous distribution in the structure

Electrodes, 6 kV, Dielectrics, Powder, Textile, Plasma, Uniformly distributed powder.
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The challenge

- How to gelate a PVC without any shearing phase?
  - turn towards PVC resins with particular gelation properties

The way we have done it:

- Estimation of the interest by numerical calculation
- Based on our expertise, selection of resins susceptible to fit with our specifications
- Testing of formulation by blending the chosen resins with different additives
- Testing on Fibroline line
- Characterization of the glass fibres PVC plates
Numerical Calculation

■ Estimation of the theoretical elastic modulus of a long glass fibres PVC sheet if:
  ➔ The fibres are randomly and regularly distributed
  ➔ The compatibility between the fibres and the resin is perfect
  ➔ There is no air bubble

■ Use of DIGIMAT developed by
  ➔ a software used to predict the nonlinear constitutive behaviour of multi-phase composite materials
Numerical Calculation : the results

<table>
<thead>
<tr>
<th>Part to weight ratio of fibres (%)</th>
<th>Calculated Modulus (GPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>70</td>
<td>19.1</td>
</tr>
<tr>
<td>50</td>
<td>12.4</td>
</tr>
<tr>
<td>30</td>
<td>7.8</td>
</tr>
</tbody>
</table>

Based on a PVC modulus of 2.8 GPa

A real interest

DGN – April 2008

PVC Conference Brighton 2008
Developments and Results

- Selection of resins and formulations
- Study of the blending conditions
- Study of the gelation behaviour
- Testing on the Fibroline line
- Characterization of the products
Developments and Results

- Selection of resins based on:
  - Their known gelation behaviour
  - Their facility to be blended with different additives
  - 5 special resins from the portfolio of Solvin

- Study of the blending
  - Type of additives (heat stabilizer, lubricant,...)
  - Conditions of blending
 Developments and Results

- Gelation behaviour
  - 2 resins (A and B) and 2 sets of additives (F1 and F2)
  - by *only pressing* the dry-blend and measuring some properties

DSC measures are still running
To begin, we chose to test only 2 products:

⇒ Same resin but 2 different formulations
  • Formulation PVC A/ F1
  • Formulation PVC A/ F2

Amount of fibres: 40% of weight

Thickness: 0.7 mm
Characterization

- Tensile resistance
- Flexural modulus
- Instrumented falling-weight Impact resistance (PTI)
- Heat deflection temperature test (HDT)
Characterization: Tensile Resistance

ISO 527-3 (1995)

Extruded profile (no glass fibres)

PVC A/F1 + glass fibres
Characterization: Flexural Modulus

ISO 178 (2001)

Flexural Modulus

Modulus (MPa)

<table>
<thead>
<tr>
<th>Material</th>
<th>Modulus (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PVC Ref</td>
<td>3000</td>
</tr>
<tr>
<td>GF/PVC A/F1</td>
<td>6000</td>
</tr>
<tr>
<td>GF/PVC A/F2</td>
<td>7000</td>
</tr>
</tbody>
</table>
Characterization: Instrumented falling-weight Impact Resistance

![Graph showing instrumented falling-weight impact resistance for different materials: PVC Ref, GF/PVC A/F1, GF/PVC A/F2. The breaking energy is measured in Joules (J).]
Characterization: Heat Deflection Temperature

ISO 75-1&2: 2004

Heat Deflection Temperature

Temperature (°C)

PVC Ref  GF/PVC A/F1  GF/PVC A/F2
Markets

Properties
- Rigid
- Very good impact resistance
- Light
- Thermoformable
- Fire resistant

Potential markets
- Electrical boxes
- Building
- Transportation
- Nautical applications
Markets: Electrical boxes

- Big electrical boxes that require outdoor sustainability
Market: Building application

- Roller shutters boxes
- Rigid and reinforced panel honeycomb sandwiches
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Conclusions

- To produce long glass fibres PVC plates with a homogeneous dispersion of the fibres presents a real interest:
  - Improvement of mechanical properties
  - Improvement of fire resistance
  - Opening to new markets

- But we need:
  - a process with no shearing step to avoid the damaging of the fibres:
  - PVC with special gelation properties:

Solvin is developing these special resins and the recipes to allow you to perform this new and high performance product.
Thank you for your attention