ISOPA and its member companies have dedicated considerable resources to study the recycling requirements of individual polyurethane user industries, so that the most effective recycling options can be identified. In the automotive industry particularly, encouraging results have been achieved with compression moulding technology, one of the recycling routes for reaction injection moulded (RIM) polyurethanes.

Recycling initiatives have focused on two areas: production trim from polyurethane processing and polyurethanes retrieved from scrapped vehicles.

Research and development programmes, undertaken together with the automotive industry, have examined the potential of compression moulding technology for both these types of polyurethane waste. The process has been used commercially for BMW in Europe and for Chrysler in the USA.
COMPRESSION MOULDING: THE PROCESS

RIM and reinforced RIM polyurethanes are ground into fine particles and subjected to high pressure and heat to generate a material which is ideal for automotive applications. The grinding techniques and compression moulding process need to be controlled accurately for individual applications:

- While there can be a small reduction in elongation or impact resistance, optimum timing, pressure and temperature can preserve the valuable properties of the original polyurethane.
- The use of finely ground polyurethane powder in the compression moulding process allows for property recovery of up to 100%.

**Typical processing parameters**

<table>
<thead>
<tr>
<th>Properties</th>
<th>Grain size (screen size)</th>
<th>0,5-3 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preheating time</td>
<td>1-12 minutes</td>
<td></td>
</tr>
<tr>
<td>Preheating temperature</td>
<td>140-150°C</td>
<td></td>
</tr>
<tr>
<td>Mould temperature</td>
<td>180-195°C</td>
<td></td>
</tr>
<tr>
<td>Mould residence time</td>
<td>1-4 minutes</td>
<td></td>
</tr>
<tr>
<td>Specific mould pressure</td>
<td>&gt; 350 bar</td>
<td></td>
</tr>
</tbody>
</table>

**Typical physical properties of amine extended RIM: comparison of original RIM parts and compression moulded parts, painted and unpainted (1mm granule)**

<table>
<thead>
<tr>
<th>Properties</th>
<th>Original Painted</th>
<th>Original Unpainted</th>
<th>Compression Moulded Painted</th>
<th>Compression Moulded Unpainted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density</td>
<td>1260</td>
<td>1220</td>
<td>1260</td>
<td>1260</td>
</tr>
<tr>
<td>Shore D-hardness</td>
<td>68</td>
<td>67</td>
<td>66,5</td>
<td>65-67</td>
</tr>
<tr>
<td>Tensile strength</td>
<td>25</td>
<td>26</td>
<td>23</td>
<td>25</td>
</tr>
<tr>
<td>Elongation at break</td>
<td>120</td>
<td>130</td>
<td>70</td>
<td>120</td>
</tr>
<tr>
<td>Flex-E-modulus</td>
<td>1100</td>
<td>1300</td>
<td>700</td>
<td>700</td>
</tr>
<tr>
<td>Impact, Dynstat -25°C</td>
<td>8,5</td>
<td>12</td>
<td>9</td>
<td>7</td>
</tr>
</tbody>
</table>

**Typical physical properties of glycol extended RIM: comparison of original RIM parts and compression moulded parts**

<table>
<thead>
<tr>
<th>Properties</th>
<th>Original</th>
<th>Compression Moulded</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density</td>
<td>1030</td>
<td>1200</td>
</tr>
<tr>
<td>Shore D-hardness</td>
<td>55</td>
<td>67</td>
</tr>
<tr>
<td>Tensile strength</td>
<td>23</td>
<td>33</td>
</tr>
<tr>
<td>Elongation at break</td>
<td>204</td>
<td>143</td>
</tr>
<tr>
<td>Flex-E-modulus</td>
<td>600</td>
<td>613</td>
</tr>
</tbody>
</table>

Glycol extended RIM parts, compression moulded at the optimum temperature of 195°C, have mechanical properties which can actually be superior to those of virgin polyurethane material.
BENEFITS

- Compression moulded parts are free from internal stresses and display improved heat resistance, sag value and torsion modulus compared to the original material.

- Good flowability of RIM polyurethanes in the compression moulding process allows the production of complex shaped products and high quality flat parts.

- Acceptable energy efficiency can be achieved through short processing cycles.

- Compression moulded parts contain 100% recycled material.

Compression moulding technology is capable of producing high performance recycled products from RRIM and RIM polyurethane granules.

STATUS

Currently, compression moulded parts are no longer produced, mainly because of economic reasons.

SUGGESTED READING


"Druck von oben"; Bild der Wissenschaft, 1991, Heft Nr. 6, S. 116-117

W. Raßhofer, U. Liman, and J. Wagner, Proceedings of the Polyurethanes World Congress; 1991, Nice, p.636,

DE 37 33 756 (06.10.87) (Bayer AG)
DE 38 02 427 (28.1.88) (Bayer AG)
DE 38 40 167 (29.11.88) (Bayer AG)
DE 40 30 282 (01.11.89) (Bayer AG)
DE 39 42 468 (22.12.89) (Bayer AG)

R.E. Morgan and J.D. Weaver, "Recycling of RIM Thermoset Polymers"; SAE Conference, Detroit 1991

R.E. Morgan, G.H. Dean, R.I. Tabor and M. Zawisza, Proceedings of the Polyurethanes World Congress; 1991, Nice, p.653


Companies actively practicing polyurethane recycling and recovery are kindly invited to submit their references to ISOPA.
ISOPA has produced a brochure and a series of fact sheets on polyurethane recycling options.

The following are now available:

- Recycling Polyurethanes (Brochure)
  - PU in Perspective
  - Densification/Grinding
  - Re-use of Particles
  - Rebonded Flexible Foam
- Adhesive Pressing/Particle Bonding
- Re-grind/Powdering
- Compression Moulding
- Chemolysis
- Feedstock Recovery
- Energy Recovery
- Energy Recovery from Flexible PU Foams
- Recovery of Rigid Polyurethane Foam from Demolition Waste
- Options in Practice

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ISOPA - the European Isocyanates Producers’ Association - is an affiliated organisation within the European Chemical Industry Council (CEFIC).

Since the original polyurethane material has not been designed for use in articles in contact with food, relevant EU (such as Directives 90/128/EEC) and national legislations need to be consulted, if and when recycled materials are used to manufacture articles and goods for possible direct and indirect food contact.

The information contained in this publication is, to the best of our knowledge, true and accurate, but any recommendation or suggestions which may be made are without guarantee, since the conditions of use and the composition of source materials are beyond our control. Furthermore, nothing contained herein shall be construed as a recommendation to use any product in conflict with existing patents covering any material or its use.

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