

Noncontact Temperature Measurement Advances for Aluminum Extrusions



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AMETEK Land looks at advances in noncontact temperature measurement for aluminum extruders.

The amount of aluminum extruded has increased considerably in recent years due to the metal's wide availability and relatively low cost. Extrusions offer a combination of light weight and excellent thermal and electrical conductivity, along with strength and resistance to corrosion. Aluminum also is commonly alloyed with other metals to produce products with specific advantages for a wide range of end-user applications.

Aluminum weighs less than half of an equivalent steel part and has been adopted for weight and energy savings on many types of vehicles. The ease of extruding a high-tolerance and detailed profile minimizes the need for additional finishing operations. Because of its high-strength to low-weight characteristics, the aerospace industry rapidly adopted the use of aluminum. For the same fuel-efficiency reasons, aluminum is now used for land-based transport, including autos, trucks and trains.

Aluminum products are renowned for being easy and inexpensive to recycle, which is another major factor in its increased use. Aluminum recycling requires only 5% of the energy that was originally used in the primary smelting process. As a result, greenhouse-gas emissions are reduced by almost 95%. Aluminum can be recycled unlimited times as well.

While aluminum extrusions are common, the process of extruding high-quality profiles is far from easy. An understanding of temperature and the control of 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 incorrect temperature means it may 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 are 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

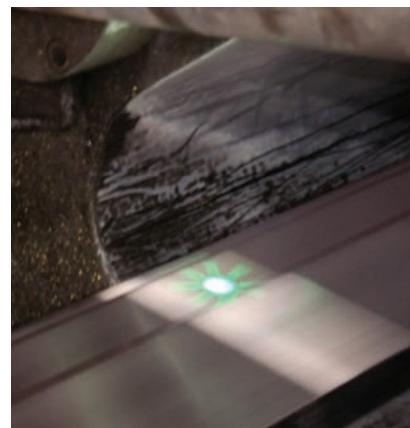


Fig. 1. Bright-green targeting LED pattern on extrusion

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 aluminum, which can damage the surface.

In comparison, noncontact temperature measurement sensors allow producers to continuously measure the temperature of the metal at each stage of the process. Noncontact temperature sensors (infrared pyrometers) do not touch the aluminum, so there is no opportunity to damage

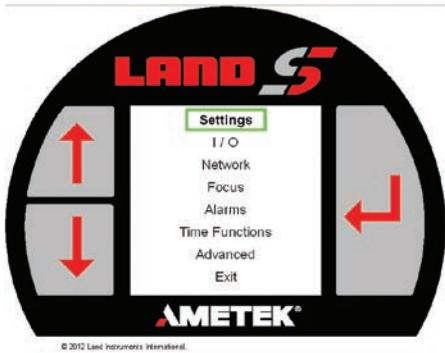


Fig. 2. SPOT AL EQS display and settings via web browser



Fig. 3. Digital outputs from the SPOT AL EQS pyrometers allow them to be integrated into control systems



Fig. 4. Pyrometer image view of the target with LED illuminated

the surface (Fig. 1). The pyrometer simply views the radiated energy that is emitted from the aluminum surface to receive and measure it.

Measuring Challenges with Aluminum Emissivity

Aluminum 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 noncontact temperature measurement.

Aluminum alloys have very low emissivity values – sometimes under 0.1. That means the aluminum alloy emits less than 10% of its energy, which is why a hot aluminum billet does not radiate heat toward a person walking close to it. 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 aluminum varies with the wavelength chosen, alloy grade and surface condition, including any slight oxidization.

Because the natural emissivity of aluminum is so low, infrared pyrometers need to employ high gain amplification. With such large amounts of signal amplification, any small changes in emissivity can cause errors in temperature readings. Compared with other metals like steel, aluminum is processed at much lower temperatures. Therefore, 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.

Commonly available single-wavelength infrared pyrometers are unable to cope with the combination of both low and variable emissivity that is prevalent with aluminum alloys. Alternative-ratio (two-color) pyrometer designs are also unsuccessful because 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 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. Their aim was to produce a device that could 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 aluminum.

Most recently, following extensive site trials and data collection from many different alloys, AMETEK Land has developed SPOT AL EQS multi-wavelength pyrometers (Figs. 2-3). Complex signal-processing algorithms were 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. The design of the SPOT AL EQS pyrometer also includes precision optics to eliminate chromatic aberrations, integrated video sighting that allows an operator to easily verify exactly what the pyrometer views and a durable sapphire protection window to ensure the pyrometer's longevity (Fig. 4).

Extrusions Begin with Aluminum Billets

Aluminum extruders measure temperatures at various locations. Here are the three most common locations.



Fig. 5. SPOT AL EQS with actuator above the press exit



Fig. 6. SPOT AL EQS at the exit of the quench

Billet Profile

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 by 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 to generate a temperature profile. The actuator can either be integrated with the press control system or driven manually from a hand-held controller.

Press Exit

The press exit is where the extrudate appears from the die. A SPOT AL EQS pyrometer (set in “E” mode) is typically positioned above the press exit looking downward onto the profile (Fig. 5). Some aluminum producers are choosing a fixed installation with manually adjustable mount that can be reoriented following a die change.

Other aluminum producers have chosen a combination of the SPOT AL EQS pyrometer along with a new motorized actuator. In that instance, the pyrometer and actuator communicate with each other directly, and the pyrometer is 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.

Quench Exit

The quench-exit measurement location is very popular, particularly with extruders who produce high-strength sections and those that produce aluminum with specialized characteristics. A SPOT AL EQS pyrometer (set in “Q” mode) is typically positioned at the exit of the quench section looking downward onto the profile (Fig. 6).

Many customers choose a combination of the SPOT AL EQS pyrometer together with a motorized actuator. In this application, the pyrometer and actuator communicate with each other, and the pyrometer is 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 the dynamic tracking.

The same model of SPOT AL EQS pyrometer can be used at all three measurement locations. This makes keeping a spare pyrometer on hand very affordable. 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 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.

Conclusion

Having consistently accurate data on exact temperatures throughout the process will allow producers to improve quality and increase production yields, providing greater consistency and a competitive advantage. ■

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