Lower Temperature Cure Powder Coatings

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INTRODUCTION

Historically, the temperature required to cure a standard powder coating has been 350 to 400°F. Often, the actual oven temperature needed to be higher to compensate for a variety of parameters, including part mass or line speed requirements. Low temperature cure powders would maintain all of the current application parameters with the exception of a significant reduction in oven air temperatures and/or residence times.

The participation of powder coatings in critical application areas is expanding exponentially as the sophistication in technology increases. This sophistication is directly related to both improved and new application techniques along with a higher degree of technical expertise. Application systems alone have opened new doors in the type and configuration of substrates that can be realistically powder coated.

Current state of the art in lower temperature cure powder coatings technology offers products with functional performance characteristics and aesthetic properties consistent with standard cure materials. Most functional and aesthetic requirements can be met or exceeded with low temperature cure powders.

The purpose of this article is to give the current and potential user a better understanding of the options available in powder coatings. It will not only address the benefits of lower temperature cure powder coatings, but also some of the drawbacks.

TEMPERATURE SENSITIVE COMPONENTS

Temperature sensitive components have always created a problem in industrial finishing of assembled parts. The coating used must offer a consistent cure range which does not damage sensitive components.

Assembled parts can be considered temperature sensitive for a variety of reasons. They may contain electrical components or seals that are sensitive to temperature. The substrate alone may be considered temperature sensitive in terms of its composition, i.e. plastics, magnesium, etc. One of the major benefits in using low temperature cure powder coatings is that they offer the user the ability to coat completed assemblies under this critical temperature value.

Temperature sensitive parts can now be coated without potential danger to the functionality of the part. An excellent example of a part considered to be temperature sensitive is an automotive strut or shock absorber. These parts contain a seal that has a critical temperature above which degradation occurs, creating unit failures. Another example where temperature sensitivity may be critical occurs when the oven used for curing is shared with another coating technology. An example of this would be an oven shared by a liquid and powder line. Frequently, the liquid has lower temperature limitations than the powder for overbake discoloration. The powder must have lower cure capability to protect the liquid coating's performance.

PART MASS OR SUBSTRATE DENSITY

The next area to be taken into consideration when selecting the type of coating for a specific application is the mass or density of the part.

Many parts finished in today's industry can be relatively massive in size. They may contain weld areas or additional plating which will increase the overall part density. Hollow tubes or spaces may contain dead air which acts as an insulator and effectively delays the metal from reaching the cure temperature. The ability and economics required to cure a standard powder coating in these situations can be prohibitive.

Massive or high heat sink parts such as trailer hitches, gas cylinders, exercise weights, or engine blocks require lengthy oven residence times or elevated air temperatures. This is necessary to bring the part temperature up to a level high enough to cure a standard powder coating. Once these parts achieve the temperature necessary for cure, they lose that heat very slowly. This lengthy residual heat period, coupled with the high oven temperatures, can create warm climatic conditions in the manufacturing facility.

An indirect concern, but one of equal importance, is the logistics involved in handling parts coming off the line at elevated temperatures. Because of their high heat sink they require lengthy cool down times before they can be handled and packaged properly.

TEMPERATURE RESTRICTIONS

Another item to be considered when examining coating requirements is equipment restrictions. It is possible that an oven is unable to reach the elevated stoving temperatures required for standard cure powder coatings on massive parts. Quite simply, many ovens cannot, for a variety of reasons, reach and maintain upwards of 550°F for residence times of 30 to 45 minutes. The ability to reach and maintain these elevated temperatures is not only a logistical nightmare but also quite costly.

There is also very little room for error in cure. Slight fluctuations in climate conditions, oven temperatures or coating reactivity may cause major problems in cure and reduce or inhibit the subsequent physical characteristics. This may lead to an overall decrease in product quality or, in the worst case scenario, field failures. Because of the restrictions that standard cure powder coatings impose, many parts are excluded from the economical, functional and environmental benefits of

Table I. Oven Energy Comparison

		Std. Cure	Low Temp.
1.	Specific Gravity	1.60	1.60
2.	Theoretical Coverage, sq ft per lb @ 100%	118	118
3.	Efficency of Deposition, %	95	95
4.	Film Thickness, mils	1.8	1.8
5.	Actual Coverage, sq ft per lb (2/4 x 3)/100	62	62
6.	Production, sq ft per hour	6500	6500
7.	Applied Coating, lb per hr 6/5	104.8	104.8
8.	Air Temperature of Plant, °F	80	80
9.	Oven Temperature, °F	400	325
10.	Heat Expansion Factor, (9 + 460°F)/(8 + 460°F)	1.59	1.45
11.	Powder Exhaust, scfm (7 x 2.16)	226.4	226.4
12.	Combustion Exhaust, scfm (BTU/hr)/5700	325	325
13.	Total Oven Exhaust, cfm (11 + 12) x 10	876.7	799.5
14.	Oven and Plant Temperature Difference, °F (9 – 8)	320	245
15.	Oven Energy Requirement, BTU/hr (14 x 13 x 1.08)	302988	211548
16.	Conveyor and Hanger Load, lb/hr (conveyor wt/ft + hanger wt/ft) x conveyor speed x 60	11000	11000
17.	Part Load, lb/hr (6 x part lbs/ft^2	10400	10400
18.	Total Load, lb/hr (16 + 17)	21400	21400
19.	Specific Heat of Steel, BTU/lb/°F	0.125	0.125
20.	Total Heat Loss to conveyor & hangers, BTU/hr (14 x 18 x 19)	856000	655375
21.	Ovens Radiation Loss Thru Walls, BTU/hr	648960	496860
22.	Energy Required for Conveyor, Hanger & Radiation BTU/hr (20 + 21)	1504960	1152235
23.	Total Oven Energy Requirement, BTU/hr (15 + 22)	1807948	1363783

powder.

Low temperature cure powder coatings offer the user flexibility in both temperatures and line speeds. While low temperature cure products are not technically considered quick cure coatings, time is not wasted in reaching high metal temperature because of their higher rates of reactivity. This translates into curing at lower temperature settings.

Low temperature cure powders are not as susceptible to extraneous fluctuations and can offer consistent and reproducible results in terms of application and physical characteristics.

FLOOR SPACE

When floor space is at a premium and a lengthy or large oven is not a viable consideration, a lower temperature cure powder can minimize oven durations, subsequently reducing oven size. As an example, examine a curing situation using an oven air temperature of 350°F. A typical standard cure type product would require 10 minutes at a metal temperature of 350°F to achieve full cure. Add on 10 minutes of time to bring the part up to cure temperature and that brings that total dwell time in the oven to 20 minutes. At a line speed of eight feet per minute, this calculates out to 160 feet of oven conveyor length. If a product was selected offering the ability to cure at 300°F in the same 10 minutes, the time to bring the part to 300°F is about five minutes instead of 10. This would cut 40 feet off the oven length.

In reality, the actual cure time would be even less for a 300°F curing product. In a 350°F oven air environment, the part would exceed the needed 300°F cure temeprature requirement. This would accelerate the cure rate or shorten the exposure time necessary to achieve full cure. This could reduce the conveyor length requirement another 16 to 32 feet. The net effect would be a reduction in oven conveyor length from 160 to approximately 96 feet.

LINE SPEED

Another possible advantage of low temperature cure is the ability to increase line speed in an existing oven. If the same example cited above is used, a possible scenario might be as follows: An oven of 160 feet of conveyor length with a 350°F air temperature and a line speed of eight feet per minute is currently being used to cure a standard cure type powder (10 minutes at 350°F) Introducing a lower temperature cure powder capable of curing in 10 minutes at 300°F would require an oven dwell time, at this oven air temperature, of only 12 minutes. In 160 feet of oven length, the conveyor speed could be increased to 13 feet per minute, or more than 60% over the original eight feet per minute. Assuming the ability to load and unload the line at this speed is maintained, the net effect would be more than a 60% increase in throughput.

ENERGY SAVINGS

Another possible consideration for selecting low temperature cure would be reduced energy costs. Less fuel is required to maintain an oven at 325°F than the same oven at 400°F. Additionally, less energy will be expended cooling parts down from 325°F for packaging than from a 400°F part temperature. The cool down requirements vary considerably from one manufacturing situation to another so for this energy savings comparison, the focus will be on the oven's energy consumption. Assuming the only variation is oven temperature, the calculations as noted in Table I can be made. To determine dollars saved, multiply the difference in total oven energy requirements of the standard cure and low temperature cure by the cost of a BTU of energy for dollars saved per hour.

CONCLUSION

Low temperature cure powder coatings are not a solution for every application problem. They do, however, have their own niche and are expected to become more prevalent in the coatings industry as the special needs arise. These systems are also not limited to strictly "critical" applications. Their end uses are only limited to what application skills and knowledge can evolve.

It is also important to reiterate that while low temperature cure systems offer many advantages and economical savings over standard epoxies, they do not come without disadvantages. Questionable leveling characteristics, climate controlled storage, limited gloss ranges and shorter shelf lives are a few of the potential drawbacks. Experience has shown that despite these potential drawbacks, the payback time on investments, in both time and material, is usually very short. All of the particulars involved would, of course, be specific to each individual application. MF