Title: Industrial temperature measurement: quantitative thermal imaging

Abstract

Thermal imaging is the fastest growing sector of the world temperature sensing market and is becoming a widely used technique for quantitative temperature measurement and non-destructive testing in a large cross section of industrial fields like aerospace, construction, chemistry, healthcare, manufacturing process control and material processing. It is predicted that the thermal imager market will continue growing: it already represents 4bn € and increases at a yearly rate of about 10 %. It is the responsibility of the metrology institutes to help set up adapted measurement, characterisation and calibration means and methods to assist industrial stakeholders using or manufacturing thermal imagers over a wide temperature range.

Keywords

Temperature, thermal imaging, infrared, surface temperature, aeronautic industry, non-destructive testing, calibration, emissivity, characterisation.

Background to the Metrological Challenges

Thermal imaging is a rapidly developing technology for temperature measurement. It has a huge potential but this is currently limited by poor temperature performance and insufficiently understood uncertainty sources. For example, currently in the low-temperature range thermal imagers suffer from large uncertainties (in the order of 1 % to 2 %); and in the high temperature range 200 to 1800 ^{o}C, measurements suffer from a number of uncertainties related to calibration to SI units via secondary standards.

Thermal imaging in the low temperature region is the most used technique in safety, non-destructive testing, building energy efficiency assessment, medical thermography, preventive/predictive maintenance. Even if the temperature evolution in time is usually sought, some applications require absolute temperature measurement with a low uncertainty. For other industrial or medical applications high thermal and high spatial uniformity are required to distinguish hidden defects or anomalies with equivalent temperature differences in the image in the order of 0.1 ºC. Moreover factors like the response time of the measuring device, in case of fast detection, and the thermophysical characteristics of the target material(s) will need to be accounted for in the assessment of the uncertainty budgets.

In metallurgy many processes like soldering and roll plating suffer from difficult temperature measurement, as the emissivity varies largely during the process. Especially for high reflecting metals, like Al or Cu, a stable temperature measurement is practically impossible due to changes of surface quality during the process (roughness, oxidation). The result is that the process tuning is usually achieved by multiple tests oriented to the empirical optimisation of the process results (and to large waste rates). The application of thermal imaging systems would reduce the optimisation time significantly, if the thermal image represents the surface true temperatures. The difficulties are quite similar in the glass and semiconductor industries in which remote temperature measurements are necessary and emissivity unknown.

Objectives

Proposers should address the objectives stated below, which are based on the PRT submissions. Proposers may identify amendments to the objectives or choose to address a subset of them in order to maximise the overall impact, or address budgetary or scientific / technical constraints, but the reasons for this should be clearly stated in the proposal.

The JRP shall focus on the traceable measurement and characterisation of temperature measurements in industrial applications.

The specific objectives are

1. To measure traceable temperatures using thermal imagers at low temperatures (below 120 °C) in an industrial and medical settings and to develop common approach towards standardisation and uncertainty analysis.
2. To develop validated techniques for quantitative thermal imaging using radiation thermometry methods in the range 200 °C to 1800 °C applied to highly reflective surfaces.
3. To develop validated bi-chromatic or multispectral thermal imaging techniques for use in industry.
4. To develop characterisation and calibration methods for use with high temperature thermal imaging with CCD or CMOS type thermal imagers (above 800 °C).
5. To ensure that the outputs from the JRP are effectively disseminated to and exploited by industry using thermal imagers. To facilitate the take up of the technology and measurement infrastructure developed by the project, and to support the development of new, innovative products and thereby enhance the competitiveness of EU industry.

Proposers shall give priority to work that meets documented industrial needs and include measures to support transfer into industry by cooperation and by standardisation. An active involvement of industrial stakeholders is expected in order to align the project with their needs – both through project steering boards and participation in the research activities.

Proposers should establish the current state of the art, and explain how their proposed project goes beyond this. In particular, proposers should outline the achievements of the EMRP JRPs IND01 HiTeMS, and IND13 T3D and how their proposal will build on those.

EURAMET expects the average EU Contribution for the selected JRPs to be 1.5 M€, and has defined an upper limit of 1.8 M€ for any project.

EURAMET also expects the EU Contribution to the external funded partners to not exceed 30 % of the total EU Contribution to the project. Any deviation from this must be justified.

Any industrial partners that will receive significant benefit from the results of the proposed project are expected to be unfunded partners.

Potential Impact

Proposals must demonstrate adequate and appropriate participation/links to the “end user” community, describing how the project partners will engage with relevant communities during the project to facilitate knowledge transfer and accelerate the uptake of project outputs. Evidence of support from the “end user” community (e.g. letters of support) is also encouraged.

You should detail how your JRP results are going to:

- Address the SRT objectives and deliver solutions to the documented needs,
- Drive innovation in industrial production and facilitate new or significantly improved products through exploiting top-level metrological technology,
- Improve the competitiveness of EU industry,
- Feed into the development of urgent documentary standards through appropriate standards bodies,
- Transfer knowledge to the temperature measurement sector.

You should detail other impacts of your proposed JRP as specified in the document “Guide 4: Writing Joint Research Projects”

You should also detail how your approach to realising the objectives will further the aim of EMPIR to develop a coherent approach at the European level in the field of metrology and include the best available contributions from across the metrology community. Specifically the opportunities for:

- improvement of the efficiency of use of available resources to better meet metrological needs and to assure the traceability of national standards
- the metrology capacity of EURAMET Member States whose metrology programmes are at an early stage of development to be increased
- organisations other than NMIs and DIs to be involved in the work

Time-scale

The project should be of up to 3 years duration.