Coordinate Measuring Machines

Performance Assessment Method of Coordinate Measuring Machines

Regarding the performance assessment method of coordinate measuring machines, JIS was revised in 2003. In the revised JIS, the standards for scanning measurement and rotary tables have been added to the conventional test items. Also, the concept of "uncertainty" has been incorporated into the latest JIS. At that point in 2003 the four items in Table 1 were standardized.

Table 1 JIS B 7440 (2003) Series

	Item	JIS Standard No.	Year of issue
1	Terms	JIS B 7440-1 (2003)	2003/4
2	Dimensional measurement	JIS B 7440-2 (2003)	2003/4
3	Rotary table-equipped CMM	JIS B 7440-3 (2003)	2003/4
4	Scanning measurement	JIS B 7440-4 (2003)	2003/4

Maximum Permissible Measuring Error MPE_E [JIS B 7440-2 (2003)]

The test procedure under this standard is that a coordinate measuring machine (CMM) is made to perform a series of measurements on five different test lengths in each of seven directions, as shown in Figure 1, to produce a set of 35 measurements. This sequence is then repeated twice to produce 105 measurements in all. If these results, including allowances for the uncertainty of measurement, are equal to or less than the values specified by the manufacturer then the performance of the CMM has been proved to meet its specification.

The standard allows up to five measurements to exceed the specified value (two NG results among 3-time measurements in the same position are not allowed). If this is the case, additional 10-times measurements for the relevant position are performed. If all the 10 results, including the uncertainty allowance, are within the specified value, the CMM is assumed to pass the test. The uncertainties to be considered in determining the maximum permissible measuring error are those concerning calibration and alignment methods used with the particular material standards of length involved with the test. (The values obtained by adding an extended uncertainty combining the above two uncertainties to all test results must be less than the specified value.) The result of the test may be expressed in any of the following three forms (unit: μm).

$MPE_E = A + L/K \leq B$
$MPE_E = A + L/K$
$MPE_E = B$

A: Constant (μm) specified by the manufacturer
K: Dimensionless constant specified by the manufacturer
L: Measured length (mm)
B: Upper limit value (μm) specified by the manufacturer

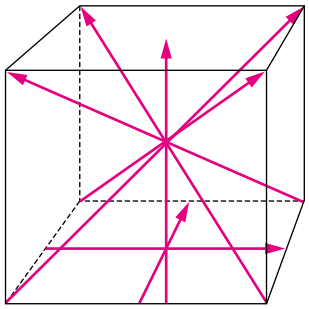

Figure 1 Typical test measurement directions within the CMM measuring volume

Maximum Permissible Probing Error MPE_P [JIS B 7440-2 (2003)]

The test procedure under this standard is that a probe is used to measure defined target points on a standard sphere (25 points, as in Figure 2) and the result used to calculate the position of the sphere center by a least squares method. Then the distance R from the sphere center for each of the 25 measurement points is calculated, and the radius difference Rmax - Rmin is computed. An extended uncertainty that combines the uncertainty of the stylus tip shape and that of the standard test sphere is added to the radius difference. If this final calculated value is equal to or less than the specified value, the probe has passed the test.

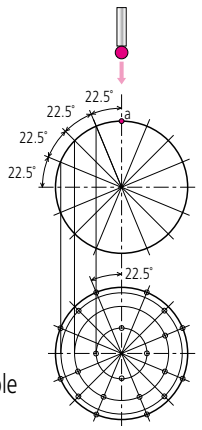

Figure 2 Target points on standard sphere for determining the Maximum Permissible Probing Error

Maximum Permissible Scanning Probing Error MPE_{THP} [JIS B 7440-4 (2003)]

This is the accuracy standard for a CMM if equipped with a scanning probe. Scanning probing error was standardized in JIS B 7440-2 (2003) for the first time. The test procedure under this standard is to perform a scanning measurement of 4 planes on the standard sphere and then, for the least squares sphere center calculated using all the measurement points, calculate the range (dimension 'A' in Figure 3) in which all measurement points exist. Based on the least squares sphere center calculated above, calculate the distance between the calibrated standard sphere radius and the maximum measurement point or minimum measurement point, and take the larger distance (dimension 'B' in Figure 3). Add an extended uncertainty that combines the uncertainty of the stylus tip shape and the uncertainty of the standard test sphere shape to each A and B dimension. If both calculated values are less than the specified values, this scanning probe test is passed.

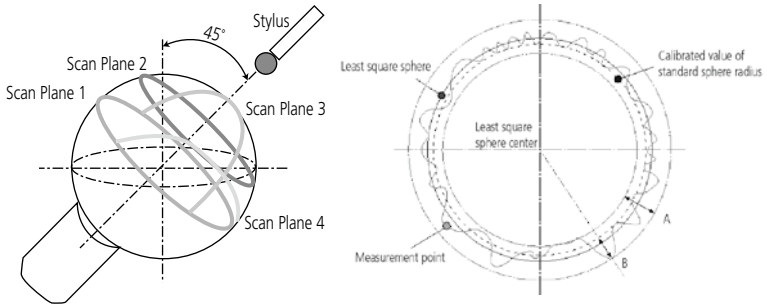

Figure 3 Target measurement planes for the maximum permissible scanning probing error and its evaluation concept

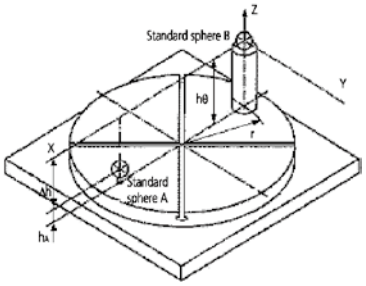

Figure 4 Evaluation of a CMM with a rotary table

Maximum Permissible Rotation Axis Radial-Direction Error MPE_{FR}, Maximum Permissible Rotation Axis Connecting-Direction Error MPE_{FT}, and Maximum Permissible Rotation Axis Axial-Direction Error MPE_{FA} [JIS B 7440-3 (2003)]

The test procedure under this standard is to place two standard spheres on the rotary table as shown in Figure 4. Rotate the rotary table to a total of 15 positions including 0˚, 7 positions in the plus (+) direction, and 7 positions in the minus (-) direction and measure the center coordinates of the two spheres in each position. Then, add the uncertainty of the standard sphere shape to each variation (range) of radial direction elements, connecting direction elements, and rotational axis direction elements of the two standard sphere center coordinates. If these calculated values are less than the specified values, the evaluation test is passed.