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Infrared Equipment Division of IHEA

This column is provided to you by members of the Infrared Equipment Division (IRED) of the Industrial Heating Equipment Association (IHEA). The group includes infrared (IR) curing equipment suppliers from throughout North America. We publish the column three times a year to give you the latest information about IR curing techniques and equipment. Contact information is at the end of the column. Most IR manufacturers offer testing for free or for a fee. Any IRED member can assist you in finding solutions to curing problems and best practices for finishing of coatings. This issue's column was submitted by IRED member Michael J. Chapman, Heraeus Noblelight America, Buford, Ga.

Developing a thermal profile for your infrared oven

Any large scale industrial thermal process is going to be a major energy user. Therefore, trying to keep the operating costs under control is going to be a challenge. Thermal processes usually have critical temperature requirements. Although identifying the variables is straightforward, applying tight control to achieve the required results in an energy-efficient manner can be troublesome. The starting point is to get a very accurate temperature profile of the process, interpret the results, and know which variables to adjust (and by how much) to affect the required result.

If consistent temperature profiling is carried out as part of a regular process control procedure or planned maintenance regime, then changes in performance can be easily spotted. In this article, we will discuss why developing a temperature profile for your infrared (IR) oven will lead to improved process control and maximum energy savings.

Evaluating convection ovens

Setting up a powder coating oven to give optimal performance is always a challenge. A conventional convection oven has very few variables. It is generally a balance between track speed, heat input, and heat distribution.

Convection ovens do offer burner control, which can provide stepped levels of heat output that will have an overall effect on the internal temperature of the oven. The other main variable is track speed, which is usually determined by the desired production rates. If a longer cure is required for a particular batch of parts, then the track speed can be reduced. However, reduced track speeds will affect productivity.

When using a convection oven in a mixed batch production environment, smaller parts will end up spending the same length of time in the oven as larger parts. The oven is set up for a shift and then left running with little control over heat input. The settings used are generally "one setting suits all." This is where inefficiencies start to creep in and more energy is used than required. Get the settings wrong and parts will run the risk of either scorching or being under cured. In either of these cases, expensive rework is required. This situation can be overcome, to a certain extent, by the use of combination ovens. Combination ovens consist of a pre-gel infrared (IR) oven that is placed directly in front of a convection oven.

Examining IR ovens

IR ovens offer better control than convection ovens. In IR ovens, track speed can be set to suit production output while PLC controls offer precise regulation of heat input.

The most quoted rule of thumb relating to infrared is the 3:1 rule. Put simply, this rule states that an IR oven requires one-third of the time to cure parts than a convection oven. This means that there is an immediate reduction in the amount of energy required, resulting in lower costs. IR provides the opportunity to split an oven into independently controlled zones. For example, in the first few sections of an oven, heat output can be high. For powder coating applications, this means that IR is very quickly absorbed into the powder sitting on the surface of the part and flowing of the powder happens very rapidly. As the part moves through subsequent sections of the oven, the heat can be backed off progressively since all that is needed is to keep the now curing powder at the required cure temperature indicated in the powder manufacturer's cure schedule. Since less energy is required, overall operating costs are reduced.

A very high degree of customization of heat output is available with the use of an IR oven PLC control system. Recipes can be created, saved, and recalled when required. This feature enables operators to ensure that only the required amount of IR is used at the appropriate section in the oven. The nature of the IR operating environment is such that when a new recipe is dialed in, it can be effective almost instantaneously with electric IR and in less than a minute with gas catalytic and gas fired premix IR. This means that small batches of parts can be processed and grouped together by size.

Creating a thermal profile

How do you know what settings to use for each of the zones? Basically, the answer is to create an accurate, measured temperature profile for a given part as it goes through the oven. It is important to understand with IR that it is not the air temperature around the part that we are trying to measure, but the surface temperature.

Here is a typical process:

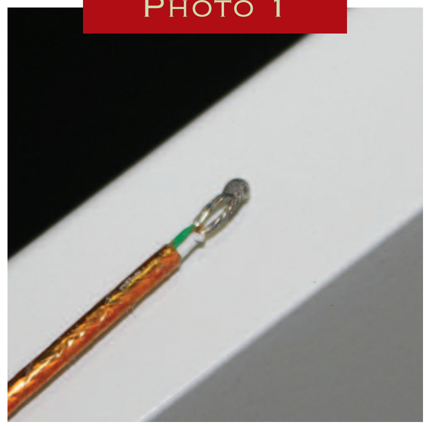
1. Part assessment. Divide the typical range of parts that you powder coat into different groups based on the cross sectional size. Length is not an issue; just pay attention to the part window. Depending on the range of parts, the maximum number is typically around six.

2. Thermocouple up. Take one representative part from each group, powder coat and cure it, and then attach pin head type thermocouples at key positions on the part where it is vitally important that a cure is achieved. See Photo 1.

The thermocouples should be attached using a high-temperature epoxy resin (550°F). Ordinary household repair epoxy glue will not be good enough, as it will it be unable to withstand the high temperatures in the oven. Epoxy resin is used because it absorbs IR at the same rate as powder, so it will give an accurate indication of the surface temperature of the part.

Simply using high-temperature tape to hold the thermocouple against the substrate will not provide a consistent point of contact, as there will be air spaces between the thermocouple and the part. Epoxy eliminates these gaps, ensuring good contact with the substrate. See Photo 2.

PHOTO 1



A typical pin head thermocouple.

3. Connect the thermal profile device (data logger). Simply plug in the thermocouple tails to your profiling equipment, place in its heat resistant box, and you are nearly ready to go. See Photo 3.

4. Set the IR oven up. Choose a representative line speed, set the first zone to about 80 percent output and the rest to about 50 percent, and run the part and data logger through. See Photo 4.

Interpreting results

After downloading results to the appropriate software, the data logger will produce a very accurate graph showing the surface temperature at each of the thermocouple attachment points as the part progresses through the oven. See Figure 1. Inspection of these results will indicate if the required cure temperature of the powder is being reached and maintained for the required length of time.

Making necessary adjustments

The percentage output settings of each zone in the oven can now be adjusted to add or remove heat as necessary to achieve the required cure. It is recommended that outputs are changed in increments of 5 percent initially. The data logger and part can then be passed through the oven again, and results reviewed. See Figure 2.

Once the desired profile has been achieved, the PLC zone settings for that type of part can be saved as a recipe that can be recalled whenever required.

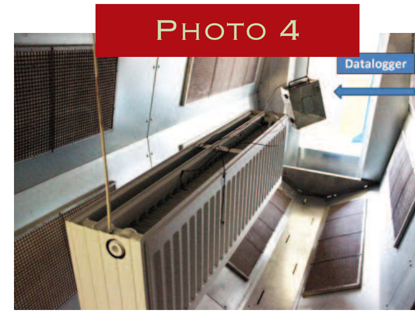
PHOTO 2

A thermocouple attached to a part using high-temperature epoxy resin. Note that the tail is also attached to the part to ensure there is no load on the thermocouple head.

PHOTO 3

A typical data logger; this one is from Datapaq.

PHOTO 4



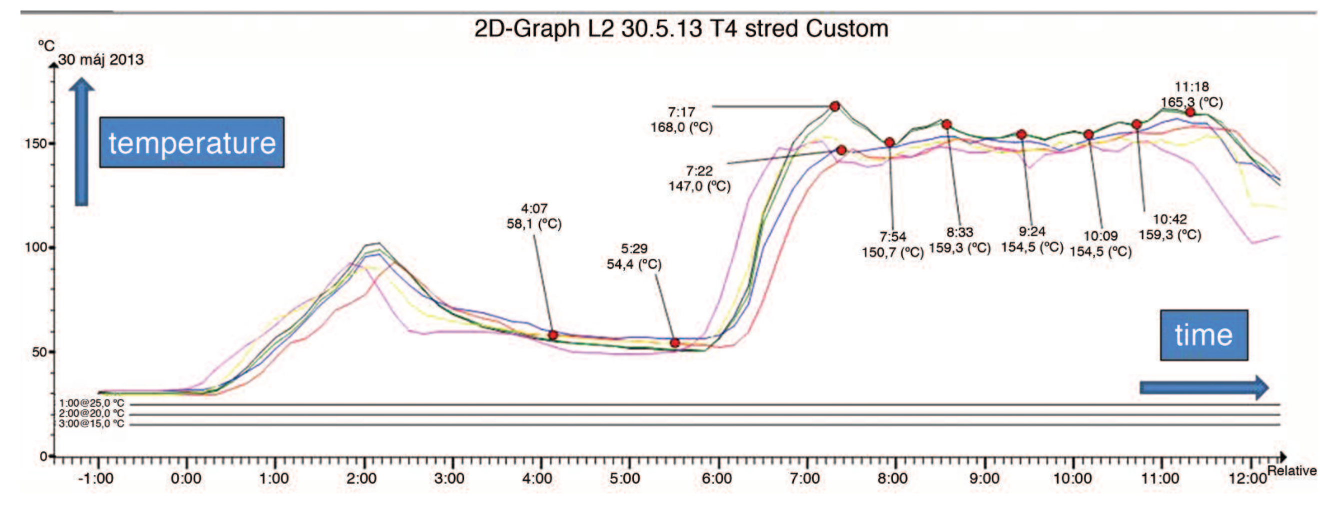
A part with thermocouples attached to the part and data logger is shown progressing through the oven.

Helpful tips and tricks

Here are a few things to keep in mind:

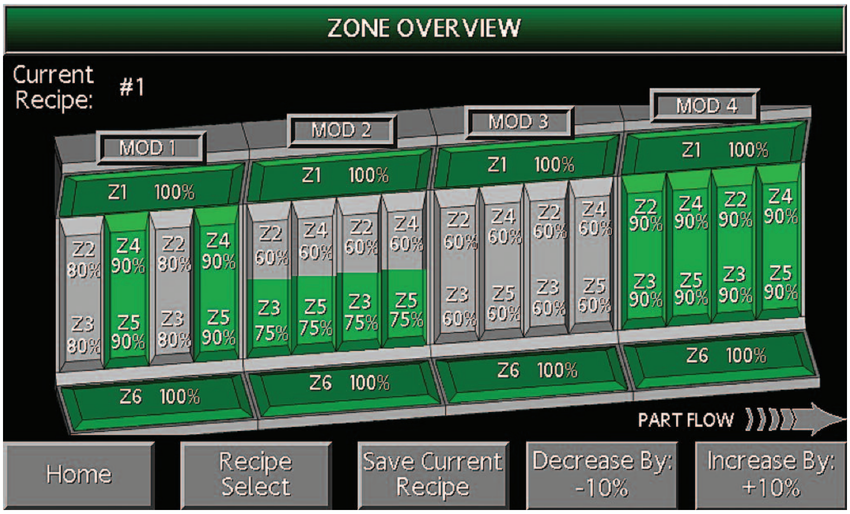
- Always attach thermocouples with high-temperature epoxy adhesive.
- Carefully choose the critical points on the part to attach thermocouples.

FIGURE 1



This typical graphical output from a data logger shows individual thermocouple temperatures as the part passes through the oven.

FIGURE 2



A screenshot of typical PLC controls showing zones and adjustable heat output settings.

- Ensure there is no load on the thermocouples which may act to pull them off.
- Hang the data logger as far away from the part as possible to minimize its effect as a thermal mass in the oven relative to the part.
- Some data logger protection boxes are powder coated—a great absorber of long-wave IR. Wrap the box with aluminum foil to reflect the IR, thus keeping the box cool and allowing easy handling when removing.
- Profile your oven regularly as part of your process control procedures and as part of a planned maintenance schedule.
- Once a powder coated part is fully thermocoupled up, keep it for future oven testing as part of the preventative maintenance program or routine process control.

In conclusion

Creating an IR oven temperature profile for typical parts is a good way to ensure energy efficiency, keep operating costs under control, provide tight process control, improve quality, and maintain a planned maintenance program.

As ever, practice makes perfect, so carrying out routine temperature profiling will reinforce confidence in the process. The ultimate goal of reducing energy usage and improving quality will then become very achievable. **PC**

For more information or to submit a question, contact Anne Goyer, executive director of IRED, at 859/356-1575; anne@goyermgt.com; http://www.ihea.org/?page=IRED.

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