Evaluation of thermosetting materials and polymerisation techniques

Projet de Master en Science et Génie des Matériaux
Automne 2012    Benjamin Guerra

Background and Objectives

The company Turck is producing inductive sensors, which use coil and magnetism to detect the presence of metals. The sensors are made of electronic circuits, that are sensitive to moisture. In order to facilitate the maintenance and cleaning of the sensors, Turck encapsulates them with a thermosetting material. The actual thermosetting material does not have great sealing capacities and needs at least six hours to harden, which decreases the reactivity of the company. Therefore, the two aims of this project are:

- Improve the water resistance of the sensors.
- Accelerate the production of the sensors.

Experimental part

Different techniques were explored to bring energy to the thermosetting material and accelerate the polymerisation. Most of those techniques are limited by important factors:

- Electron beams: The installation costs 4 millions dollars, which is an investment too important for the company.
- X-rays: No resin supplier has a true knowledge in this field.
- Ultraviolet: The radiation can not penetrate the sensor deep enough and only the top of the resin is polymerised.
- Infrareds: The heating is not homogeneous enough due to the potencial heating. Otherwise, it behaves like induction.
- Induction: The heating is too violent to avoid the formation of cracks, or the polymerisation is too slow.

Only the convection was able to produce interesting results in term of sealing capacities. It is a quite slow process, but some materials react faster than others and it does not need a consequent investment.

Study the different thermosetting materials available on the market and the different hardening processes proposed by the resin suppliers.

Results

This first test is useful, as the finished product is directly tested. It is a simple test, but it is slow, as the samples have to stay three days in the oven for the thermal cycles and two days in the water. It is possible to reach the norm IP68 with the resin A by changing the upper cap. All the sensors produced with the four resins are at this level of water resistance. The resin B has been tested only on seven sensors. A larger number of sensors should be produced with this resin to be certain of the water resistance.

Water resistance IP68

<table>
<thead>
<tr>
<th>Resin</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemistry, hardness</td>
<td>Epoxy, 80D</td>
<td>PU, 75A</td>
<td>Epoxy, 80D</td>
<td>Epoxy, 80D</td>
</tr>
<tr>
<td>Cure</td>
<td>6h at 50°C</td>
<td>1h30 at 60°C</td>
<td>1h at 70°C</td>
<td>1h at 70°C</td>
</tr>
<tr>
<td>Nb. pieces IP68</td>
<td>10/10</td>
<td>7/7</td>
<td>10/10</td>
<td>10/10</td>
</tr>
</tbody>
</table>

Polypropylene is one of the hardest material to seal and some components of the sensor are in this material, that is why it is used here. The test is extremely simple and cheap, but it takes 24 hours.

On resin A, the adhesion of the resin on the PP is so poor, as air sheaths are formed. The penetrating liquid can infiltrate on a longer distance when the resin B is used, than when the two other resins are used, which means slightly lower sealing capacities for the resin B.

Once produced, the sensors should sense the presence of metals at a distance of 2mm. However, the resin influences the detection distance, specially at high and low temperatures. After thermal cycles, it often happens that the detection distances increases, due to stresses of the resin. The red lines define the range of tolerance.

A: Results highly dispersed.
B: Excellent results stable at all the control steps.
C: Excellent results with an extremely small dispersion.

Conclusion

In this project, different polymerisation techniques have been reviewed and convection has been selected as the most adequate. An analysis of the resin suppliers on the market has been made and only three suppliers were selected for an advanced trial.

With convection, it has been possible to produce water resistant sensors according to the norm IP68 with four different thermosetting materials.

On polypropylene, the reference resin A produces poor performances compared to the three other resins. The company possesses now three resins that can adhere on PP.

The resins B, C and D fully correspond to the needs of the company, as they harden 4-6 times faster than the reference resin and they have an excellent influence on the detection distances of the sensors.