A TRAINING CONSORTIUM TO EXPLORE AND EXPLOIT SURFACE METROLOGY

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Abstract: The importance of surface finish in all aspects of manufacturing influences economic considerations as well as environmental aspects and functionality. The ability to effective and efficient characterise surface topography is an important tool in the manufacturers arsenal which is often overlooked or underutilised. By providing a comprehensive, affordable training package, a gap in the industrial knowledge is filled giving manufacturers the ability to increase their competitive edge.

Keywords: surface metrology, education, knowledge transfer.

1. INTRODUCTION

The measurement and characterisation of surface topography is a critical tool in manufacturing control, as well as in research and development. The surface control loop (see figure 1) where the surface, rather than the product, is in focus emphasises the importance to link function, manufacturing and characterisation in order to understand and produce well-functioning surfaces (Stout and Davis, 1984). In fact, 90% of all engineering failures are surface initiated, which alone highlights the importance of understanding the functional surface of a process or part.

In addition to this, surfaces can give valuable information about the way processes and parts perform in service. Being able to comprehensively characterise a surface can be a useful descriptor which can enable process control, waste reduction, functional enhancement as well as being used as a forensic tool to predict or investigate failure or reduction in functionality. If the benefits to effectively and efficiently characterise surface topography can be shown – that information about surface finish influences various aspects of manufacturing, functional as well as economic and environmental considerations – manufacturers will get an important tool in their arsenal giving them valuable, and even vital, information about the way processes and parts perform in service.

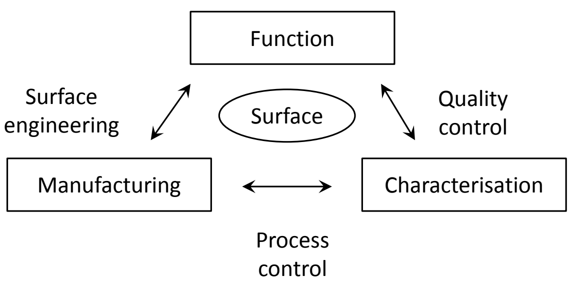

Fig. 1. The surface control loop; *function* - what a surface shall do, *manufacturing* – how to produce that surface, and *characterisation* – how to measure and describe desired surface (adapted from Morris *et al*., 1990).

This paper aims to be the starting point to a three-years project with the final goal to provide a comprehensive 'training school' to educate industry professionals on measurement and characterisation of surface topography through a web-based platform where academic, institute and industry employees could meet and continuously exchange knowledge, experience and requirements.

2. MARKET NEED

Surface characterisation is already used as a tool to control manufacturing processes today, especially the mechanical profilers used to measure the value of Ra (arithmetic mean deviation) giving a simple description of the surface topography of a part or process. But, the quality and reliability of output from users of measurement instrumentation is not comparable to today’s capabilities of surface measurement instrumentation. More effective instrumentation and ways of characterising surface topography of functional surfaces are well established in research today, and there is a move in leading sectors such as biomedical, aerospace and automotive to use these techniques (Jiang *et al*., 2007a, b). But, to implement new techniques into sectors relying on outdated equipment and non-standardised procedures for surface measurements, or to better utilise techniques they already have, is not an easy task - tradition and working practice is hard to change. And, critically, there is in fact lack of simple and effective training tools to enable these techniques to be exploited, which results in valuable information being overlooked, or not investigated due to lack of education of operators, researchers and/or metrologists.

Previous and on-going studies have shown the benefits for academy, institutes and industry to work together in projects, share lab- and workshop facilities, and provide common courses. Such projects aim to adapt and implement commercial metrology into production chains and, not to forget, to introduce and educate interested personnel to new devices and methodologies. Below two cases are presented, one from the automotive industry and one from a life science company not only showing the use of surface metrology, but also the strength of academic and industrial cooperation.

2.1. Case 1 – Automotive industry

A manufacturer of automotive components had a variation in performance with a particular bearing in the system. Traditional surface texture analysis and characterisation techniques did not show any significant variation. Within the company, advanced areal surface topography measurement instrumentation was available. Investigations showed that areal surface measurement, analysis and characterisation clearly identified the variation in performance through differences in surface characteristics. The difference in characteristics were only identifiable through filtering of the form, roughness and waviness components and also correct selection of the descriptors to enable identification of topographical features which impacted upon performance. The identification of the topographical features was easily traceable to a particular manufacturing process which was impacting upon the performance and early failure of the component. The analysis held both economic and environmental benefits attached to improvements in the manufacturing process and also introduced quality control procedures to control the process and ensure product performance.

Figure 2 shows an extreme case of the component variation which is clearly identifiable with good areal measurement practice. Proper and correct training would have enabled the company to quickly and efficiently identify this variation in house with their existing instrumentation, thus saving measurement consultation fees and further improving process efficiency.

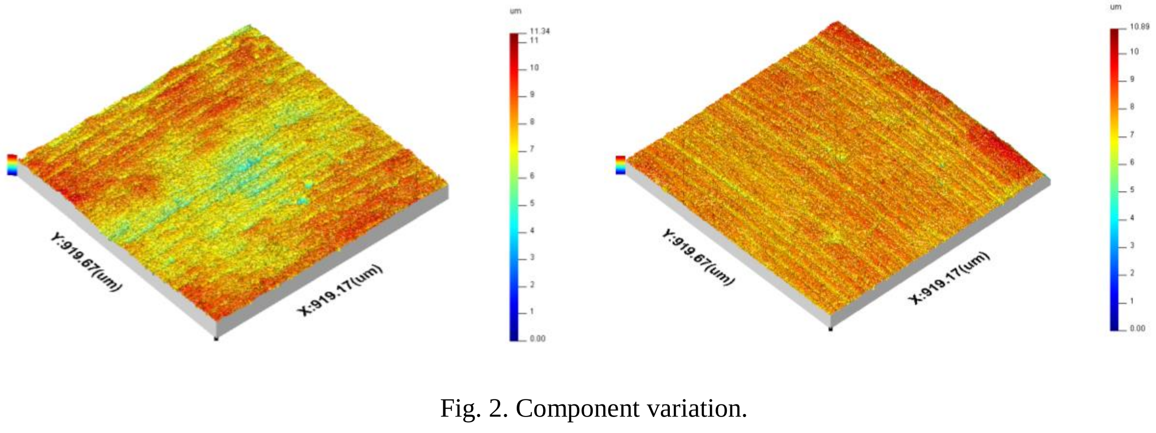

Fig. 2. Component variation.

2.2. Case 2 – Life Science company
The actual company wanted to find new materials with similar, or even better, technical requirements, and with higher levels of user stimulation, than their traditionally used stainless steel to get complementary materials and surface textures to increase design possibilities of medical equipment. With the base in Kansei Engineering (Nagamachi and Lokman, 2011), customer requirements were identified and correlated to other demands, especially cleanability and bacterial growth prevention (which is restricted by legal demands). Several alternative materials were found, e.g. a type of glass, a spray painted aluminium and a type of acrylic plastic material, which then were measured and tested for their cleanability and bacterial growth prevention in order to better understand the relation between function and surface texture (Bergman, *et al.*, 2013). The study is not yet completely implemented in the production, but the 'new' materials are not only improving the design abilities, they are also expected to reduce manufacturing costs.

3. TRAINING CONSORTIUM

The idea is to form a 'training consortium' in purpose to diminish the gap of knowledge and resistance to new technical solutions for surface metrology. But, to build up and organise such activity, several yeas of investigation and planning are needed. Follow-ups from finished projects and collaborations, like interviews and questionnaires, as well as experiences in the field will form the base of this planned training school on surface metrology.

A first layout of how a training package to industry could be built up is shown in figure 3;

- *Basic modules* cover the main topics, which are divided into sub-areas in order to get smaller lecture units and possibilities to tailor-make training packages.
- *Case modules* covers specific areas of applications, i.e. how to apply theories and methods learned from the basic modules on 'real components/situations'. Hands-on exercises are central here.
- *Training periods* involve general and individually adapted exercises and time for reflecting, e.g. how to select the most appropriate instrumentation for company specific needs, and how to effectively utilise the capabilities of existing metrology instrumentation. Here the web-platform is vital for the communication.
- *Final examination* and possibilities to get accredited.

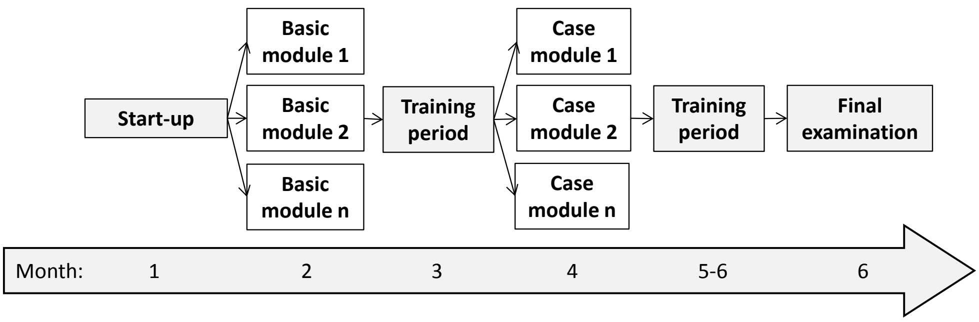

Fig. 3. Schematic work-flow of a training package on metrology for industry.

New learning and teaching concepts will be implemented to overcome the limitations of the more conventional lecturing in form of traditional lectures and seminars. The advantages with web-based education are no traveling time and costs for participants, and possibilities to make illustrations, simulations, demonstrations, experimentations etc. an infinite times without extra costs, or do recordings of lectures and such. This strategy is also less expensive and more time efficient, and students can go back and retry previous lecture material. However, physical meetings are needed for hands-on sessions. All course material will be available via e.g. Adobe Connect, where all participants can meet and upload their own presentations, reports etc. The consortium should also have its own platform where ideas, projects, literature, articles etc. could be exchanged.

3.1 Basic modules
The aim of the basic modules is to give the participants fundamental knowledge in surface metrology, either an overview on a lower level covering the basics or part of it on a more advanced level depending on the interest of the client. The basic modules are planned to cover topics such as;

Surface integrity to answer the question 'what is a surface?'. Belonging terminology, the history of surface metrology and todays research focus/challenges, specifications (what do they really mean?) and, of course, successful examples to further motivate and inspire participants.

Instrumentation covers the basics of different measurement techniques available, their main area of application, advantages and shortcomings, and the importance of calibration. A guide to choose the 'right instrument' including the concepts resolution, range etc. will be discussed, as well as different standards connected to surface metrology – how to be able to interpret and adhere to ISO standards?

Surface analysis covers the data handling, i.e. how to treat surface measurements and what to be gained? Traditional as well as the latest characterisation and filtering techniques will be included to illustrate what type of information that can be extracted from a surface measurement. Also, relevant ISO standards and concepts like uncertainty, reliability etc. (connected to statistics) will be discussed.

3.2 Case modules

The case modules should cover specific areas of applications and are expected to vary from year to year due to recent research and the interest of the participants. The aim is therefore to apply theories and methods learned from the basic modules on 'real components/situations'; how to attack and adapt to a new type of instrumentation and/or application and/or analysis method, and how to get confidence in their results? Also, practical usage of various measurement devices will be carried out since the handling of both instrumentation and samples are important – why, where, what and when to measure?

3.3 Training periods

These parts of the course constitute self-studies and individual work based on previous modules. Participants have time to reflect and solve given assignments with help of recordings, provided literature and articles. Virtual labs (e.g. discussed by Domingues *et al*., (2010)) shall give them the possibility to practice different surface analysis packages, which should be further discussed and presented during the next coming physical meeting.

4.4 Final examination

This part is needed to assess/judge if participants have reached the goals for the actual module, either as a final exam or as continuously written or orally presented assignments. The possibility to be accredited needs special treatment.

4. ORGANISATION

A schematic overview of how the organisation could be structured is shown in figure 4;

- The *advisory board* should give objective advice to the reference group and should consist of diverse skills, expertise and experience to form the direction (vision) and constraints of the training consortium with the holistic perspective in mind.
- A *reference group* shall, together with the coordinators, be in charge of the consortium and make sure that all modules have relevant contents. Numbers of different academic institutes, each able to deliver their own expertise in their field, are expected to jointly generate the course material, and to give the opportunity for the training to be delivered to a wider international audience. They shall also coordinate the trainers in different countries/areas/topics, and organise trainer-meetings every year.
- *Trainers* are the teachers, and specialists in specific areas/modules, who need to update both course material and themselves every year.
- *Companies* means representatives from industry, users as well as suppliers, who are important to include e.g. to decrease any scepticism.
- A *support team* should consist of administration, marketing, economy and IT to manage all above the surface metrology itself.

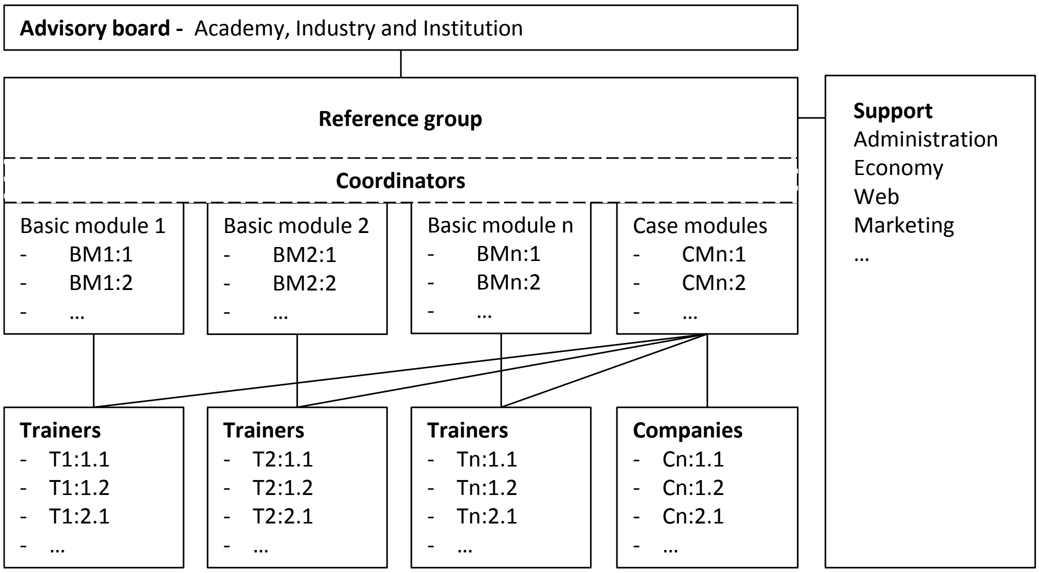

Fig. 4. Schematic overview of the organisation structure.

5. CONCLUSION

Previous projects have shown that there is a knowledge gap surface metrology in industry that needs to be filled in in order to give manufacturers the ability to increase their competitive edge. Today's information and communication technologies provide new learning and teaching possibilities facilitating web-based individually adapted educations. The suggestion is to start up a project in order to build up a consortium providing an accredited training package for surface metrology to be delivered remotely all over Europe in different languages.

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