New EERC algorithm for infrared temperature measurement in the extrusion of aluminium

by Albert Book

Temperature is one of the most important production parameters in the extrusion of aluminium. Contact thermometers are only partly suitable. For this reason, non-contact infrared measurement is being used more and more. However, optical temperature measurement in the extrusion of aluminium is a complex measuring task. Special multi-channel pyrometers were developed for this purpose more than 40 years ago. The following report describes the special features of the thermal radiation of aluminium and compares the technological status of earlier measurement methods with the newly developed EERC algorithm of infrared temperature measurement.

Importance of temperature in the production of aluminium profiles

Even though the production of extruded aluminium profiles is very advanced, the thermal process of extruding high-quality profiles is still complex. When pressing the heated aluminium block through the die, friction occurs between the bolt and the container. As a result, there is a temperature rise from the beginning to the end of the strand. If the block temperature is too cold, the die in the extruder may wear more quickly due to the higher hardness of the metal, resulting in changing the dimensions of the profile. Therefore, controlling the temperature to regulate the extrusion speed and pressure during extrusion is crucial for the quality of the profiles.

Contact measurement of the profile temperature

Usually, the temperature is carried out by contact measurement using a penetration probe. The big disadvantage is that the measurement is carried out manually and only sporadically. Thus, there is no continuous monitoring, so that no automatic control is feasible. Furthermore, the surface of the hot aluminium is damaged by the penetration probe and causes rejects. The service life of the wear-prone measuring tips of the probe is limited. Regular replacement causes consumption costs.

Infrared temperature measurement

Compared to contact measurement, pyrometers optically detect the infrared radiation of the measuring object in milliseconds and from a safe distance and determine the temperature from it. This enables continuous measurement of the aluminium profile temperature at the extruder outlet (**Fig. 1**) for the control of the pressing speed and the pressing pressure. Damage to the surface is excluded with this non-contact measuring meth-

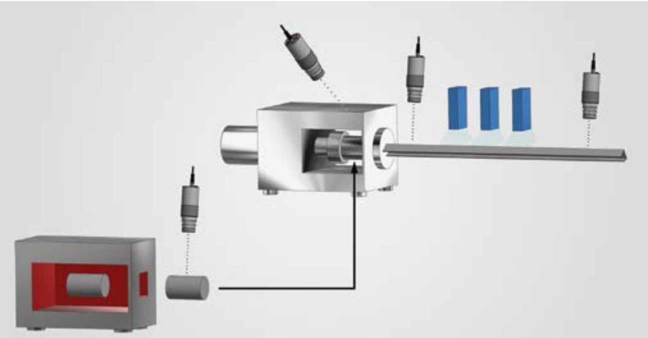

Fig. 1 *Pyrometric temperature measurement at the extruder outlet.*

od. The measurement does not produce any rejects and there are no regular consumption costs. Therefore, infrared temperature measurement is basically the ideal measuring method. However, the pyrometric temperature measurement of aluminium is a demanding measuring task and involves some special features.

Special features of heat radiation of aluminium

Aluminium alloys are extremely poor heat emitters. The emissivity, i.e. the ability of an object to emit infrared radiation, is sometimes only 10 %. Under this assumption and at a profile temperature of 500 °C, the pyrometer shows a measured value of approx. 340 °C without correction of the emissivity. For a correct temperature measurement, the emissivity must therefore be set on the pyrometer.

At an extrusion temperature of 500 °C and due to the very low emissivity of aluminium, the energy of infrared radiation is low. The signal preparation and processing in the pyrometer must be of a correspondingly high quality. Even with appropriate compensation, even minor fluctuations in emissivity lead to larger differences. If, for example, the emissivity changes from 10 % to 15 %, the pyrometer already indicates a temperature that is about 20 °C higher.

The two-colour measuring method was developed more than 40 years ago to compensate for emissivity fluctuations. The quotient is determined from the infrared radiation recorded at two different wavelengths. As long as the emissivity of the measuring object changes regardless of the wavelength (grey radiator), a two-colour pyrometer determines the correct temperature. However, aluminium is a so-called “non-grey radiator” (**Fig. 2**). Therefore, the emissivity ratio of the two measuring channels can also change, for example, with different alloys or surfaces. A conventional two-colour pyrometer reacts to this with not inconsiderable measurement deviations and is therefore only partially suitable for the measurement of aluminium profiles.

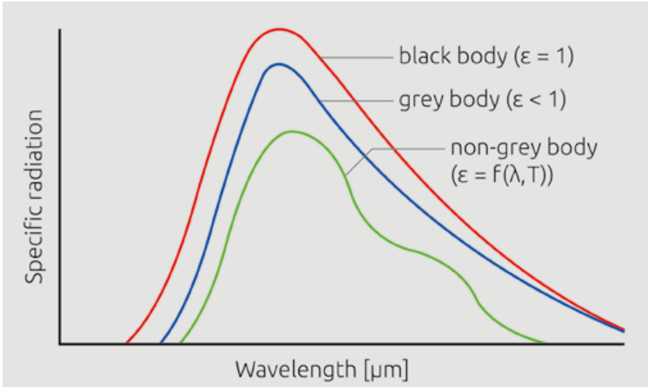

Fig. 2 *With aluminium, the emission is wavelength-dependent (non-grey body).*

Geometry influence of the profiles

Very different profile geometries are sometimes produced on an extruder (**Fig. 3**). So it happens that the measuring field of the pyrometer is oriented purely to the surface or to a recess. In case of a recess, multiple reflections lead to an “artificial” increase in emissivity. A pyrometer will then show a much higher reading at the same emissivity setting.

Function and limitations of multi-channel pyrometers

In the 1980s, multi-channel pyrometers were developed to compensate for emissivity-related and profile-dependent interferences, which recorded infrared radiation at up to 4 wave-

Fig. 3 *The profile of the aluminium can influence the infrared temperature measurement.*

lengths. Internally, the devices worked with a chopper wheel with different filters, which rotates in front of the sensor. The mechanical design was complex and the motorized drive was susceptible to faults. The measuring signals were evaluated via a separate computer. Although the devices delivered better measurement results than conventional two-colour pyrometers for the time, a complex so-called teach-in procedure for comparing the devices was necessary for the different alloys and profiles. For material and profile changes, a different correction algorithm had to be selected.

The detection sensitivity of the infrared sensors at the time, the computing power of the microprocessors and the inferior quality of the amplifier technology impaired the measurement. In addition, chopping meant that the individual channels could only be measured one after the other. In combination with the movement of the aluminium profile, there was consequently always a temporal and spacial offset in the detection of the different measuring signals. Therefore, this technology quickly reached its metrological limits.

Modern devices with EERC algorithm

Today's modern sensor technology, high-quality amplifier components and high-resolution transducers make it possible to develop devices which operate on constant light technology, i.e. without motor and moving filters. KELLER ITS has developed the EERC (Extended Emissivity Ratio Correction) algorithm to compensate for the wavelength-dependent change in the emissivity ratio of aluminium caused by different alloys. As an extended two-colour measuring method, the signals of the spectral channels are also dynamically included in the measured value determination. The compact pyrometer CellaTemp PX 69 is based on the latest powerful processor technology. This makes it possible to carry out the complex calculation algorithms in real time (**Fig. 4**). To check the alignment and focus, the pyrometer is optionally equipped with a see-through sight, a laser pilot light or, to monitor the measuring point on a control monitor in the control room, with a video camera.

A reference measurement using a penetration thermometer determines the value of the new EERC parameter to be set. As with previous infrared measuring methods, it is still necessary to determine the value per profile for different strand geometries. The values are stored in the control system and transmitted to the devices via the modern IO-Link communication interface when the profile is changed.

Fig. 4 *CellaTemp PX 69 pyrometer with new EERC algorithm and modern IO-Link communication interface*

Conclusion

For physical reasons, the infrared temperature measurement of aluminium profiles is still a demanding measuring task today. For temperature-dependent automation of the production process, continuous temperature measurement by means of a pyrometer is the only applicable measuring method. Even though there is still a desire to use pyrometers to precisely measure the temperature of a wide variety of aluminium profiles, if possible without any corrective measures, this is now possible in a largely automated manner using the latest device technology and networking to the control system.

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