A large graphic element consisting of two overlapping diagonal stripes, one yellow and one red, set against a black background. The stripes are separated by thin white lines with a hatched pattern.

TEMPERATURE MEASUREMENTS IN METAL REHEAT FURNACES **APPLICATION NOTE**



Reheat furnaces bring cold metal to the correct temperature for rolling, extruding or forging. For optimum quality, and to reduce wastage, the temperature should be uniform throughout the product, which requires accurate temperature monitoring.

In addition, temperature measurements are key to providing optimised heating trajectories for the metal, which results in significant energy savings, consistent metallurgical properties and minimal surface scaling.

The most effective and accurate method of achieving these measurements is through thermal imaging.

REHEAT FURNACES

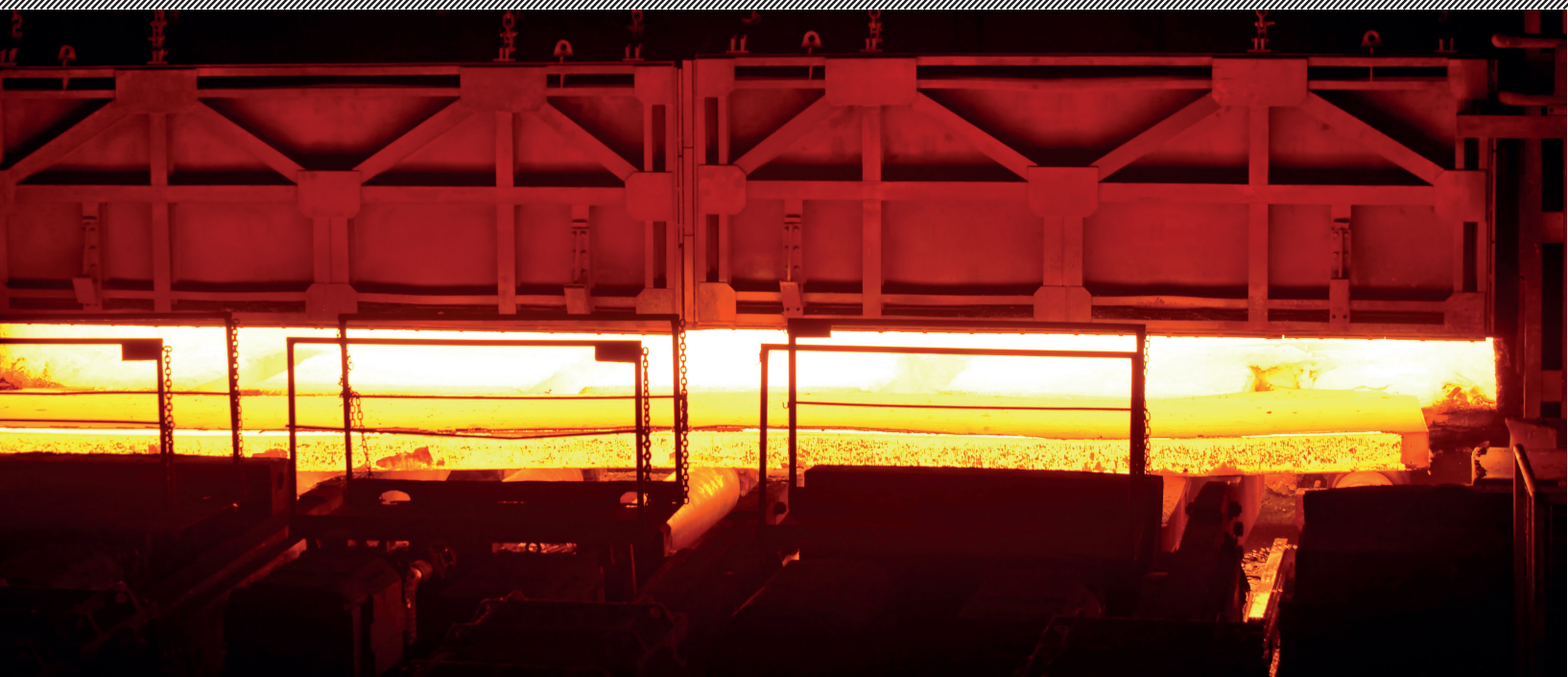
Most steel mills and metal forging operations rely on reheat furnaces to ensure that metal slabs or billets reach a uniform and repeatable temperature prior to being sent to their rolling mills and forge presses.

The purpose of the reheat furnace is to bring the product temperature up to the working level so that it can be rolled, extruded or forged.

There are two major types of reheat furnaces – continuous and batch. Each can use various heating methods, but the most common uses either natural gas/methane, or natural gas with oxygen enrichment.



APP NOTE
Typically, a reheat furnace in a hot rolling mill for steel has to raise the metal temperature from ambient to around 1200 °C (2192 °F).



CONTINUOUS REHEAT FURNACES

Continuous reheat furnaces have evolved from simple pusher furnaces – where stock is sequentially pushed through the furnace as each new product is added – to the more advanced walking beam furnaces.

The walking beam design – where stepping, alternating skids ‘walk’ the product through the process – produces a much more uniform underside temperature that results in higher-quality finished products.

Continuous reheat furnaces are typically used in hot rolling mills. The slab or billet is loaded into the cool end of the furnace,

then passes through pre-heat, heating and soaking zones before being discharged for rolling.

In this system, the pre-heat zones warm up the material, then the heating zone delivers the main heating for the product. The soaking zone allows the heat to homogenise throughout the steel, so that when it is discharged it has a uniform temperature distribution throughout its thickness, length and width.

The aim of this method is to create a tightly controlled heating trajectory as the stock travels through the furnace. For

maximum fuel efficiency, the stock should achieve the desired temperature shortly before discharge.

However, in many cases, the steel is heated too quickly, particularly in the pre-heat zone. This is very fuel inefficient, and so wastes energy and increases costs. It can also affect the metallurgical properties of the steel and increase surface scaling.

BATCH REHEAT FURNACES

Batch reheat furnaces are commonly used in forging operations, where the metal is hammered to improve its density and strength.

If the metal drops to a certain temperature, it can damage the forging machinery and negatively affect the forging quality. To prevent this, the part needs to be returned to the batch reheat furnace and brought back up to temperature for further forging.

Once the reheated part is ready, it is quickly transported back to the forge

for further work. This pattern of heating, forging, and return to the furnace for reheating, can be repeated several times during the forging process.

Again, the heating needs to be uniform to ensure that the entire product is at the correct temperature for forging to continue.



TRADITIONAL TEMPERATURE MEASUREMENTS: THERMOCOUPLES

Typically, thermocouples were installed through the furnace roof or walls to measure the furnace temperature in each zone. The furnace temperature was controlled based on those readings.

However, thermocouples do not measure the stock temperature – the temperature of the metal being passed through the furnace. Instead, they only measure the furnace atmosphere and surroundings. Mathematical heating models are then used to infer the stock temperature.

This historical 'blind' method of temperature profiling provides an approximation of the metal's surface and bulk temperature during its movement through the furnace, assuming that movement is steady and repeatable.

Whenever the product is delayed in the furnace or environmental conditions change, this method becomes highly unpredictable. It is also affected by mixing a variety of products with different sizes or emissivities. Sophisticated modeling is required to accommodate these factors.

There are other problems with using thermocouples. They need to be checked on a regular basis and replaced when they become out of specification or broken. This may happen quite often, as the protective sheath around the thermocouple can be damaged when the refractory surface expands or contracts.

In addition, when thermocouples operate at elevated temperatures for an

extended period of time, their accuracy degrades due to tip migration – this is when the alloys at the tip start to combine rather than remain as two separate metals.

Some operators compensate for the problems of thermocouple measurement by overheating the product, leaving it in the soaking zone for longer. This is seen as more desirable than having to completely reheat the product.

However, this wastes energy and often affects the metallurgical properties of the product, causing additional scaling on the surface.

TRADITIONAL TEMPERATURE MEASUREMENTS: THERMOMETERS

Non-contact radiation thermometers, also referred to as infrared pyrometers, have been used for many years to measure actual stock temperatures directly.

Readings from pyrometers are a sum of the emitted and reflected radiation from the stock and furnace background. To determine the correct stock temperature, the background temperature must be measured and its effects subtracted from the pyrometer reading.

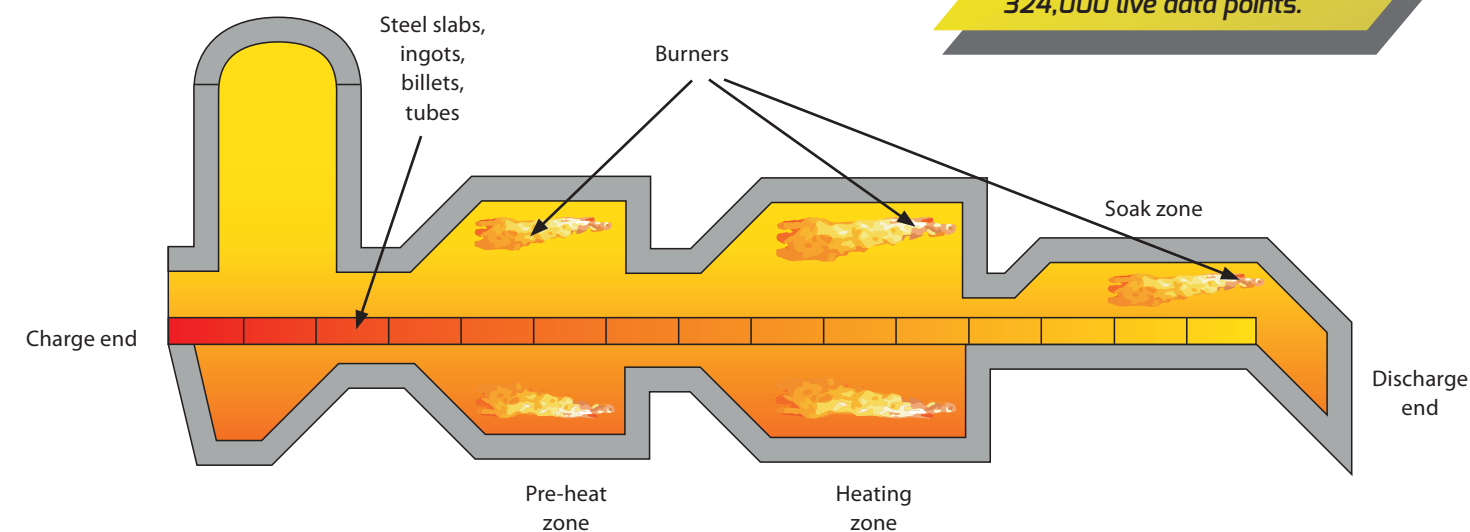
A thermocouple can be used to measure the background temperature. The AMETEK Land Furnace Thermometer System (FTS) provides this measurement, as do SPOT thermometers which have a secondary input as standard.

Once the correct pyrometer system is chosen, accurate stock temperature values can be fed to the furnace control model to improve quality and reduce fuel costs.

The one disadvantage of using this method is that the pyrometer only measures a single spot. This limits usage to locations where the target is in a known position and it is acceptable to measure a small area on the surface of the metal. A complete picture of the surface temperature is not provided.

TYPICAL CONTINUOUS REHEAT FURNACE – CROSS-SECTION

The product proceeds through pre-heat, heating and soaking zones before being discharged for rolling.



APP NOTE

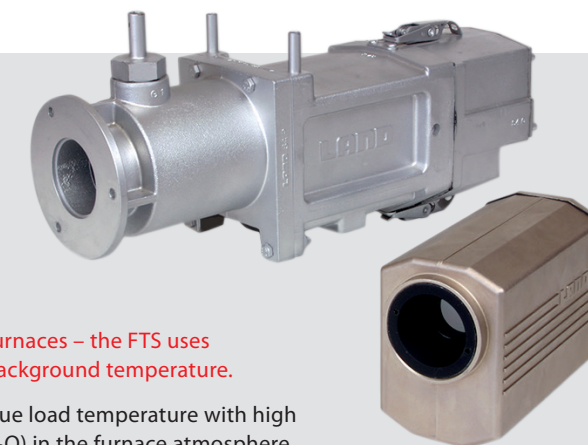
While thermometers only measure at a single spot, NIR-B thermal imagers measure from any of 324,000 live data points.

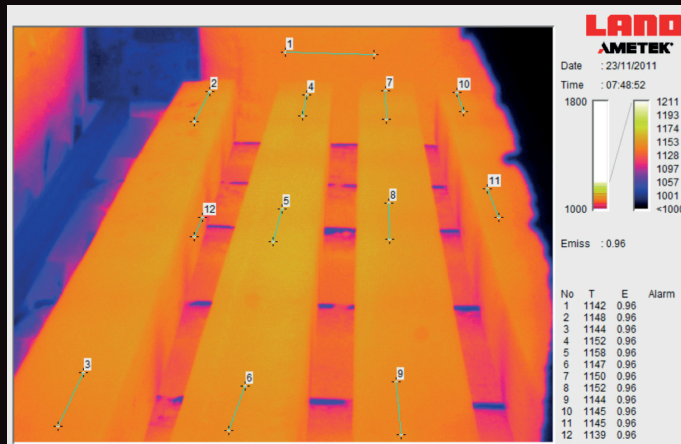
FURNACE THERMOMETER SYSTEM (FTS)

A RADIATION THERMOMETER SYSTEM, USING TWO SENSORS, PROVIDES A CONTINUOUS TRUE TEMPERATURE OF THE REHEAT FURNACE LOAD AND WITH IT THE POSSIBILITY OF BIG SAVINGS IN OPERATION COSTS.

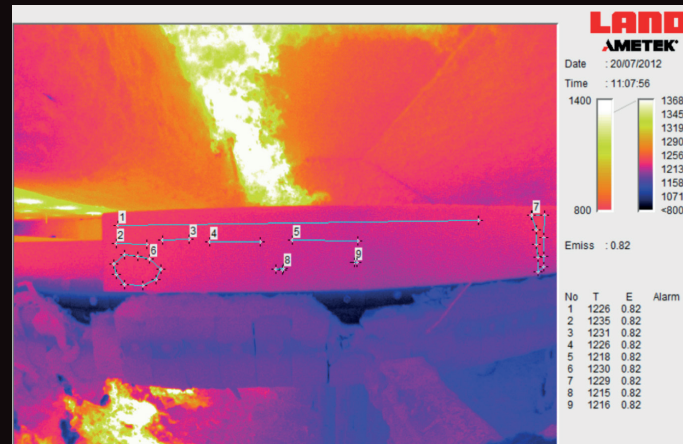
Designed specifically for reheat furnaces – and suitable for gas-fired and oil-fired furnaces – the FTS uses AMETEK Land's leading-edge infrared sensing to measure both furnace load and background temperature.

Linking to the advanced Landmark Graphic MKII signal processor, it provides the true load temperature with high accuracy, avoiding the effects of hot carbon dioxide (CO₂) and hot water vapour (H₂O) in the furnace atmosphere.





Multiple billets approaching the furnace exit.



Billet side approaching the furnace exit.

THERMAL IMAGING

With increasing quality requirements, companies are switching to process thermal imaging systems to provide temperature measurements of the entire metal stock. The starting point for higher product quality is knowing that the temperature is homogenous – the same throughout the product – not just at single points.

These systems deliver a highly detailed image and are fully radiometric, enabling accurate temperature readings within their entire field of view.

Measurement points, areas of interest and profiles can be configured to measure multiple areas on multiple targets within the scene.

In this way, thermal imaging cameras allow the measurement of loads which are varied in quantity, size and location in the furnace.

The thermal imaging camera can measure the entire product as it exits the reheat furnace, identifying any erroneous or anomalous measurements. It also provides a live visual image, which is particularly advantageous compared to other temperature monitoring methods.

For example, when reheating billets, the steel may be heated correctly, but it could have a bent end (known as a hooked billet) which is likely to hinder the movement of the billet out of the furnace.

The live image allows the operator to identify this problem and manipulate the billet out of the furnace prior to any problems occurring. It also supports the detection of any issues with surface properties that could affect product quality.

Traditional thermal imaging cameras require a large hole to be cut in the furnace wall to provide a viewing window for the camera. This results in costly heat wastage, while the heat can also damage the camera itself. In addition, the required viewing window requires frequent cleaning and maintenance, and introduces an additional source of error to the system.

NEXT GENERATION: THE NIR BORESCOPE

To overcome the issue of heat loss, the AMETEK Land NIR Borescope (NIR-B) process thermal imager features through-the-furnace-wall borescope optics that allow a wide-angle view inside the furnace. This requires only a very small insertion hole through the wall, making it very easy to install and significantly reducing heat loss.

The NIR-B system can survive in conditions where the furnace temperature might be 1600°C, and also features secondary temperature inputs from the furnace background. This allows the imager to subtract the effects of background reflections, providing the most accurate surface temperature measurements of the stock.

Once installed, the NIR-B operates 24 hours a day for continuous monitoring. Generally, this information is output into a control system while operators take advantage of the live visual image to monitor for problems.

The NIR-B provides real-time, accurate process control using actual stock temperatures, along with automatic file archiving and storage of complete temperature data. This supports both quality control and process improvement.

THE INFORMATION FROM THE NIR-B ALLOWS THE PRODUCT TO BE PRE-HEATED, HEATED AND SOAKED FOR PRECISELY THE RIGHT TIME, WHICH WILL:

- SAVE ENERGY THROUGH REDUCED FUEL USE
- INCREASE THROUGHPUT AND REDUCE DOWNTIME
- IMPROVE PRODUCTION YIELDS AND FURNACE LIFE BY REDUCING FURNACE TEMPERATURE
- PROTECT DOWNSTREAM PROCESSING MACHINERY FROM UNDER-TEMPERATURE PRODUCTS

NIR BORESCOPE



Process thermal imaging borescope

FEATURES

- High temperature measurement accuracy
- Short wavelength sensor
- Dedicated software package
- High-performance water cooling
- Integrated air purge
- Two-year warranty

BENEFITS

- Optimum process control
- Simple installation and ease of use
- Low sensitivity to emissivity changes
- Low running costs even in the highest temperatures
- Dust-free optical system; consumes minimal instrument air
- Confidence in product reliability

CONCLUSION

The NIR Borescope offers significant benefits over more traditional single point pyrometers for Metal Reheat applications.

THE NIR-B:

- /// Allows simultaneous measurement of multiple objects in different locations
- /// Measures temperature profile over the entire metal stock
- /// Minimizes furnace heat loss - Long borescope lens needs only a small hole
- /// Can be easily integrated into 24/7 control and monitoring systems

This makes the NIR-B massively more capable for metal reheat furnace applications than a single-point thermometer or thermocouple.

By providing the most accurate measurements for temperature of the entire metal stock, the NIR-B thermal imaging camera delivers significant benefits in cost savings and product quality.

AMETEK LAND SOLUTIONS FOR METAL REHEAT FURNACES:

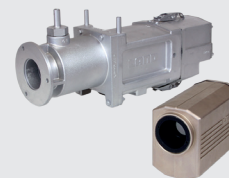
SPOT Pyrometers

Fully-featured, high-performance pyrometers for fixed, non-contact infrared spot temperature measurements.



FTS

A two-sensor temperature monitoring system designed to continuously measure true load temperatures in reheat furnace applications.

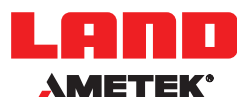


NIR-B

A short-wavelength radiometric infrared borescope imaging camera, designed to measure temperature profiles in furnace interiors.



DOWNLOAD THE NIR-B BROCHURE NOW: WWW.AMETEK-LAND.COM



www.ametek-land.com
land.enquiry@ametek.com

Land Instruments International
Stubley Lane, Dronfield
S18 1DJ
United Kingdom
Tel: +44 (0) 1246 417691

AMETEK Land China Service
Part A1 & A4, 2nd Floor Bldg. 1
No. 526 Fute 3rd Road East,
Pilot Free Trade Zone 200131
Shanghai, China
Tel: +86 21 5868 5111 ext 122

For a full list of international offices, please visit our website www.ametek-land.com

AMETEK Land - Americas
150 Freeport Road,
Pittsburgh, Pennsylvania, 15238
United States of America
Tel: +1 (412) 826 4444

AMETEK Land India Service
Divyasree N R Enclave, Block A,
4th Floor, Site No 1, EPIP Industrial Area
Whitefield, Bangalore- 560066
Karnataka, India
Tel: +91 - 80 67823240



APPLIES IN THE UK



APPLIES IN INDIA



APPLIES IN THE US

Copyright © 2008-18 LAND Instruments International.
Continuous product development may make it necessary to
change these details without notice.

MARCOM0471 Metal Reheat Furnace Application Note Rev 1