CMM Calibration and the ISO Standards

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Abstract

Coordinate Measuring Machines (CMMs) are evaluated to National and International standards for the purpose of commerce – i.e. the buying and selling of measuring machines. In addition, periodic re-verification is required so that the continued validity of measurements is assured. However, the data obtained from these measuring tests are used for other purposes, among them: suitability for various measuring tasks and inferring measurement uncertainty.

Standards for CMMs

B89.4.1 – 1997

In the US, the B89.4.1 standard – originally the B89.1.12 standard – has been the primary standard for purchase and assessment of CMMs for some time. The suite of tests described by this standard includes probing performance, linear accuracy, and volumetric performance tests. The volumetric performance value, associated with the "ball bar test," is the most commonly used number for describing the quality of a CMM tested to this standard. This test should not be run in isolation, and relies on the linear displacement accuracy (LDA) test and the offset probe test to fully capture the geometric capability of the CMM in question. The probing tests are also necessary to understand the performance that can be expected when measuring actual parts.

ISO 10360

The ISO standards for CMM performance are the 10360 series of standards, entitled *Geometrical Product Specifications (GPS) — Acceptance and reverification tests for coordinate measuring machines (CMM)*. This series contains the following parts:

ISO 10360-1: Vocabulary
ISO 10360-2: CMMs used for measuring linear dimensions
ISO 10360-3: CMMs with the axis of a rotary table as the fourth axis
ISO 10360-4: CMMs used in scanning measuring mode
ISO 10360-5: CMMs using multiple-stylus probing systems
ISO 10360-6: Estimation of errors in computing of Gaussian associated features

The actual tests for determining the performance of a 'conventional' CMM are found in part 2 of this series. In the simplest terms, two values are determined experimentally by measuring standards of calibrated size. These values are E, the length measuring error, and P, the probing error.

The determination of E is obtained by measuring 5 lengths (gage blocks, or steps on a step gage) 3 times each, and repeating in 7 different orientations. The maximum deviation of the indicated

length from the calibrated length is the error E. The probing error is found by measuring a calibrated test sphere with 25 points, and finding the range in the radial distances of the individual measurement points to the sphere's center.

ISO 10360-2 and -5: 200x

Parts 2 and 5 of the ISO 10360 series are currently under revision; this work is being carried out in ISO Technical Committee 213, Working Group 10 (ISO213/WG10). While the final outcome of this revision is not yet determined, the use of an offset probe test and some evaluation of the CMM's repeatability are likely to be included.

Calibration

Calibration is defined by the VIM (*Vocabulaire International des Termes Fondamentaux et Généraux de Métrologie, **or** International Vocabulary of Basic and General Terms in Metrology*) to be the

> *set of operations that establish, under specified conditions, the relationship between values of quantities indicated by a measuring instrument or measuring system, or values represented by a material measure or a reference material, and the corresponding values realized by standards.*

Calibration of a CMM using the ISO 10360 series of standards requires that calibrated artifacts be used to determine the values of E and P (at a minimum). If these values are within (less than or equal to) the maximum permissible errors (MPEs) given, the CMM is usually considered to be operating in an acceptable manner. Where issues often arise is when the CMM does not meet the MPE values, and adjustments must be made to the CMM and its compensation tables before testing the CMM again. During our panel discussion we will consider what different customers and calibration houses consider to be appropriate when a "CMM calibration" is purchased.

Test Uncertainty

A final issue that is integral to the CMM evaluation process is the reference to the default rule of ISO 14253-1 for the acceptance of a CMM based on the MPEs specified by the manufacturer. The uncertainty of the test itself (a tricky issue, addressed by Jim Salsbury on this panel) must be accommodated in the acceptance process. There is a risk that this could introduce "specsmanship" to not only the manufacturer's claims about their CMM, but also to the uncertainty they claim might be reasonably associated with the test and the testing process.

Current US activities

The standards activities in the United States that relate to the 10360-series are two-fold: the ASME B89.4 committee and its project teams continue to meet to discuss the B89.4 standard and its implementation, while subject matter experts (SMEs) who participate in ISO TC213/WG10 work with their international colleagues to develop the ISO 10360 standards for the international community. As many industries, and most CMM manufacturers, are truly international businesses, it seems that the future will undoubtedly realize more uniformity in CMM standards. The US committees must recognize this eventuality, and strive to bring the US standards closer to the ISO standards, while not placing domestic companies at a competitive disadvantage during this transition.