Development trends in powder coatings for the twenty-first century

Franco Busato, Irfab Chemical Consultants

This article focuses on development trends in powder coatings through the end of the first decade of the twenty-first century. It compares consumption rates in North America, Western Europe, and the Asia-Pacific primarily; discusses how deep powder has penetrated into those parts of the world; and looks at how other coatings compare technically with powder. The article concludes with some predictions about binder technologies.

The pace of implementing new and novel coating technologies hasn’t been similar and consistent in today’s borderless global market. The key reason comes from the demand side: Technological changes have been brought about by the stringent needs of the end user and through higher pressure from environmental regulations. Although this has triggered user-friendly solutions that were considered unreachable even in the early- and mid-eighties, it has made developments in powder coatings technology in different parts of the world rather inconsistent. Even so, a global strategy can still be found.

Some years ago, the main argument for introducing powder coatings was the environmental factor, that is, to reduce emissions of volatile organic compounds (VOCs). While differences over limits in VOCs still exist in the US, Europe, and Japan, powder coatings are accepted more than ever before as one of the basic new emerging coating technologies because of their excellent appearance and performance in general.

From a level of 225,000 metric tons in 1996, powder coating consumption in Western Europe could nearly double in the first decade of the twenty-first century. This is particularly interesting because corresponding overall paint consumption, stagnant in 1996, currently remains stagnant and will experience only a limited growth during the first decade of the next century.

This stagnancy indicates that powder coatings will penetrate several sectors to a significant degree. However, the underlying assumption is that the powder coating industry will meet the challenge of the automotive industry and that lower-temperature systems will be put into place, opening new markets in general-industrial applications. In the next 5 years, thinner-film systems than the ones available now will become state-of-the-art, which consequently will slow the current yearly Western European powder coating growth rate of about 5 percent.

Powder coatings have been acclaimed in many industrial sectors. For example, the appliance industry uses them on refrigerators, washers, dryers, air conditioners, water heaters, dishwashers, and microwave ovens. Other industries use powder coatings on aluminum windows, door frames, cladding panels, interior partitions, store fixtures, modular furniture, highway guard rails, and fences.

In the automotive industry, powder coats products such as wheels, bumpers, door handles, and decorative trim. Several automakers use powder primers on hoods and body panels. More recently, German automaker BMW has started to use clear powders as a topcoat on actual production models; and Chrysler, Ford, and General Motors, as part of a USCAR Low-Emissions Paint Consortium (LEPC) project, powder clearcoated their first full-car bodies under actual production conditions at an LEPC test site.

Powder coating production in the world

Total global paint production in 1996 was estimated at 23 million metric tons. As Table 1 shows, North America led with nearly 28 percent of total global paint production. Europe produced 27 percent, and the Asia-Pacific produced 23 percent. This means that nearly 80 percent...
of global paint production occurred above the thirtieth parallel of the Northern Hemisphere.

With more than 70 percent of total consumption taking place in the industrialized world, paint-sector growth in these regions has been stagnating in recent years, affected simultaneously by the economic recession in Europe, by the rise of newly industrialized nations in the Far East, and by the liberalization policies adopted by other East-Asian countries, including China.

Table 1 also indicates the percentage of powder coatings penetration in different regions of the world. Penetration in Europe is the highest at 4.2 percent. In the US and in the Asia-Pacific, penetration is the same—1.2 percent. Globally, powder coatings penetration is 2.3 percent. This means that powder coatings still have much room for growth in the world paints arena.

Regardless of the stagnation in consumption, a greater understanding is necessary of the developments in and the penetration of powders compared with other so-called clean technologies (see Table 2). These technologies include waterborne, radiation-cured, and high-solids solvent-based coatings.

In 1994, a study was completed on paint consumption in Western Europe (an update is in progress). The study found that the share of clean technologies didn't exceed 35 percent of total paint consumption. Based on more than 500 interviews over 3 years, the study predicted that the clean technologies will only be able to penetrate about 50 percent of the total paints market in Western Europe by the middle of the first decade of the next century. The study also indicated that, of the clean technologies, powder coatings represented only about 20 percent of total paint consumption in 1994.

### Table 1

World paint and powder coatings production in 1996

<table>
<thead>
<tr>
<th>Region</th>
<th>Total paints ('000 metric tons)</th>
<th>Powder ('000 metric tons)</th>
<th>Powder penetration (%)</th>
<th>Future growth (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>North America</td>
<td>6,400</td>
<td>130</td>
<td>24</td>
<td>2.0</td>
</tr>
<tr>
<td>Western Europe</td>
<td>6,200</td>
<td>255</td>
<td>48</td>
<td>4.2</td>
</tr>
<tr>
<td>Asia-Pacific</td>
<td>5,400</td>
<td>130</td>
<td>21</td>
<td>2.0</td>
</tr>
<tr>
<td>Rest of world</td>
<td>5,000</td>
<td>40</td>
<td>7</td>
<td>0.8</td>
</tr>
<tr>
<td>Total</td>
<td>23,000</td>
<td>535</td>
<td>100</td>
<td>2.3</td>
</tr>
</tbody>
</table>

Source: Irfab Chemical Consultants

### Table 2

Penetration of technologies in industrial paints in 1994 (on a solids basis)

<table>
<thead>
<tr>
<th>Technology</th>
<th>Western Europe (%)</th>
<th>US (%)</th>
<th>Japan (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solvent-based</td>
<td>57.4</td>
<td>55.3</td>
<td>93.3</td>
</tr>
<tr>
<td>Waterborne</td>
<td>11.6</td>
<td>11.4</td>
<td>11.0</td>
</tr>
<tr>
<td>High-solids</td>
<td>14.8</td>
<td>20.9</td>
<td>1.4</td>
</tr>
<tr>
<td>Powder</td>
<td>12.3</td>
<td>5.2</td>
<td>3.6</td>
</tr>
<tr>
<td>Radiation-curable</td>
<td>3.9</td>
<td>1.2</td>
<td>0.7</td>
</tr>
</tbody>
</table>

Source: Irfab Chemical Consultants
Possible contenders to powder coatings

From an end user's point of view, why use powder coatings? Between the conventional paints and clean technologies, with their merits and problems, one of them doesn't emerge as a clear winner. Because none of the clean technologies can completely replace the traditional solvent-based paints, it's presumed in some cases that the solvent-based systems may continue to be a predominant technology.

The introduction of solvent recovery techniques and incineration with energy recovery are contributing to the acceptability of solvent-based paints. The well-known ultrafiltration technique used with cataphoretic electrodeposition paints is now being used with conventional waterborne paints. In such a situation, each of the four clean technologies will get its independent position in the marketplace.

Figure 1 places the clean technologies into a grid to give a bi-dimensional perspective of the extent of product development undertaken based on these paint systems and the future uncertainty associated with their use, considering price performance attributes. In the grid, the position of powder and waterborne coatings are in the same competitive arena for their future use because of the strong focus in research and development in both technologies.

Based on our understanding of coatings, radical breakthroughs into one or the other technologies are not yet evident. More research is being undertaken to identify acceptable waterborne coatings. And the use of powders is now more promising than it was 20 years ago. After several ups and downs, powder coatings have attained sustained average annual growth in Western Europe of about 5 to 7 percent. In Japan, the average annual growth rate has also been 5 to 7 percent. In the US, however, the growth rate has been almost double that of Europe and Japan—10 to 12 percent.

A comparison of powder coatings and other clean technologies

Although the development of clean technologies isn't radically changing the market, the level of progress is consistent with the rising demands of end users, which, in turn, motivates coatings producers to come up with better formulations. At the same time, paint manufacturers worldwide must understand that the precursor for solvent emissions reduction shouldn't be based solely on environmental factors. It must also be based on improved performance characteristics and cost benefits.
For example, the application of waterborne acrylic dispersions to aluminum and steel coil coatings in Scandinavia in the 1970's was chosen primarily because of improved performance, not for environmental reasons.

The shift from low-solids coatings to higher-solids coatings has been slower than projected in previous market surveys because, for many applications, suitable substitutes have simply not been developed. Many applications have met existing guidelines, or at least significantly reduced emissions, by using coatings with 45 to 55 percent solids. In addition, use of new application equipment has permitted higher transfer efficiency in many operations.

Binders for high-solids coatings and conventional systems are of the same polymer type. The majority of high-solids coatings are based on epoxy, unsaturated...
polyester, and polyurethane resin systems. Market segments that use unsaturated polyesters include coatings for wood, putties for car repair, and coatings for metal substrates. Major market segments that use higher-solids 2-K acrylic and polyester-isocyanate reactive systems include heavy-duty-anticorrosion and maintenance, and agricultural and construction equipment.

Recently, products having 85 percent solids (which are as good as powders) in volume have been introduced. Carboxylated acrylic-epoxy systems and high-solids saturated polyester resins are used to formulate high-quality stoving enamels for white goods. Solids content at application viscosity, however, doesn’t exceed 72 percent weight solids. Therefore, these are considered higher-solids content coatings.

When it comes to powder coatings, epoxy-polyester hybrids and all-polyester systems accounted for 50 percent of Western Europe’s total powder coatings market in 1994. In the US, polyurethane systems are relatively more important than polyester systems in general. In Japan, acrylics are used more than the other systems. Powder coatings have penetrated these regions to a larger extent in some niche market sectors such as can coatings, though the penetration is slower in automotive coatings.

In Western Europe, ultraviolet curing of powder coatings for heat-sensitive substrates is in an advanced stage of development. Infrared-curing technology is used for sensitive substrates such as plastics and wood. Japan and the US lag behind Western Europe in development of these technologies.

Reverse powder coatings—cataphoresis could regain importance in the future. In fact, at the end of 1977, at the Termini Imerese plant in Sicily, Fiat produced its Panda model, coating the car body with powder primer and then passing it through a cataphoretic bath. Powder is also being used on precut blanks and continuous metal coil, considered emerging technologies for the appliance industry.

With all the developments centered on two or three main technologies, where does the crunch exist? Technical comparison of these technologies, shown in Table 3, points out their differences. However, the critical issue is whether these differences translate into cost-effective, quality products.

### Trends in binder technologies

In closing, the following trends in binder technologies in the powder coating industry are worth mentioning.

* The use of epoxy-resin binder-based powder for decorative purposes will continue to decrease. It will be targeted exclusively for anticorrosion purposes.

* The share of epoxy-polyester binder-based powder will continue to increase in the future, mainly for general-industrial and indoor applications.

* The use of polyester-resin binder-based powder will increase considerably because of growing demand for exterior-durable coatings for architectural and other outdoor structures. The new exterior-durable coatings based on TGIC-free polyester will also seek better prospects.

### Table 3

<table>
<thead>
<tr>
<th>Technology</th>
<th>Dry weight (%)</th>
<th>Solvents (%)</th>
<th>VOC reduction (%)</th>
<th>Material reduction (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Powder coatings</td>
<td>100</td>
<td>None</td>
<td>100</td>
<td>40</td>
</tr>
<tr>
<td>Radiation-curables</td>
<td>100</td>
<td>None</td>
<td>100</td>
<td>40</td>
</tr>
<tr>
<td>High-solids</td>
<td>80</td>
<td>20</td>
<td>85</td>
<td>33</td>
</tr>
<tr>
<td>Waterborne</td>
<td>50</td>
<td>10</td>
<td>90–95</td>
<td>20</td>
</tr>
<tr>
<td>Solvent-based</td>
<td>30–60</td>
<td>40–70</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

Note: Compared with solvent-based paints
Source: Infab Chemical Consultants
The polyurethane binder-based powder will be used mainly for outdoor applications and exterior-resistant matte powders. The use of polyurethane powders based on aromatic polyurethane hardeners, which are still used in Italy, will decrease in favor of the use of hybrid powders.

Acrylic-resin binder-based powders will be used more in Western Europe. The acrylic powder coatings are predominantly hydroxyl functional acrylic polymers that are crosslinked with a blocked isocyanate. One powder coatings manufacturer has recently developed acrylic powder technology based on acid-curing acrylates for use as automotive OEM clearcoats. The process was first used by BMW.

**Endnotes**

1. Study done by Irfab Chemical Consultants.
2. Herberts.

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**Editor’s note**

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