EMRP Call 2012 – Open Excellence, Industry and SI Broader Scope

Selected Research Topic number: **SRT-s21**
Version: 1.0

Title: Metrology for thermal protection materials

Abstract

Thermophysical property data for thermal protection materials, such as advanced insulation and composites, is essential for modelling the heat transfer in aerospace, structural fire safety and processing applications. However, the state-of-art in thermal metrology is not sufficient to evaluate the significant improvements promised by new materials that are currently under development. Even for conventional materials, there is a lack of thorough understanding and traceability in the measurements required to support mandatory European regulations. A framework of traceable metrology and a step-change in industrial measurement techniques are needed to enable new materials to deliver their potential improvements in efficiency and safety.

Conformity with the Work Programme

This Call for JRPs conforms to the EMRP Outline 2008, section on “Grand Challenges” related to Industry & Fundamental Metrology on pages 35 and 36.

Keywords

Traceability, thermal conductivity, advanced insulation materials, advanced composite materials,

Background to the Metrological Challenges

A large amount of investment is being channelled into the development of a wide variety of new fibrous, foam and aerogel based composites for thermal protection at medium to high temperatures. These new materials have the potential to provide thermal performance that is several-fold better than conventional materials. However, there is currently no reliable metrology framework with which to evaluate improvements in their thermal performance. The existing metrological techniques for temperatures up to 800 °C are sound and provide a good foundation for development, but there are many aspects that are still not sufficiently advanced. Until these remaining metrology issues are resolved, thermal conductivity metrology within Europe is still a long way from meeting the requirements of industry.

The advanced manufacturing sector has to bear significant extra cost in over engineering or under-performing materials. They cannot reliably select materials for their applications as measurements of thermophysical properties using different techniques have shown significant level of scatter, sometimes over 100 %. Insufficient knowledge of the thermal conductivity of newly developed insulation and composite materials leads to the lack of uptake and obligation to make more full-scale tests during the development of aerospace components, structural fire safety systems and process plants. This resource hungry approach increases the time and cost taken to implement the production of new technologies. Today’s thermal modelling capabilities provide an opportunity to design industrial systems far more efficiently. However, accurate thermal properties of materials is the main limiting factor on the predictive power of thermal modelling and high quality data must be made available to allow designers to precisely engineer these systems, rather than just adopting a costly over-engineering approach.

Unreliable thermophysical property data of advanced thermal protection materials has forced the field of fire engineering for buildings, industrial facilities and transportation to bear the potential high risks of industrial disasters/incidents. Ensuring that load-bearing capacity of structures is maintained for a long enough time to allow evacuation of people depends upon the application of multifunctional materials that are able to both reduce energy consumption during normal use, but also act to protect structural integrity during a fire situation.

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There is also an urgent need for improved measurement traceability to support new European Regulations [1] in the form of mandatory Product Standards for insulation used in industrial installations. The current level of agreement between reference laboratories using guarded hot-plates is three times greater than the maximum 5 % required in the new EU regulations.

Scientific and Technological 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 JRP-Protocol.

The JRP shall focus on the traceable measurement and characterisation of modern advanced thermal protection materials. The overall aim is threefold. Firstly to understand the limitations of current industrial measurement techniques used for measuring the thermal conductivity of advanced composite materials. Secondly to identify and develop appropriate techniques for the measurement of thermophysical properties of advanced insulation and composites to provide traceability for industrial measurements and thirdly to identify the causes and where possible resolve existing discrepancies to enable the agreement between reference laboratories using guarded hot plates to be improved by a factor of 3 from the current level of 15 % to 5 %, thus enabling industry to meet the mandatory requirements of new EU regulations. The specific objectives are

1. To improve the techniques for determining the radiant heat transfer within thermal protection products to enable the tolerance in surface emissivity of measurement apparatus components to be specified and the viability of using transient techniques in industrial thermal measurements to be assessed.
2. To improve thermal guarding systems, temperature sensor arrangements and thermal contact resistance aspects in order to improve performance under heat cycling, to reduce the distortion of the heat flux and to obtain temperature measurements that are more representative of the specimen boundary conditions within regions of heat flux.
3. To identify and characterise coatings that can withstand abrasion from contact with specimen; withstand thermal cycling up to 900 °C and remain securely bonded to plate materials; and provide a consistent high emissivity (0.8 or higher is required) with a specified value/tolerance.
4. To identify and develop suitable techniques for the characterisation and uncertainty evaluation for composite thermal protection materials which have significantly different thermal conductivity in the through-thickness direction to that in the in-plane direction, thus enabling industry to select appropriate measurement techniques for heterogeneous materials and estimate uncertainties when using transient methods.
5. To identify certified reference materials with an appropriate level of thermal conductivity (0.02 W m^{-1} K^{-1} to 1 W m^{-1} K^{-1}) and at temperatures up to 800 °C suitable for the investigation of anomalies between laboratories.

These objectives will require large-scale approaches that are beyond the capabilities of single National Metrology Institutes and Designated Institutes. To enhance the impact of the research work, the involvement of the larger community of metrology R&D resources outside Europe is recommended. A strong industry involvement is expected in order to align the project with their needs and guarantee an efficient knowledge transfer into industry.

Proposers should establish the current state of the art, and explain how their proposed project goes beyond this.

The total eligible cost of any proposal received for this SRT is expected to be around the 2.7 M€ guideline for proposals in this call. The available budget for integral Research Excellence Grants is 42 months of effort.

Potential Impact

Proposals must demonstrate adequate and appropriate participation/links to the “end user” community. This may be through the inclusion of unfunded JRP partners or collaborators, or by including links to industrial/policy advisory committees, standards committees or other bodies. Evidence of support from the “end user” community (eg letters of support) is encouraged.

You should detail how your JRP results are going to:

- feed into the development of urgent documentary standards through appropriate standards bodies
- transfer knowledge to the construction product testing sector.

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

You should also detail how your approach to realising the objectives will further the aim of the EMRP to develop a coherent approach at the European level in the field of metrology and includes 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 Member States and countries associated with the Seventh Framework Programme whose metrology programmes are at an early stage of development to be increased
- outside researchers & research organisations other than NMIs and DIs to be involved in the work

Time-scale

The project should be of up to 3 years duration.

Additional information

The references were provided by PRT submitters; proposers should therefore establish the relevance of any references.

[1] REGULATION (EU) No 305/2011 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 9 March 2011 laying down harmonised conditions for the marketing of construction products and repealing Council Directive 89/106/EEC