# The Rock and Roll of continuous furnace aluminium log homogenisation monitoring

By **Dr Steve Offley***

## The homogenisation heat treatment process

After casting, aluminium logs/billets undergo a homogenising heat treatment process to ensure uniform distribution of the alloying elements, such as Zn, Cu, or Mg2Si and Fe, within the structure of the log. This involves heating the log at a controlled rate, soaking at temperature (typically 480 °C to 540 °C / 896 °F to 1004 °F ) for a specific period of time, and cooling at a specific rate to allow the precipitating elements to become more evenly distributed throughout the material. Each phase of the heat treatment process is temperature critical. An accurate means of monitoring the log internal temperature throughout the whole furnace cycle is, therefore, important to the success of the homogenisation process, material properties, and efficiency of the furnace heat treat operation.

## Log Temperature Measurement Challenge

When setting furnace conditions for new production batches, monitoring the actual product temperature of the logs throughout the furnace is vital to maximise production throughput, while ensuring the correct metallurgical structure of the product.

Measurement of the product temperature is generally not considered a problem when the operation is conducted in a batch furnace. In such case, thermocouples can be run from the static logs, loaded in the furnace, to an external data logger without significant issues.

However, when homogenising is conducted in a continuous process, such as a walking beam furnace, monitoring the product temperature from a data logger external to the furnace is not possible because the logs generally travel in different directions as they enter, move through the hot zone, and exit the furnace. Also, the logs can slowly rotate due to the action of the walking beam. These factors make external monitoring with long trailing thermocouples impractical, and even if possible, would not comply with every increasing safety requirement for technical plant operatives.

The solution is to use a 'thru-process' temperature monitoring system where a thermal barrier can be attached to the log protecting a data logger as it gathers temperature data from thermocouples set within the test product. In this way the product temperature profile can be accurately monitored as the test product travels through the process. Short thermocouples are safely contained within the thermal barrier, before running along pre-cut routing channels within the log, eliminating the risk of tangling or being caught during the log movement through the furnace (**Fig 3**).

The innovative cylindrical thermal barrier design is critical to the success of the temperature monitoring system. The diameter and length of the thermal barrier matches a machined gap at the end of the aluminium log so that loading the log, with the monitoring system attached, can be achieved as if a standard log. No height restriction challenges are faced

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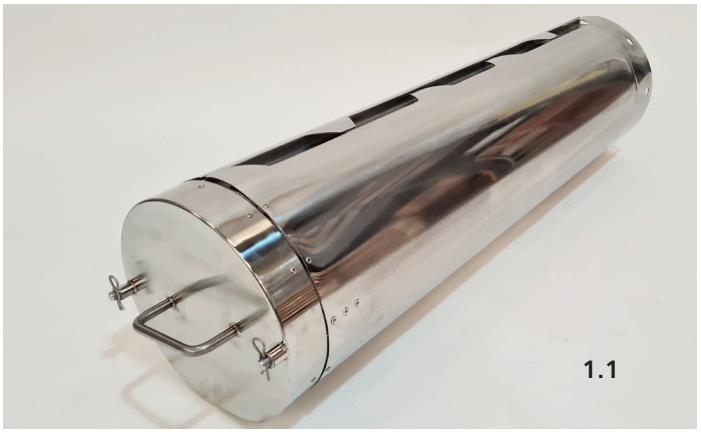


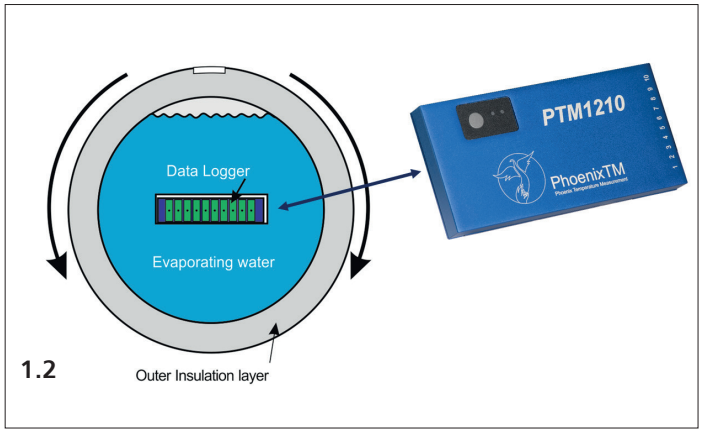


Fig 1. PhoenixTM TS57 Rotating Evaporative Water Barrier solution.
1.1 Cylindrical thermal barrier fixed to aluminium log being monitored.
1.2 Schematic showing the PTM1210 datalogger located in cylindrical water tank that rotates with the aluminium log during transfer through walking beam furnace.

Fig 2. PhoenixTM TS57 Rotating Evaporative Water Barrier Solution Set-Up
System used to successfully monitor, in real time, the Homogenisation of cast aluminium logs in Service Center Metals (SCM) walking beam furnaces. Rotating cylindrical water barrier attached to a 356 mm/ 14" log with thermocouples positioned along its length at varying depths.

and most importantly being cylindrical the system can rotate safely with the log as it is transferred through the walking beam furnace.

## The 'thru-process' Monitoring System Design Solution

The PhoenixTM 'thru-process' monitoring system to accommodate the size restrictions of the homogenising processes and its long duration (up to 10 hrs) / high temperature (600 °C/1112 °F), employs a phased evaporation method of thermal protection. The data logger is encased in a thermally insulated cylindrical water tank employing evaporating water as a phase change medium. As the water reaches its boiling point it changes from liquid to gas (steam) as it evaporates, but maintains the operating temperature of the logger at a safe 100 °C/212 °F, so prolongs the period it can remain in the furnace. The thermal protection provided by the thermal barrier can be controlled by selecting the volume of the water tank and so water capacity (Litres).

The innovative barrier design must allow the steam to evaporate whilst not losing any water as the barrier rotates. For this type of system, it is also necessary for the data logger to be able to operate at 100°C as it is surrounded by boiling water (**Fig 1**. PhoenixTM TS57 Rotating Evaporative Water Barrier)

Having established the diameter range of the logs and the process parameters, the size of the system (length and diameter) can be calculated and a piece of the log equal to the length of the thermal barrier can be cut off and discarded. The end of the log is then machined to allow the thermal barrier to be secured directly with steel bolts. Alternatively, a custom mounting plate can be bolted to the end of the cut log to which the barrier can be efficiently fixed and removed from test to test (**Fig 2**). A slot is machined longitudinally along the log to guide the thermocouples to holes drilled at right angles to the correct measuring depth. This ensures that both the thermocouples and the 'thru-process' system are kept within the boundaries of the product (**Fig 3**).

When this is complete the thermocouples are positioned, the data logger reset and placed in the thermal barrier fixed to the test log, and the trial is ready to run.

## Winning Solution providing Accurate Process Validation

Requiring a solution to allow process monitoring of their walking beam aluminium log homogenisation furnace Service Center Metals (SCM) located in Prince George, VA, USA approached PhoenixTM.

The resulting 'thru-process' temperature monitoring system provided to SCM is shown in **Fig 2**.

Fitted with a RF telemetry module the data logger allowed live 'Real Time' product temperature to be monitored through the whole furnace. With such information, SCM were able to validate mathematical models used to control the furnace and so optimise the efficiency of the entire homogenisation process.

Mr Calvin Wiggins, Quality Director at SCM, is quoted as saying "The ease of use of the PhoenixTM system allows us to do more surveys per year than compared to feeding thermocouple wires attached to a rigid log. However, its single best-selling point is improved safety by keeping tech's away from the furnace entry door, where they would otherwise be feeding TC wires to the survey log as it advances through the furnace."

## PhoenixTM Service with Style!

Recently a TS57 system was successfully commissioned at the Finnish aluminium profile manufacturer Mäkelä Alu Oy who have been in business for over 80 years

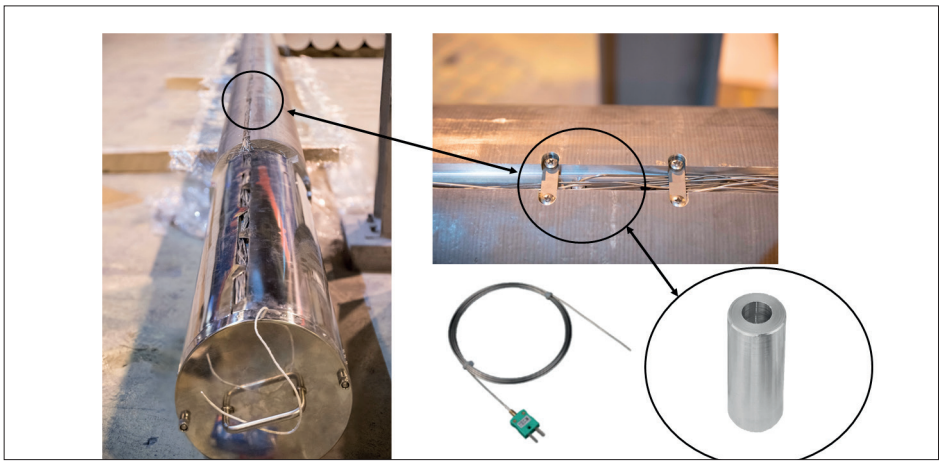

Fig 3. Thermocouple Installation
Installation of thermocouples on the aluminium log to allow of monitoring core temperatures in a machined channel along the length of the test piece. The thermocouple measuring tip (Hot junction) is inserted into aluminium bushes, located into drilled pilot holes, to required core depth in the log.

Fig 4. Commissioning Style
Michael Taake on site at Mäkelä Alu Oy Finland to commission the PhoenixTM TS57 system after his 2000 km / 1250 miles motor bike road trip from the PhoenixTM office in Germany.

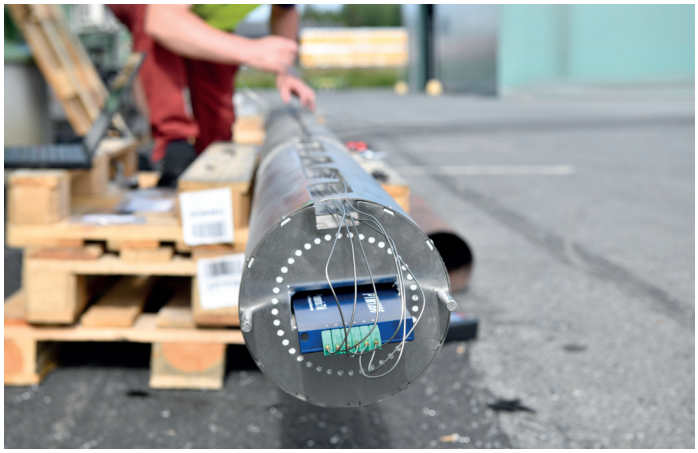

Fig 5. PhoenixTM TS57 Rotating Evaporative Water Barrier Thru-process Monitoring System Set-up at Mäkelä Alu Oy
5.1 PhoenixTM PTM1206 six channel high temperature data logger installed in TS57 cylindrical barrier
5.2 TS57 cylindrical thermal barrier fixed to test log in situ within the homogenisation heat treat process

(https://makelaalu.fi/en/). The PhoenixTM system was ordered to help Mäkelä Alu Oy with the recycling of production scrap into low-emission aluminium billets. PhoenixTM prides itself with not only providing monitoring technology but ensuring that it is fit for purpose and working to specification on site. Living up to the company tag line "where experience counts!" Managing Director Michael Taake took on the challenge of commissioning the system with the help of Scandinavian partner CalorMet .

Traveling from the PhoenixTM office in Bad Oeynhausen in Germany you would have thought the obvious transport choice would have been by plane. Micheal decided otherwise as he says "Why should I sit on a cramped plane and sleep in overcrowded hotels when I can explore and enjoy the beautiful nature of Scandinavia by motorbike?". It took him around 2,000 km along the coast of Sweden and the forests of Finland to Mäkelä Alu Oy.

On site, Michael, together with CalorMet conducted a comprehensive briefing on the PhoenixTM temperature measurement system, and witnessed the system being used for the first thru-process temperature profile.

"It is fascinating that Mäkelä is always familiar with the latest technologies, implements improvements precisely and carries out their work in a sustainable and environmentally conscious way," says Michael Taake.

## Monitoring Power

By employing the 'thru-process' temperature monitoring solution from PhoenixTM, major key casting plants have been able to measure the temperature profile of their aluminium log in all three stages of the homogenisation process. With such critical information it has been possible to minimise time in the soak zone to increase productivity and optimize fuel efficiency without compromising product quality. ■