Monitoring Aluminium Log Temperatures During Homogenisation in a Walking Beam Furnace

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Introduction

Using 'Hot Box' temperature profiling systems to monitor product temperatures in furnaces has become accepted in many areas of the heat treatment and allied industries. 20 years ago the concept of putting an electronic data logger into a furnace with products was seen as radical, but today In applications such as aluminium brazing, furnace surveying, and even steel slab re-heating use of these systems is commonplace. In most applications furnaces can easily accommodate the monitoring system as well as the product, but in some, a great deal of resourcefulness is required to ensure the monitoring operation can be carried out. Homogenising aluminium logs in a walking beam furnace is one of these.

The heat treatment process

After casting, aluminium logs undergo a homogenising heat treatment process to ensure uniform distribution of the alloying elements within the structure of the log. This involves heating the log at a controlled rate, soaking at temperature for a specific period of time, and cooling at a specific rate.

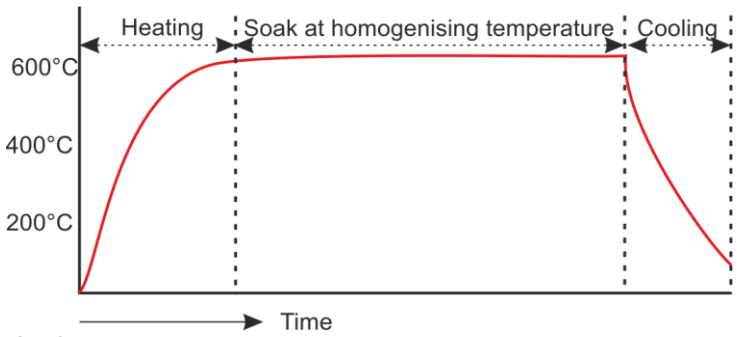

Figure 1 heat treatment stages of the homogenisation process

Log temperature measurement

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 not considered a problem when the operation is carried out in a batch furnace as thermocouples can be inserted at the required depth in a test log in any part of the load, and led out through an aperture to a data logger etc. outside the furnace. As the log does not move during the process the temperature data can be collected with relatively few problems.

However when homogenising is carried out in a continuous process, such as a walking beam furnace, then 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 thermocouples impractical.

Figure 2 rotating 'Hot Box' system for aluminium logs

The solution is to use a ‘hot box’ 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 system travels through the process. After the system exits the furnace and data is downloaded from the logger, software capable of carrying out a fast and accurate analysis of the process is the final important element of this type of system.

The design challenges

Designing a ‘hot box’ system to operate attached to logs in a walking beam furnace is not without difficulty however as:

- There are generally size restrictions at the entrance and exit of the walking beam furnace so the thermal barrier of the ‘hot box’ system must be designed to be the same diameter, or preferably smaller than the log, or it may impede it’s travel through the furnace
- Total time in the process can be up to 10 hours or more at temperatures approaching 600°C, and designing a system to withstand these conditions, while working within the product diameter restrictions, can be difficult as normal thermal barrier design (to insulate the data logger), will not be able to withstand the heat of the furnace over such a long period of time.
- The interface between the log and the thermal barrier must be well designed to ensure the system and log do not part company in the furnace
- The aluminium logs can be up to 8 metres long, and thermocouples feeding back data from one end of the log to the data logger be kept within the product boundary to ensure they do not snag during the process

Figure 3 the monitoring system and thermocouples must not exceed the boundaries of the product

Design solutions

'Hot box' monitoring systems normally operate using a two stage insulation package consisting of a highly effective insulation layer around a phase change heat sink to protect the data logger. The phase change medium is generally a type of eutectic salt which absorbs energy during the phase change period, changing from a solid to a liquid state. However where thermal barrier size is restricted and processes involve long duration / high temperature, then evaporating water is used as a phase change medium, changing from liquid to gas (steam) as it evaporates and prolongs the period it can remain in the furnace.

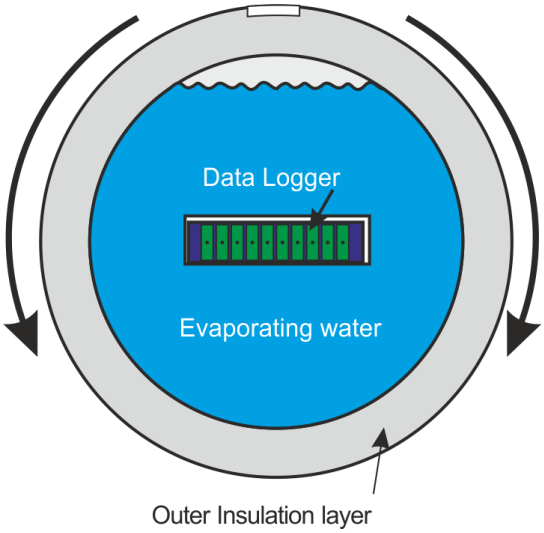

Figure 4 when fixed to the test log, the thermal barrier and data logger must rotate with the product

Designing the barrier with enough thermal capacity to get the test log through the furnace before the water has fully evaporated is the key to successfully monitoring this process, and so the amount of water within the thermal barrier has to be maximised. The barrier design must also 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. This requires careful selection of the electronic components and circuit design.

Good communication with the customer at design stage is essential as prior to trial the test log must be machined to accept both the system and the thermocouples, keeping both within the boundaries of the product.

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 accept the holder section of the thermal barrier where steel bolts secure it securely. 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 'hot box' system are kept within the boundaries of the product.

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.

Figure 5 the test log and system after exit from the furnace

Conclusion

In a recent commissioning of a ‘hot box’ system at a major German casting plant the customer was able to accurately monitor the temperature profile of the test log in all three stages of the heat treatment process. Following this trial they were able to substantially reduce the time the products were spending in the soaking zone of the furnace with no loss of product quality.

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