Association for Coordinate Metrology Canada

Association canadienne de métrologie de coordonnées

2005 ACMC Annual Workshop

McMaster University, Hamilton Ontario
9-10 June 2005

Thursday, 9 June 2005

08:30 - 08:50 CONFERENCE REGISTRATION
Coffee & breakfast refreshments

08:50 - 09:00 Welcoming Remarks
Dan Connelly, ACMC Chairman
Dr. Allan Spence, McMaster University

09:00 - 10:30 Interim Checking of CMMs - the Responsibility of the User
Dr. Eugen Trapet, Unimetrik, Spain

Interim checking of CMMs by the user helps to get an image about the state of the CMM accuracy at any time, reduces costs and time for re-compensation and re-verification by the supplier or by third parties if the machine is stable, may indicate the need for a service earlier than planned, and is particularly useful in the search for the sources of discrepances in the daily parts verification (at least the CMM may be excluded in the search for sources of mistakes). In the case of bridge type CMMs working under good environmental conditions, studies have shown that many of these machines are very stable in time, and that, once perfectly compensated, they need not be touched for years (except for the service of their mechanical components which suffer from wear). The same studies have shown that users which are able to verify themselves the outcome of the service and compensation performed by their supplier, had in average machines with better accuracy. For large CMMs there exists less knowledge from manufacturer-independent studies. However it is known that large machines, particularly machines mounted to foundations embedded in the underground, suffer much more from changes of their geometry than smaller machines and should be monitored quite frequently. Interim checking gives the user as well an idea of the effects on the accuracy that temperature variations cause. Interim checking should be performed with methods that require only a couple of minutes machine down time so that the user is really in a position to perform it frequently. In this presentation the above-mentioned aspects of interim checking are discussed and recommendations for interim check means and procedures are given.

10:30 - 10:45 COFFEE BREAK

10:45 - 11:45 New Techniques for Profile Filters
Dr. Michael P. Krystek, PTB, Germany

Profile filters have been used for years in roughness and form measurement. However, the classical filter techniques have some disadvantages and new techniques for profile filters have been developed in recent years. These filters are applicable in classical roughness and form measurement instruments as well as in scanning mode CMMs. They can not only be used to filter planar profiles, but also space curves, even in the case of unequally spaced data points.

Starting from the history of classical electrical and digital profile filters, such as the RC filter or the Gaussian filter, and their disadvantages, the new filter techniques will be introduced and their advantages will be shown. The presentation will cover new linear filters, e.g., spline filters as well as non-linear filters such as morphological profile filters. It will also be shown how spikes or outliers within the measured data sets may automatically be removed by a new class of robust linear filters or by alternating morphological profile filters, or how morphological operations can be used to reconstruct surface data from measured data distorted by tactile probing, as usual in CMM applications.

11:45 - 12:30 **New Techniques for Turbine Blade Metrology**
Bill Verwys, Application Engineering Manager,
Optical Gaging Products, Inc., Rochester, USA

Dimensional measurement of turbine blades and vanes, as used in jet engines, auxiliary power units, and power generating equipment, has traditionally been a laborious process. Custom hard-gaging, optical sectioning microscopes, guillotine gages, profile gages, and other special purpose devices have long been the tools of choice for measurement of airfoil cross-sectional form, leading/trailing edge radii, root form profile, seal slot geometry, and true position of cooling holes. Recent advances in multi-sensor metrology, defined as a coordinate measuring machine with optical, tactile, and laser scanning sensors, have enabled turbine manufacturers to significantly improve the accuracy and productivity of blade and vane metrology.

This presentation covers the use of multi-sensor metrology systems in the practical application of measuring turbine blade dimensional characteristics. Presentation topics include descriptions of measurements unique to turbine blade and vane geometry, optical design criteria for accurate imaging of seal slots and cooling holes, five-axis servo control and positioning, laser profile scanning for cross-sectional analysis, real-time coordinate transformations in five-axis space, datum “nest” creation by iterative probing and three-dimensional fitting, as well as two and three dimensional fitting analysis for root form and airfoil cross-sections.

12:30 - 13:30 LUNCH

13:30 - 14:30 **Measurement Uncertainty, CMMs and Standards: Today and the Future**
Dr. Steve Phillips, NIST, USA

Over the past decade measurement uncertainty has evolved from an obscure art practiced at National Measurement Institutes (NMIs) to an increasingly intertwined aspect of industrial metrology. This presentation examines the progression of measurement uncertainty from the NMIs to the calibration laboratories and onto the shop floor. National and international standards relevant to uncertainty considerations are described, and how measurement uncertainty is impacting the specification of CMMs is presented. Addressing the work of the ISO/TC213 Working Group 10 on CMM - the new ISO 10360-2 standard (to be published soon) .

14:30 - 15:15 **Influence of measurement uncertainty on process variations**
Dr. Paulo Pereira, Caterpillar, USA

It is usual to see in use the 4:1 or 10:1 rules about part tolerance to gage resolution ratios. It is also very common to use Gage Repeatability and Reproducibility (GR&R) requirements of 10 %. They all derive from older documents like the military standard MIL-STD-45662 “Calibration Systems Requirements” (now canceled). People who understand metrology can comprehend why the requirement: not to influence the underlying measured information. That is, the user wants to know the part dimensions without excessive misrepresentation from the gaging process.

Manufacturing processes have inherent variations due to a myriad of variables influencing them. These variations must be kept within limits and metrology is used to verify that and provide valuable information to be used to improve the process.

Being a measure of process variation, cpk is influenced by gage uncertainty that, mathematically speaking, only increases the total variation. Since the data used to calculate cpk values is furnished by the gaging equipment, there is no way of separating process from gaging variations. The best way to have reliable measures of process variations is to guarantee proper measurement uncertainty before collecting data. The 10:1 is a very valid and useful rule as shown by calculations.

15:15 - 15:30 COFFEE BREAK

15:30 - 17:00 Forum: Implication of Small-Arc Radius Measurements to Industry

Panel Chair–Greg Hetland
Panel Members—Steve Phillips, Kostadin Doytchinov, Kim Summerhays

17:00 - 17:30 ACMC Business
Annual Report and Election of Officers

17:30 - 18:15 Open Discussions and Vendor's Time

18:45 - 19:15 RECEPTION (Cash Bar)
Royal Botanical Gardens

19:15 DINNER
Royal Botanical Gardens

Friday, 10 June 2005

08:00 - 08:30 CONFERENCE REGISTRATION
Coffee & breakfast refreshments

08:30 - 09:30 A Versatile Tool for the Evaluation of CMM Task-Specific Measurement Uncertainty
Dr. Kim D. Summerhays, MetroSage, LLC

The wide assortment of measurands, broad scope of measurement conditions, and complexity of data analyses encountered in CMM-based metrology make evaluation of task-specific measurement uncertainties a formidable undertaking. Difficulties in the–*a priori* assessment of required sensitivity coefficients and correlations render purely analytic approaches, as frequently described in the GUM, ill-suited to the need. Thus ISO is currently engaged in the development of a supplement to the GUM focused on numerical methods for the propagation of distributions. In addition, the ISO 15530 series addresses techniques for determining the uncertainty of measurement in CMM applications. Part 4 of that series is specific to numeric simulation. The methods cited in the 15530 series will be briefly reviewed and compared. It will be seen that, among these alternatives, simulation methods, when properly formulated, offer numerous advantages.

09:30 - 10:15 **An Alternative Statistical Procedure to Estimate the Uncertainty of Coordinate Measurements Using Calibrated Workpieces**

Crhistian Raffaelo Baldo, *Gustavo Daniel Donatelli*
Labmetro– Laboratory of Metrology and Automation
Federal University of Santa Catarina
Florianópolis – Brazil

The measurement uncertainty is a key element in the modern concept of traceability. In order to avoid wrong decisions and unnecessary expenditure on more accurate measuring systems, the uncertainty estimation should be neither conservative nor optimistic. In addition, the procedures used to estimate the uncertainty have to be time efficient and easy to understand. This ideal, however, has not been achieved in the field of coordinate measurements so far. Some methods have been proposed based on computer simulation, experimental procedures, or even a mix of both. Experimental methods are particularly attractive because they use a black-box approach that is easy to understand by average metrologists. That is the case of ISO-DTS 15530-3, which suggests a procedure to estimate the task-specific uncertainty by repeated measurements on one or more calibrated workpieces. In a previous paper of the authors, some objections were made to the statistical processing proposed by the standard; in particular, to the way in which the systematic error and the standard deviation of the repeatability error are estimated. The authors pointed out that there is no reason to consider that these errors are consistent for all measured workpieces. In this presentation, an alternative statistical procedure based on the concept of calibrated workpieces is proposed. The procedure is consistent with the GUM and uses control charts to assess the consistency of the estimates. Thus, eventual inconsistencies can be isolated and investigated to decide if they are due to outliers or intrinsic to the measurement strategy. It is also shown how the proposed technique can improve the estimation of the measurement uncertainty in time.

10:15 - 10:40 COFFEE BREAK

10:40 - 12:30 **Implications of Datums and Datum Modifiers related to Single Segment and Composite Position Tolerancing**

Dr. Greg Hetland, International Institute of Geometric Dimensioning and Tolerancing, U.S.A.

Significant sources of measurement uncertainty in the physical metrology arena are uncorrected because a large percentage of inspectors/metrologists are not aware of their presence and how to correct for them. In application specific examples related to single-segment and composite position tolerancing, this presentation will focus on implications of datums and datum modifiers, and review “2D Restrained” and 2D-Unrestrained” solutions. The objective is for users to be able to confidently identify these sources of measurement uncertainty and to correct for them in future applications.

12:30 - 13:30 LUNCH

13:30 - 14:00 **McMaster University laboratory tour**

Dr. Allan Spence, Associate Professor
Mechanical Engineering, McMaster University

The McMaster University laboratory tour will include the modern design, manufacturing, and inspection facilities within the Department of Mechanical Engineering, including stereo anaglyph and shutter glass 3-D displays of CAD models, and 3 and 5 axis machine tools and lathes. Inspection facilities include laser digitizers, touch trigger and analog probes, a dual drive bridge CMM, and FARO portable arm CMM. Selected industrial research projects will also be on display.