

# INDUSTRIAL HEATING

The International Journal of Thermal Processing

AUGUST 2020

## The Product's-Eye View 31



**FNA 2020  
Show Issue #1**

**INSIDE**

- 36 Extending Refractory Life
- 40 High Standards: Medical Devices
- 44 Heavy Industry Heat Treatment
- 56 FNA Virtual Show Preview

**FNA 2020  
TECHNOLOGY  
EQUIPMENT  
& TRENDS**

**PAGES 51-54**

# Applying Through-Process Optical Profiling for a Product's-Eye View

**Dr. Steve Offley – Phoenix™ Ltd.; United Kingdom**

Do you know what truly happens in your furnace? Applying through-process optical profiling will help you fully understand what is happening inside your heat-treat process.

**Fig. 1. Thru-process temperature-profiling system traveling through a conveyorized heat-treatment furnace measuring product and/or air temperatures**

In the global industrial heat-treating market, tens of thousands of products are sent through conveyorized ovens or furnaces each and every day. The thermal processing of these products – whether heat treating the core material or even curing a surface coating – is often critical to the quality or performance of the finished product. Whether aluminum brazing a radiator or curing paint on a car body, achieving the correct process times and temperatures is essential.

Learning what is truly happening to the product inside the black box that is your furnace is important and shapes the success of your operation and customer satisfaction.

As discussed in a previous article,<sup>[1]</sup> an essential technique to fully understand the operational characteristics of the heat-treat process is that of thru-process temperature profiling, where the environment and product temperature are continuously measured as the product travels through the process. Such a technique provides what is referred to as a “temperature profile,” which is basically a thermal fingerprint for that product in that particular process.

This thermal fingerprint will be unique and allows understanding, control, optimization and validation of the heat-treat process. As shown in Figure 2, a temperature profile of a continuous aluminum brazing (CAB) furnace shows the detailed critical phases of the heat-treatment process each contributing to the quality of the final product.

## Root-Cause Analysis: Process Profiling Help

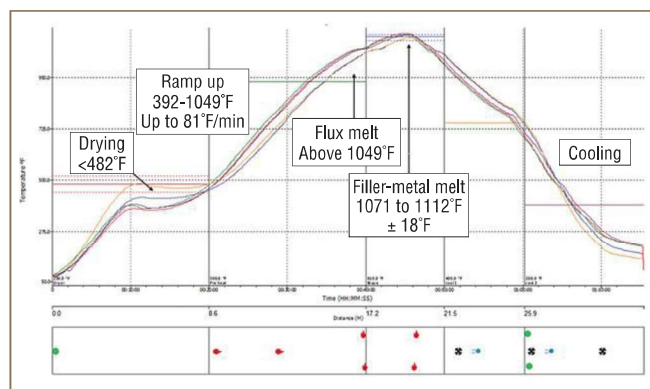
The temperature profile of any thermal process is invaluable to get a better understanding of how the furnace is working,

and it is a critical tool in fault finding when things go wrong – because they do and they will!

Root-cause analysis is a standard tool used in industry to identify the root cause of product or process problems without jumping to conclusions or making knee-jerk reactions. In root-cause analysis, it is important to distinguish between symptoms and problems and drive to find, in the midst of many potential causes, the true root cause.

Taking an example of the CAB process, the temperature-profile trace may show that the cause of a quality issue is due to the product braze temperature in a particular zone of the furnace being too low. This, although identifying a cause, does not necessarily explain the root cause.

A low product temperature in a particular furnace zone may be due to many possible different root causes – faulty control



**Fig. 2. The typical temperature profile of a continuous aluminum brazing furnace (CAB) showing the critical temperature transitions.**



Fig. 3. Phoenix™ optical profiling “Optic” system – optical-profile view

### 3.1. High-temperature thermal barrier for aluminum brazing system with camera and dual torches

thermocouple, burner, recirculating fan or even damage to furnace structure/insulation. The low product temperature may in some circumstances not be detected by onboard furnace controls and will require a deeper-dive investigation.

Identifying the root cause will require inspection at the source of the problem. This action is commonly referred to as “going to Gemba,” a Japanese word that means “the real place.” In this situation, going to Gemba means investigating what is actually happening in the furnace in a particular zone at the point of occurrence.

#### Root-Cause Analysis: CAB Example – Automotive Radiator Line

**Symptom:** High number of radiator rejects identified in QA.

**Problem:** Poor product quality due to weak braze joints.

**Cause:** From temperature profiles, product braze temperature identified to be too low in Zone 4.

**Root Cause:** Recirculating-fan fault in zone 4, which results in poor, nonuniform heat transfer to radiators.

Going to Gemba is not always the easiest of tasks, especially when considering identifying the root cause of furnace problems. Any task involving the internal inspection of a furnace generally requires that the furnace is switched off, allowed to cool and then dismantled to allow access by operators.

Taking our aluminum brazing (CAB) example, internal inspection of the furnace is not a quick and easy task.

### 3.2. Low-temperature thermal barrier for automotive paint applications with single camera and torch

Operating at 1000°F, the cool-down period is significant to allow engineers safe access for inspection and corrective action. There is a further delay to get the furnace back up to a stable operating temperature. Such-maintenance action may mean one or two days of lost production from that line, which is obviously detrimental to productivity, meeting production schedules, satisfying key customers and your bottom line.

In addition to process temperature problems, there are many other production issues that can be faced relating to furnace operation and safe, reliable transfer of the product through the furnace or oven itself. A day-to-day hazard of the CAB process is the build-up of flux debris. Flux materials used to remove oxides from the metal surface and allow successful brazing can accumulate within the internal void of the furnace. These materials are most problematic at the back end of the muffle section of the furnace, where – due to the drop in temperature entering the cooling zone – materials condense out. Flux build-up can create many different process issues, including:

- Physical damage to the conveyor belt or support structure, which requires expensive replacement
- Reduction in belt lubricity, which creates jerky movement and causes unwanted product vibration
- Lifting of the belt mesh, which creates an uneven transfer of products and causes possible excessive product movement, clumping or clashing
- Reduction in inner furnace clearance, which creates possible product impingement issues and blockages

Regular scheduled inspection and clean out of the furnace are necessary to prevent these problems. This is not a pleasant, quick operation and requires chipping away flux debris with pneumatic tools. Often requiring a furnace downtime of one to two days, this task is only performed when essential. Leaving the clean-up operation too long can be catastrophic, however, causing dramatic deterioration in product quality or risk of mid-production-run stoppages.

Until now there has been no easy way to see how your product travels through the furnace under normal operating conditions or means by which the need for furnace repair or clean-down can be confirmed. A new technology called optical profiling changes all this and for the first time gives you the means to see what your product sees in production – a true product’s-eye view!

### Optical Profiling

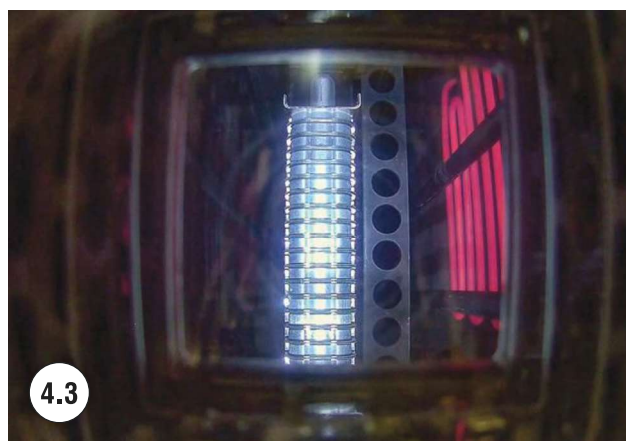
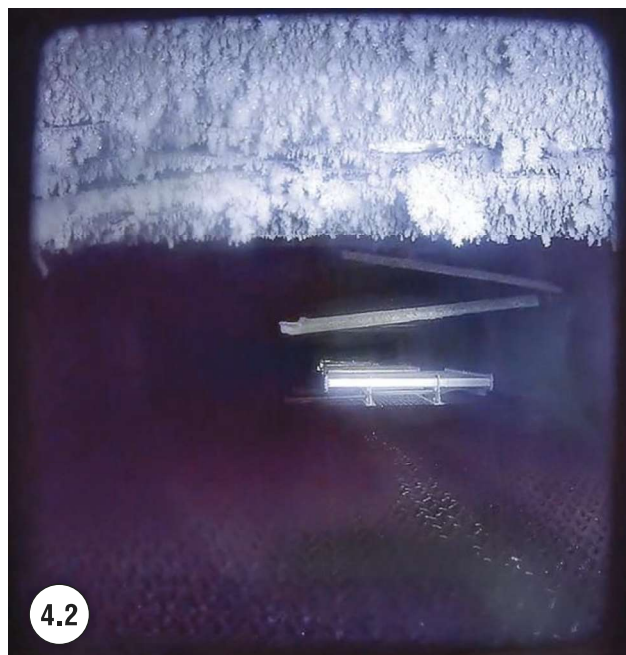
Optical profiling is a new, complementary technique to that of thru-process temperature profiling. The new technology allows for the first-time process engineers to view the inner workings of the furnace under normal production conditions. Travelling through the furnace with the products being processed, the optic system gives a product’s-eye view of the entire heat-treatment journey (Fig. 3).

Employing similar thermal-protection technology thermal barrier used in temperature profiling, a compact video camera and torch are used (in place of the temperature data logger) to record a video of what a product would see traveling through the furnace. The principle is just like your car’s dash cam. The only difference is that your journey is being performed in a furnace at up to 1000°F. The resulting video, “Optical Furnace Profile,” shows process engineers so much about how their process is operating without any need to stop, cool

### Optical Profiling – “Going to Gemba” New Technology Benefits

- **Instant** – View the inner workings of your furnace without needing to dismantle the furnace or stop production.
- **New understandings** – See the actual heat-treat process and visual changes to product possibly for the first time.
- **Production conditions** – See the operation of the furnace under actual production conditions, fully loaded.
- **Time saving** – No delay to cool, disassemble and reassemble like with normal inspection procedures.
- **Complementary** – Run video profile simultaneously with temperature profile to combine thermal and visual information for the complete picture of your heat-treat process.

**Fig. 4. Phoenix™ optical-profiling system being used in a conveyORIZED aluminum brazing furnace**



**4.1. Optical-profiling system entering a brazing furnace**

**4.2. Video profile screen shot – exit of muffle furnace showing heavy flux build-up**

**4.3. Video profile screen shot – vacuum brazing furnace showing faulty IR heating element**

and dismantle the furnace. This allows safe, routine furnace inspection without the problems of costly lost production and days of furnace downtime.

### Benefits of Applying the Optical-Profiling Principal in Conveyorized Furnace Processes

#### Furnace Condition

- Check the condition of the internal walls of the furnace to ensure they are fit for purpose.
- Identify damaged or distorted panels/sealing gaps/corrosion.
- Build-up of dirt/flux/condensate or general processing debris – contamination risk – identifies the need for critical cleaning action (Fig. 4.2).
- Correct alignment adjustment of ducting to allow correct airflow/convective heat transfer.
- Identify ignition events or other safety-related issues within the furnace.

#### Product Transfer

Check that the product travels safely and smoothly through the process without conflict or obstruction.

- Conveyor belts run flat and product orientation is kept constant – no belt damage or distortion.
- No product vibration or excessive movement, which may cause damage to the product or affect a processing step (e.g., brazing).
- Check that product is able to pass through without clashing with furnace furniture or clumping.

#### Condition and Operation of Key Furnace Features

Check that key furnace features are working correctly and not damaged. These include fans, ducting, control thermocouples, gas-feed pipes and zone separation curtains/brushes (Fig. 4.3).

#### Thermal-Process Observation

Check that the process is being performed correctly where heat-treatment action is physically visible. For brazing, check the melt and flow of filler metal. For painting, visually identify drips and identify their source.

#### Summary

Thru-process optical profiling is a new, revolutionary technique for visually inspecting the condition of, and also

## Has your HEARTH PLATE supplier gone south?

*American owned, American made.*

Call 708-849-1000 for a local distributor.

[refractoryshape.com](http://refractoryshape.com)



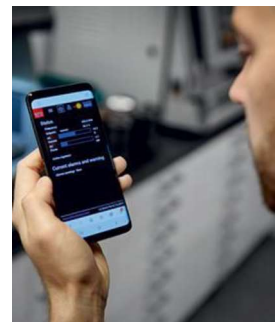
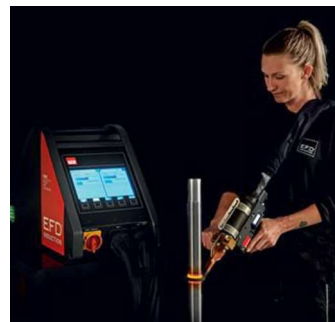
transfer of product through, a continuous furnace. Combining such information with a product temperature profile, process engineers can work with maintenance teams to not only understand, control, optimize and validate the heat-treat process but also maintain the furnace to protect productivity and quality.

Employing the optical-profile information, preventive maintenance or furnace clean-down can be scheduled with confidence. When problems do occur, rapid fault finding is possible. Furnace inspection as part of the production flow at temperature eliminates days of furnace downtime, lost production and an interrupted product supply chain.

**References:**

1. *Industrial Heating*, June 2019, "Through-process Temperature Profiling for Heat-Treat Efficiency," Dr. Steve Offley, PhoenixTM Ltd.

**For more information:** Contact Dr. Steve Offley, product marketing manager, Phoenix Temperature Measurements (PhoenixTM Ltd. U.K.); tel: +44 (0) 1353 223100; e-mail: Steve.Offley@phoenixtm.com; web: www.phoenixtm.com.



## Induction Heating **DIGITAL TO THE CORE**

With the new fully digital control system, EFD Induction sets you up for Industry 4.0.

- Future-proof and user-friendly
- Maximum reliability
- Unmatched control and efficiency
- 10-inch capacitive colour touch screen and latest technology in man-machine interface
- Advanced machine audits and troubleshooting
- Enhanced diagnostics
- Fault logs
- Short service response time
- Reduced maintenance requirements
- Easy software upgrades
- Quicker process setup



[www.efd-induction.com](http://www.efd-induction.com)

PUTTING THE SMARTER HEAT TO SMARTER USE

**All the best of  
IndustrialHeating.com  
content, all the time.**

**INDUSTRIAL HEATING**  
Register for open access.  
**IT'S FREE!**  
[www.Industrialheating.com/registertoday](http://www.Industrialheating.com/registertoday)





**PhoenixTM**  
Phoenix Temperature Measurement

*Optical Profiling...  
....the eye thru your furnace!*



# PhoenixTM Optic System `Thru-process` Optical Profiling

Capture a high resolution video of what your product sees through the entire furnace during a live production run



Flux build-up in a CAB furnace



Faulty heater in a vacuum furnace



The ideal set-up and maintenance tool for your Aluminum CAB & Vacuum Brazing line!

## Benefits

- Discover furnace structural damage
- Spot product transfer / belt problems
- Locate faulty furnace equipment
- Detect obstacles - build up of debris
- Identify need for furnace clean down

## Value

- No Line Stoppages
- No Lost Production
- No lengthy Cool Down Delays
- No need to Dismantle Furnace
- No heavy labor costs



## New Innovative Technology

from PhoenixTM complimenting it's range of thru-process temperature profiling systems. Discover so much more - Combine Optical and Temperature Profiling.

See us at  
**FNA 2020**  
Virtual

[www.phoenixtm.com](http://www.phoenixtm.com)

PhoenixTM LLC info@phoenixtm.com Tel.: (727)6084314