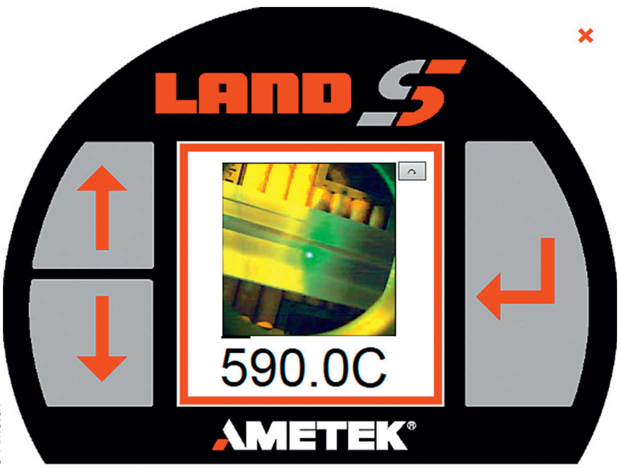
The importance of accurate temperature measurement for aluminium extrusions

Peter Unwin, Global Industry Manager – Metals at Ametek Land looks at the latest developments in non-contact temperature measurement for aluminium extruders

The aluminium extrusion industry is undergoing impressive growth and world market forecasts show this is set to continue. Extrusions offer lightweight properties, excellent thermal and electrical conductivity, along with strength and corrosion resistance, making them suitable for a wide range of applications, particularly in the automotive industry where fuel efficiency is crucial.

However, the process of extruding high-quality profiles is not without its challenges. Understanding temperature and controlling press speed and quench rates during the extrusion process are critical to producing products that have the required quality and performance properties. The extrusion press exit temperature, for example, affects the dimensional properties and surface finish of the final product. Should the temperature be too high, the surface finish may suffer imperfections that, apart from being unattractive, can potentially lead to cracks.

Extruding a product at an out-of-tolerance temperature means it may not achieve the design dimensions once cooled. If the extrusion temperature is even slightly too cool, the die in the extrusion press may wear more rapidly due to the increased hardness of the metal and additional pressure required to extrude it. As a die wears, the physical size of the extruded section changes – whilst new dies are very expensive. For these reasons, it is imperative to continuously monitor press exit temperature as accurately as possible.



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SPOT AL EQS pyrometer display

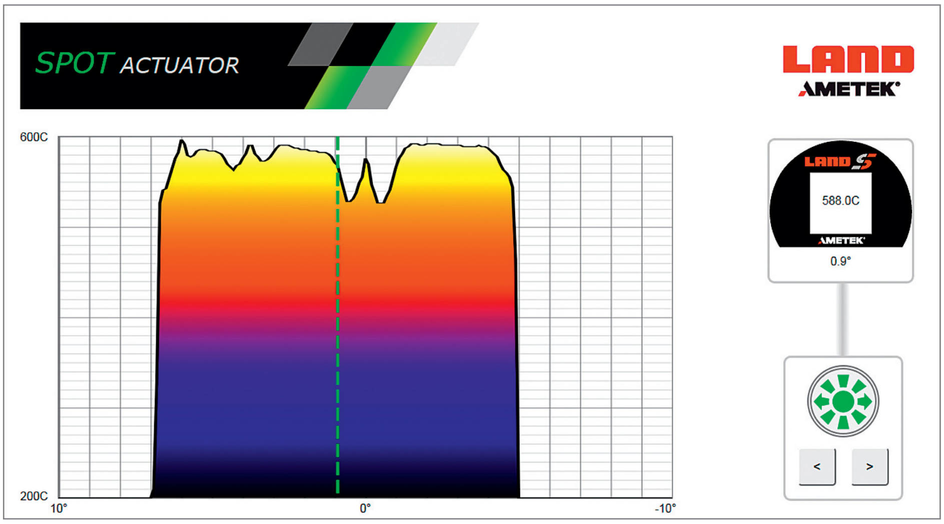
Temperature measurement methods that involve direct contact are not well suited to the extrusion process. These measurements are usually taken manually and at a single point. In addition, many contact measurement devices make an impact upon the hot aluminium, which can damage the surface. In comparison, non-contact temperature measurement sensors allow producers to continuously measure the temperature of the metal at each stage of the process.

Non-contact temperature sensors (infrared pyrometers) do not damage the surface of the aluminium because there is no contact. The pyrometer simply views the radiated energy that is emitted from the aluminium surface to receive and accurately measure temperature.

Unfortunately, aluminium alloys have unique emissivity and reflectivity characteristics that challenge conventional infrared pyrometers. Emissivity is an object's ability to emit (radiate) infrared energy. Knowledge of the precise emissivity value of an object is a critical factor for accurate non-contact temperature measurement.

Aluminium alloys have very low emissivity values, sometimes under 0.1, which means the aluminium alloy emits less than 10% of its energy. That is why when you approach a hot aluminium billet, it does not radiate heat towards you. This lack of emissivity, if uncorrected, can lead to an apparently low temperature reading from the infrared pyrometer. The reading needs to be compensated for by applying an appropriate emissivity (gain) correction factor. The emissivity value of the aluminium varies with the wavelength chosen, alloy grade and surface condition, including any slight oxidisation.

Because the emissivity of aluminium is so low, infrared pyrometers need to employ high gain amplification. With such large amounts of signal amplification, any small changes in emissivity will be amplified and cause errors in temperature readings. In comparison with other metals like steel, aluminium is processed at much lower temperatures, so fundamentally less energy is emitted even before factoring in the effects of very low emissivity. It is extremely challenging to compensate for emissivity variations on these small signals, making accurate temperature measurements difficult to achieve.



SPOT actuator scan graph

Commonly available single-wavelength infrared pyrometers are unable to cope with the combination of both low and variable emissivity that is prevalent with aluminium alloys. Alternative Ratio (2-colour) pyrometer designs are also unsuccessful, as the emissivity at their two measurement wavelengths varies at different rates. The ratio pyrometer's non-greyness (e-slope) adjustment cannot compensate accurately for the diversity of aluminium alloy types.

Research-based approach

In the 1980s, research was undertaken by some pyrometer companies to find methods of correlating the energy emitted at many wavelengths and developing application specific algorithms that would make sense of that radiation data. The aim was to produce a device that would accurately measure these materials with little or no adjustment requirements.

SPOT AL EQS pyrometer and SPOT actuator…

Some resulting devices demonstrated much better results than prior measurement methods. However, the limited number of infrared detectors, low-noise amplifiers and computational circuits available at that time affected the performance of these early devices.

Over the years, with improved designs and a better understanding of the applications, product performance improved greatly. Today's infrared pyrometer designer can choose from an extensive menu of high-quality and high-performance components. Advanced application-specific infrared pyrometers are now available for challenging materials like aluminium.

Most recently, Ametek Land has developed the SPOT AL EQS multi-wavelength pyrometer with the aid of extensive site trials and data collection from many different alloys. Complex signal processing algorithms have been developed and function in real time with the aid of powerful high-speed digital signal processing and ultra-low noise signal amplification. These application-specific algorithms and computational capabilities produce accurate results over a wide range of different alloys and surface conditions.

Measurement locations

At the start of the process, a billet is heated to temperature as it slowly progresses through a specialized reheat furnace. At the furnace exit, the billet temperature is measured, either a single reading on its cut face or a profile along the side of the billet from head to tail. Many extruders now prefer to measure the billet profile temperature just as the billet arrives at the extrusion press. Ametek Land offers a motorized actuator, which rapidly scans the SPOT AL EQS pyrometer along the length of the billet generating a temperature profile. The actuator can either be integrated with the press control system or driven manually from a hand-held controller.

A SPOT AL EQS pyrometer (set in 'E' mode) is typically positioned above the press exit, looking downwards onto the profile. Some customers choose a fixed installation with manually adjustable mount that can be re-oriented following a die change.

Other customers choose a combination of the SPOT AL EQS pyrometer along with a new motorized actuator. In that example, the pyrometer and actuator communicate with each other directly, causing the pyrometer to be automatically aimed at the optimum measurement position on the new profile. This temperature measurement is typically fed back to the press control system to enable dynamic press speed control. The small and well-defined measurement spot of the SPOT AL EQS, combined with its rapid 15 mS response speed, facilitates this dynamic tracking.

The quench exit is a popular measurement location, particularly with extruders who produce high-strength sections and those with specialized characteristics. A SPOT AL EQS pyrometer (set in 'Q' mode) is typically positioned at the exit of the quench section looking downwards onto the profile. Many customers choose a combination of the SPOT AL EQS together with a motorized actuator. In this application, the pyrometer and actuator communicate with each other directly causing the pyrometer to be automatically aimed at the optimum measurement position on the profile. Extrusions can wander laterally at this location and the actuator dynamically tracks any movement of the extrusion. Here too, the small and well-defined measurement spot of the pyrometer, combined with its fast 15 mS response speed, facilitates such dynamic tracking.

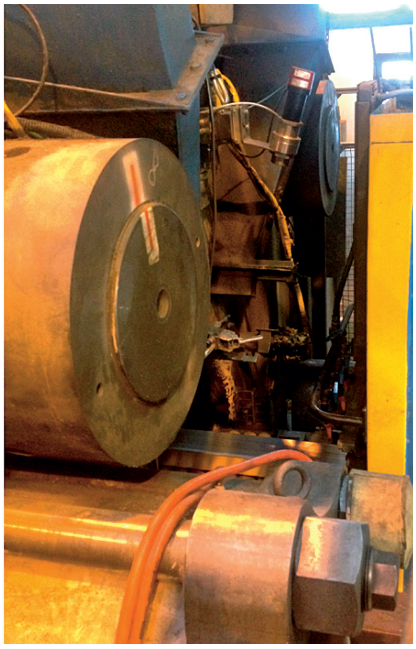
The same model of SPOT AL EQS pyrometer is used at all measurement locations. This makes keeping a spare pyrometer on hand very affordable. The SPOT pyrometers digitally communicate over an Ethernet connection via Modbus TCP.

There are versions of the AL EQS software available that combine data from multiple SPOT pyrometers and calculate quench rates, and some customers have integrated SPOT AL EQS pyrometers directly into their PLCs or press controls.

Fully integrated temperature measurements of billet 'taper', extruded sections and quench rate help to ensure superior extrusions with exact dimensions and superior finish surfaces.

Case study: Hydro Extrusions Hungary

Hydro Extrusions Hungary recently commissioned Ametek Land's SPOT AL EQS pyrometer and SPOT actuator to optimize the quality of its extruded aluminium profiles. The manufacturing plant in Székesfehérvár is Hydro's largest European extrusion plant. It features six presses, surface coating capabilities and 220 machines for fabrication and



… installed at press exits …

supplies customers in many industries, including automotive. The company required an infrared pyrometer that would enable fast profile tracking and highly accurate temperature measure-ment results. It wanted one that was compact in size, insensitive to outside light conditions and easy to set up.

Before commissioning the SPOT AL EQS pyrometer, Hydro carried out rigorous tests alongside two alternative infrared pyrometers from other manufacturers. "We decided to seek a new infrared solution as we needed to more accurately profile temperature measurement of our products after the quench zone," said László Domokos, process reliability team leader at Hydro Extrusions Hungary. "Our tests with the SPOT AL EQS pyrometer revealed that it offered accurate alignment on profiles every time, giving us greater reliability. With the addition of the SPOT actuator, this pyrometer ensures that our customers receive the highest quality aluminium products."

Ametek Land's SPOT AL EQS pyrometer was ideal for this application as it operated in the temperature range 200 to 700 °C / 392 to 1292 °F while offering quick and accurate temperature measurements. The innovative pyrometer was installed on two presses at the profile exit and quench. Hydro Extrusion Hungary integrated the data into their advanced data collection system, delivering enhanced process control.

Hydro was also impressed with the fact that the profile tracking is automatic, as a result of the SPOT actuator, which means operators do not have to spend time setting up the instruments. Since implementing the pyrometer, the plant has been able to enhance quality in the finished profile.

The SPOT AL EQS provides aluminium producers with complex embedded software algorithms for both temperature and emissivity outputs. Coupled with the smart SPOT actuator for automatic alignment, the pyrometer can provide accurate temperature measurements for most current extrusion, quench and strip applications.

Designed in close collaboration with industry-leading aluminium producers and plant control system engineers, the SPOT AL EQS pyrometer and the SPOT actuator are helping lead the way in improving aluminium extrusion and strip plant throughput, quality and energy efficiency. The pyrometer can capture huge amounts of data, while offering smart interpretation from multiple instruments, with application appropriate logging of derived parameters.

The pyrometer uses the latest cutting-edge temperature detector design in combination with the most-advanced data processing algorithms to provide extremely accurate and repeatable results with an industry-leading response time of 15 mS. Specifically designed to work in low emissivity environments in which regular pyrometers might struggle to provide accurate and reliable readings, the SPOT AL EQS is able to measure a wide temperature

... and quench

range from 200 to 700 °C / 392 to 1292 °F.

In combination with the SPOT actuator, the SPOT AL EQS pyrometer is an extremely flexible system with pre-configured algorithms that make it especially suitable for use at the extruder press exit and quench position, as well as at mill entry and exit positions in hot rolling mills.

Ametek Land's motorised SPOT Actuator simplifies the process of taking accurate temperature measurement readings. Traditionally, as die changes occur, they would require an operator to verify the correct pyrometer alignment and then either physically reposition the pyrometer's mounting bracket or manually manipulate it using a motorised SPOT actuator via a handheld, remote controlled keypad.

The actuator enables an extremely accurate alignment as it takes 900 measurement points over 90 degrees and aligns on the optimum measurement position on the profile. This measurement combination can be very useful at the exit of the quench, as the extrusion may be liable to wander from side to side at this location. Using the SPOT AL EQS pyrometer with the SPOT actuator can rapidly and repeatedly locate, target and measure the laterally shifting profile, producing an accurate temperature reading. The intelligent scanning function provides an additional mode that allows localisation to the hottest spot within a profile. For example, this is applicable to more complex profiles with hotter inner structures that need to be cooled down to a certain temperature after the quench.

Compact, quick and easy to configure, the SPOT actuator is designed for mounting the SPOT AL EQS pyrometer onto the press face or a suitable part of the press superstructure.

Another feature of the SPOT Actuator is a hotspot 'autoscan', which, when triggered, causes the device to scan the entire range of movement and then align the SPOT AL EQS pyrometer with the hottest part of the extrusion. This can be activated either locally by the operator or from an external command. This functionality significantly simplifies the alignment of the pyrometer, allowing the operator to focus on more critical tasks.

Future aluminium applications may require improved surface finishes and metallurgy. Knowledge of exact temperatures throughout the process will allow producers to improve quality and increase production yields.

Hydro Extrusions Hungary will experience all the benefits of data capture, interpretation, management and autonomy that it offers. The company can easily log into the pyrometer and SPOT actuator webserver for each measurement position and access all the data they need. The SPOT AL EQS pyrometer can automatically scan to identify profile positions after a die change; alert the customer to uneven die cavity or quench conditions; provide temperature measurements for perfect press and quench control; and make slight positional adjustments to track wandering profiles.

Summary

As market demand for extruded aluminium continues, producers are finding that by being able to accurately monitor temperature measurement at key locations is helping them to optimize quality and achieve product specifications. The latest advanced infrared pyrometers are enabling producers to meet Industry 4.0 requirements, with enviable access to data at all stages of extrusion, with numerous benefits.

Ametek Land will be exhibiting at Aluminum USA 2019 in Nashivlle, Stand 130