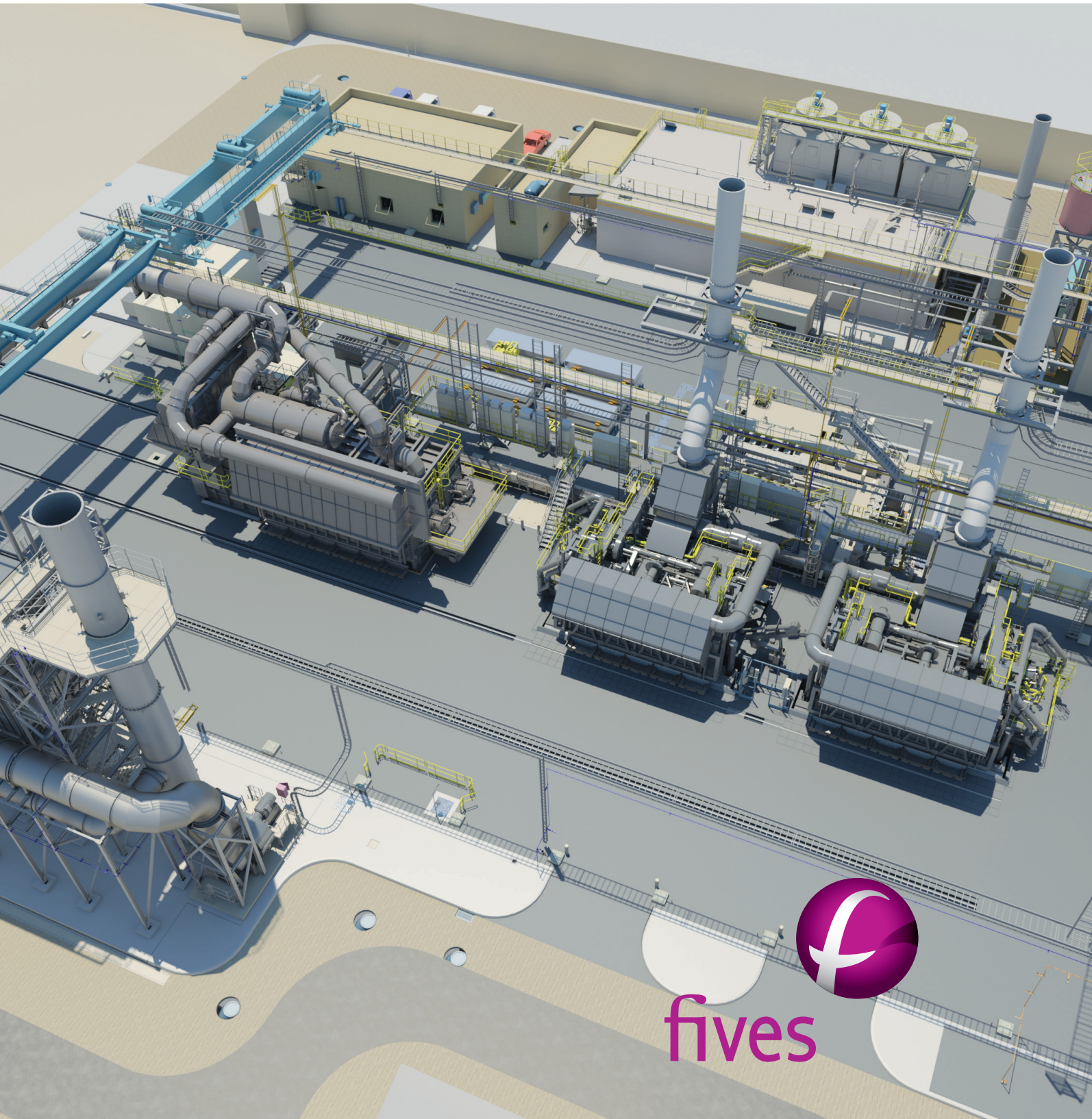
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Non-contact temperature measurement for extrusions

Richard Gagg* discusses advances in non-contact temperature measurement for aluminium extruders.

While aluminium extrusions are common, the process of extruding high-quality profiles is far from easy. Understanding temperature and controlling press speed and quench rates during the extrusion process are critical to producing products that have the required quality and 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 improper temperature can cause it to not achieve the design dimensions once cooled. If the extrusion temperature is even slightly too cold, the die in the extrusion press may wear more rapidly due to the increased hardness of the metal and additional pressures required to extrude it. As a die wears, the physical size of the extruded section changes, and new dies are very expensive. For those reasons, it is imperative to continuously monitor press exit temperature as accurately as possible.

Contact temperature measurement methods are not well suited to the extrusion process. When these measurements are taken, they are typically done manually at a single point. In addition, many contact measurement devices require prodding 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) never touch the aluminium, so there is no opportunity to damage the surface. The pyrometer views the radiated energy that is emitted from the aluminium surface to measure it.



SPOT AL EQS Pyrometer display and settings

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.

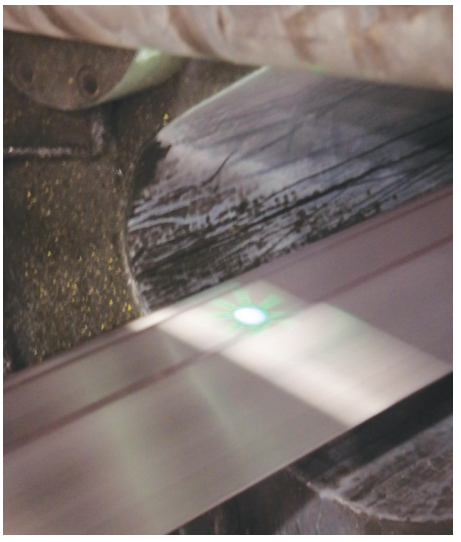
Aluminium alloys have very low emissivity values sometimes under 0.1. That means the aluminium alloy emits less than 10% of its energy. That is why when someone walks close to a hot aluminium billet it does not radiate heat towards you. It has none of the "body language" associated with a very hot object. That 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 native 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

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SPOT AL EQS on a manually adjusted mounting at the press exit.



Bright Green targeting LED pattern on extrusion.

processed at much lower temperatures, so fundamentally less energy is emitted even before factoring in the effects of very low emissivity. It is challenging to compensate for emissivity variations on these small signals, making accurate temperature measurements difficult to achieve.

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 also are 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.

In the 1980's 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.

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 pyrometers 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 ange of alloys and surface conditions.

Extrusions begin with aluminium billets

Aluminium extruders measure temperatures at various locations. The three most common tend to be:

Billet Profile

1. At the start of the process, a billet is heated to temperature as it slowly progresses through a specialised 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 motorised 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.

2. The press exit as the extrudate appears from the die. 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 measurement spot of the SPOT AL EQS, combined with its rapid 15mS response speed, facilitates this dynamic tracking.

Typical SPOT AL EQS Installations at the Press Exit

The Quench Exit

1. This measurement location also popular, particularly with extruders who produce high- strength sections and those with specialised 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 Pyrometer together with a motorised 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 f15mS response speed, facilitates such dynamic tracking.

The same model of SPOT AL EQS pyrometer is used at all three measurement locations. The SPOT AL EQS 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 PLC's 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.

Future 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. ■