



The 15th CIRP CAT Conference

June 11th-13th, 2018

Milano, Italy

Conference Programme

First Day

Monday June 11th, 08:00 – 09:00

Conference Registration

Monday June 11th, 09:00 – 09:30

Conference Opening

- Giovanni Moroni, *Conference Chair*
- Marco Francesco Boccione, *Head of Mechanical Engineering Department, Politecnico di Milano*
- Tullio Tolio, *President of AITeM - Associazione Italiana di Tecnologia Meccanica*
- Alessandro Marini, *Cluster Manager, AFIL – Associazione Fabbrica Intelligente Lombardia*

Monday June 11th, 09:30 – 10:50

Keynotes

- **Kn1:** Geometrical Variations Management 4.0: towards next Generation Geometry Assurance
B. Schleich, K. Wärmefjord, R. Söderberg, S. Wartzack
- **Kn2:** A Brief Analysis of Recent ISO Tolerancing Standards and Their Potential Impact on Digitization of Manufacturing
E.P. Morse, C.M. Shakarji, V. Srinivasan

Monday June 11th, 10:50 – 11:10

- Coffee Break

Monday June 11th, 11:10 – 12:25

A1: Tolerance Specification

Chair: Denis Teissandier

- Interactive multimedia learning environment for geometrical specification indication & verification rules – *Z. Humienny, M. Berta*
- A new approach to first tolerance evaluations in the conceptual design stage based on tolerance graphs – *S. Goetz, B. Schleich, S. Wartzack*
- A graph-based method and a software tool for interactive tolerance specification
S. Patalano, F. Vitolo, S. Gerbino, A. Lanzotti

B1: Tolerance Verification 1

Chair: Wahyudin P. Syam

- New development and distribution concepts for Education in Coordinate Metrology
M. Marxer, L. Rocha, N. Anwer, E. Savio
- Toward a Classification of Partitioning Operations for Standardization of Geometrical Product Specifications and Verification – *N. Anwer, P.J. Scott, V. Srinivasan*
- Reference data simulation for L^∞ fitting of aspheres
Y. Arezki, C. Mehdi-Souzani, N. Anwer, H. Nour



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Monday June 11th, 12:25 – 13:45

- Lunch

Monday June 11th, 13:45 – 14:25

Keynotes

- **Kn3:** Information-rich surface metrology
N. Senin, R. Leach

Monday June 11th, 14:25 – 15:40

A2: Robust Design and Uncertainty 1

Chair: Nabil Anwer

- Robust-Design-Optimization of mechanisms based on kinematic requirements considering uncertainties – *B. Heling, B. Schleich, S. Wartzack*
- Tolerance Analysis - Key Characteristics Identification by Sensitivity Methods
D. Idriss, P. Beaurepaire, L. Homri, N. Gayton
- Application of a graphical scheme for representing the mode of action of products for identification of key characteristics – *K. Bjarklev, T. Eifler, N.H. Mortensen, S. Linnebjerg, M. Ebro*

B2: Tolerance Verification 2

Chair: Paul Scott

- A Study of a priori knowledge-assisted multi-scopic metrology for freeform surface measurement
D. Li, C. Fai Cheung, B. Wang, M. Liu
- Accurate measurements in a production environment using dynamic length metrology (DLM)
L. De Chiffre, D. González-Madruga, G. Dalla Costa, M.R. Sonne, A. Mohammadi, J.H. Hattela, H.N. Hansen, K. Mohaghegh, M. Meftahpour, J. Meinertz, C. Meinertz
- Compensation of in-line metrology of polymer parts based on 3D thermomechanical analyses
M.R. Sonne, G. Dalla Costa, D.G. Madruga, L. De Chiffre, J.H. Hattel

Monday June 11th, 15:40 – 16:00

- Coffee Break

Monday June 11th, 16:00 – 17:40

A3: Robust Design and Uncertainty 2

Chair: Rikard Söderberg

- Quality-driven Optimization of Assembly Line Configuration for Multi-Station Assembly Systems with Compliant Non-Ideal Sheet Metal Parts – *V.J. Shahi, A. Masoumi, P. Franciosa, D. Ceglarek*
- Comparison of different methods for scrap rate estimation in sampling-based tolerance-cost-optimization – *M. Hallmann, B. Schleich, B. Heling, A. Aschenbrenner, S. Wartzack*
- Function-Oriented Quality Control Strategies for High Precision Products
R. Wagner, B. Haefner, G. Lanza
- Study on the Robust Tolerance Design with Multiple Resource Suppliers on Cloud Manufacturing Platform – *Z. Wu, K. Yang, L. Ting, Y. Cao, J. Yang, Y. Gan*



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B3: Tolerance Verification 3

Chair: Edward Morse

- Uncertainty analysis of a six-degree-of-freedom surface encoder for a planar motion stage
Y. Shimizu, M. Furuta, Y.-L. Chen, X. Chen, H. Matsukuma, W. Gao
- Uncertainty of coordinate measurement of geometrical deviations
W. Płowucha
- Metrological evaluation of a Coordinate Measuring Machine with 5-axis measurement technology
A.R. Sousa
- Method for Measurement Uncertainty Evaluation of Cylindricity Error Based on Good Point Set
L. Ren, T. Liu, Q. Zhao, J. Yang, Y. Cao

Monday June 11th, 17:40 – 20:00

Mechanical Engineering Department Lab Visit and Welcome Aperitif

Second Day

Tuesday June 12th, 09:00 – 10:40

A4: Tolerance Analysis 1

Chair: Wilma Polini

- Taking into account form variations in polyhedral approach in tolerancing analysis
D. Teissandier, V. Delos, S. Arroyave-Tobon, Y. Ledoux
- Comparative Study of Tolerance Analysis Methods Applied to a Complex Assembly
S. Ramnath, P. Haghighi, A. Chitale, J.K. Davidson, J.J. Shah
- Generating T-Maps with the kinematic transformation to model manufacturing variations of parts with position tolerancing of cylinders –
A. Chitale, N.J. Kalish, J.K. Davidson, J.J. Shah
- Statistical Tolerance Analysis with T-Maps for Assemblies
G. Ameta, J.K. Davidson, J.J. Shah

B4: Additive Manufacturing 1

Chair: Giovanni Moroni

- Tolerancing and Verification of Additive Manufactured Lattice with Supplemental Surfaces
G. Ameta, J. Fox, P. Witherell
- Shape Transformation Perspective for Geometric Deviation Modeling in Additive Manufacturing
Z. Zhu, N. Anwer, L. Mathieu
- Prediction and visualization of achievable orientation tolerances for additive manufacturing
H. Budinoff, S. McMains
- A categorical framework for formalising knowledge in additive manufacturing
Q. Qi, L. Pagani, P.J. Scott, X. Jiang

Tuesday June 12th, 10:40 – 11:00

- Coffee Break



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Tuesday June 12th, 11:00 – 12:40

A5: Tolerance Analysis 2

Chair: Sandro Wartzack

- Consideration of Working Conditions in Assembly Tolerance Analysis
L. Ting, Z. Zuowei, C. Yanlong, N. Anwer, Y. Jiangxin
- Statistical Tolerance Analysis Technique for Over-Constrained Mechanical Systems
L. Homri, P. Beaurepaire, A Dumas, E. Goka, N. Gayton, J.Y. Dantan
- Computing clearances and deviations in over-constrained mechanisms
A. Mabire, P. Serré, M. Moinet, J.-F. Rameau, A. Clément
- Tolerance analysis of hyperstatic mechanical systems with deformations
L. Pierre, O. Rouetbi, B. Anselmetti

B5: Additive Manufacturing 2

Chair: Gaurav Ameta

- Typology of geometrical defects in Electron Beam Melting
T.H. Vo, M. Museau, F. Vignat, F. Villeneuve, Y. Ledoux, A. Ballu
- Additive manufacturing with vat polymerization method for precision polymer micro components production – *A. Davoudinejad, L.C. Diaz-Perez, D. Quagliotti, D. Bue Pedersen, J.A. Albajez-García, J.A. Yagüe-Fabra, G. Tosello*
- Data fusion methods for statistical process monitoring and quality characterization in metal additive manufacturing – *M. Grasso, F. Gallina, B.M. Colosimo*
- In-process measurement of the surface quality for a novel finishing process for polymer additive manufacturing – *W.P. Syam, R. Leach, K. Rybalcenko, A. Gaio, J. Crabtree*

Tuesday June 12th, 12:40 – 14:00

- Lunch

Tuesday June 12th, 14:00 – 15:40

A6: Tolerance Analysis 3

Chair: Alex Ballu

- Tolerance Analysis of Surface-to-Surface Contacts Using Finite Element Analysis
S. Camuz, R. Söderberg, K. Wärmefjord, M. Lundblad
- Computer Aided Tolerancing of Composite Elevator Assembly Involving Clamping Forces Coordination – *H. Wang, S. Zhang, J. Yu*
- The Applicability of CAT tools in industry – boundaries and challenges in tolerance engineering practice observed in a medical device company – *N. Sigurdarson, T. Eifler, M. Ebro*
- Tolerance analysis using a Computer Aided Tolerancing Software: ANATOLE 3D
L.-M. Frère, M. Royer, J. Fourcade



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B6: Additive Manufacturing 3

Chair: *Leonardo De Chiffre*

- X-ray computed tomography for metal additive manufacturing: challenges and solutions for accuracy enhancement – *F. Zanini, E. Sbettega, S. Carmignato*
- Surface extraction algorithm influence on the uncertainty assessment and tolerance compliance of computed tomography measurements
J.A. Yagüe-Fabra, R. Jiménez, S. Ontiveros, M. Torralba, G. Tosello
- A Discussion on Performance Verification of 3D X-Ray Computed Tomography Systems
G. Moroni, S. Petrò
- Industrial needs and available techniques for geometry assurance for metal AM parts with small scale features and rough surfaces – *J. Berglund, R. Söderberg, K. Wärmefjord*

Tuesday June 12th, 15:40 – 16:00

- Coffee Break

Tuesday June 12th, 16:00 – 17:40

A7: Functional Tolerancing

Chair: *Kristina Wärmefjord*

- On the usage of Least Material Requirement for Functional Tolerancing
L. Pierre, B. Anselmetti, N. Anwer
- An adaptive tolerancing algorithm for freeform profiles
L. Pagani, Q. Qi, J. Wang, X. Jiang, P.J. Scott
- Functional ISO specification of a blade: a tolerancing challenge
Y. Fallo, F. Thiébaud, M. Royer
- A tolerance design method for hydrostatic guideways motion accuracy based on error averaging effect – *J. Zha, Y. Chen, Z. Wang*

B7: Micro-Manufacturing

Chair: *Massimiliano Annoni*

- Tolerance verification of precision injection moulded Fresnel lenses
D. Loadi, M. Calaon, D. Quagliotti, P. Parenti, M. Annoni, G. Tosello
- Multiscale dimensional tolerance specifications established on shrinkage assessment in ceramic micro injection molding – *D. Quagliotti, H.N. Hansen, G. Tosello*
- Comparison of micro and conventional injection moulding based on process precision and accuracy
F. Baruffi, A. Charalambis, M. Calaon, R. Elsborg, G. Tosello
- Meta-Model Based on Artificial Neural Networks for Tooth Root Stress Analysis of Micro-Gears
B. Haefner, M. Biehler, R. Wagner, G. Lanza

Tuesday June 12th, 20:00 – 22:30

Conference Dinner

- Fondazione Stelline, Milano, Corso Magenta n.61
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Third Day

Wednesday June 13th, 09:00 – 10:40

A8: Form Deviation in Tolerance Analysis

Chair: *Lihong Qiao*

- An Approach to the Sensitivity Analysis in Variation Simulations considering Form Deviations
B. Schleich, S. Wartzack
- Shape Error Modelling and Analysis by Conditional Simulations of Gaussian Random Fields for Compliant Non-Ideal Sheet Metal Parts – *M. Babu, P. Franciosa, D. Ceglarek*
- FEA integration in the tolerance analysis using Skin Model Shapes
A. Corrado, W. Polini
- Tolerance analysis of annular surfaces considering form errors and local surface deformations
Z. Zhang, J. Liu, X. Ding, N. Shao

B8: Tolerance Verification 4

Chair: *Stefano Petrò*

- Reverse Engineering of Turbine Blades Kaplan's type for Small Hydroelectric Power Station
S. Zivkovic, L. Cerce, J. Kostic, V. Majstorovic, D. Kramar
- Study of measurement process capability with non-normal data distributions
G. Genta, M. Galetto
- Can A Low Cost Sensing System Be Exploited For High Precision Machining?
F. Modica, V. Basile, S. Ruggeri, G. Fontana, I. Fassi
- Highly accurate optical μ CMM for measurement of micro holes
K. Zangl, R. Danzl, F. Helml, M. Prantl

Wednesday June 13th, 10:40 – 11:00

- Coffee Break

Wednesday June 13th, 11:00 – 12:40

A9: Actual Mating Conditions

Chair: *Benjamin Schleich*

- The Calculation Method of the Inspection Tolerance Zone When Two Datum Features Apply MMC/LMC – *Y. Wu*
- Assembly simulation of Skin Model Shapes: a comparison of two methods taking into account external forces – *X. Yan, A. Ballu*
- Research on computing position and orientation deviations caused by mating two non-ideal planes
J. Zhang, L. Qiao
- A study of contact state for non-ideal planar surface assembly
Y. Li, L. Qiao



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B9: Quality

Chair: *Maurizio Galetto*

- An Industrial Product-Service System approach for Laser Process Quality Control
D. Mourtzis, N. Boli, K. Alexopoulos, P. Pittaro, A. Terreno
- Geometrical Variation from Selective Laser Heat Treatment of Boron Steels
V.R. Sagar, K. Wärmefjord, R. Söderberg
- Evaluating evolutionary algorithms on spot welding sequence optimization with respect to geometrical variation – *R.S. Tabar, K. Wärmefjord, R. Söderberg*
- Evaluation of the spring-in of CFRP thin laminates in dependence on process variation
A. Corrado, W. Polini, L. Sorrentino, C. Bellini

Wednesday June 13th, 12:40 – 13:00

Conference Closing

Wednesday June 13th, 13:00 – 14:00

- Lunch

Wednesday June 13th, 15:00 – 17:00

Conference Visit: Fine Arts in Milano

- Veneranda Biblioteca Ambrosiana, *Milano, P.zza Pio XI n.2*
- Highline Galleria