LAND
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AMAP Kolloquium

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AMAP GmbH, Aachen, Germany

Manfred Hayk
Global
IR Product
Manager

Advanced Non-contact Application Pyrometers and Thermal Imaging Solutions for the Aluminium Industry

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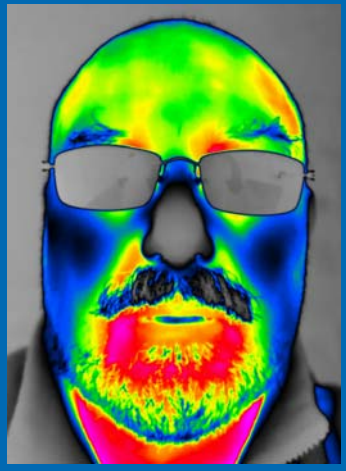
INTRODUCTION



Manfred Hayk
Global Infrared (IR) Product Manager

With a degree Dipl.-Ing. (FH) from the university of applied science MFHI, specialising in laser technology and optical metrology, Manfred Hayk has over 25 years of technical, product and application development and sales support experience in optical and infrared metrologies. He focuses on developing our full range of non-contact temperature measurement products, including process thermal imagers and applications.

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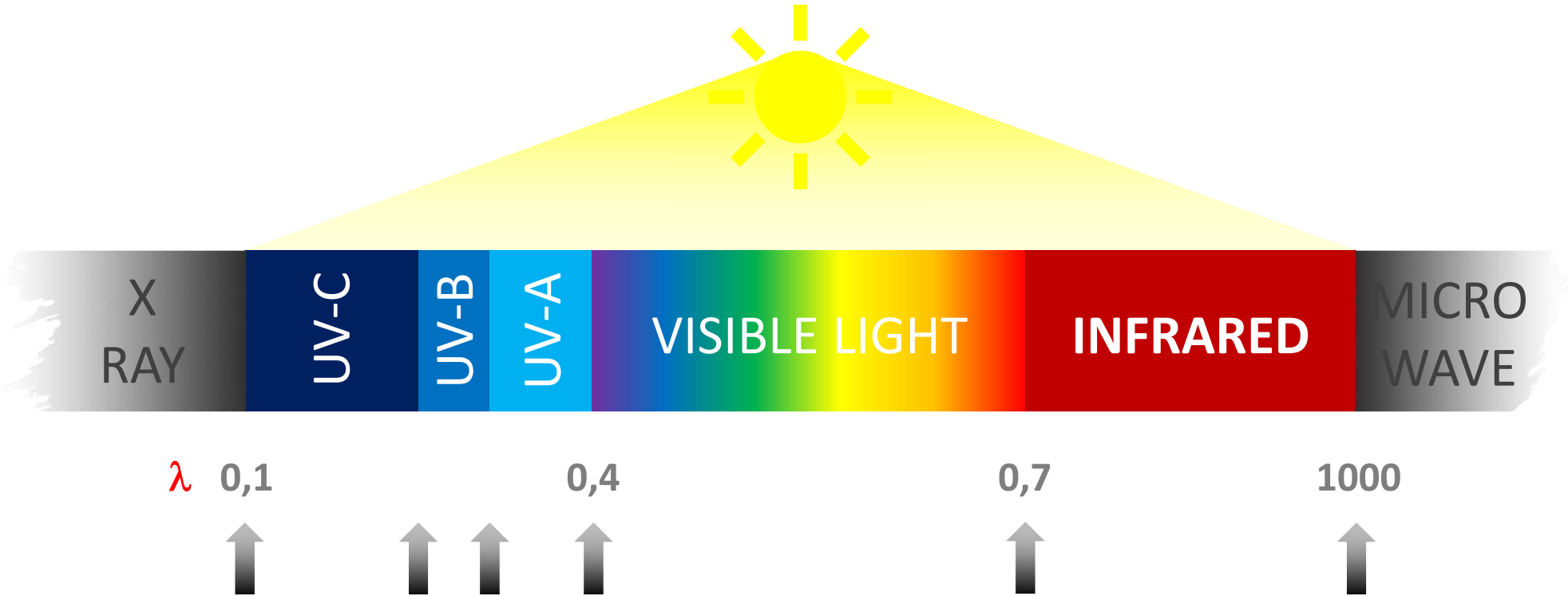
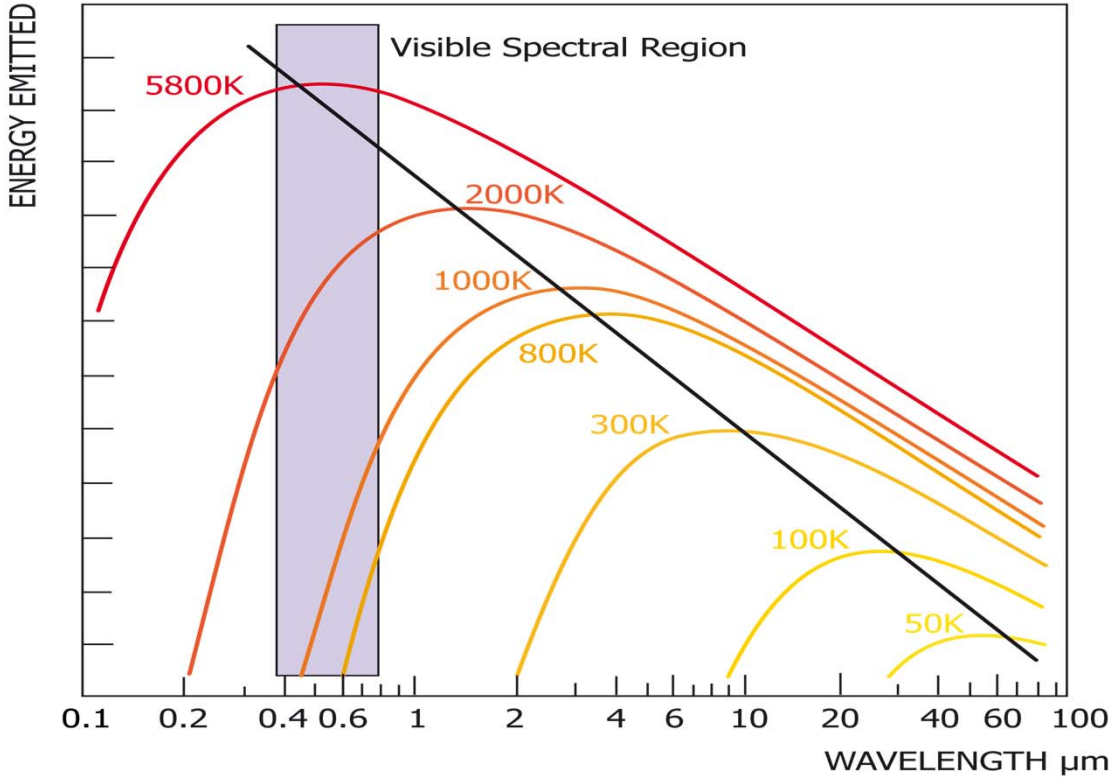
CONTENT

- Infrared Non-contact Temperature Measurement Technologies, Capabilities and Limitations in Challenging Aluminium Applications
- How to Reliably Measure Aluminium Temperatures
- *Application Solutions* – Liquid Aluminium in Foundry Processes
- *Application Solutions* – Aluminium Extrusion Processes
- *Application Solutions* – Hot and Cold Rolling Applications
- *Application Solutions* – Induction Heating, Shrinking, Forging and Forming
- *Future Applications* – Aluminium Smelting Furnace Applications and Artificial Intelligence
- *Q&A* – Closing Comments

WAVELENGTHS



PLANK'S RADIATION LAW & WIEN'S DISPLACEMENT LAW



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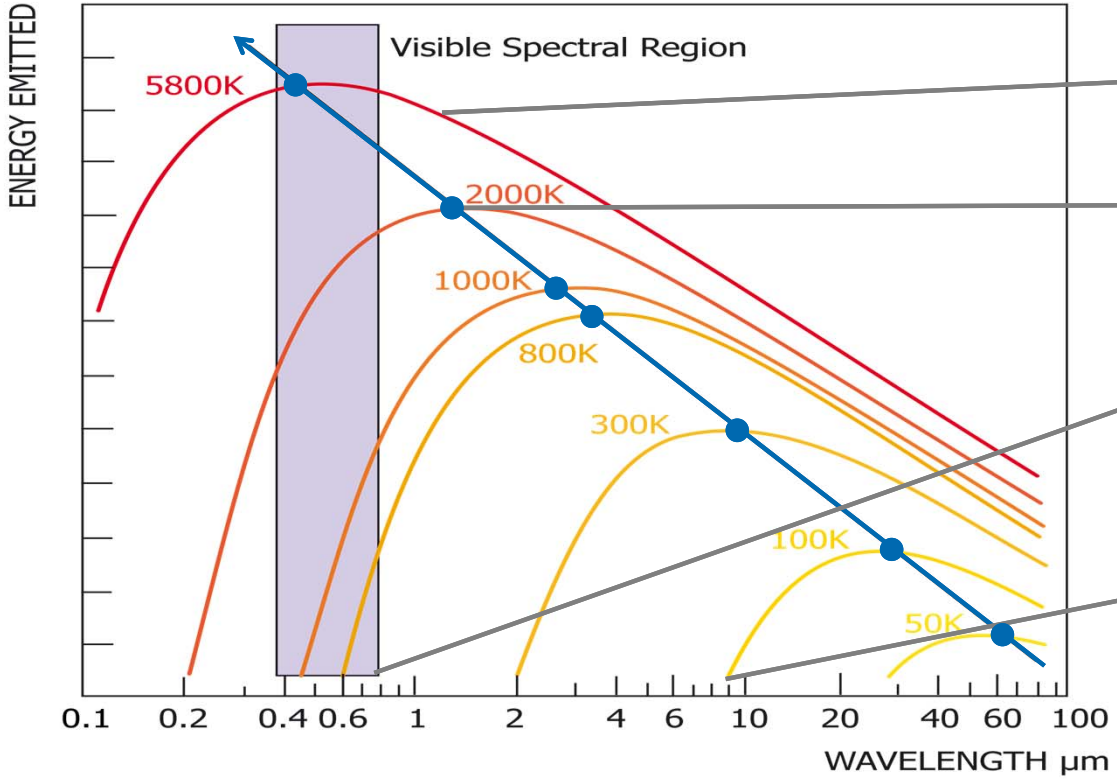


With growing object temperature …
there is an increase of the radiation power (radiation power factor)

With growing object temperature …
the maximum and the entire curve shifts towards shorter wavelengths

With growing object temperature …
the emission curve shifts into the visible spectrum/shorter wavelengths (glowing colors are „visible")

Lower object temperatures …
need to be measured at „longer wavelength", usually in the LWIR spectrum

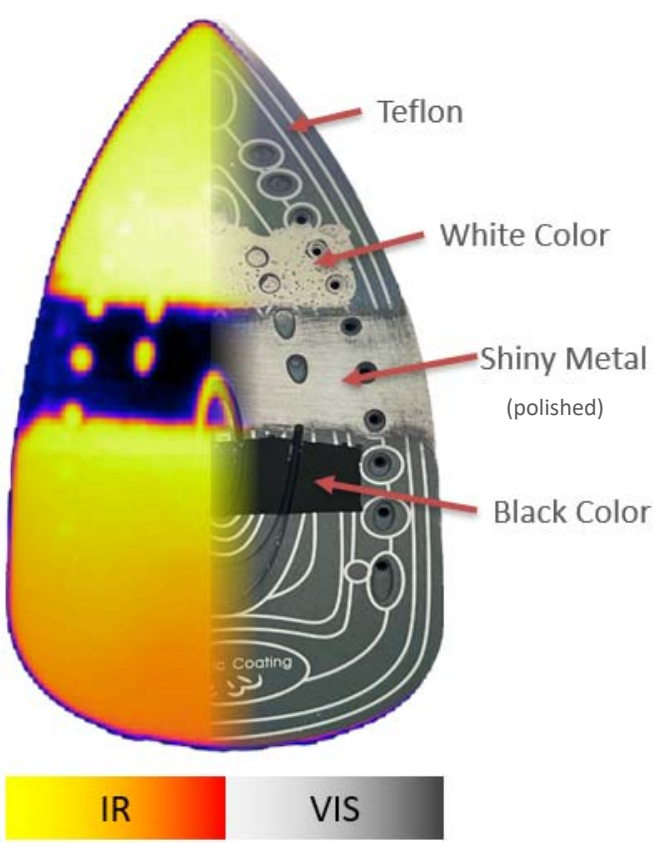
IT IS ALL ABOUT EMISSIVITY

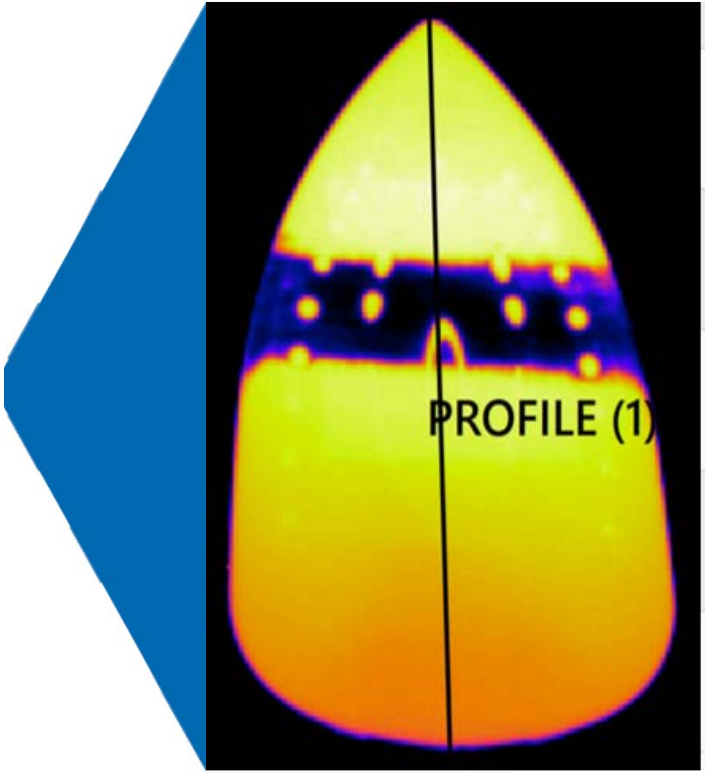
The temperature of the pot surfaces are the same. They emit energy, mainly infrared radiation with different intensities, because of their different materials and surfaces.

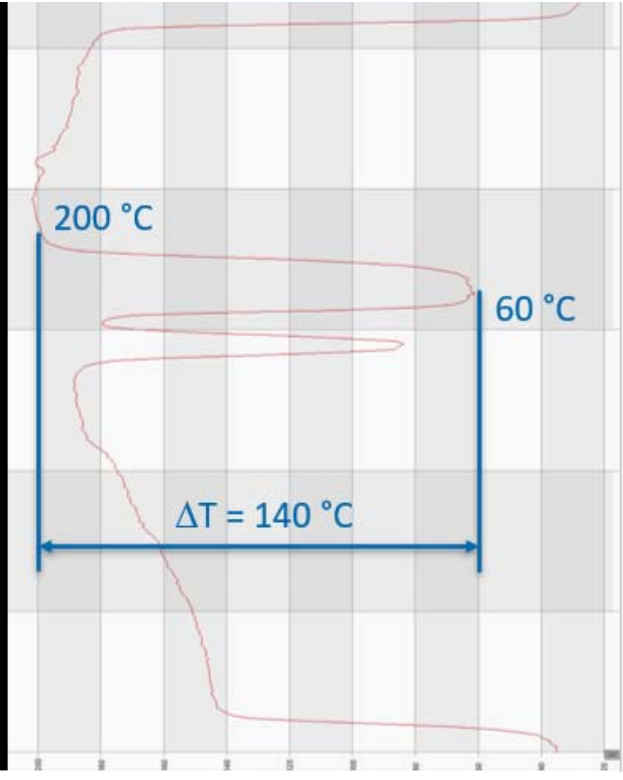
The EMISSIVITY* describes how much radiation energy is emitted from a surface at a certain spectral range (wavelength)

**The emissivity ε is defined as the ratio of the emitted radiation of a real object to the emitted radiation of a black body at the same temperature*

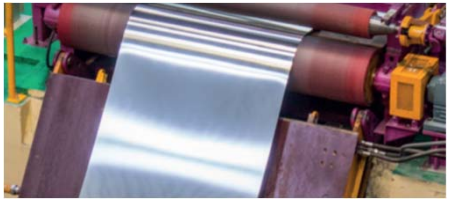
IT IS ALL ABOUT EMISSIVITY



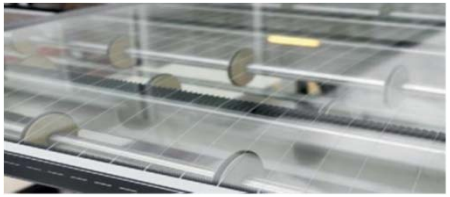




EMISSIVITY INFLUENCES



Material & Surface Condition

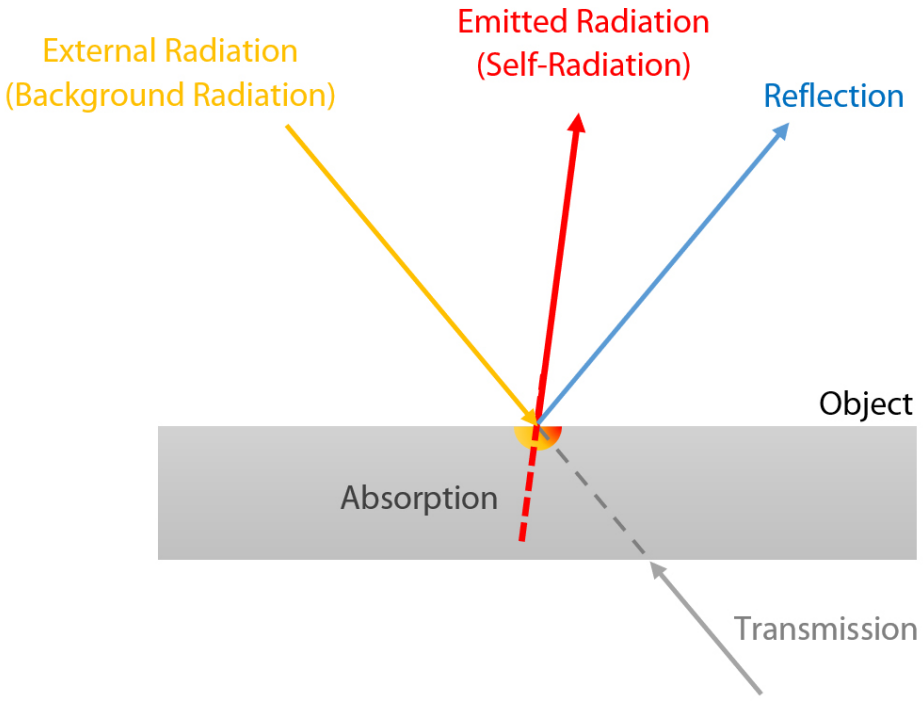


Wavelength & Spectral Response

Viewing Angle

Temperature

EMISSIVITY REFLECTION & TRANSMISSION



1 (100%) = Absorption (α) + Reflexion (γ) + Transmission (τ)

Absorption (α) = Emission (ε)
(KIRCHHOFF'S RADIATION LAW)

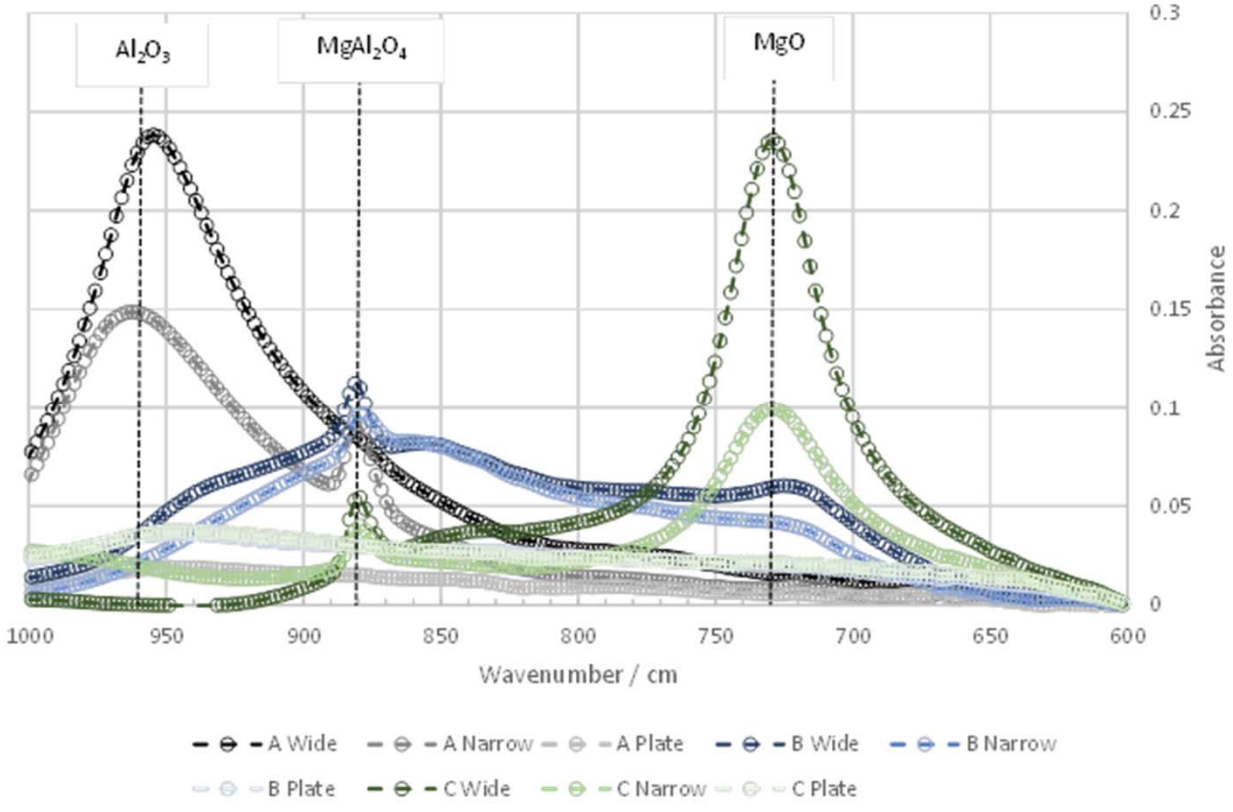
1 (100%) = Emission (ε) + Reflexion (γ) + Transmission (τ)

To measure the object temperature at a high accuracy and a reasonable signal to noise ratio, the emissivity should be as big as possible and the reflection should be as low as possible (most of the materials do not transmit any IR radiation)

ALUMINIUM IS DIFFERENT !

- Aluminium presents significant challenges to measure its temperature by non-contact radiation thermometry
- Aluminium has a fundamentally low emissivity value – AND – the emissivity varies with alloy grades, surface finish, oxidation and measurement wavelength
- Low magnesium content alloys like the common 6000 series typically have emissivity values around 0.1 (10 %)
- This means they are capable of reflecting over 90% of energy from their surroundings – AND – the low signal is more sensitive against emissivity changes
- Single wavelength pyrometers or imagers are unable to cope with the low and variable emissivities of aluminium alloys
- Standard ratio (2-color) pyrometers are also unsuccessful as the emissivity at the two wavelengths varies at different rates
- A simple non-greyness or e-slope adjustment cannot compensate correctly for the variety of popular alloy types

UNDERSTANDING ALUMINIUM



Different emissivity behaviors for different aluminium alloys

**absorbance = emissivity following the Kirchhoff's radiation law*

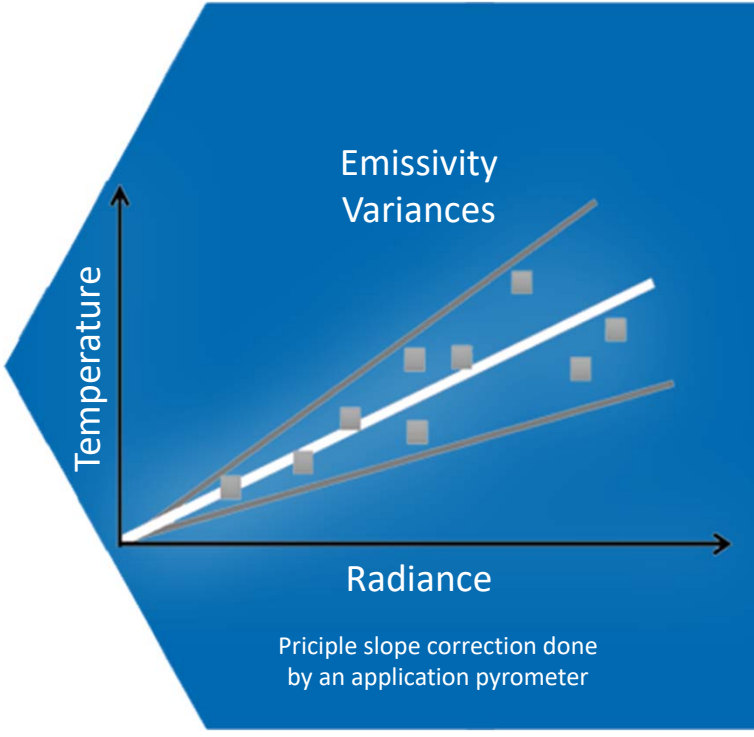
ADVANCED NON-CONTACT ALUMINIUM TEMPERATURE MEASUREMENT

- The ***SPOT AL*** – smart advanced application pyrometer handles multiple unknown parameters like temperature, emissivity changes and the complex relationship at different wavelengths.
  AMETEK Land introduces the First Aluminium Pyrometer in the early 90th

- For each temperature measured by an application pyrometer, the instrument calls on a huge '3D dataset' of historically measured values, emissivity and radiance at each waveband of the instrument to cope the specific behavior of different alloys and surface conditions

- Those application pyrometers are available for specific industrial process and materials that have been thoroughly researched, such as aluminium, galvanised/ galvannealed or silicon/electrical steels and liquid metals

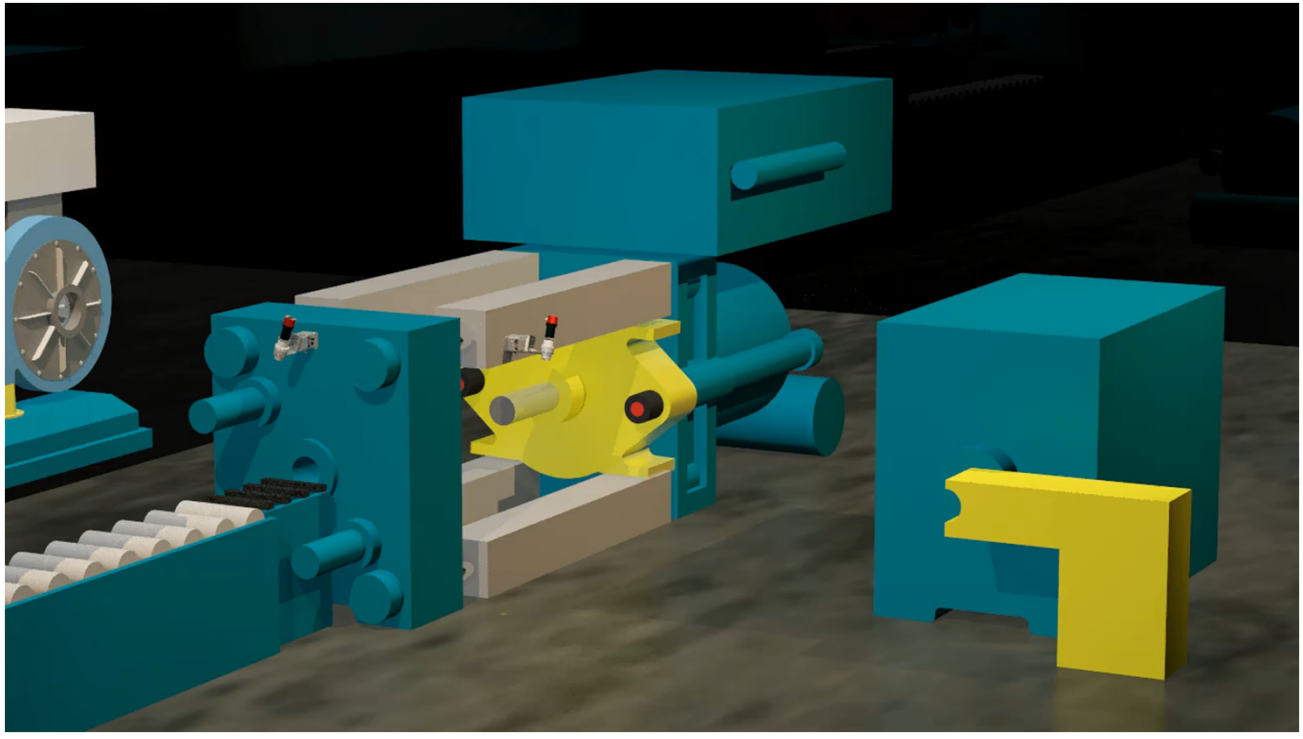
- The ***SPOT AL*** smart multi-mode application pyrometer provides several modes (algorithms) and can be adapted to additional applications, based on optimized application modes by a firmware update

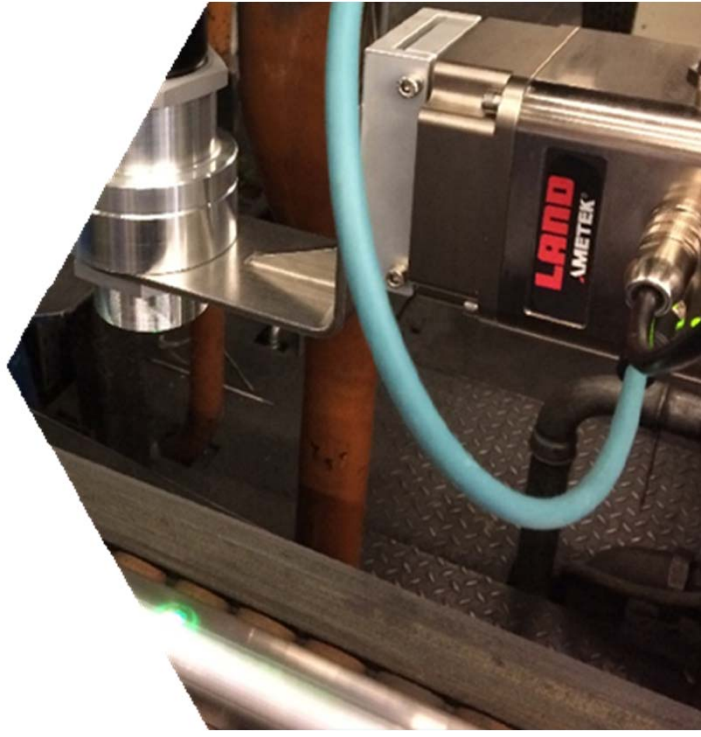


Application Solutions – Liquid Aluminium in foundry processes

- Plug'n'Play setup – just choose the operating mode
- Highly accurate readings with 15 ms responsivity
- Dedicated liquid aluminium application mode with intelligent data processing for optimized process control
- Fixed or pan-and-tilt installation via ***SPOT Actuator*** for manual or automatic alignment with the tapping stream
- Smart system with integrated web servers in both the SPOT AL and ***SPOT Actuator***
- Multiple interfaces using analogue and digital I/O and Modbus TCP/IP Ethernet/IP or Rest API
- Remote access and integrated visual camera allows fully remote process control and safe 24/7 operation

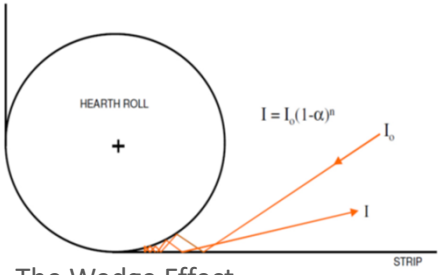
Application Solutions – Aluminium Extrusion Processes



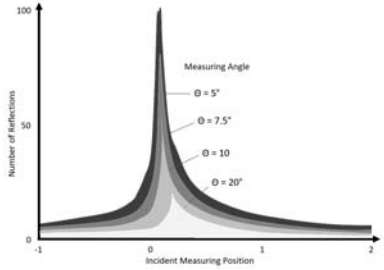


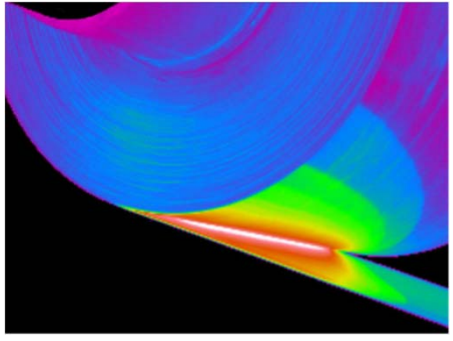
Application Solutions – Hot and cold rolling applications

COLD & WARM ROLLING

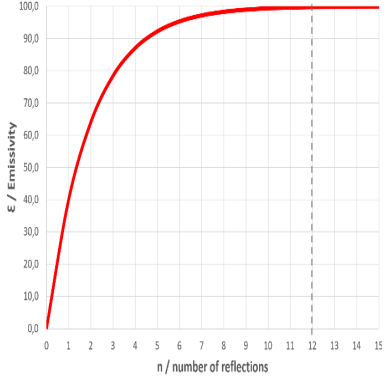


The Wedge Effect





Thermal Imaging System (LWIR)



The radiation is entering the wedge and is reflected in the wedge between the strip and the roll a number (n) of times:

$I = I_0(1-\alpha)^n$.

By increasing number of reflections, the energy exiting the wedge decreases and becoming very small

$I/I_0 = (1-0.4)^{12} = 0.002$

(E.g. if n=12 and a=0.4)

The absorption gets to 99,8% in this case. Following Kirchoff's law: absorption = emission: Ɛ = 99,8%

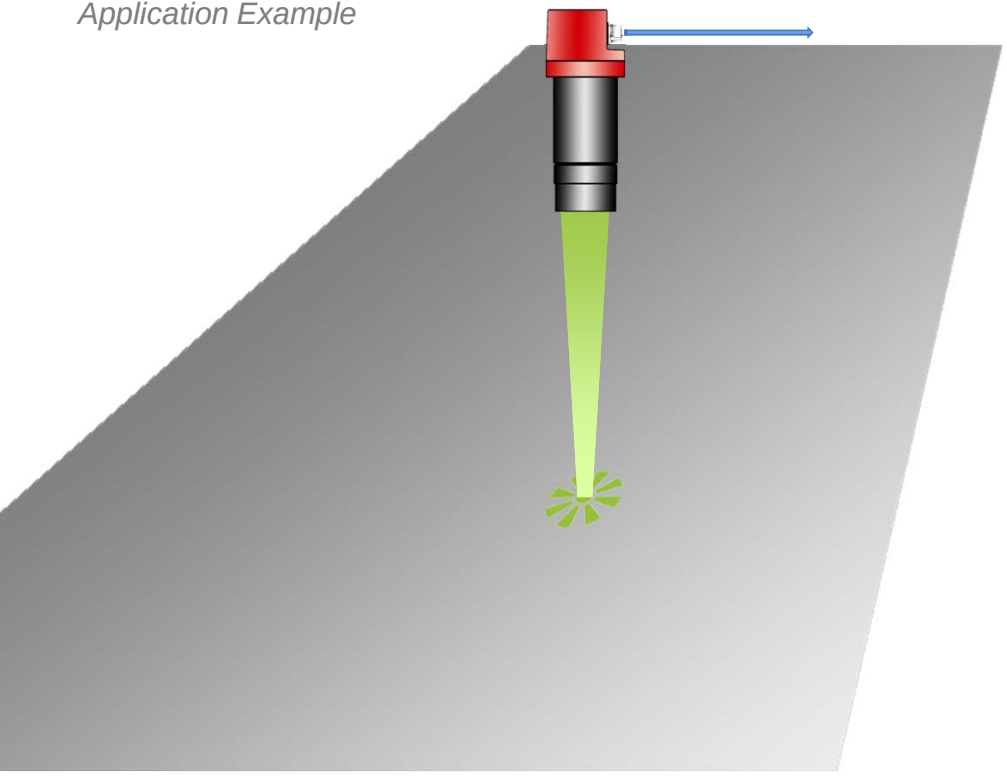
Application Solutions – Induction heating, shrinking, forging and forming

- During heating or forming processes the aluminium surface is changed in the process
- With increasing temperature and time, the oxide layer is growing, and the emissivity is increasing
- The ***SPOT AL*** provides different pre-defined modes to cope those kind of applications and provide accurate temperature readings

ALGORITHM	MODE DESCRIPTION	EMISSIVITY	SPOT AL	SPOT AL LT
E	Extrusion	Low	☐ 200 -800 °C / 392-1472 °F	☐ 150-700 °C / 302-1292 °F
Q	Quench	Low to Medium	☐ 200 -800 °C / 392-1472 °F	☐ 150-700 °C / 302-1292 °F
S	Strip	Low to Medium	☐ 200 -800 °C / 392-1472 °F	☐ 150-700 °C / 302-1292 °F
F	Forming/Forging	Medium	☐ 200 -800 °C / 392-1472 °F	☐ 130-700 °C / 266-1292 °F
F Mg	High Magnesium Alloy	Medium	☐ 200 -800 °C / 392-1472 °F	☐ 130-700 °C / 266-1292 °F
L	Liquid	Low	☐ 200 -800 °C / 392-1472 °F	☐

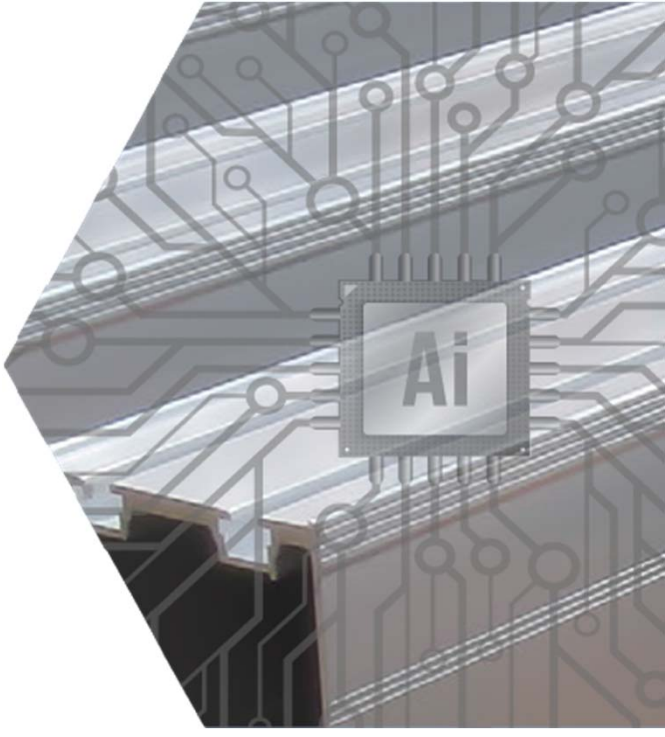
Future Applications – INTELLIGENT EMISSIVITY REFERENCE CALCULATION

Application Example



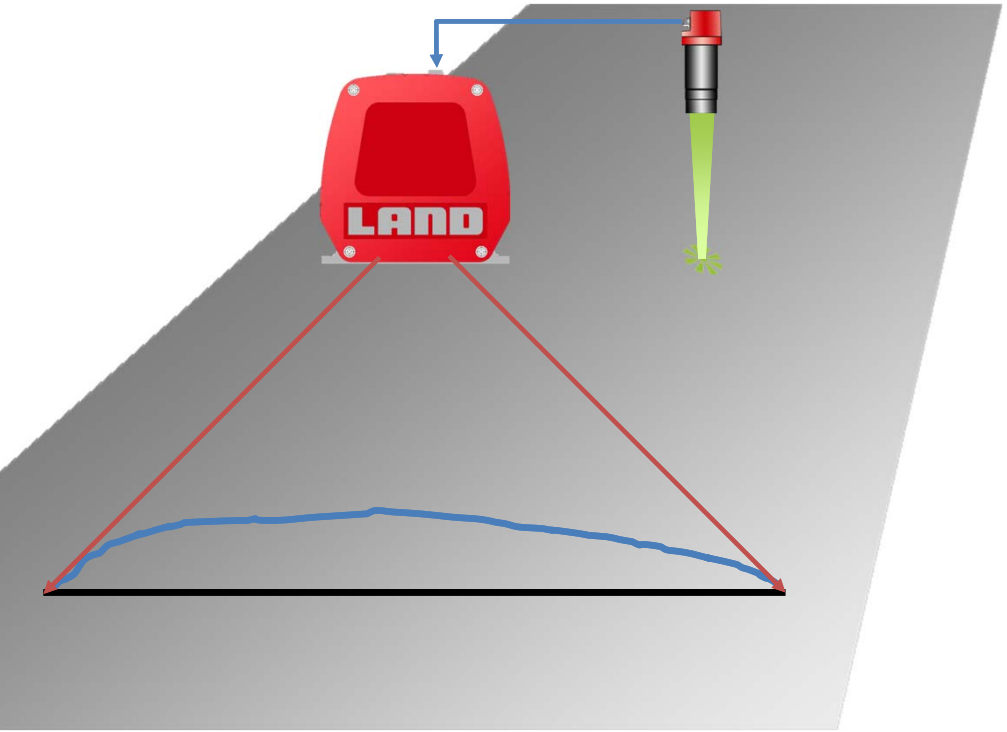
Measuring system principle (example: rolling)

The smart ***SPOT*** Application Pyrometers calculate and provide the actual surface emissivity with each measured value within 15 ms based on the Intelligent application algorithm



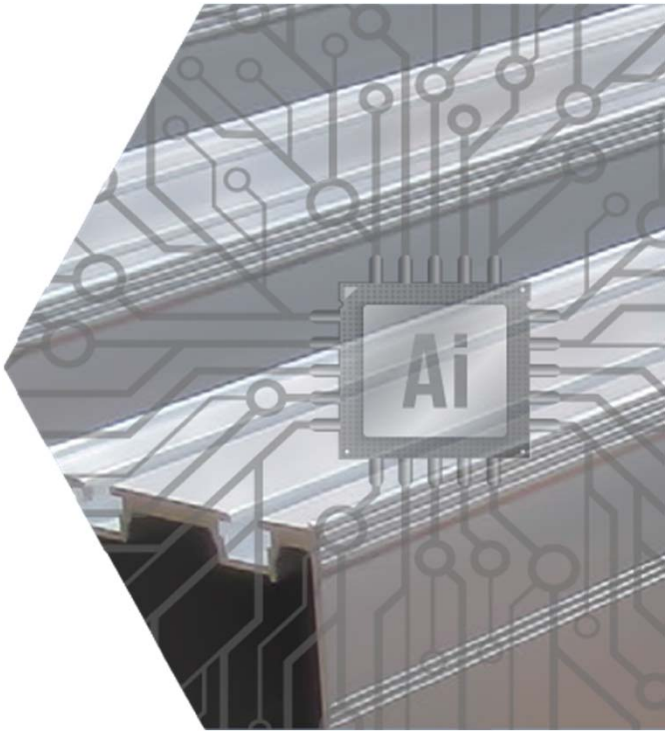
Future Applications – INTELLIGENT EMISSIVITY REFERENCE CALCULATION

Application Example



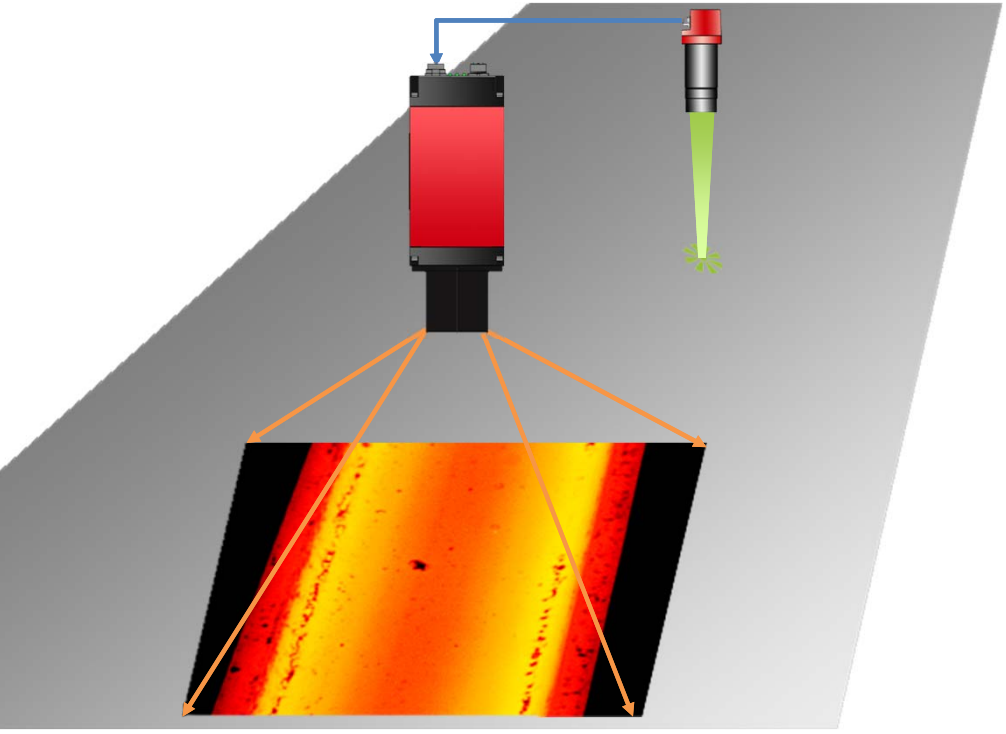
Measuring system principle (example: rolling)

Based on the calculated Emissivity from the ***SPOT AL***, the ***LSP-HD*** line scanner temperature profile is corrected online for accurate profile temperature measurment



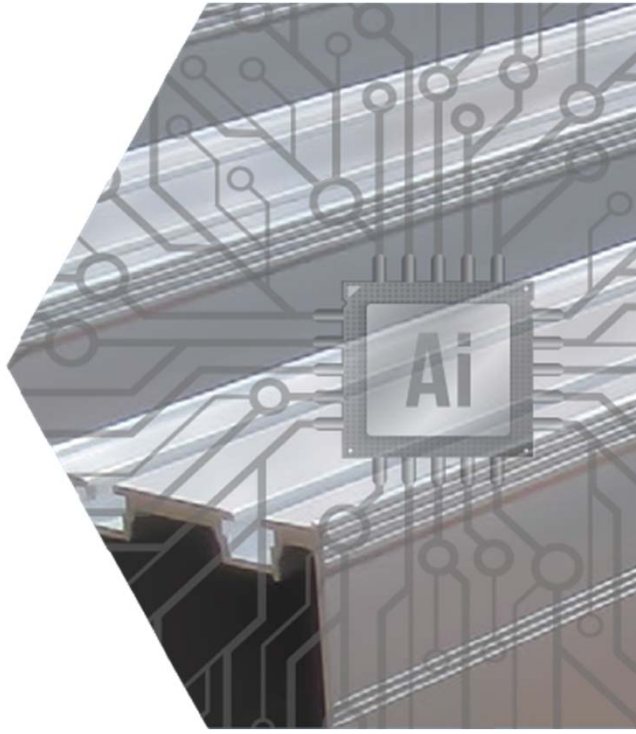
Future Applications – INTELLIGENT EMISSIVITY REFERENCE CALCULATION

Application Example



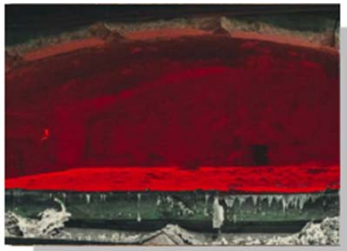
Measuring system principle (example: rolling)

Based on the calculated Emissivity from the ***SPOT AL***, the ***LWIR-640*** thermal imager image is corrected online for accurate temperature measurment



Future Applications – Aluminium smelting furnace applications & AI

Smelting Furnace



Complex, dynamic process with high energy consumption

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IR Furnace Camera

Continuous, high-quality measurements

Advance Anlytics

idletechs

Measurements transformed to process knowledge

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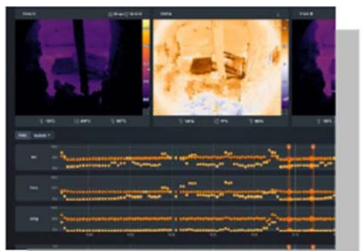
Domain Knowledge



Increased production and reduced costs and emissions

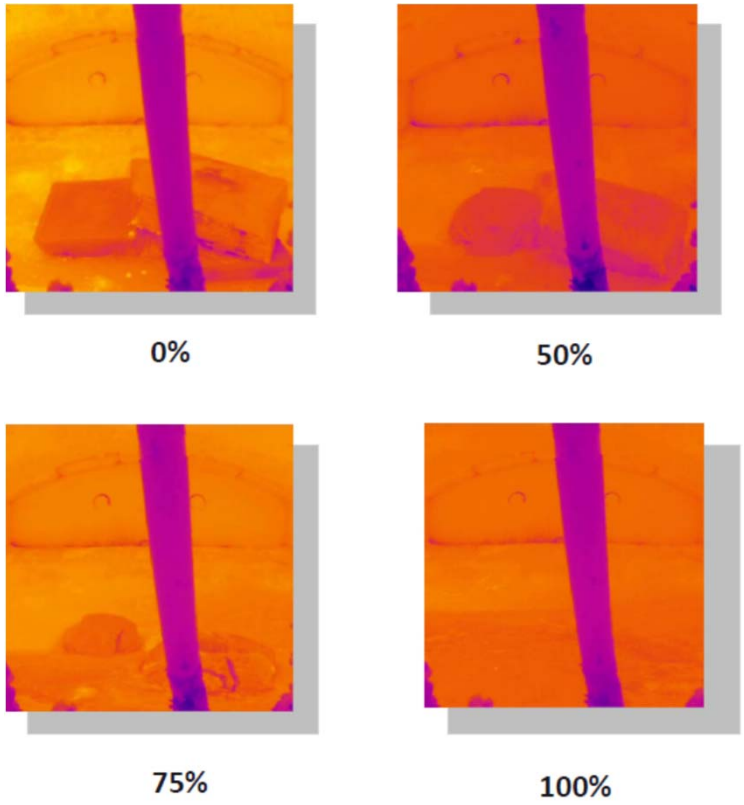
Idletechs' Furnace Monitoring solution combines thermal cameras with advanced real-time analysis to provide operators with unparalleled process insight, enabling decisions at each process step

Source: idletechs.com

idletechs

Source: idletechs.com

Future Applications – Aluminium smelting furnace applications & AI



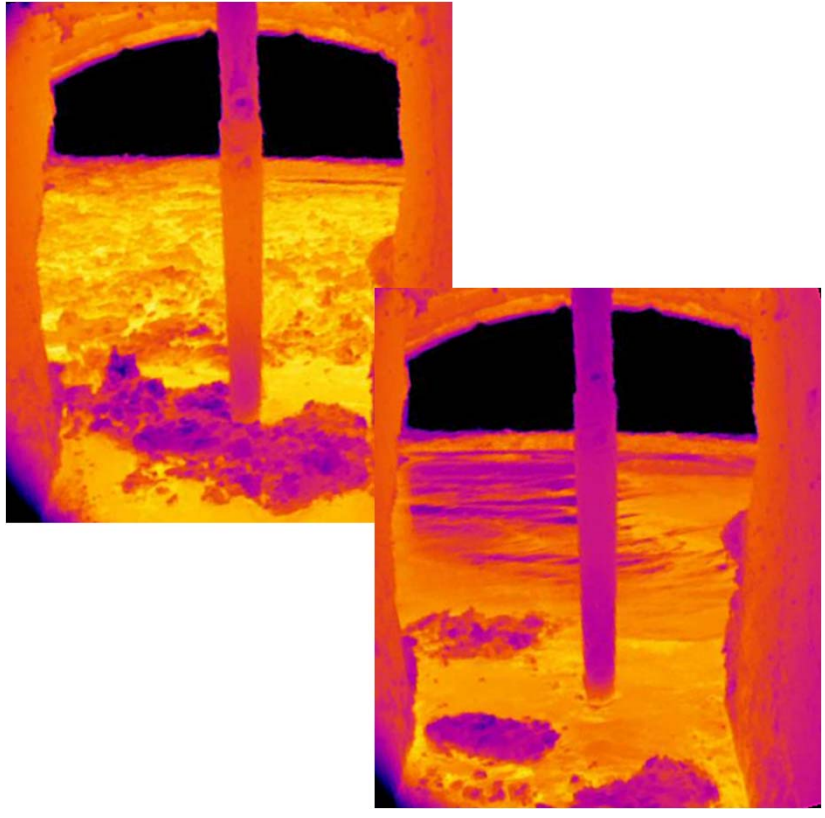
Reduce the batch time
by monitoring progress
and rate of melting
of solids in the furnace

Source: ideltechs.com

Images taken with
AMETEK Land's **MWIR-B-640**

idletechs
Source: ideltechs.com

Future Applications – Aluminium smelting furnace applications & AI



Quantify and track dross to improve raking processes and optimize the operation

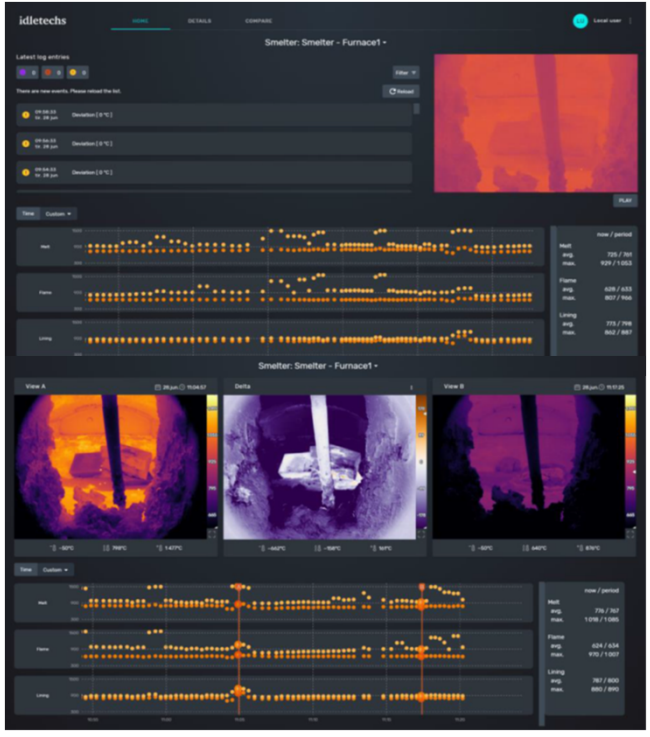
Source: ideltechs.com

Images taken with AMETEK Land's **MWIR-B-640**

idletechs

Source: ideltechs.com

Future Applications – Aluminium smelting furnace applications & AI



Reduce process time with continuous metal temperature measurements during process.

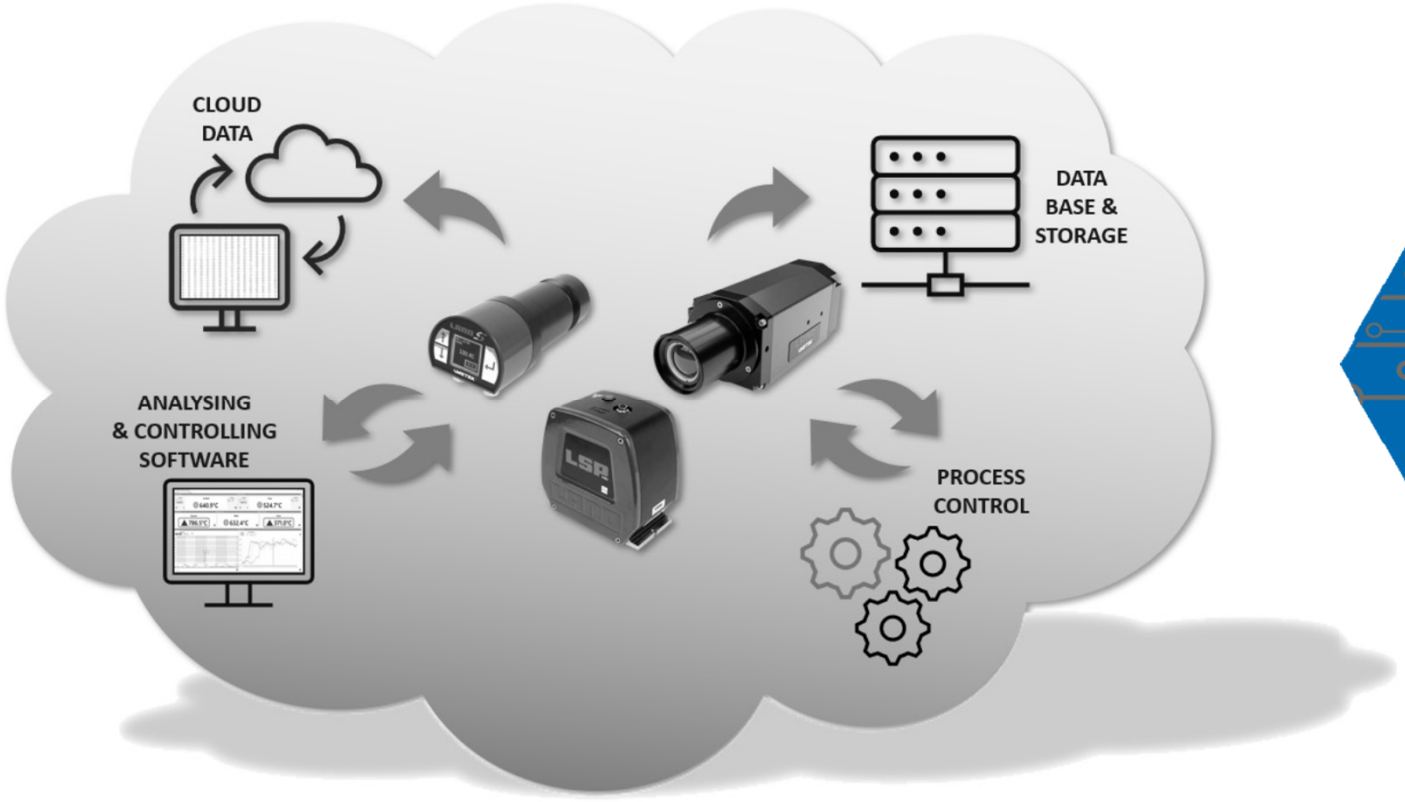
Less risk overheating the metal and waiting for metal to cool down.

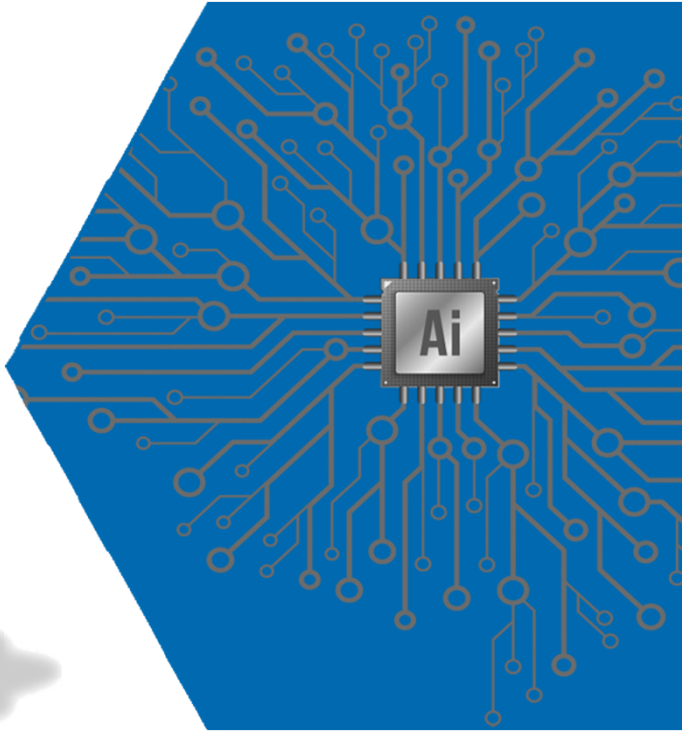
Detect and monitor changes in the process and understand impact of recipes and process parameters to optimize production.

Source: idletechs.com

idletechs
Source: idletechs.com

Future Applications – INTERFACING AND INDUSTRY 4.0 / 5.0 | IIoT





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