High-Gloss, UV-Cured Powder Coating on MDF—A One-of-a-Kind Finish

By Michael Knoblauch

Up until this year, a one-coat, high-gloss, UV-cured powder coating on medium density fiberboard (MDF) could not be produced. With significant time spent in research and development (R&D), both in the lab and on the application floor, a one-coat, high-gloss, UV-cured powder coating for MDF was successfully developed in the spring of 2013. This finish can achieve a high-gloss range from 70 to 90 on a 60° Gardner Gloss Scale.

Consumers today are looking for products and processes that meet environmental regulations, require lower energy consumption, generate lower total applied costs, and produce a higher return on investment. This article explains the ways UV-cured powder coating is a superior coating method; challenges faced in the R&D process to develop a high-gloss finish; and gives some insight into how the coating was successfully produced.

History

Powder coating is an industrial finishing technology with a resilient and durable finish that is solvent-free. It has superior wear resistance, barrier properties and is cost-effective. UV-curable powder coating and application systems were first developed and commercialized in the late 1990s and early 2000s. The economic incentive for these initial systems was to expand the base of traditional powder coating application

Figure 1

Powder coating processes

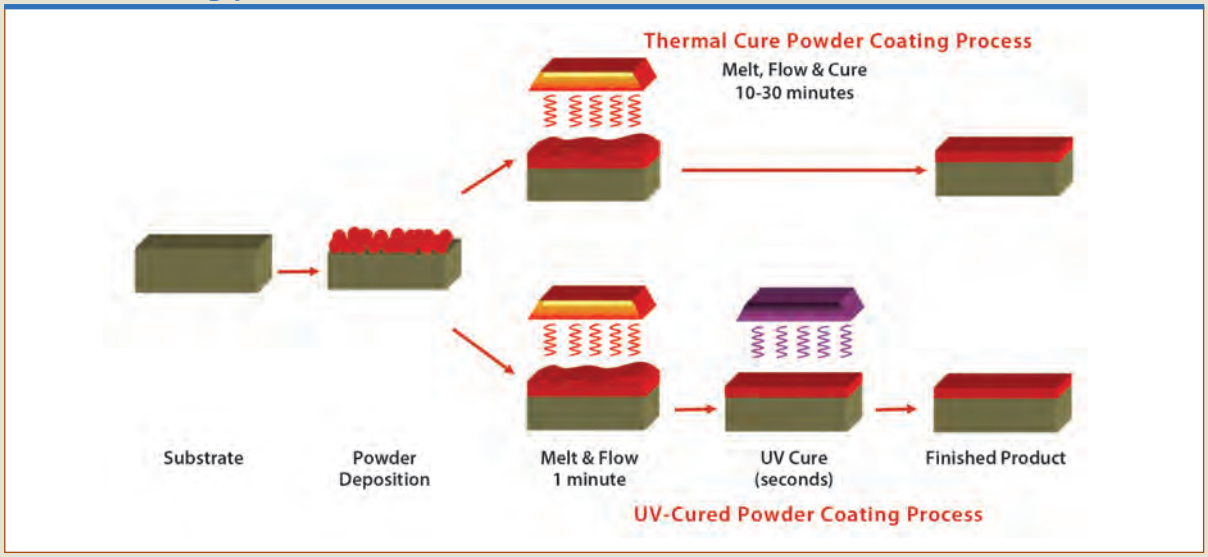


Figure 2

Pinholing defect

and coating chemistry by utilizing the inherent advantages of UV curing.

Up until the development of UV powder, thermal-cure powder coatings were used. The main differentiating characteristic between UV and thermal powder coatings is the separation of the melt/flow and cure functions. (Figure 1) Thermoset powder coating uses only thermal energy to melt and cure the powder, while UV-cured powder uses thermal energy to melt the powder and UV light energy to cure the powder.

Since the introduction of UV-curable powder coating, external market conditions have changed, making the advantages and benefits even more compelling. Heat-sensitive materials, such as MDF wood, were the natural product market for the technology because the melting and curing process is done at lower temperatures and UV curing is instantaneous. UV powder could be used to finish products and materials that could not be previously finished with thermal powder coatings. As the consumer market grew for these finishes, the demand for a high-gloss finish also grew. However, the process to create high gloss has its challenges.

Figure 3

High-gloss coating sample

Challenges

A few years ago, our researchers completed a high-gloss project for a major retail chain. While the product was produced successfully and the client was happy, this project brought to light the challenges of achieving a high-gloss finish on MDF. Issues such as pinholing, orange peel and edge dive were discovered. The parts ended up having to be prepared by hand to get the look that the retailer wanted. (Figure 2)

One of the biggest challenges in achieving a high-gloss finish is in the application of the powder because it must be a precise amount. If too much powder is applied, it results in defects such as pinholing and orange peel. If too little is applied, then it's hard to achieve the desired higher gloss range. (Pinholing is the formation of small holes through the thickness of the coating caused by air trapped under the surface, and normally appears on the edges and the back of surfaces. Orange peel is a wavy, irregular surface caused by the application of too much powder.)

The third potential defect in the high-gloss finish is a condition called "edge dive," which occurs when the viscosity of the melting powder changes. The coating ends up getting "sucked into" the edge, causing a loss of film build and gloss on the edge of the part.

These were all difficult obstacles that needed to be solved to successfully develop and apply the high-gloss finish in a single-step coating process.

Solution

The challenge of creating the high-gloss finish was in the application and melting process, not the cure. The resin used for high gloss is different than the one used in traditional, textured UV-cured powder coatings. The resin is the binding part of

Figure 4

UV-cured powder coating compared to two thermal-cured powder systems (energy, material and labor costs)

Example #1 - 7MM parts per year	UV Powder	Thermal 1	Thermal 2
Total Energy Cost / Part	$0.0046	$0.0407	$0.0275
Total Material Cost / Part	$0.0625	$0.0217	$0.0217
Total Labor Cost / Part	$0.0058	$0.0613	$0.0300
Total	**$0.0728**	$0.1237	$0.0792
Example #2 - 320M parts per year			
Total Energy Cost / Part	$0.0046	$0.0407	$0.0275
Total Material Cost / Part	$0.0625	$0.0217	$0.0217
Total Labor Cost / Part	$0.0263	$0.2800	$0.1371
Total	**$0.0934**	$0.3424	$0.1864
System Production Capacity 50 week year 24/5	19,440,000	1,080,000	1,987,200

Customer Supplied Data 2013

the formulation in which pigments and other additives are mixed in. A traditional textured coating for MDF has a lower gloss range, typically between 10 and 30. A desired high-gloss coating range for MDF is typically 70 to 90. (Figure 3)

The resin used in high-gloss coatings is uniquely different than a texture system because it enables the smoothness and correct film build that creates a high-gloss finish. Once the right resin was developed and the high-gloss powder was formulated, the next piece to the puzzle was determining the application process and technique. The chemists knew the formula they wanted and had success in the lab, but trying to apply that to the production setting was somewhat of a challenge.

After a number of trials, it was determined that that the one-coat, high-gloss, UV-cured powder coating could be achieved by making adjustments to the oven settings during the melting phase. From there, it was a matter of aligning all the process steps and running trials. The high-gloss, UV-cured powder coating was then successfully developed and applied.

Performance

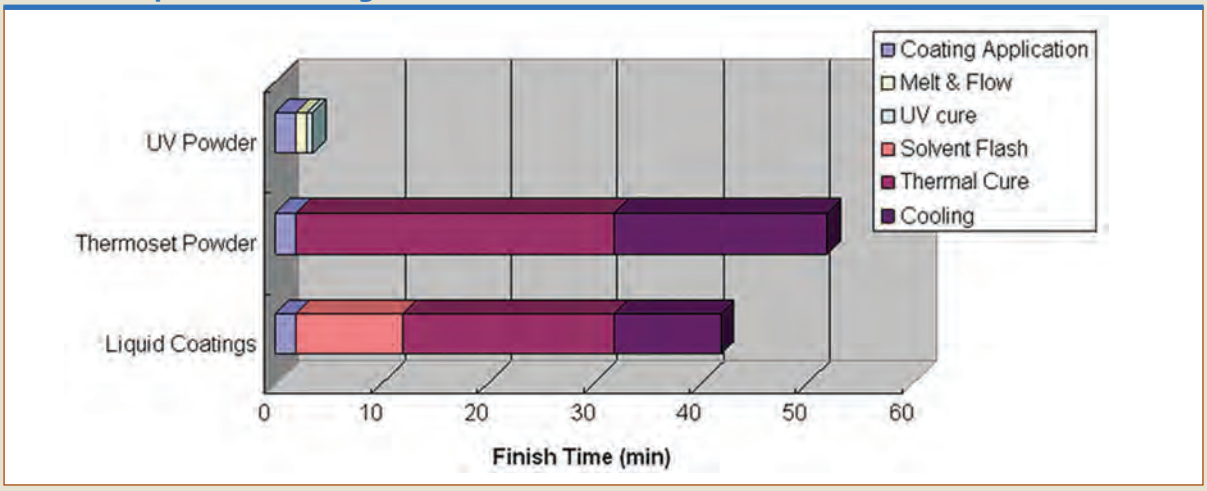
Sample materials of the high-gloss finish were tested by the AIDIMA (a furniture, wood and packaging technology institute in Valencia, Spain) using various testing methodologies. The scale ranges from 1 to 5, with 1 being a very poor performance and 5 being excellent. The results proved that a high-gloss powder for MDF performed just as well or better than a traditional UV-cured powder coating formulation.

Testing Assessment

According to the results (Table 1), the tested finishing system fulfills the

Figure 5

Part cycle time analysis of thermal-cure coating systems (powder and liquid) versus UV-powder coatings



specifications laid down in:

- The standards UNE 11022/1 and UNE 11023/1
- The document "FIRA Standard 6250"

This finishing system is for interior *general* use in:

- Horizontal surfaces, excluding kitchen worktops
- Other surfaces (such as front and side parts of furniture, vertical wall panels, etc.)

This finishing system is for interior *severe* use (except for acetone and butyl acetate resistance) in:

- Horizontal surfaces, excluding kitchen worktops
- Other surfaces (such as front and side parts of furniture, vertical wall panels, etc.)

Advantages

One of the drivers of the market has been the desire to move away from solventborne coatings in both the manufacturing and application of these coatings. The majority of liquid coatings contain solvents. The regulatory issue is in the emissions from these solventborne liquid coatings, thus creating an opportunity for UV-cured powder coatings. In order for a powder coater that is not UV-cured to achieve a level of high gloss, multiple steps are often required (such as a primer coat) before finishing or sanding the parts.

If the coater is painting with liquid, they have to wait for each coat to dry before moving on to the next one, resulting in added time, cost and labor. The UV-cured powder coating process

Table 1

AIDIMA test results

Test	Standard	Results	Test	Standard	Results
Adhesion (rating code)	BS 3662-6 UNE 11019-6	4	Oils and fats resistance (rating code)	BS 3962-5 UNE 11019-5	5
Scratch resistance Scratch point Substrate appearance	BS 3662-6 UNE 11019-6	4 5	Cold Check resistance	ASTM 1211 UNE 48025	No defects
Impact resistance (rating code)	BS 3662-6 UNE 11019-6	5	Light fastness	UNE EN ISO 11341	5
Dry heat resistance (rating code) 85°C 100°C	EN 12 722	 5 5	Wear resistance Number of cycles	EN 438-2	250
Wet heat resistance (rating code) 55°C 70°C 85°C	EN 12 722	 5 5 5	Thickness (microns)	95±5	
Cold liquid resistance (rating code) Acetone Butyl acetate Cleansing solution Ethanol 48% Tea Coffee Bleach Ammonia solution 10%	EN 12 702	 1 1 5 5 5 5 5 5			

Assessment Guidelines

Description	Assessment
No change	5
Change slight	4
Moderate change	3
Significant change	2
Strong change	1

takes only 20 minutes from raw MDF part to ready-to-ship product. The seamless coating produces a visually sleek appearance that flows around edges, curves, corners and cutouts to give an unparalleled clean look. The durable finish makes the product easy to clean and maintain; and it lasts a long time.

The curing process with UV-powder coatings is much simpler than other finishing technologies. Curing of a liquid finish requires solvent flash-off and thermal curing requires 30 minutes or more to cure. Although thermoset powder coatings do not require solvent flash-off, the cure temperatures are higher than UV-cured powder coating—sometimes reaching 400°F and often requiring an additional cooling period prior to handling. Thermal curing is not suitable for substrates that are heat-sensitive such as MDF, plastics, composites and pre-assembled parts.

UV-curable powder coating significantly reduces process time, which generates a number of efficiency benefits, including shorter startup and shutdown time, increased finish capacity, and reduced energy, material and labor costs when compared to thermal powder coatings. (Figure 4) With the single-step, UV-cured powder coating process, many more parts can be finished compared to liquid coating—of course, part size and geometry has an influence on system output and productivity. (Figure 5)

In addition, in an environmentally conscious world, users expect products to have a small carbon footprint. UV-powder has one of the smallest carbon footprints of all commercially available coatings. The technologically advanced UV-cured powder coating process sets higher standards with these environmentally friendly qualities—solvent-free; non-toxic; no harmful chemicals, VOCs or HAPs; and it qualifies for LEED credits.

Conclusion

A single-step, high-gloss powder coating finish for MDF has been in demand in the market for years. Though the development and application of the coating had its challenges; innovation, continuous R&D and product improvement prove to be the key in creating a successful product line for any company.

The coating chemistry and application technology is fast, clean and green. The productivity and economic capability of this finishing technology generates greater gross profit margins and higher return on investment. UV-cured powder coating technology and chemistry are poised to capture a significant and profitable market share of the global coatings industry as consumption increases.

The demand for innovative, sustainable products and services will only continue to grow, and market opportunities for UV-curable powder coatings will continue to develop. A single-step, high-gloss coating will only continue to develop and penetrate new markets and applications as it continues to become a more viable one-of-a-kind finish!

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