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Managing uncertainty in the new manufacturing era

Giovanni Moroni[a,*], Stefano Petrò[a]

[a]*Department of Mechanical Engineering, Politecnico di Milano, Via Giuseppe La Masa, 20156 Milano, Italy*

[*] Corresponding author. Tel.: +39 02 2399 8530; fax: +39 02 2399 8585. *E-mail address:* giovanni.moroni@polimi.it

Abstract

The new manufacturing era is characterized by a relevant shift of manufacturing from the physical to the digital world. In this context the proper management of product and manufacturing information is fundamental. The CIRP CAT provides a technical forum for researchers, industrial practitioners, and policy makers to exchange ideas, share research findings, and discuss the various issues in the fields of dimensional and geometrical tolerancing, dimensional metrology, uncertainty management, standardization.

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Keywords: Tolerancing; Uncertainty; Geometrical Metrology.

1. Introduction

The new manufacturing era, that we may name Smart Manufacturing, Intelligent Factory, or Industry 4.0, is characterized by a relevant shift of manufacturing from the physical to the digital world, so that products exist in the memory of computers before, in parallel, and after the existence of their physical counterparts. The main actors of this shift are the Cyber-Physical Systems (CPS), which are systems of collaborating computational entities which are in intensive connection with the surrounding physical world and its on-going processes, providing and using, at the same time, data-accessing and data-processing services available on the Internet [1]. The application of the CPS in manufacturing are named Cyber-Physical Production Systems (CPPS).

In this context the proper management of product and manufacturing information is fundamental. Among this, in the field of mechanical engineering, dimensional and geometric tolerances are the most relevant, in order to properly deal with uncertainty from the conception to the end of life of a product [2–4].

This is the motivation of the scope of the 15th CIRP CAT, where the management of the uncertainty in whole manufacturing is considered. In particular, the link between product geometrical specification and its verification is fundamental, because, if manufacturing opens the loop by converting digital parts into physical parts, geometrical verification closes the loop by turning physical parts into information. The CIRP Conference on Computer Aided Tolerancing focuses on the progress in the fields of dimensional and geometrical tolerancing, dimensional metrology, uncertainty management, standardization. It provides a technical forum for researchers, industrial practitioners, and policy makers to exchange ideas, share research findings, and discuss the various issues they encounter. The CIRP CAT refers to the Scientific Technical Committee Design (STC Dn) of the International Academy for Production Engineering (CIRP), who has been supporting contributions in the areas of design theories, methodologies, IT tools and their practical applications over the past decades.

From this starting point, the CIRP CAT 2018 conference has been focused on:

- Robust Design and Uncertainty
- Functional Tolerancing
- Tolerance Specification
- Tolerance Analysis
- Form Deviation in Tolerance Analysis
- Actual Mating Conditions
- Tolerance Verification
- Quality
- Additive Manufacturing
- Micro-Manufacturing

In the following three of these main topics are highlighted as special one for the CIRP CAT 2018.

1.1. Robust Design and Uncertainty

Robust Design is a well-acknowledged design approach that strives for designing products, devices and production equipment so that their performance and function is insensitive to the variability and uncertainty inherent in manufacturing, as-

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sembly, and use processes [2]. Focusing on systematic efforts during product and process development, Robust Design significantly widens the scope of uncertainty management and quality control practices and offers an enormous potential in terms of reducing quality issues, scrap, or delayed product launches. At the same time, it is largely unclear how corresponding design approaches can benefit the indispensable tolerancing and geometrical variations management tasks in order to systematically and successfully account for variability and uncertainty in product and process development. Therefore, it is relevant the need to discuss novel approaches and tools that allow for a coherent consideration of variability and uncertainty throughout the whole process of design and geometry assurance, and that enable the minimization of variations as well as the continuous monitoring and optimization of the resulting product performance by means of suitable verification and validation activities.

1.2. Additive Manufacturing: A new challenge

It is well established that additive manufacturing (AM) is a historical breakthrough in manufacturing and deeply impacts the overall design and manufacturing process chain as well as the entire life cycle of a product [5]. The greater benefits of AM come from the fact that by adding material point-to-point and layer-by-layer, it is possible to control both the shape and material complexity of a product. This complexity for free requires alterations to current methods to describe and communicate complex design. This need is particularly true and well recognized with respect to the development of methods to tolerance complex freeform surfaces [6]; to communicate and tolerance heterogeneous materials and internal features; and to verify dimensioning and tolerancing requirements of the additively manufactured parts.

1.3. Micro-Manufacturing: Specification and Verification

Nowadays, many manufacturing processes are available capable of manufacturing components whose size is well below 1 mm. However, the correct definition and inspection of such components is still a difficult task: at micro-scale level the geometry of the part influences the functionality not only in terms of mating and movement. Then, the question arises whether or not the current GD&T and GPS practices are still adequate [7]. Therefore, new techniques for tolerance analysis, synthesis, and allocation are needed. Verification also needs to be harmonized with the new tolerancing techniques, but in this field an additional challenge is present. In general, inspection systems for micro metrology are non-contact measuring systems. A complete infrastructure guaranteeing the traceability of non-contact micro-measuring systems like quantitative microscopes still needs to be developed and implemented, including instruments calibration and verification, and measurement uncertainty estimation.

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References

[1] Monostori, L., Kdr, B., Bauernhansl, T., Kondoh, S., Kumara, S., Reinhart, G., et al. Cyber-physical systems in manufacturing. CIRP Annals - Manufacturing Technology 2016;65(2):621–641. doi:10.1016/j.cirp.2016.06.005.

[2] Morse, E., Dantan J.-Y. aand Anwer, N., Soderberg, R., Moroni, G., Qureshi, A., Jiang, X., et al. Tolerancing: managing uncertainty from conceptual design to final product. CIRP Annals - Manufacturing Technology 2018;67(2):In press.

[3] Morse, E., Heysiattalab, S., Barnard-Feeney, A., Hedberg T., J.. Interoperability: Linking design and tolerancing with metrology. Procedia CIRP 2016;43:13–16. doi:10.1016/j.procir.2016.04.106.

[4] International Organization for Standardization, . ISO 1101: Geometrical product specifications (GPS) - Geometrical tolerancing - Tolerances of form, orientation, location and run-out. 2017.

[5] Thompson, M., Moroni, G., Vaneker, T., Fadel, G., Campbell, R., Gibson, I., et al. Design for additive manufacturing: Trends, opportunities, considerations, and constraints. CIRP Annals - Manufacturing Technology 2016;65(2):737–760. doi:10.1016/j.cirp.2016.05.004.

[6] of Mechanical Engineers, T.A.S.. ASME Y14.46-2017 (Draft Standard for Trial Use) Product Definition for Additive Manufacturing. 2017.

[7] Weckenmann, A., Hartmann, W.. A model- and simulation-based approach for tolerancing and verifying the functional capability of micro/nano-structured workpieces. Measurement: Journal of the International Measurement Confederation 2015;76:70–79. doi:10.1016/j.measurement.2015.08.010.