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Temperature Uniformity Survey Tips Part Three: Ovens

"In the field by the knowledgeable observer is the number of older ovens (some dating back over 60 years) and ovens in terrible shape still being used in critical applications. Many times ovens



are overloaded or restrictions on uniform temperature areas ignored. How do we do it right? Let's learn more.

Tips For Proper Oven Operation

Here is some advice gathered from years of working to enhance oven performance and doing surveys and from a number of industry experts on how to ensure proper operation and what you should watch out

for when conducting temperature uniformity surveys (TUS) in ovens.^[1] Specifically:

1. Deliver the air where it's needed. So-called combination airflow (Fig. 1) ensures that heat is uniformly distributed evenly along the length of the chamber. In this flow pattern, air is delivered along the full length of the work chamber via supply ducts located on the sidewalls. A return duct normally located in



Fig. 1. Combination airflow oven design

the roof helps to evenly remove the air after it passes over the load. Both the supply and return ducts should have adjustable louvers in order to achieve the best uniformity. Horizontal airflow is also common. Here, all the air is delivered to one side of the heating chamber, flows across the parts and returns on the opposite sidewall. This design is used for multi-layer loads (e.g., shelf or rack ovens) that would prevent air from passing vertically through the load.

- 2. Maintain a positive pressure inside the oven. To operate efficiently and achieve good temperature uniformity, the pressure inside the oven must be neutral or slightly positive. The proper balance prevents cold air from being drawn in. To check your oven's pressure balance, use a pressure gauge calibrated in inches of water column (inches w.c.) or Pascals (Pa) mounted through the oven wall. A well-balanced oven will show a positive pressure of 0.0-0.2" w.c. (0-49.8 Pa) in relationship to the ambient conditions.
- 3. A simple method of checking to see if you have proper air flow throughout the oven work chamber is to tie ribbons or hang pieces of yarn onto parts and fixtures. Then with the oven at room temperature and the door blocked by a Plexiglas sheet (so you can see through it), turn on the fan and observe the pattern of the streamers. Adjust louvers as necessary to improve the flow pattern, then remove the test rig and perform a TUS before returning the oven to service.
- 4. Leakage around the door can also be checked using streamers. If the streamer hangs limp or is blown slightly outward by air escaping from below the door, the oven balance is usually acceptable. If the streamer is being sucked in, the oven has a negative pressure, which is undesirable. The balance can be corrected by adjusting the exhaust and air inlet dampers. If the oven pressure is negative, open the inlet damper or close the exhaust damper until balance is achieved.
- 5. Work with your supplier to ensure adequate airflow is inherent in the design. An oven with insufficient air will not achieve proper temperature uniformity and be a poor performer overall. Generally, the greater the volume of air circulated, the tighter the temperature uniformity. Work with your selected oven vendors to understand how they calculate airflow and what exit velocity can be expected coming out of the ducts (so you can measure it over time once the unit is in the field). Increasing the blower RPM can improve the uniformity as well



(this is also true for existing ovens). Finally, pay attention to the style of adjustable duct louver and the ease of its adjustment. These are key to longterm temperature uniformity.

- 5. Set the intake and exhaust dampers properly. One of the most overlooked items when running ovens day in and day out is damper adjustment, both intake and exhaust dampers. It is not uncommon to find that these settings have never been adjusted and that no one can recall how they were originally. Static pressure inside the oven and velocity in the ductwork can be negatively affected.
- 6. Pay attention to exhausters. Ovens, especially those running workloads that involve potentially combustible/ flammable gases or other hazardous materials, are normally equipped with exhausters designed to dilute the mixture to non-explosive limits. Exhausters pull a tremendous amount of air through the oven, which can have a dramatic influence on heating and temperature uniformity. Remember that ovens should be tested under the conditions in which they will be used.
- 7. Size ovens properly. It is too often the case that large loads are placed in oven chambers that are too small for them or small loads placed in large ovens. In either case there is a danger that the loads will not heat uniformly. The oven should be sized properly for the load being processed.
- 8. Perform regular TUSs. It is important to understand that operating conditions change over time, and ovens (just because they operate at fairly low temperatures) are no exception. As time passes, fans go out of balance, belts stretch and wear, heating elements burn out, door seals become frayed and worn, louver alignments need to be changed,



Fig. 2. Oven temperature-uniformity survey (Photograph courtesy of Super Systems Inc.)

louvers become damaged and air passages can become restricted. Separately or in combination, these factors lead to a loss of temperature uniformity. So performing TUSs (Fig. 2), perhaps even more frequently than specification requirements, is very necessary.

- 9. Understand temperature rating. Ovens come in a variety of temperature ranges. It is not uncommon to purchase ovens designed for a limited temperature. Heat input is often limited as is the amount of insulation used. Most ovens operating up to 500°F (260°C) will have at least 4 inches (50 mm) of insulation, typically mineral wool. Ovens operating in the range of 500-1000°F (260-538°C) require a minimum of 6 inches (75 mm) of insulation. Today, ovens can be rated as high as 1400°F (760°C), so insulation type and thickness are important considerations for good temperature uniformity. If purchasing a new oven, remember that adding an additional 1 or 2 inches of insulation is an inexpensive way to improve uniformity. In older ovens, hot spots (often indicated by peeling or discolored paint) are signs of areas where insulation has deteriorated or compressed and are often indicators of temperature-uniformity problems.
- 10. Properly arrange the load in the oven. To maximize even heating, the parts must be arranged in a manner that allows the heated air to reach all areas. If racks or shelves are used, be sure they elevate the load off the floor and do not

block the air. There also must be sufficient space between each layer for air to circulate and transfer the heat properly. This sounds obvious, but overloading is frequently a hidden cause of heating and uniformity problems. In addition, the cart or racks should be constructed from as lightweight materials as possible to minimize the energy required to heat them.

11. One size does not necessarily fit all. To ensure good temperature uniformity and even heating, the oven chamber should only be slightly larger than the load being heated. For example, in a small or large oven air may pass around rather than through the load, resulting in poor uniformity between the outside and the center of the parts being treated.

Final Thoughts

Ovens are simple machines, really. Their fans need to be well maintained, balanced and operating within their design parameters. Louvers need to be properly adjusted, and workloads need to be placed within them with adequate space for good airflow for convective heating. If you pay just a little attention, you will find that ovens can easily be made to conform to the requirements of AMS 2750D and other temperature-uniformity requirements. **IH**

References

- 1. Grande, Mike, "7 Ways to Improve Temperature Uniformity," *Process Heating*, January 2005.
- Mr. James Oakes, Super Systems Inc. (www. supersystems.com), private correspondence.