Title: Dimensional characterisation of functional structured surfaces

Abstract

Surface texture parameters are key in the development of technical surfaces influencing properties such as friction, wear, wetting, lubrication, adherence, sealing, optical diffusivity, porosity and many more. The challenge is to be able to carry out traceable measurement of the new surface texture parameters. Written standards, such as the ISO 25178 series, are now available but to push forward surface technology it is necessary to design, manufacture and calibrate surface texture standards and to ensure metrological traceability. Currently calibration is mainly based on a number of profile roughness standards that are not appropriate for areal surface texture. Research addressing these challenges will improve processes in many industrial fields such as energy, automotive, communication and medical.

Conformity with the Work Programme

This Call for JRPs conforms to the EMRP 2008, section on "*Metrology R&D for applied and fundamental metrology"* related to *Industry* on pages 13-14 and pages 38, 39 and 42.

Keywords

Areal surface texture, areal material ratio, structured surfaces, twist measurements, stylus instruments, non-contact surface texture instruments, scanning probe microscopes, calibration artefacts, calibration guidelines, measurement uncertainty, traceability, pattern analysis, segmentation, micro-scale measurement, characterisation.

Background to the Metrological Challenges

Engineered surface textures allow the design and tailoring of properties such as friction, wear, wetting, lubrication, adherence of coatings, optical aspects, corrosion, sealing properties, etc. The ability to measure and reliably reproduce specific surface textures is of great importance in many industrial fields, such as the automotive, aerospace, communications and medical implants industries.

Despite the drive for increased miniaturisation, for example in microelectronics and the emergence of micro-electro-mechanical systems (MEMS) in products, small critical dimensions are not necessarily restricted to very small-sized samples, for example;

- Roughness of a sheet metal for car body production where paintability is required.
- The edge in an optical filter for telecommunication, where the edge itself may be several µm
- Porosity of polymer molecular membranes for advanced drug delivery
- Distances within molecules, where the function is associated with particular geometrical configurations

Technical surfaces of metal sheet or other materials are used in a large variety of products, including car and aircraft production and façade engineering. The quality of such surfaces and their micro- or nanotopography pose challenging problems at present. More accurate control of parameters during inspection in production and between manufacturer and customer would help to improve the quality of products, reduce the costs and minimise the waste due to the higher reliability of inspection.

In order to improve e.g. the adherence of paint coatings or the tribological properties of metal sheets their surface is roughened with special techniques during deep drawing to obtain a specific structured surface of high quality. In this case the profile surface parameters available today are not sufficient for the characterisation of the tribological properties. Techniques like laser, electron or ion beam texturing are used to fabricate surfaces with deterministic structures making the development of more informative areal parameters necessary.

The accurate separation of form and roughness needed to ensure the determination of roughness parameters is only possible with true 3D measurements. To ensure the effective function of sealing or bearings in mass production items, boundary conditions have to be respected. A technique used to characterise such surfaces is the application of twist measurements developed for ground cylindrical surfaces, however, this method is currently only standardised through internal company standards, and agreed European, international written standard or calibrated artefacts are not available. The challenge for such measurements is the large ratio between the surface texture values compared to radius or diameter of the shaft.

Roughness measurements today are based on stylus instruments and related international agreed written standards and profile calibrated artefacts. Depth setting standards for the calibration of the topography measurement axis are available in the range from 6 nm up to 5 mm. Profile roughness artefacts on the other hand cover a range from Rz ~ 150 nm up to 10 µm and are produced by diamond turning and grinding. They are used to calibrate stylus instruments before they are applied to profile roughness measurements in general. A few special profile artefacts are available for the measurement of metal sheet properties (prEN10049), however, with the exception of the superfine roughness artefacts, the profile roughness artefacts are not applicable to optical microscopy.

Beside the stylus instrument, which is up to now the only instrument internationally standardised for the evaluation of roughness parameters, the schemes of measurements of profile/areal surface texture parameters including the subsequent data evaluation methods must be adapted to optical microscopes and scanning confocal chromatic instruments. The advantage of optical microscopes is their high acquisition speed and the direct areal measurement, however they suffer from an unknown lateral bandwidth of the optics that act as lateral filters of surface properties. Results need to be comparable within, and between, customers, so to fulfil this condition the instruments used have to be calibrated and critical parameters of measurement, like the spatial bandwidth, have to be determined. Therefore, artefacts must be created with well-designed surface properties that allow the determination of the critical parameters and the calibration of the instrument.

For the applications mentioned above the characterisation of surface texture parameters will be an essential task for production and for the functional behaviour. A significant step forward towards improved characterisation of surfaces will be the transfer of the general set of evaluation rules defined in ISO 25178 - standard family “Geometrical Products Specifications – Areal Texture” and in ISO 16610 “Geometrical Products Specification – Filtering” to practicable rules and calibrated artefacts for daily use in industry and community. At present, however, no international roughness standards are available to calibrate instruments for areal parameters (areal and volume material ratio and twist parameters).

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 general objective is to meet the industrial need to design, manufacture and calibrate surface texture standards and to ensure traceability of curved, truly 3D surfaces.

The specific objectives are:

1. Development of techniques to design areal and truly 3D surface texture artefacts for selected, industrially relevant parameters and realisation of the designed surfaces by using modern production technologies.

2. Traceable calibration of the produced artefacts by stylus and optical instruments with accurate separation of form and roughness. Development of guidelines describing the measurement of areal parameters and instructions for efficient calibrations with sufficient measurement uncertainty.

3. Comparison of the characterisation results of the developed artefacts obtained with stylus and optical techniques to ensure reliability of the measurements.
4. Provision of algorithms for the analysis of the data following the guidelines in ISO 25178 and ISO 16610, including software validation.
5. Contribution to the use of new functional surface parameters for cylindrical surfaces, such as the twist, by instrument developments, specific artefacts and software tools.
6. Contribution to understanding of the product surface functionality and surface structuring capability through development of measurands and specifications.

Proposers shall give priority to work that meets documented industrial needs and that which supports transfer into industry e.g. by cooperation and/or by standardisation.

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

Potential Impact

Proposals must demonstrate adequate and appropriate participation/links with 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.

Where a European Directive is referenced in the proposal, the relevant paragraphs of the Directive identifying the need for the project should be quoted and referenced. It is not sufficient to quote the entire Directive per se as the rationale for the metrology need. Proposals must also clearly link the identified need in the Directive with the expected outputs from the project.

You should also detail other impact of your proposed JRP as detailed in the document “Guidance for writing a JRP”

You should detail how your JRP results are going to:

- feed into the development or application of standards through appropriate standards bodies such as CEN and ISO
- transfer knowledge to the automotive, aerospace, medical and construction sectors.

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. 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 3 years duration.