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Picture courtesy of Rio Tinto Aluminium

Do you know what truly happens in your CAB furnace?

Fig 1. Thru-process temperature profiling system travelling through a conveyorized heat treatment furnace measuring product and or air temperatures providing a 'temperature profile' a thermal finger print for that product

Applying 'thru-process' optical profiling to fully understand, what is happening inside your Al brazing furnace…a products eye view! By **Dr Steve Offley***

In the global Industrial heat-treating market tens of thousands of aluminium brazed products are sent through conveyorized CAB furnaces each and every day. The thermal processing of these products is often critical to the quality or performance of the finished product.

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 editorial[1] to fully understand the operational characteristics of the aluminium CAB heat-treat process an essential technique is that of thru-process temperature profiling where the environment and brazed product temperature is continuously measured as the product travels through the process.

Such technique provides what is referred to as a 'temperature profile' which is basically a thermal finger print for that product in that particular process. This thermal finger print will be unique and allow understanding, control, optimization and validation of the heat treat process.

Root Cause Analysis – Process Profiling Help

The temperature profile of any thermal process is invaluable to get a better understanding how the furnace is working and 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 mist of many potential causes, the true root cause.

Taking an example of the Aluminum CAB brazing 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 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 referred to commonly as "Going to Gemba" a Japanese word which 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 – Controlled Aluminum Brazing (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 resulting

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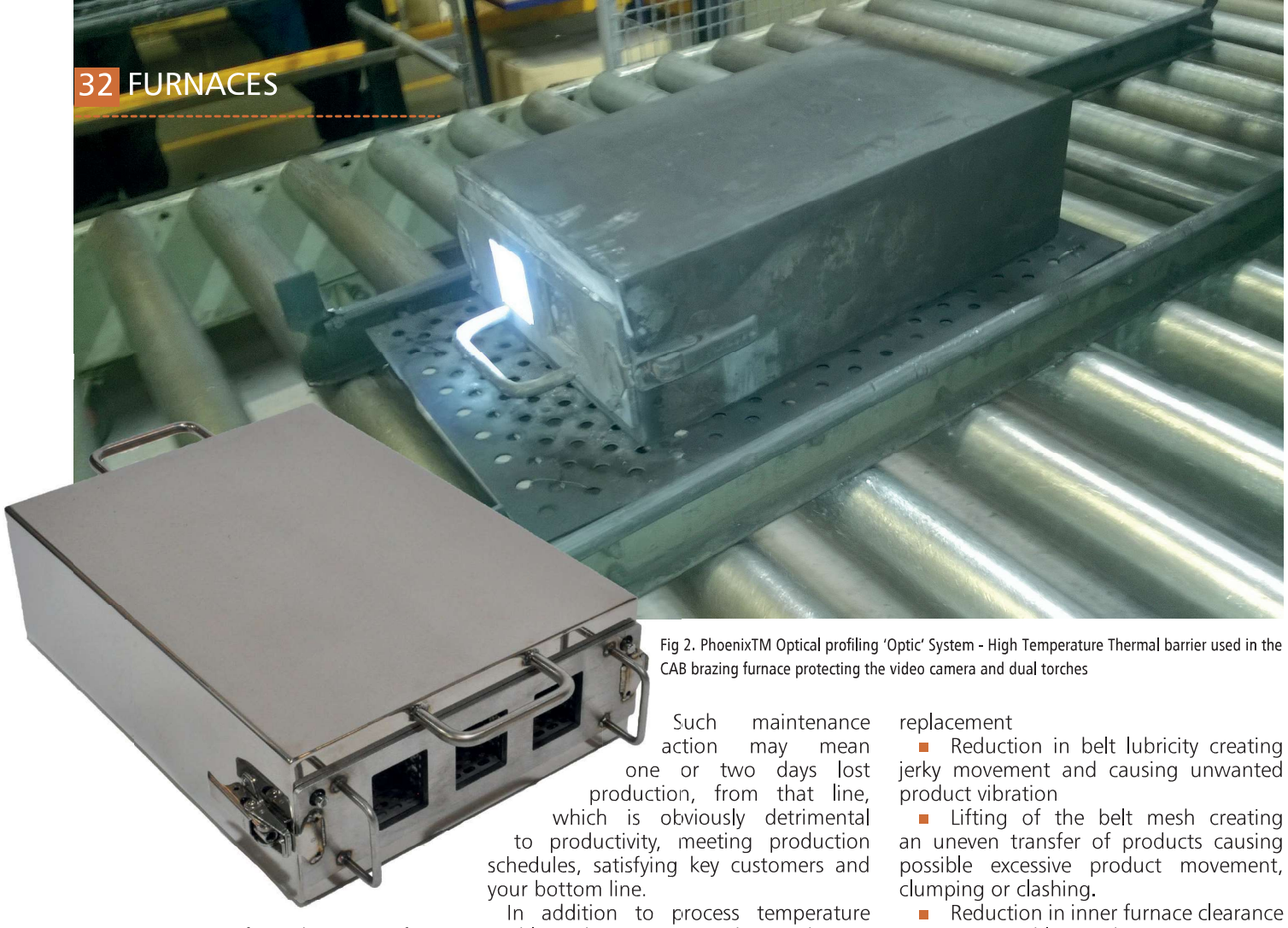


Fig 2. PhoenixTM Optical profiling 'Optic' System - High Temperature Thermal barrier used in the CAB brazing furnace protecting the video camera and dual torches

in poor non uniform 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 operatives.

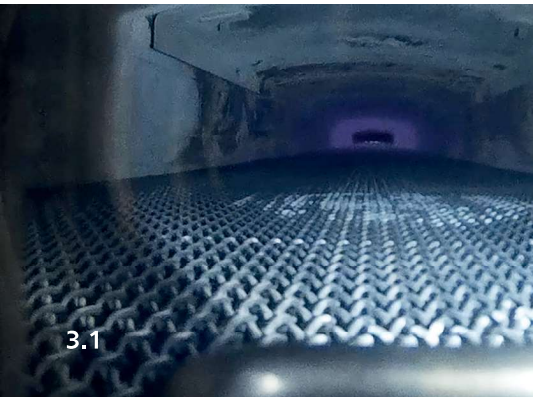
Taking our aluminium brazing (CAB) example, internal inspection of the furnace is not a quick and easy task. Operating at 600 °C the cool down period is significant to allow engineers safe access for inspection and corrective action and then further delay to get the furnace back up to a stable operating temperature. Such maintenance action may mean one or two days 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 the furnace operation and safe reliable transfer of the product through the furnace or oven itself. In the CAB process a day to day hazard of the 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 requiring expensive replacement
- Reduction in belt lubricity creating jerky movement and causing unwanted product vibration
- Lifting of the belt mesh creating an uneven transfer of products causing possible excessive product movement, clumping or clashing.
- Reduction in inner furnace clearance creating possible product impingement issues and blockages

To prevent such problems, regular scheduled inspection and clean out of the furnace is necessary. This is not a pleasant, quick operation, and requires chipping away flux debris with pneumatic tools. Often requiring a furnace down time of 1 to 2 days, this task is only performed when essential. Leaving the clean-up operation too long though can be catastrophic 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 operation



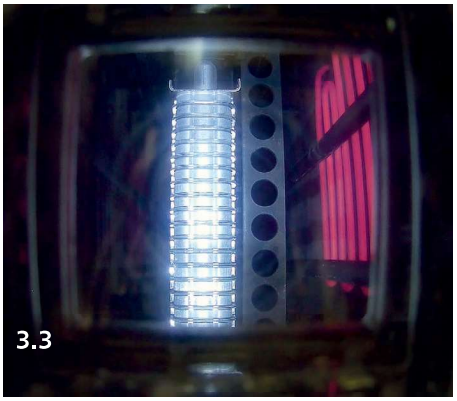


Fig 3. PhoenixTM Optical Profiling System – Your Products Eye View in the operational Al CAB furnace. **3.1** Video profile screen shot – view down entire length of a single Furnace Zone **3.2** Video profile screen shot – exit of muffle furnace showing heavy flux build up. **3.3** Video profile screen shot – vacuum brazing furnace showing faulty IR heating element

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 products eye view!

Optical Profiling – What is it?

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. Employing similar thermal protection technology 'thermal barrier' used in temperature profiling, in place of the temperature data logger a compact video camera and torch are used to record a video of what a product would see travelling through the furnace. The principle is just like your car's dash cam, the only difference being that your journey is being performed in a furnace at up to 600°C. The resulting video "Optical Furnace Profile" shows process engineers so much about how their process is operating without any need to stop, cool and dismantle the furnace. This allows safe routine furnace inspection without any of the problems of costly lost production and days of furnace down time.

Benefits of applying the Optical Profiling principle in conveyorized furnace processes:

Furnace Condition

Check the condition of the internal walls of the furnace to ensure they are fit for purpose

- Damaged or Distorted panels / Sealing gaps / Corrosion
- Build-up of dirt/flux/condensate or general processing debris – Contamination risk – identify need for critical cleaning action
- Correct alignment adjustment of ducting to allow correct air flow / 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 product or affect processing step eg: brazing
- Check that product is able to pass through without clashing with furnace furniture or product clumping

Condition & Operation of Key Furnace Features

Check that key furnace features are working correctly and not damaged

- Fans, Ducting, Control thermocouples, Gas Feed pipes, Zone separation curtains/brushes

Thermal Process Observation

Check that the process is being performed correctly where heat treatment action is physically visible

- Bazing – Melt and Flow of filler metal

Summary

'Thru-process' optical profiling is a new revolutionary technique for visually inspecting the condition of and also 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 preventative maintenance or furnace clean down can be scheduled with confidence, and when problems 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. Aluminium International Today Magazine Set/Oct 2019 : Brazing Basics - 'Thru-process' Temperature Profiling a means to achieve process understanding, control, optimisation and validation. Dr Steve Offley PhoenixTM Ltd.

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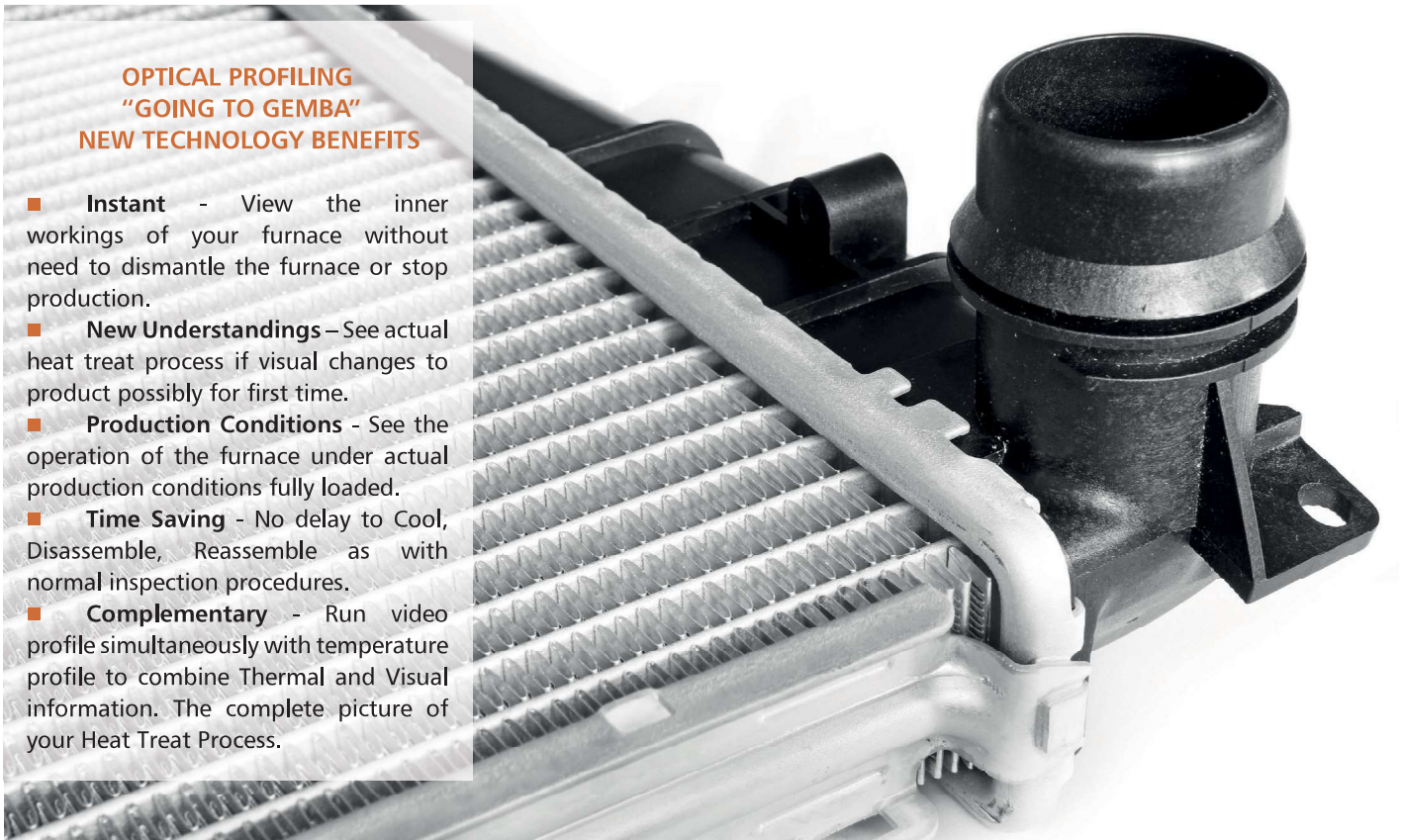

OPTICAL PROFILING "GOING TO GEMBA" NEW TECHNOLOGY BENEFITS

- **Instant** - View the inner workings of your furnace without need to dismantle the furnace or stop production.
- **New Understandings** – See actual heat treat process if visual changes to product possibly for first time.
- **Production Conditions** - See the operation of the furnace under actual production conditions fully loaded.
- **Time Saving** - No delay to Cool, Disassemble, Reassemble as with normal inspection procedures.
- **Complementary** - Run video profile simultaneously with temperature profile to combine Thermal and Visual information. The complete picture of your Heat Treat Process.